Educational Research and Innovation

Fostering Students' Creativity and Critical Thinking

WHAT IT MEANS IN SCHOOL

OECD

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Stéphan Vincent-Lancrin, Carlos González-Sancho, Mathias Bouckaert, Federico de Luca, Meritxell Fernández-Barrerra, Gwénaël Jacotin, Joaquin Urgel and Quentin Vidal

OECD
BETTER POLICIES FOR BETTER LIVES

Please cite this publication as:
Vincent-Lancrin, S. et al. (2019), *Fostering Students' Creativity and Critical Thinking: What it Means in School*, Educational Research and Innovation, OECD Publishing, Paris, *https://doi.org/10.1787/62212c37-en*.

ISBN 978-92-64-94313-1 (print)
ISBN 978-92-64-68400-3 (pdf)

Educational Research and Innovation
ISSN 2076-9660 (print)
ISSN 2076-9679 (online)

Foreword

We live in a world where the things that are easy to teach and test have also become easy to digitize and automate. In this respect, creativity and critical thinking become increasingly important, both to ensure that we harness technology and continue to work together towards a more sustainable and humane world. It is neither surprising that most curricula give them more emphasis, nor that teachers find them difficult to teach and test.

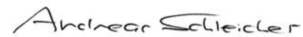
Tomorrow's schools need to help students think for themselves and work with others. They have to grasp the limits on individual and collective action, and become better at seeing and understanding our own perspectives, and the world around us. At work, at home and in the community, people will need a deep understanding of how others live, in different cultures and traditions, and how others think, whether as scientists or artists. People also have to become better at imagining new solutions, at seeing new possibilities, new connections, and turning them into new products or ways to better live together.

This is why schools need to nurture students' creativity and critical thinking, help them look at things from different perspectives, understand the limits of their and of others' views, and help transform their ideas into innovative solutions: inquire, imagine, do and reflect, as our OECD rubrics on creativity and critical thinking put it.

None of this is easy, and it will not be done overnight, but this book offers concrete opportunities to make progress. It provides teachers and schools with new tools to build learning environments that give students opportunities to practice their creativity and critical thinking skills, without diminishing the value of subject-matter content and procedural knowledge. The book also provides policy makers with insights on how to support teachers in improving their practices and make their education systems more evidence-informed.

All the resources presented in the book have been developed and tested in a network of schools and teachers from eleven countries. The work has also fed the development of the conceptual framework of "creative thinking", the innovative domain of the OECD Programme for International Student Assessment (PISA) in 2021.

The hundreds of teachers that participated in the work are committed that our education systems develop first-class humans, not second-class robots and believe in the value of international collaboration to serve that goal.



Andreas Schleicher

OECD Director for Education and Skills

Acknowledgements

This book was co-authored by Stéphan Vincent-Lancrin (Senior Analyst, OECD), Carlos González-Sancho, Mathias Bouckaert, Federico de Luca, Meritxell Fernández Barrera (Analysts, OECD), Gwénaël Jacotin (Statistician, OECD), Joaquín Urgel and Quentin Vidal (Consultants, OECD).

Chapters were authored as follows: Chapters 1 and 2: Stéphan Vincent-Lancrin; Chapter 3: Stéphan Vincent-Lancrin and Joaquín Urgel, with inputs from Jillian Hogan (Studio Thinking, Modern Band Movement, Teaching for Artistic Behavior), Zemira Mevarech (Metacognitive pedagogy) and Keith Whitescarver (Montessori); Chapter 4: Carlos González-Sancho and Meritxell Fernández-Barrerra; Chapter 5: Mathias Bouckaert; Chapter 6: Carlos González-Sancho; Chapter 7: Federico de Luca; Chapter 8: Quentin Vidal, Federico de Luca, Gwénaël Jacotin and Stéphan Vincent-Lancrin; Technical Annex: Quentin Vidal and Federico de Luca.

Stéphan Vincent-Lancrin edited the book. Jennifer Allain (Literate) copy-edited it. Sophie Limoges and Alison Burke (OECD) oversaw the publication process.

The book is one of the outputs of a project of the OECD Centre for Educational Research and Innovation (CERI) at the OECD Directorate for Education and Skills that was led and conceptualised by Stéphan Vincent-Lancrin. Madeleine Gereke provided invaluable assistance to the project, as well as Rhodia Diallo and Parissa Nahani (OECD) at its earlier stages.

The instruments for the quantitative data analysis for a validation study were developed by Stéphan Vincent-Lancrin, Carlos González-Sancho, Gwénaël Jacotin and Nicolas Jonas (UNESCO, formerly OECD), and refined by Federico de Luca during the quantitative analysis. The database of the pilot data collection was built and cleaned by Gwénaël Jacotin, Judit Pál and Soumyajit Kar. The quantitative work was mainly carried out by Federico de Luca, Gwénaël Jacotin and Quentin Vidal.

Larry Hedges (Northwestern University, United States) is gratefully acknowledged for his advice and feedback on the quantitative analysis of the pilot data.

The scientific advisory board of the project was composed of: Paul Collard (Creativity, Culture and Education, United Kingdom), Jillian Hogan (Boston University, United States), Todd Lubart (University of Paris Descartes, France), Bill Lucas (University of Winchester, United Kingdom), Zemira Mevarech (Bar Ilan University, Israel), Katariina Salmela-Aaro (University of Helsinki, Finland), Barbara Schneider (Michigan State University, United States), and Ellen Winner (Boston University, United States). They provided invaluable advice throughout the project and are thankfully acknowledged.

The pedagogical resources supporting and exemplifying how to foster creativity and critical thinking in school constitute key outputs of the project. They were co-designed by the OECD Secretariat, the scientific advisers to the project and the country teams that participated in the project (including teachers in the field). Each lesson plan mentions its author(s). Cassie Hague (consultant to the OECD) edited all lesson plans. As part of her design of the web application displaying all the pedagogical resources for teachers and other stakeholders, Gerri Burton (New Learning Ventures) contributed many ideas to the project and how to make the pedagogical resources more useful to teachers.

Andreas Schleicher (OECD Director for Education and Skills), Deborah Roseveare (Head of CERI) and Dirk Van Damme (former Head of CERI) are thanked for the advice, support and encouragements they gave throughout the duration of the project.

The European Union co-funded the project for two years as part of Creative Europe. Walter Zampieri (Head of Section for Cultural Diversity and Innovation, European Commission [EC]) and the different EC officers that followed and supported the project are gratefully acknowledged: Peggy Genève, Carmela Cutugno, and Dorota Nigge.

The project co-ordinators of the country teams and the support of their education ministries (or other local educational authorities) were essential to make the project happen, and its implementation, successful. Acknowledgements in country teams are as follows.

Brazil: At Ayrton Senna Institute: Laura di Pizzo (Project coordinator, Ayrton Senna Institute), Viviane Senna (President), Tatiana Filgueiras (Executive Director of EduLab21), Mozart Neves (Director of Innovation and Political Liason), Maria Clara de Paula Couto (Implementation Manager 2017), Cesar Augusto A. Nunes (Specialist), Katia Mori (Specialist). The Santa Catarina State Department of Education, the Chapecó Municipality Department of Education, and Santa Catarina State´s Industry Federation (FIESC) were fully engaged in the project operated under a formal partnership with the Ayrton Senna Institute, who also counted on Fundação Itaú Social as a Supporting Partner.

France: At the Centre for Interdisciplinary Research (CRI): Jean-Philipe Maître and Filippo Pirone (project co-ordinators), Ange Ansour, and François Taddéi; at La Main à la pâte Foundation: Elena Pasquinelli (project coordinator) and David Jasmin; at the Ministry of Education, Isabelle Robin, Bénédicte Galtier and Florence Lefresne.

Hungary: At T-Tudok Centre for Knowledge Management and Educational Research and Education Authority, Budapest: Szilvia Németh (project coordinator) and Anita Kaderják; At T-Tudok Centre for Knowledge Management and Educational Research:, Judit Kádár Fülöp, Judit Lannert, Daniel Vince, Dezső Máté; At the University of Pécs: Attila Lengvárszky, Péter Lengyel, and Endre Raffay; at the Step by Step Programme Hungary, Bertalanné Zágon and Éva Deák; At the Educational Authority, Budapest: Sándor Brassói, László Ostorics and László Pongrácz.

India: At Learning Links Foundation: Anjlee Prakash (CEO), Usha Bhaskar (project coordinator), Sakshi Singh; Subject Experts from National Council of Education, Research and Training (NCERT) supported the project; At the Ministry of Human Resource Development: Shri S.C. Khuntia.

The Netherlands: At the Kohnstamm Institute (University of Amsterdam): Marieke Buisman (project coordinator), Marianne Boogaard and Liselotte van Loon; At the SLO: Marc van Zanten; At ILO (University of Amsterdam): Marie-Thérèse van de Kamp; at the Ministry of Education: Rosa van der Tas (project supervisor), Jeanne Van Loon and Rien Rouw.

Russian Federation: At the National Research University "Higher School of Economics": Marina Pinskaya (project coordinator), Aleksandra Mikhailova, Nadezhda Avdeenko, Stas Khanin, Aleksandr Smirnov, Alexander Sidorkin, and Isak Froumin; The Ministry of Education and Sberbank Charitable Foundation «Investment to the Future» supported the project.

Slovak Republic: At Constantine the Philosopher University: Vladimíra Kurincová Čavojová (project coordinator); Dana Malá (data collection coordinator); Eva Ballová Mikušková (data processing); Katarína Szíjjártóová (coordination with schools). Collection of contextual data was done with the help of other colleagues from the Department of School and Pedagogical Psychology and Department of Pedagogy. At the Ministry of Education: Matej Šiškovič, Michal Kozák.At the Ministry of Foreign Affairs: Dagmar Repčeková.

Spain: At the Madrid Department for Education: Ismael Sanz Labrador (Director General of Innovation), Luis Pires Jiménez (project coordinator, Assistant Director of Innovation), Antonia Muñiz de la Arena (pedagogical coordinator), and María Ángeles Díez Santos and Maryan Puga Zuccoti (data co-ordinators).

Thailand: At the Equitable Education Fund (EEF): Vicharn Panich (Chairman) and Kraiyos Patrawart (project coordinator); At Sripatum University at Chonburi (SPUC), Thanyawich Vicheanpant (Lead Researcher); At the Research Institute for Policy Evaluation and Design (RIPED) (University of the Thai Chamber of Commerce): Weerachart Kilenthong; At the Ministry of Education: Mr. Nataphol Teepsuwan (Minister of Education, 2019-present), Mr. Teerakiat Jareonsettasin (Minister of Education, 2016-2019) and Mr. Boonrak Yodphet (Secretary General, Office of Basic Education Commission).

United Kingdom (Wales): At the Arts Council of Wales: Diane Hebb (project coordinator, Director – Arts engagement) and Sian James (project manager); At Wavehill Ltd.: Mair Bell (research coordinator) and Endaf Griffiths (Director). At the Welsh Government (Department for Education): Kirsty Williams AM (Minister for Education), Steve Davies (Director, Education Directorate), John Pugsley (Head of Arts), and Richard Thurston (Deputy Chief Social Research Officer).At Creativity, Culture and Education (CCE): Diane Fisher-Naylor (Director of Programmes).

United States: At the Vista Unified District (California): Matt Doyle (project coordinator, Assistant Superintendent Innovation), Craig Wiblemo (data coordinator), Robert Crowell (assessment coordinator), Anne Fennell and Craig Gastauer (action research leads); At the National Center for Montessori in the Public Sector (NCMPS): Keith Whitescarver (Executive Director), Jacqueline Cossentino (Director of Research), Katie Brown (Project Manager), Phil Dosmann and Katie Grabowski; Milwaukee Public Schools (MPS) and Furman University are acknowledged for allowing schools to participate; At the Education Department: John Easton (former President of the Institute of Education Sciences), Thomas Brock (former Commissioner of the National Center for Education Research), Peggy Carr, Dana Kelly and Daniel McGrath (National Center for Education Statistics).

The project has benefited from the advice and encouragements of the CERI Governing Board, collectively, and of many of its past and present members, individually. They are all thanked.

Finally, the work would not have been possible without the contribution of all the teachers, students and school principals who participated in the study in many different ways. They are too many to be acknowledged individually, even for those who made an extraordinary contribution, but the improvement of education worldwide depends on the implication of all stakeholders committed to support the improvement of the educational enterprise through research and innovation. The report is dedicated to them.

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Executive summary

Critical thinking and creativity are becoming increasingly important in the labour market, and contribute to a better personal and civic life. People will increasingly have to contribute to and absorb innovation. Moreover, with artificial intelligence and robotics possibly leading to automation prospects for a sizeable share of the economy, skills that are less easy to automate such as creativity and critical thinking become more valued. Even if there was no economic argument, creativity and critical thinking contribute to human well-being and to the good functioning of democratic societies.

Most curricula in OECD countries include in one form or another critical thinking and creativity as students' expected learning outcomes. However, teachers often find it unclear what creativity and critical thinking mean and entail in their daily teaching practice.

The OECD Centre for Educational Research and Innovation (CERI) carried out a project on "Fostering and Assessing Creativity and Critical Thinking in Education" which aimed to develop a shared professional language on creativity and critical thinking in education and thus eventually facilitate its teaching, learning and formative assessment across countries within a given curriculum.

Over a five-year period (including two school years of fieldwork and data collection), the OECD co-ordinated and worked with an international network of schools and teachers in 11 countries representing a wide variety of cultures and approaches to education. This report presents the findings of the project.

A series of OECD rubrics on creativity and critical thinking were developed and field trialled for both language and usage. They provide a first element of language that is both teacher-friendly and aligned with the research literature on creativity and critical thinking. The rubrics were incrementally developed during the project and improved based on teachers' and project co-ordinators' feedback following the field trial. The domain-general and domain-specific rubrics describe four sub-skills involved in creativity and critical thinking: inquiring, imaging, doing and reflecting.

The conceptual rubrics help teachers to better understand creativity and critical thinking, and to be more intentional and consistent in their teaching to nurture those skills. They are used to design new lesson plans, improve existing lesson plans and to discuss with students what creativity and critical thinking entail.

The assessment rubrics articulate different levels of proficiency in creativity and critical thinking. They are used to assess student work or their learning process, in a formative or summative way.

Experts and teachers in the network also developed additional resources to exemplify how these goals translate in practice. These resources are available online as a repository of pedagogical resources on creativity and critical thinking. They include: a set of design criteria for lesson plans, about 100 peer-reviewed examples of lesson plans as well as other pedagogical resources highlighting different ways of fostering students' creativity and critical thinking. Examples of signature pedagogies that teachers could use in their practice were also highlighted.

It is important to provide teachers with robust professional development plans drawing on training sessions, individual feedback and participation in a professional learning community, both through face-to-face meetings and digital platforms.

Most teachers worked in collaboration with their peers to adapt the project materials to their local context and exchanged with colleagues about their experiences in the classroom.

School principals evaluated the collaboration dynamics that the project sparked among teachers very positively. Around 75% of principals in intervention schools estimated that the project led to collaboration between teachers in unusual and positive ways, and that the project provided professional development opportunities that their teaching staff would not have otherwise had.

The project demonstrated that creativity and critical thinking can be taught, learnt and assessed in schools, both in primary and secondary education.

The lesson plans show that teaching and learning creativity and critical thinking can be done as part of existing curricula and as part of learning traditional school subjects.

The fieldwork showed that changing teaching practices and expanding teachers' teaching portfolio proved difficult.

The project developed a clear pedagogical intervention and survey instruments to evaluate its efficacy and better understand in which contexts and for whom it would work. The survey instruments measure both the local contexts in which the intervention takes place and the effects of the intervention on a series of outcomes of interest for students and teachers, including the change in teachers' pedagogical practices, attitudes and beliefs, as well as the effects of those practices on their students' tests scores, their understanding and attitude towards creativity and critical thinking, their engagement in school, and their scores in standardised creativity tests.

In brief, teachers working in real schools with real students showed that, with some guidance and resources, they were willing to change their practices and to foster and assess their students' creativity and critical thinking while teaching their usual curriculum subjects. While the results are tentative, the initial analysis of the pilot student data shows that the intervention has promising effects on the outcomes of interest. The next phase of the project should entail a validation (or efficacy) study before countries scale up the effective approaches.

Chapter 1

Overview

The OECD Centre for Educational Research and Innovation (CERI) ran an international action research in 11 countries on "Fostering and Assessing Creativity and Critical Thinking Skills in Education". The objective of the project was to build a shared language and understanding of what fostering creativity and critical thinking entails in primary and secondary education. After highlighting why creativity and critical thinking skills matter, the chapter presents the project's goals, its main outputs (rubrics on creativity and critical thinking, examples of lesson plans and professional development plans) as well as insights from the fieldwork that were captured through mixed qualitative and quantitative methods.

Why creativity and critical thinking matter

Critical thinking and creativity are becoming increasingly important in the labour market, and contribute to a better personal and civic life. OECD economies are increasingly driven by innovation. People will increasingly have to contribute to and absorb innovation. Moreover, given the digitalisation of society, with artificial intelligence and robotics possibly leading to automation prospects for a sizeable share of the economy, skills that are less easy to automate such as creativity and critical thinking become more valued. But even if there was no economic argument, creativity and critical thinking contribute to human well-being and to the good functioning of democratic societies. In an age where sources of information (and misinformation) multiply, critical thinking must be exercised more often, and in a variety of domains.

Skills for innovation

There is a broad consensus that people should be empowered to innovate. Innovation policy typically emphasises the role of science, technology, engineering and mathematics in innovation; the role of entrepreneurship; and usually emphasises advanced higher education degrees such as doctorates. Avvisati, Jacotin and Vincent-Lancrin (2013[1]) show that tertiary education graduates from all fields of study do actually contribute to innovation in the labour market. However, when it comes to product or technology innovation, engineers, scientists and mathematicians tend to be more likely to contribute to the innovation process compared to their peers in other domains.

The analysis of two international surveys of tertiary education graduates covering 19 European countries and Japan (Reflex and Hegesco) allowed to identify the skills that distinguish “innovators” from “non-innovators” the most: creativity (“come up with new ideas and solutions”) and critical thinking (the “willingness to question ideas”), followed by the “ability to present ideas in audience” (communication), “alertness to opportunities” (entrepreneurialism), “analytical thinking”, “ability to co-ordinate activities”, and the “ability to acquire new knowledge”. (Innovators refer to professionals having a job that contributes to innovation in an organisation being at the forefront of absorbing innovation.) On average, all types of innovation combined, innovators are about four times as likely as non-innovators to say that creativity is a very important skill to perform their job – and three times as likely for critical thinking.

Skills for the digital age

The development of artificial intelligence (AI) and of robotics, and the globalisation of OECD societies have led many observers and media to speculate on the future of jobs. Will some jobs disappear from OECD economies and be outsourced to countries where workers receive a comparatively lower compensation? More fundamentally, will a large share of the jobs performed by human beings be automated and performed by different types of computers (notably robots and AI-supported agents)? According to recent OECD estimates, 14% of jobs in the OECD are at risk of being completely automated while another 32% are likely to change significantly (OECD, 2019[2]).

In 2018, chief executive officers and chief human resource officers of multinational and large domestic companies that answered the World Economic Forum's "Future of Job" survey identified critical thinking and creativity as the third and fifth most demanded skills (with "analytical thinking and innovation" and "complex problem solving" being first and second). Forecasts expect them to become the fifth (critical thinking) and third (creativity) most demanded skills, respectively, in 2022, giving a small edge to creativity (WEF, 2018[3]).

Other reports using different methodologies point in the same direction. Recent market research by LinkedIn Learning finds that creativity was the second most demanded skill by companies in 2019 (after cloud computing) (Petrone, 2019a[4]; 2019b[5]). The company identified the most demanded skills by analysing which skills people hired at the highest rates display in their LinkedIn profile. An analysis of the O*NET database of the US Department of Labor showed that creativity is the skill whose importance and demand increased the most in science and engineering roles between 2004 and 2017, and that its importance has increased in all other roles of the economy as well. This is also true for complex reasoning (that includes critical thinking in the study) (Accenture, 2018[6]). Finally, in a forecasting exercise of the demand for skills in all sectors of the economy in the United States and in western Europe, the McKinsey Institute finds that the demand for high-level cognitive skills such as creativity and critical thinking skills will increase by 2030: according to their forecasts, the demand for creativity will increase by 40% and 30% in the United States and western Europe, respectively, and the demand for critical thinking and decision making will increase by 17% and 8% (Bughin et al., 2018[7]).

All in all, there seems to be a consensus that creativity and critical thinking will become more important in people's professional life, and in much higher demand in the labour market in the decades to come.

Creativity and critical thinking for personal and social well-being

Beyond the economic argument, higher order skills such as creativity and critical thinking matter because they contribute to people's well-being and to democratic societies.

One of the strong arguments for and interests in creativity lies in the feeling of focus and well-being that it creates, according to positive psychologists. Csikszentmihalyi famously described the state of "flow" that often comes with creativity, and, generally speaking, challenging tasks. Flow refers to "a state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will continue to do it even at great cost, for the sheer sake of doing it" (Csikszentmihalyi, 1990[8]). Research on creativity has also focused on other types of positive association between creativity and well-being, and the lasting positive emotional states creativity generally triggers.

Critical thinking also plays a role for individual well-being, but is more often seen as an essential pillar of the functioning of modern democracies. The ancient philosophical tradition saw it both as a way to have a good and happy life and as a means toward good government. Nowadays, in modern democracies, people are expected to exercise their critical thinking as an integral part of being a citizen, with the ability to make an independent and well-grounded opinion to vote, weigh the quality of arguments presented in the media and other sources of authority. In a digital world in which a multiplicity of facts, views, theories and assumptions compete, critical thinking has become even more important.

Fostering creativity and critical thinking in education: Project objectives

Most curricula in OECD countries include in one form or another critical thinking and creativity as students' expected learning outcomes. Their importance in education and higher education has become consensual worldwide. The role of education in the development of critical thinking is also increasingly acknowledged within many countries, where a majority of the population believe that schools should help students to become "independent thinkers" rather than merely transmit knowledge.

However, it often remains unclear for teachers what creativity and critical thinking (and some other complex thinking skills) actually mean and entail in their daily teaching practice. Rather than a problem of "resistance to change" or "innovation fatigue", the lack of implementation comes from a lack of clarity about what these big concepts actually mean, and how they translate into teaching, learning and formative assessment.

The OECD Centre for Educational Research and Innovation's (CERI) project on "Fostering and Assessing Creativity and Critical Thinking in Education" (referred to as "the OECD-CERI project" or "the project" in the rest of this book) aimed to develop a shared professional language on creativity and critical thinking in education and thus eventually facilitate its teaching and learning across countries.

The main goal of the project was to make it tangible and visible to teachers and education policy makers what it means to teach, learn, and assess creativity and critical thinking in school – within a given curriculum and in the traditional school subjects. Achieving this goal relied on a series of other objectives:

- articulating an international understanding and language on what students' creativity and critical thinking mean in school
- identifying a progression in the acquisition of these skills in primary and secondary education

- exemplifying how this language translated into teaching and learning in different subject areas (science, mathematics, music and visual arts) through a repository of lesson plans and other pedagogical resources
- developing a research protocol and instruments for the evaluation of the final, stable intervention, to gather information about the local contexts as well as measure the effects of the intervention on a series of outcomes for students and teachers.

Over five years (including two school years of fieldwork and data collection), the OECD co-ordinated and worked with an international network of schools and teachers in 11 countries representing a wide variety of cultures and approaches to education: Brazil, France, Hungary, India, the Netherlands, the Russian Federation, the Slovak Republic, Spain, Thailand, the United Kingdom (Wales) and the United States. Each country team had project co-ordinators usually encompassing a mix of expert pedagogues and researchers. They worked with teachers who tested and contested the pedagogical resources that were presented to them, proposed alternatives, and shared their professional knowledge so that it could be codified and made visible to other teachers.

The OECD worked with experts and project co-ordinators to design a first set of pedagogical resources: an initial rubric (that was subsequently modified) and a set of example lesson plans. This was the initial proposed language to be tested in the field. The final pedagogical resources were then developed through a quick prototyping method: after the initial design of the instruments, feedback from the field through teachers and project co-ordinators led to their incremental improvement, before going back to the field, being improved again, etc. Lesson plans guided by the OECD rubrics were developed and taught locally, and some of them were shared with the network for discussion, which led to the design of new resources and further improvements to the pedagogical ideas and methods.

All country teams were asked to support the participating teachers and provide them with some professional development opportunities; to share the qualitative feedback from teachers on the piloted rubrics and their uses; to document some of the lesson plans designed or revised by teachers to provide their students with opportunities to develop their creativity and critical thinking; to have focus groups and interviews with teachers and students at different stages of the implementation of the project.

School principals were also expected to play an important role in this change process by leading, encouraging and supporting teachers as they trialled the project tools and implemented the pedagogical intervention.

In addition, country teams were asked to implement a pilot data collection based on instruments and a research protocol that would allow evaluating the effectiveness of the developed intervention and its tools in a second phase of the project. The instruments and protocols were designed for a quasi-experimental research design so that country teams recruited two groups: 1) an intervention group that would have access to the project materials and would focus on the intentional teaching of creativity and critical thinking; 2) a control group that would ideally have another intervention not assumed to develop creativity and critical thinking (or just operate under a "business-as-usual" mode). The instruments targeted school principals, teachers and students. School principals were asked to answer a pre- and post-questionnaire (just a pre- for control schools); teachers, a pre- and post-questionnaire; students, a pre- and post-questionnaire, a pre- and post-test measuring their achievement in the domain of their intervention, and a pre- and post-creativity test in the domain of their intervention.

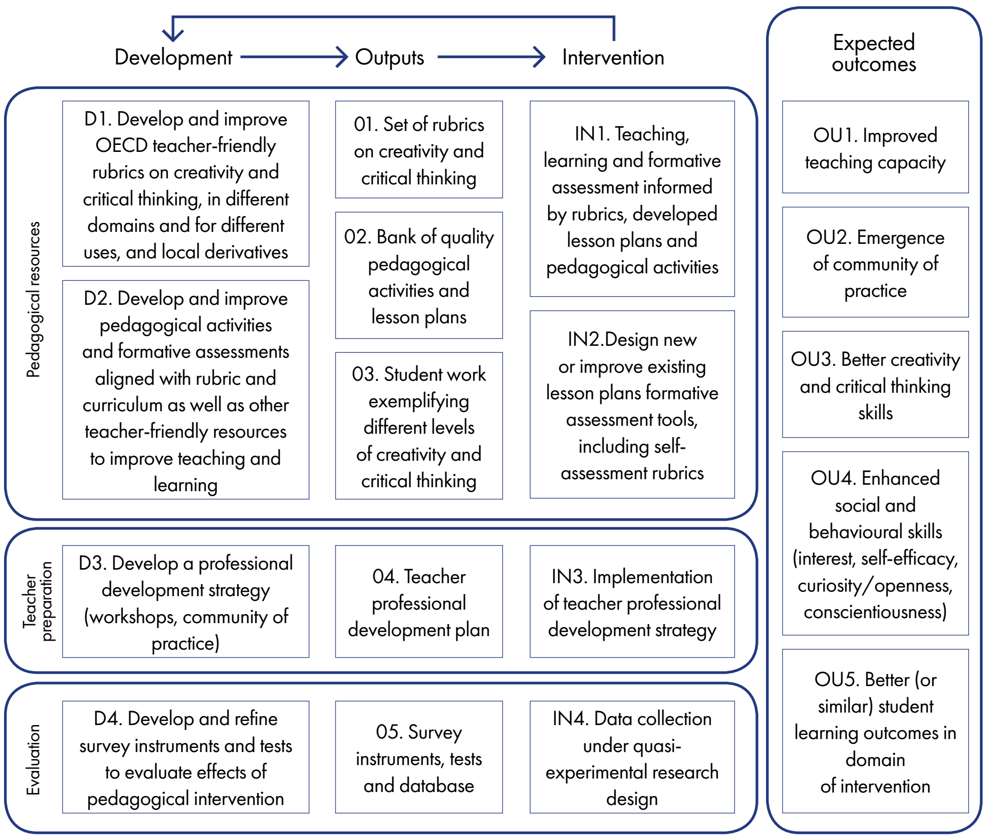
Figure 1.1 presents the theory of action of the development phase of the project, highlighting how the fieldwork was part of the development process, the different types of outputs of the project – and the expected outcomes for teachers and students. Three types of outputs were developed: pedagogical resources, professional development strategies and evaluation instruments.

In the staged continuum of experimental intervention projects, this is a "development" project: pedagogical resources, professional development plans and survey instruments were developed for a validation or efficacy study in a subsequent stage of the project. The project developed an "intervention" that can be implemented internationally and evaluated with the developed instruments. This method could easily be adopted by educational authorities and school principals, and be extended to other skills that remain less familiar to school teachers (e.g. collaboration, communication, etc.).

The work took place in both primary education (Grade 3, about 10-year-old students) and secondary education (Grade 8, about 14-year-old students). Altogether, in the 11 countries involved, close to 800 teachers participated in the project. Across country teams, the average number of participating teachers was 63, but sample sizes ranged widely, from less than 20 teachers in the French teams to up to 159 teachers in the Thai team. In terms of students, 20 273 students overall participated in the project at some point (8 949 in primary education and 11 324 in secondary education), ranging across country teams from 354 to 5 021. Among those students, 17 291 answered at least one instrument (questionnaire or test) of the data collection. Altogether, 319 schools and 753 classes participated in the project.

Figure 1.1. Theory of action of the development phase of the project

Prototyping resources and survey instruments for teaching, learning and assessing creativity and critical thinking



Better understanding creativity and critical thinking

Creativity and critical thinking are two distinct but related higher order cognitive skills. As such, both require great mental effort and energy and are cognitively challenging. They are related in that they involve some similar thought processes, but their goals differ. Creativity aims to create novel, appropriate ideas and products. Critical thinking aims to carefully evaluate and judge statements, ideas and theories relative to alternative explanations or solutions so as to reach a competent, independent position – possibly for action.

The research on creativity and on critical thinking do not actually overlap much, even though critical thinking sometimes plays an important role in creativity, and vice versa. School curricula and educational rubrics are, however, prone to group them together and to talk about "creative and critical thinking". In some cases, this conflation leads to nuances and differences getting lost, but this also highlights that some educational tasks may allow expanding and practicing sub-skills that are important for both.

Sternberg and Lubart (1999[9]) proposed a simple definition of creativity: "creativity is the ability to produce work that is both novel (i.e. original, unexpected) and appropriate (i.e. useful, adaptive concerning tasks constraints)". Appropriateness recalls that creativity happens within a system or context with its standards and constraints; it is not just about doing something new. As Dennett (2012[10]) puts it: "Being creative is not just a matter of casting about for something novel – anybody can do that, since novelty can be found in any random juxtaposition of stuff – but of making the novelty jump out of some system, a system that has become established, for good reason".

Emphasising both process and output, Lubart (2000[11]) defines creativity as "a sequence of thoughts and actions that leads to novel, adaptive production." What is this sequence? Creativity research has explored the cognitive processes involved in creativity. Guilford emphasised two processes leading to creativity: divergent thinking (generating many ideas) and convergent thinking (choosing and developing a good one). Torrance distinguished four aspects of the creativity process: fluency (having many relevant ideas), flexibility (having different types of relevant ideas), originality (having statistically novel ideas) and elaboration (being able to elaborate one's ideas). Most standardised tests of creativity or creative potential (e.g. Torrance, Wallach-Kogan, Guilford, Getzel-Jackson, Mednick, Runco, Lubart-Besançon-Barbot) decompose the creative process along similar lines and focus on some of its aspects.

Critical thinking can be a step in the creative process or not: convergent thinking does not necessarily have to adopt a "critical" stance. Critical thinking mainly aims at assessing the strength and appropriateness of a statement, theory or idea through a questioning and perspective-taking process – which may in turn result (or not) in a possibly novel statement or theory. Critical thinking need not lead to an original position to a problem: the most conventional one may be the most appropriate. However, it typically involves the examination and evaluation of different possible positions.

While the idea can be traced back to Socrates and has been at the core of western philosophy for centuries, Hitchcock (2018[12]) summarises some recent conceptions by defining critical thinking as "careful goal-directed thinking" – another version of Ennis' definition: "reasonable reflective thinking focused on deciding what to believe or do" (Ennis, 2018[13]). In many cases, definitions of critical thinking emphasise logical or rational thinking; that is, the ability to reason, assess arguments and evidence, and argue in a sound way to reach a relevant and appropriate solution to a problem. Critical thinking also includes a dimension of "critique" and "perspective-taking" though. In addition to rational or logical thinking, critical thinking includes two other dimensions: the recognition of multiple perspectives (or possibility to challenge a given one) and the recognition of the assumptions (and limitations) of any perspective, even when it appears superior to all other available ones.

Many of the cognitive processes involved in creativity and critical thinking share commonalities. Both require prior knowledge in the domain of application. The sub-skills that need to be deployed for each competence involve imagining, inquiring, doing and reflecting. Creativity puts more emphasis on imagining (brainstorming, generating ideas and alternatives), while critical thinking puts more emphasis on "inquiring", including its more analytical and systematic dimension (understanding and decomposing the problem, etc.). Critical thinking is mainly inquisitive, a detective way of thinking; creative thinking is imaginative, the artist way of thinking. However, critical thinking involves imagining alternative theories, counterfactuals, reasons and results in an action (making a judgment); creativity requires making judgments and decisions about the alternative ideas generated in the imaginative process, and more fundamentally to examine the assumptions of existing solutions and conventions before action (creating something novel and appropriate).

Both creativity and critical thinking require a certain level of openness and curiosity. Both may lead to challenging authority, values or accepted norms, and this is what may make them both valuable and sometimes challenging. Critical thinking requires scientific integrity; creativity requires discipline and judgment. When education is conceived as the mere transmission of socially accepted knowledge, there is little room for creativity and critical thinking. On the other hand, like most other skills, creativity and critical thinking only have to be exercised at some points: even if this were concretely possible, a world in which people were all the time creative or all the time critical would be very hard to live in. Chances for cumulative knowledge and learning would become scarce, and the lack of accepted conventions would make life in society difficult. Students also need to learn when and about what they can or should think creatively or critically.

In an educational context, both creative and critical thinking pursue the deeper understanding of knowledge and solutions, and thus deeper learning. Developing creativity and critical thinking is actually a way to improve learning and get students to acquire more expertise in a domain – whether it leads to the proposition of new knowledge and solutions or not.

Even though one can describe them at the conceptual level in a domain-general way, both creativity and critical thinking are mainly domain-specific in practice: they require knowledge about a field or context to be practiced, and usually being very creative or a strong critical thinker in one domain does not imply any transfer of those skills to another domain. They may also involve different types of activities in different fields. This is why the project emphasises the nurturing of creativity and critical thinking as part of the learning of specific disciplinary content knowledge (rather than as a generic activity, i.e. classes of creativity or of critical thinking).

Rubrics to support creativity and critical thinking in teaching and learning

There is overall a common understanding among researchers on the key dimensions of creativity and of critical thinking. However, transferring the concepts to an educational application requires further translation. This is where rubrics intervene.

Rubrics are a way to simplify, translate and construct a social representation of what creativity and critical thinking look like in the teaching and learning process. They aim to create a shared understanding of what creativity means in the classroom, and share expectations among teachers, and among teachers and students. The function of rubrics is to simplify the big concepts of creativity and critical thinking so that they become relevant to teachers and learners in their actual educational activities. They also allow teachers to monitor and formatively assess whether their students develop those skills. Rubrics are a metacognitive tool that helps make learning visible and tangible, and teaching intentional.

A portfolio of rubrics was developed during the project, serving different purposes and demands from teachers in the field. "Conceptual rubrics" were designed to clarify "what counts" or "what sub-skills should be developed" in relation to creativity and critical thinking and to guide the design of lesson plans and support discussions about those skills in the classroom. "Assessment rubrics" articulate levels of progression or proficiency in the acquisition of creativity and critical thinking skills and are meant to assess students (formatively or summatively).

A balancing act in developing rubrics lies between simplicity and complexity. To be useful, rubrics have to be teacher-friendly (and possibly student-friendly), and have a language that is easy to understand by different types of teachers. On the one hand, the descriptors of the different key ideas have to relate enough to the concepts as understood by experts in creativity and critical thinking. On the other hand, the descriptors have to be simple enough to be easily understood by teachers and students, and have to relate to skills and activities that are meaningful in a school setting. Ideally, one would easily memorise some of their language so that it becomes internalised.

Informed by the "five creative habits of mind" rubric developed by Lucas, Claxton and Spencer (2013[14]); by a review of other existing rubrics and curriculum documents; and by project co-ordinators' and teachers' feedback during the action research, the final OECD rubrics capture different dimensions of both creativity and critical thinking through four high-level and easily memorable descriptors: imagining, inquiring, doing, reflecting. Each of these active words is then associated with some descriptor for creativity and for critical thinking.

Two domain-general conceptual rubrics were developed: a "comprehensive" rubric and a "class-friendly" rubric. Domain-specific adaptations of those rubrics were also developed. Table 1.1 shows the "comprehensive" domain-general rubric, while Table 1.2 presents the "class friendly" rubric. The development of a portfolio of rubrics rather than of just one is an outcome of the fieldwork: some teachers called for a simplified rubric, others for domain-specific rubrics corresponding to the typical teaching activities in their subject, while others preferred to stick with the comprehensive rubric.

Table 1.1. OECD rubric on creativity and critical thinking (domain-general, comprehensive)

	CREATIVITY Coming up with new ideas and solutions	CRITICAL THINKING Questioning and evaluating ideas and solutions
INQUIRING	• Feel, empathise, observe, describe relevant experience, knowledge and information • Make connections to other concepts and ideas, integrate other disciplinary perspectives	• Understand context/frame and boundaries of the problem • Identify and question assumptions, check accuracy of facts and interpretations, analyse gaps in knowledge
IMAGINING	• Explore, seek and generate ideas • Stretch and play with unusual, risky or radical ideas	• Identify and review alternative theories and opinions and compare or imagine different perspectives on the problem • Identify strengths and weaknesses of evidence, arguments, claims and beliefs
DOING	• Produce, perform, envision, prototype a product, a solution or a performance in a personally novel way	• Justify a solution or reasoning on logical, ethical or aesthetic criteria/reasoning
REFLECTING	• Reflect and assess the novelty of the chosen solution and of its possible consequences • Reflect and assess the relevance of the chosen solution and of its possible consequences	• Evaluate and acknowledge the uncertainty or limits of the endorsed solution or position • Reflect on the possible bias of one's own perspective compared to other perspectives

Note: This rubric is meant for teachers/faculty to identify the student skills related to creativity and to critical thinking that they have to foster in their teaching and learning, not for assessment.

Table 1.2. OECD rubric on creativity and critical thinking (domain-general, class-friendly)

	CREATIVITY Coming up with new ideas and solutions	**CRITICAL THINKING** Questioning and evaluating ideas and solutions
INQUIRING	Make connections to other concepts and knowledge from the same or from other disciplines	Identify and question assumptions and generally accepted ideas or practices
IMAGINING	Generate and play with unusual and radical ideas	Consider several perspectives on a problem based on different assumptions
DOING	Produce, perform or envision a meaningful output that is personally novel	Explain both strengths and limitations of a product, a solution or a theory justified on logical, ethical or aesthetic criteria
REFLECTING	Reflect on the novelty of the solution and of its possible consequences	Reflect on the chosen solution/position relative to possible alternatives

Note: This rubric is meant for teachers/faculty to identify the student skills related to creativity and to critical thinking that they have to foster in their teaching and learning, not for assessment.

The different aspects of creativity and critical thinking described in the rubrics do not necessarily come in a definite order. They are typically solicited at different points in the learning process.

The OECD rubrics were developed incrementally after being trialled by teachers in the 11 countries of the international network: they provide a common terminology and understanding of what creativity and critical thinking mean in education. The field work showed that, on average, seven in ten teachers participating in the international network did use the OECD rubrics to design new lessons or improve existing ones during the project implementation. The rubrics have thus proven to be relatively well adopted by teachers in most of the countries in which the project was implemented. In some cases, local teams generated adaptations of the rubrics to their local context, self-assessment tools for students or used an aligned rubric.

Beyond a better understanding of the skills that one should develop, rubrics can also be used to assess student work. In fact, this is usually their main use in countries where they are popular. Assessment rubrics on creativity and on critical thinking were also developed during the project (see Chapter 2).

Lesson plans to support creativity and critical thinking

Teachers were asked to use the rubrics in different ways: designing and revising lesson plans so that they would give students the opportunity to develop their creativity and critical thinking skills; assessing student work and progression in the acquisition of these skills; documenting some of their lessons so they could be shared with other teachers. While all country teams and teachers shared the common objective to intentionally foster students' creativity and critical thinking, as defined by the project rubric and materials, all teams (and teachers) had full pedagogical freedom. In its development phase, one objective of the project was to document those pedagogical practices and to develop a repository of lesson plans and pedagogical activities that could inspire teachers (and be subsequently researched from an efficacy standpoint).

Several "signature pedagogies" were used by some of the teams, including project-based learning, research-based learning, Montessori, Creative Partnerships and Orff Schulwerk (see Chapter 3). Those holistic and well-structured pedagogical models appeared particularly well suited to the development of students' creativity and critical thinking skills, partly because they provide a good balance between structure and openness of instruction, and gave students enough agency to exercise their critical thinking or their creativity within a well-defined learning framework. (In many cases, it was because local project co-ordinators felt that those pedagogies were developing students' creativity or critical thinking [or both] that they participated in the project.)

Most other teams designed short projects or activities, or worked with teachers on the marginal improvement of their existing lesson plans, adding some pedagogical techniques to their lessons. Teachers did indeed provide students with appropriate tasks for them to develop their creativity or critical thinking. Especially in countries where teachers were not familiar with rubrics or where they did not see creativity or critical thinking as being part of their teaching duties, the most common approach was to change incrementally some elements of their existing lessons (see Chapter 4).

At the beginning of the project, in addition to the initial project rubric, teachers were provided with a few examples of lesson plans in different domains. They were asked to use the conceptual rubric as a reference point to check whether or when their lesson gave students assignments or tasks fostering at least some of the sub-skills associated with creativity or critical thinking. The proposed method was to decompose their lesson plans in steps, to identify at what stage they were giving students occasions to practice the sub-skills identified in the rubric – and to revise the lesson and its tasks when no such occasion occurred. This mapping of the different steps of the lesson against the sub skills of the conceptual rubrics represented a key reflection process before teachers internalised the pedagogical techniques associated with the development of creativity and critical thinking. Some lessons may just develop a few sub-skills of the rubric, while others could cover its full range, with an emphasis on creativity or critical thinking (or both).

The first set of lesson plans coming from the field showed that while teachers across the network largely accepted the language of the rubrics, they did not always manage to translate it into compelling lesson plans. Another set of "design criteria" was thus developed to support teachers further, building on learning science principles, including motivation, cognitive activation, self regulation and opportunities for formative assessment (Table 1.3). These design criteria for good lesson plans represented another set of quality checks and a new perspective on how to approach pedagogical redesign to foster students' creativity an critical thinking. (They were also the basis for the peer review of lesson plans included in the online OECD repository of lesson plans).[1]

Country teams were asked to work with teachers in science, mathematics, music, visual arts and interdisciplinary projects. One important aspect of the project was to show that, while different disciplines offer different opportunities for the development of creativity and critical thinking, those skills can be developed in any discipline – and involve different types of tasks depending on the discipline. The arts are not the sole territory of creativity; science, maths and philosophy are not the only medium to stimulate critical thinking. Creativity and critical thinking are not the monopoly of any specific discipline.

However, as highlighted by the "design criteria", tasks to train and demonstrate creativity and critical thinking skills in education share some general features: they are engaging, may have a deliberate open nature, encourage students to explore multiple solutions to problems within parameters and constraints that clarify goals and yet remain relatively flexible to allow students to address them with a certain level of agency. The experience of project participants highlights that the successful teaching of creativity and critical thinking hinges critically on creating learning environments where students feel safe to take risks in their thinking and expressions, which in turn presupposes a positive attitude towards mistakes and learner empowerment on the part of teachers. A positive attitude among teachers towards student "mistakes" was also important: for example, using mistakes to trigger reflection about opportunities for learning, helping students to see misunderstandings as a chance for improvement rather than as a failure, or choosing questions and tasks that teachers themselves cannot resolve can make it clear to students that the thinking process behind a problem can be as important as its answer.

While this was not the main focus of the project, it is noteworthy that most of the lessons developed by teachers or expert curriculum developers also allow students to develop their social and behavioural skills: most of them include sequences of co-operative learning and include some presentations or discussions that will typically develop communication skills.

During the project, teachers and experts across the 11 countries developed close to 100 lesson plans in different subjects with a focus on creativity and critical thinking. These examples of pedagogical practice aim to inspire teachers internationally by making visible the kind of approaches and tasks that allow students to develop their creativity and critical thinking while acquiring the content and procedural knowledge across different domains of the curriculum. These lesson plans are publicly available as open educational resources. The OECD repository on lesson plans on creativity and critical thinking proposes a variety of teaching techniques without prescribing any particular

Table 1.3. Design criteria for activities that foster creativity or critical thinking skills

A pedagogical activity aligned with the OECD rubric on creativity and critical thinking should:	Comments
1. Create students' need/interest to learns and ideas, integrate other disciplinary perspectives	• Usually implies starting with a big question or an unusual activity. • May imply coming back to these questions several times during the activity.
2. Be challenging	• Often, the lack of student engagement comes from learning goals or activities that lack challenge. The tasks should be challenging enough, though not too difficult given the students' level.
3. Develop clear technical knowledge in one domain or more	• The activity should include the acquisition and practice of both content and procedural knowledge (technical knowledge).
4. Include the development of a product	• A product (a paper, a presentation, a performance, a model, etc.) makes the learning visible and tangible. • Teachers and students should also be attentive to and possibly document the learning process.
5. Have students co-design part of the product/solution or problem	• Products should thus in principle not all look alike.
6. Deal with problems that can be looked at from different perspectives	• Problems should have several possible solutions. • Several techniques may be used to solve them
7. Leave room for the unexpected	• Teachers and students do not have to know all the answers. • The most commonly adopted techniques/solutions may have to be taught and learnt, but there should be room for exploring or discussing unexpected answers.
8. Include space and time for students to reflect and give/receive feedback	

pedagogical approach, therefore showing that teaching for creativity and critical thinking can encompass a wide range of instruction methods. Box 1.1 presents one example of a lesson plan illustrating how critical thinking and creativity can be developed in science education alongside technical skills in science (content and procedural knowledge).

Box 1.1. One example of a lesson plan fostering critical thinking and creativity: What controls my health?

Developed by Adler et al. (2017[15]), "What controls my health?" is a 20-lesson course (or unit) engaging students in investigations to understand the importance of both genetic and environmental factors in their risk for disease. The lesson was designed for urban students in Michigan (United States): diabetes is a very common disease in their context. Students start the course by experiencing the phenomenon of Type 2 diabetes through the eyes of a peer recently diagnosed with the disease. They develop an initial model to answer the question "what caused Monique's diabetes?". Throughout the course, they find that diabetes, like many common diseases, is caused by a combination of both genetic and environmental factors. Students also investigate how lifestyle options for healthy food and exercise help to prevent or reduce diabetes. The lesson includes several opportunities for students to construct, test, revise and share their models to explain the investigated phenomena, while performing experiments and using computer simulations. For their final assignment, students conduct an action research project, based on their scientific knowledge and understanding, to improve the health of their school or neighbourhood to help prevent or reduce diabetes.

Here is the summary description of the course, with more details for the first sections of the lesson (publicly available as part of the OECD repository of lesson plans for creativity and critical thinking):

1. Periods 1-2: Why does Monique have diabetes? Students learn about Type 1 and Type 2 diabetes (video). They develop an initial model that explains a health phenomenon of their choice. They post their ideas on the Driving Question Board.

2. Periods 3-5: How can we describe Monique's diabetes? Students learn more (through reading), and share information about the cause, symptoms and treatment of both Type 1 and Type 2 diabetes. They perform a glucose tolerance test by analysing simulated blood plasma samples to determine if the person has Type 1 or Type 2 diabetes. They learn about the heart, as an example of an organ that may be affected by diabetes. They revisit the Driving Question Board and reflect upon their learning. They revise their models and add the biological aspect of diabetes to their model.

3. Periods 6-9: How does Monique's family affect her diabetes? Students examine pictures of a family to identify some genetic factors of characteristics that might be inherited. They collect data on tongue rolling and arm span, and use these data to explore the population variation of the inheritance patterns of single and multi-factorial genes. They use beads to simulate the inheritance of risk factors for diabetes. They identify the risk of diabetes in offspring based on the number and type of risk factors inherited during the simulation. They revisit the Driving Question Board and reflect upon their learning. They revise their models and add the effect of genetic factors on Monique's diabetes.

4. Periods 10-12: How does where Monique lives and what she does affect her diabetes? They study the influence of environment on living organisms through plant growth.

5. Periods 13-16: How do Monique's characteristics and environment affect her diabetes? Through simulation, they consider how genetics and environment affect the health of sand rats.

6. Periods 17-19: What can Monique do to make her environment healthier? They study the role of nutrition.

7. Periods 18-20: Community action projects: How can we work together to make our environment healthier? Students develop and choose their inquiry question, design and develop their research tools, then plan and carry out their investigations. They analyse the data and draw conclusions, share their findings with their peers and the broader community, suggest solutions and potential actions based on their findings.

This course is a good example of how teachers could allow their students to learn about technical science skills while giving them opportunities to develop their critical thinking and their creativity (and some social and behavioural skills).

In terms of technical skills, students clearly learn about: diabetes, the heart as an organ and the growth of plants; genetics, the influence environmental factors; nutrition; the multiple drivers of health. They also acquire procedural knowledge by making tests and experiments, including through computer simulation, and by interpreting their results.

The main focus of the lesson is critical thinking: students identify and question their assumptions or accepted ideas about diabetes and its causes (Steps 1 and 7 above); they consider several perspectives on the problem at hand (Steps 3 to 6); they explain both the strengths and limitations of their scientific solution (Steps 6 and 7); and they consistently reflect on the chosen scientific approaches that they consider relative to possible alternatives (Steps 2, 3, 4 and 7).

The lesson also allows some creativity skills to be developed: students are induced to make connections to other scientific concepts or ideas throughout the project and also to use remote examples to better understand the issue (heart, plants) (Steps 2 and 5); they generate and play with unusual ideas as they visit and revisit the questions of the Driving Question Board and have to generate their own solution (Steps 1, 4, 7); they have to propose how to solve a scientific problem in a personally novel way (Steps 1 and 7); and they have to reflect on those steps at the end of the process (Step 7).

Professional development plans

All country teams were requested to offer participating teachers professional development. At a minimum, the project objectives, rubrics and materials, as well as reflections on creativity and critical thinking had to be discussed during an induction training. More intensive professional development plans were encouraged to support participating teachers throughout the project.

The whole project could actually be described as a professional development initiative around creativity and critical thinking. The pedagogical resources described above (rubrics and lesson plans) are meant to trigger professional reflection and learning. As they are not detailed lessons plans, the resources require (and assume) strong teacher agency and autonomy. They are addressed to expert teachers who can design their learning environment and lessons. However, as was experienced in the field, pedagogical resources are not sufficient for most teachers and have to be supplemented by other learning resources.

Innovation is in itself a source of professional learning. Engaging teachers in changing some of their teaching practices is a source of professional development. Typically, teachers become more reflective, more intentional, talk more to colleagues, look for more information, try and improve. They operate in learning mode. A full educational infrastructure or ecosystem must be available to support the improvement of teaching practices. Teachers need resources (rubrics, lesson plans, examples), new knowledge, colleagues to talk to, experts giving them feedback, space for reflection, support from their hierarchy, opportunities to try these new teaching approaches with their students, etc.

Most of the participating teams put a lot of effort into shaping a strong learning environment for teachers and provided them with robust teacher development plans. Those professional development plans took many forms, depending on the teaching standards, beliefs of the teachers, and support of school and systems leaders, but most included three key elements: training sessions, individual follow-up with teachers and opportunities for peer learning (see Chapter 5).

Overall, four types of approaches were adopted. The first approach was limited to an induction session presenting the project ideas and tools to the participating teachers. The second approach consisted of a series of four to five one-day training sessions, providing room for teachers to further their understanding of how to foster their students' creativity and critical thinking, but also to discuss their classroom practice. The third approach added to the training sessions an individual follow up of teachers, with experts visiting them at regular intervals to give them feedback and foster self-reflection on their practices. The fourth approach added to training sessions and follow-up mechanisms the shaping of a professional learning community: school meetings, school visits and digital platforms allowing teachers to share lesson plans and exchange on their practice.

All these approaches have their benefits and their implementation partly depended on budget, but it is noteworthy that none was particularly expensive. The only approach that was arguably not very effective was the first one: limiting professional development to induction training. While this could work with expert teachers who are very motivated and already master most of the teaching repertoire that fostering creativity and critical thinking calls for, this approach proved less effective in sustaining teachers' engagement with the project ideas and materials over time.

The project showed teachers' readiness to engage in professional learning communities around creativity and critical thinking. Across teams, more than 400 primary and secondary level teachers were involved in intervention classes, thereby gaining access to new materials and training opportunities. Most often, their reports about the project show that they worked in collaboration with their peers to adapt the project materials to their local context and that they exchanged with colleagues about their experiences in the classroom. Participation in these professional learning communities around teaching for creativity and critical thinking helped them to move from implicit and episodic efforts towards more explicit and systematic practice to nurture these skills in their students.

Feedback from the fieldwork

Developing survey instruments that would allow evaluating the effects of the intervention in a subsequent validation or efficacy study based on a quasi-experimental design implied trialling these instruments. To that effect, questionnaires and tests were administered during the two rounds (school years) of the study to school principals, teachers and students, before and after the pedagogical work. Participants were split between a control and an intervention group. Beyond this quantitative information, project co-ordinators were asked to observe some classroom teaching and to hold focus groups and interviews with participating teachers (and, separately, with students when feasible). Finally, the lesson plans and examples of student work developed locally and shared with the network provided key information about the local interpretation of the work. The project thus gathered a wealth of information on how the project was implemented and received, and on its preliminary effects on teachers and students before a validation or effectiveness study is carried out.

Teachers

Teams in different countries experienced that setting creativity and critical thinking as explicit learning goals challenged teachers (and students alike). Modifying their teaching and assessment approaches was not straightforward, even though some teachers initially felt that their teaching approaches already fostered their students' critical thinking, if not their creativity.

The types of tasks and pedagogical techniques suggested by the initial examples of lesson plans suggested that fostering creativity or critical thinking required teachers to depart from their established teaching practices. It proved particularly challenging for them to "leave room for the unexpected"; that is, to accept that students' thinking processes and outputs would not be totally anticipated. At the same time, many teachers also found it challenging to plan teaching and learning sequences allowing for creativity and critical thinking. They also found it difficult to describe these expected learning outcomes to students in a clear and articulate manner.

A recurrent theme in teachers' reflections was that teaching for creativity and critical thinking required them to achieve a greater balance between structure and openness in their teaching. Similarly, students needed to adapt their learning strategies, and many of them felt confused as activities eliminated the certainty that comes with single-solution problems. This points to the importance of teachers' pedagogical knowledge of (and confidence in using) certain teaching and learning methods as a key part of what is needed to cultivate learners who can think more creatively and critically.

However, the project demonstrated that teachers working in real-life settings in 11 countries were willing and able to foster their students' creativity and critical thinking, to revisit their teaching approaches, and to adopt new tools and methods for that purpose. While the initial idea was to recruit teachers whose practices were already close to the objectives of the project and thus more likely to share exemplary lessons and practices, this proved difficult to realise in practice. Participating teachers volunteered to participate in the project and were thus interested, but usually not expert in fostering creativity and critical thinking.

Teachers across teams embraced the idea that creativity and critical thinking are malleable skills that can be developed in school and across the curriculum. While teachers' beliefs about creativity and critical thinking broadly mirror each other, results suggest that teachers perceive critical thinking to be better integrated into current curricula and easier to assess than creativity. Teachers perceived major difficulties in assessing student progression in creativity and critical thinking skills. While the initial expectation was that the proficiency levels would be defined by comparing teachers' expectations and observations in the field, this was largely not the case – and, given these difficulties, the OECD assessment rubrics were developed in the second school year taking a more top-down approach.

By providing teachers with a deliberate formulation of creativity and critical thinking and strategies for their development, the project triggered changes in teachers' beliefs and behaviours. Teachers tested, contested and refined many of the proposed teaching tools and strategies to make them more relevant to their own contexts.

Teacher attitudes and practices changed, but not only in one direction. Most teachers report having gained a better understanding of what creativity and critical thinking skills entail in a school context and are now more consistent in their efforts to foster them. These changes are remarkable given the relatively short duration of the intervention, as are the positive changes that teachers consistently perceived in their students' engagement with the redesigned lessons. At the same time, many teachers felt vulnerable when gaining a greater awareness of the changes required in their regular practice – including in their relationship with students. Having an explicit definition and clearer understanding of creativity and critical thinking and a few specific pedagogical ideas about how to foster them, teachers' intuitive beliefs ended up being challenged, including their confidence in being well prepared to teach those skills.

Across teams, awareness of difficulty came with a broadly positive evaluation of the project by participating teachers, including its impact on student engagement. School principals also evaluated very positively the collaboration dynamics that the project sparked among teachers. Around 75% of principals in intervention schools estimated that the project led to collaboration between teachers in unusual and positive ways, and that the project provided professional development opportunities that their teaching staff would not have had otherwise (see Chapter 6 for more details on teacher and principal reports).

Students

As mentioned above, students in the intervention and control groups answered questionnaires before and after the intervention, and took two tests (an achievement test in the domain of their intervention and a creativity test). While the objective was mainly to trial and test the instruments and evaluation protocol, the pilot data collection also provided interesting insights as students' answers were actually collected.

The pedagogical intervention of teachers with their students seemed to have had an overall positive effect on the outcomes of interest (including beliefs about and understanding of creativity and critical thinking, self-efficacy, perceived pedagogical practices, test scores, creativity test scores). Most of the analyses were carried out country team by country team (see Chapter 8). However, one question of interest was about the existence of patterns in terms of effects across country teams (see Chapter 7).

About 40% of the students had a good understanding of creativity, with similar levels in primary and in secondary education. The proportion of students with a good understanding of critical thinking was overall about the same (40%), but with a much better understanding by secondary (47%) than primary education students (30%). In fact, students in primary education clearly struggled with the idea of critical thinking, which is probably more alien to them than creativity. About 40% of the participating students perceived themselves as very creative and 30% as very good at critical thinking. In spite of some variation across country teams, there was not a huge discrepancy in the overall pattern.

In primary education, the effect of the intervention seemed to be particularly beneficial across teams in terms of achievement test scores, both for the science and maths and the visual arts and music tests. In secondary education, the effects that were most positive across all teams concerned the increased use of teaching practices related to creativity and critical thinking in science and maths classes, the increased interest of students in the arts subjects, as well as in the achievement test scores in arts.

All education levels taken together, some sub-groups of students seemed to have particularly benefited from the intervention, in a way that was fairly consistent across countries: students whose teacher believed that creativity could be taught at school when the intervention started; students who had a better understanding of critical thinking at the beginning of the project; students who did not have a good understanding of creativity at the beginning of the project.

In secondary schools, the intervention seemed to work better for students with an immigrant background; students who had a low or average perception of their creativity at the beginning of the project; students who had a low or average perception of their critical thinking at the beginning of the project. In primary schools, students who had an average perception of their critical thinking at the beginning of the project seem to have benefited more.

The design of the data collection allows performing an analysis at the class level (and not just at the individual student level). The analysis of the pilot data, for example, highlighted that, at primary level, the intervention seemed to benefit most the classes that had a challenging learning climate at the beginning of the project. The share of the most improving classes with an initially challenging learning climate was often more than double among the intervention than among the control classes. This was also true for secondary education classes, but to a lesser extent than in primary education.

The sample sizes, the relative short duration of the intervention with students, and the fact that the intervention was still under development invite interpreting them with caution. However, all these results give insights on the kind of information that a validation study will yield, and pave the way to the evaluation of the effectiveness of different strategies of implementation of the intervention.

Protocol and instruments

Following the results of the data analysis, the feedback received from the local teams and the evidence that was collected on the behaviour of the instruments, the pilot data collection seems to confirm that the developed and adopted instruments as well as the analytical strategy are appropriate to evaluate the effects of the intervention with students and teachers. The instruments and the analytical strategy allowed capturing both positive and negative effects, then identifying context-related factors that influenced them. The technical characteristics of the instruments were also appropriate.

Some lessons on the logistics and nature of the data collection could also be drawn. For example, it appeared that the evaluation protocol (questionnaire, achievement test, creativity test) was probably too heavy and time consuming for a pre- and post-measurement in school. A lighter measurement protocol should be considered for a validation study. Moreover, the size of the control group will have to be much larger than the size of the intervention group, given both the attrition between pre- and post-measurement and the needs of the statistical adjustments to analyse the data.

Take-aways and next steps

The project demonstrated through an action research that creativity and critical thinking can be taught, learnt and assessed in schools, both in primary and secondary education. More than that, it showed that a significant number of teachers in 11 countries were willing to change their teaching practices in order to better equip their students with creativity and critical thinking skills.

The project made it visible and tangible to teachers what creativity and critical thinking look like in school. This professional representation builds on a series of pedagogical resources and on the participation in an international community of practice around the fostering of creativity and critical thinking in school.

The portfolio of OECD rubrics on creativity and critical thinking provide a first element of language that is both teacher-friendly and aligned with the research literature on creativity and critical thinking. The rubrics were incrementally developed during the project, field trialled, and improved based on teachers' and project co-ordinators' feedback.

Conceptual rubrics describing the sub-skills associated with creativity and critical thinking help teachers to better understand what creativity and critical thinking mean in a school context. Teachers can thus be more intentional and consistent in their efforts to nurture those skills. Conceptual rubrics can guide the design of new lesson plans or the improvement of existing ones. They can also be used to discuss with students what creativity and critical thinking entail.

Assessment rubrics provide teachers and students with proficiency levels for both creativity and critical thinking, showing what high and lower levels of performance look like. They articulate a progression in the acquisition of those skills – a progression that does not have to be linear as they are meant to assess students' outputs or learning processes, not the students themselves.

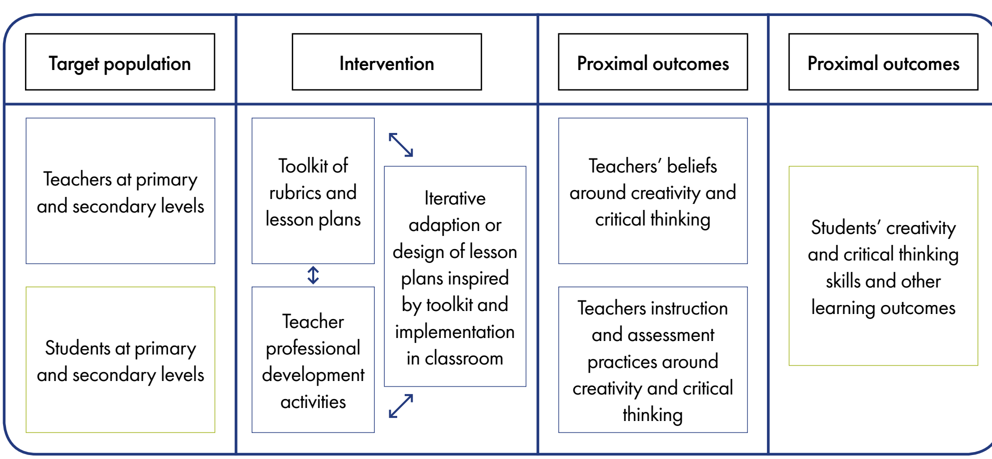
Building a social or professional representation of what creativity and critical thinking mean requires more resources than just good definitions and rubrics. Indeed, translating the goals into teaching practices is challenging. This is why, beyond rubrics, the repository of pedagogical resources developed in the project include examples of lesson plans (and a few examples of assessments). Other resources such as "design criteria for lesson plans" were also developed to support teachers in designing or improving their lessons. Examples of signature pedagogies that teachers could use in their practice or of more granular pedagogical techniques were also highlighted.

During the project, experts and participating teachers developed about 100 examples of lesson plans in different school subjects (maths, science, music, visual arts and interdisciplinary issues). The lesson plans show that teaching and learning creativity and critical thinking can be done as part of existing curricula and as part of learning traditional school subjects. They also demonstrate that many different pedagogical techniques and approaches can contribute to the development of those skills. Teachers have to provide students with appropriate tasks and assignments, but depending on their current practice, they can strike the balance between structure and openness in ways that represent the right level of challenge for them. These examples of lesson plans are publicly available as part of the repository of pedagogical resources on creativity and critical thinking.

The fieldwork showed that, even for teachers interested in these approaches, changing their teaching practices and expanding their teaching portfolio proved difficult. While resources such as rubrics and lesson plans help understand what fostering creativity and critical thinking means, they ideally have to come with professional learning opportunities. Country teams showed that professional development plans providing teachers with continuous support through workshops, individual feedback and access to a professional learning community were helpful and affordable.

Finally, the project developed a clear pedagogical intervention and survey instruments to evaluate its effectiveness and better understand in which contexts and for whom it would work. Figure 1.2 presents the theory of action of the intervention to be evaluated in a validation (or efficacy) phase of the project. The intervention consists of three elements: 1) access to the portfolio of OECD rubrics on creativity and critical thinking and lesson plans that were designed during the development phase of the project; 2) professional development plans shaping teachers' learning opportunities; 3) design and teaching of new lesson plans integrating creativity or critical thinking (or both) as one of its learning objectives, alongside technical skills in one discipline or more. Ideally, teachers would have enough time to understand and take ownership of the project materials and to develop their teaching capacity before their teaching and their students' learning would be assessed.

Figure 1.2. Theory of action for an OECD validation project on creativity and critical thinking



Should validation prove successful, the next phase would be to scale-up those practices across systems. One obstacle to any scale-up lies in the incentives to do so. While teaching and assessment have to be aligned, so does expectation in primary, secondary and tertiary education. An ongoing strand of the project undertakes similar work in higher education, working with higher education institutions internationally to develop a professional representation of what fostering students' creativity and critical thinking means in higher education.

Notes

1) See https://tinyurl.com/oecd-ceri-cct

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Chapter 2

Creativity and critical thinking: From concepts to teacher-friendly rubrics

This chapter argues that creativity and critical thinking are essential skills in innovation-driven societies and economies and key skills for employment in the digital age. Creativity and critical thinking also contribute to personal and social well-being. Most countries recognise them as key learning outcomes for their education systems. After presenting a state of the art of the research consensus on what creativity and critical thinking entail, the chapter presents the portfolio of OECD rubrics on creativity and critical thinking that were developed by working with teachers and schools networks in 11 countries, and reflects on how teachers used them to give students more opportunities to develop their creativity and critical thinking skills while teaching their usual curriculum.

Creativity and critical thinking: Two distinct skills that matter

Creativity and critical thinking as skills for innovation

Innovation has become one of the driving forces of economic growth in OECD countries and economies, and thus a focal point for policy makers and employers. Empowering people to contribute to and to adapt to innovation has become one of the objectives of education and higher education. At the individual, firm, sector and national levels, there are both proactive and receptive dimensions to innovation.This induces a dual movement of equipping people with the skills to become innovators, creators, and creative entrepreneurs or self-entrepreneurs, as well as equipping them with the skills to adapt to innovation and absorb some of the changes induced by innovation (OECD, 2010[1]; 2015[2]).

Innovation policy typically emphasises the role of science, technology, engineering and mathematics in innovation; the role of entrepreneurship; and it usually emphasises advanced higher education degrees such as doctorates. There is now a stronger acknowledgment of the diversity of the skills and qualifications involved in innovation processes, especially since design and "Design Thinking" have become more important in innovation and multidisciplinary teams have become more prevalent in formal innovation processes. The value of design in products and services has also become more visible in companies' margins. Even at the city or regional level, the "openness" in principle induced by the diversity of people and talents is now seen as one of the drivers of innovation and economic value (see, for example, Florida [2005[3], 2002/2012[4]]).

Avvisati, Jacotin and Vincent-Lancrin (2013[5]) show that tertiary education graduates from all fields of study do actually contribute to innovation in the labour market. In particular, when it comes to knowledge or method innovation, the likelihood of having a highly innovative job (defined as working in an organisation at the forefront of absorbing innovation and directly contributing to the innovation process) is more or less the same regardless of the subject one has studied in higher education. Only for technology innovation are engineers and scientists much more likely to contribute to the innovation process compared to their peers in other domains. Toner (2010[6], 2011[7]) also shows that companies from different sectors employ people with very different types of qualifications to work in their specialised innovation function, including tertiary education graduates with vocational degrees.

While this picture somewhat departs from an elitist view of innovation, this is not surprising given the diversity of the economy and the different needs of different sectors. This diversity of innovation skills is now becoming better documented (see Tether et al. [2005[8]]; Wagner [2012[9]]; Wagner and Dintersmith [2015[10]]). This is not to say that people working specifically in the innovation function of organisations (such as research and development) should not have a stronger innovation skill set, but more that at different levels, people from every field of study contribute to innovation – and possibly more people from all fields will have to contribute in the future. As a result, while some people may need stronger innovation skills than others, everyone should be equipped with them to some extent, whatever their field of study.

What do we mean by "innovation skills", and how do they relate to creative and critical thinking skills? We define "skills" as the bundle of knowledge, attributes and capacities that enable an individual to successfully and consistently perform an activity or task, whether broadly or narrowly conceived, and that can be expanded. As our focus is on education, this report focuses on the expansion of skills through learning (rather than, say, "enhancing devices" such as machines, for example). Professional and academic qualifications represent certain bundles of skills related to academic or professional fields.

Avvisati, Jacotin and Vincent-Lancrin (2013[5]) analysed two international surveys of tertiary education graduates (Reflex and Hegesco) covering 19 European countries and Japan to go one step further and identify some specific skills that matter for innovation at the individual level, whatever the field of study. By comparing the (self reported) job requirements of highly innovative and non-innovative jobs, the authors identified the most critical skills for innovation that distinguish "innovators" from "non-innovators".

Respondents to the survey were asked how important 19 pre-identified skills were in their current job. Comparing highly innovative professionals to their non-innovative peers shows that innovative professionals report a greater use of any single skill than non-innovative professionals. Highly innovative jobs are thus more demanding. The critical skills that distinguish innovators from non-innovators the most are creativity ("come up with new ideas and solutions") and critical thinking (the "willingness to question ideas"), followed by the "ability to present ideas in audience" (communication), "alertness to opportunities" (entrepreneurialism), "analytical thinking", "ability to co-ordinate activities", and the "ability to acquire new knowledge" (Figure 2.1). These innovation skills match our assumptions on individual skills for innovation, but it is noteworthy that they are triangulated in an analytical way rather than self-reported by individuals in a direct question. As it can thus not be the result of a social desirability bias, this analysis gives strong support to the (widespread) idea that creativity and critical thinking represent crucial ingredients to innovation (alongside other skills).

Figure 2.1. Critical skills for the most innovative jobs, by type of innovation

Tertiary-educated workers who contribute to their organisation's innovation activities face higher skill requirements than non-innovative graduates

Notes: Odds ratios correspond to the likelihood of mentioning the skill as required for workers in innovative jobs, compared to workers in non-innovative jobs. Generalised odds ratios are computed from logistic regressions controlling for country and sector of activity. The five most critical skills are highlighted in dark green for each type of innovation.

Source: Avvisati, F., G. Jacotin and S. Vincent-Lancrin (2013), "Educating higher education students for innovative economies: What international data tell us", www.tuningjournal.org/public/site/01/11_Educating_Higher_Education_Students_for_Innovative_Economies.pdf. Authors' calculation. Based on Reflex and Hegesco.

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On average, all types of innovation combined, innovators are about four times as likely as non-innovators to say this is a very important skills requirement of their job – and three times as likely for critical thinking. The different types of innovation require slightly different skill profiles though. Professionals who are contributing to product innovation report high requirements for their job especially in terms of creativity ("come up with new ideas and solutions", "alertness to opportunities", "willingness to question ideas"). For technology innovation, behind "coming up with new ideas and solutions", the most critical skills seem to be the "ability to use computers and the Internet", "analytical thinking", and the "ability to rapidly acquire new knowledge". Graduates contributing to innovation of knowledge or methods, in contrast, need to complement creativity ("come up with new ideas and solutions"), critical thinking ("willingness to question ideas") and other thinking skills ("analytical thinking", "ability to rapidly acquire new knowledge") with persuasion and communication skills ("the ability to present ideas to an audience") (Figure 2.1).

Creativity and critical thinking as skills for the digital age

In recent years, the digitalisation of societies, one particular form of societal innovation, has also cast a new light on the innovation debate (OECD, 2019a[11]; 2019b[12]). Regardless of the contribution to innovation, but merely as a result of digitalisation being a major societal innovation, people will need to develop a broader set of skills. The development of artificial intelligence (AI), and robotics and the globalisation of our societies have led many observers and media to speculate on the future of jobs (OECD, 2019c[13]; Baldwin, 2019[14]). Will some jobs disappear from OECD economies and be outsourced to countries where workers receive a comparatively lower compensation? More fundamentally, will a large share of the jobs performed by human beings be automated and performed by different types of computers (notably robots and AI agents)? According to recent OECD estimates, 14% of jobs in the OECD area are at risk of being completely automated while another 32% are likely to change significantly (OECD, 2019c[13]). While this is unlikely to lead to fewer jobs for humans, there will be a significant cost to adjust to these changes. Recent analysis has estimated the country-level minimum cost of helping workers at high risk of automation to move to an occupation with a low or medium risk of automation with minimum upskilling or (re)training efforts, moderate wage reductions, and limited skills excesses: these estimates range from less than 0.5% (lower bound) or 1% (upper bound) of one year's gross domestic product (GDP) in Norway to more than 2% (lower bound) or 10% (upper bound) of one year's GDP in Chile (OECD, 2019b[12]).

The debate about automation and the future of work fuels heated discussions. A common policy response has been to identify skills that might be more difficult to automate. Higher order skills such as creativity and critical thinking as well as socio-emotional skills often appear as a response in this debate (see OECD [2019b[12]]).

In 2016, chief executive officers and chief human resource officers of multinational and large domestic companies that answered the World Economic Forum's "Future of Job" survey identified critical thinking and creativity among the top ten most important skills in the labour market in 2015, ranking 4th and 10th, respectively. They foresaw these two skills as becoming even more important by 2020, with critical thinking and creativity ranked 2nd and 3rd, respectively, after complex problem solving (WEF, 2016[15]). In 2018, the survey reported similar results: critical thinking and creativity were ranked as the third and fifth most demanded skills (with "analytical thinking and innovation" and "complex problem solving" being first and second). Forecasts expected them to become the fifth (critical thinking) and third (creativity) most demanded skills, respectively, in 2022, giving a small edge to creativity (WEF, 2018[16]).

Interestingly, the report underlines the importance of skills such as creativity, originality and initiative, critical thinking, persuasion and negotiation, and presents them as being "human" and as an important supplement to an enhanced proficiency in new technologies (assuming that a more automated world and the development of new technologies will require coding and designing the new machines) (WEF, 2018[16]). A new motivation to develop skills such as creativity and critical thinking is that they do appear more difficult to be automated or simulated by computers and algorithms. They seem to be, at least temporarily, beyond the reach of artificial intelligence – even though we already know that AI can create by convincingly imitating a given production style (e.g. in arts). As experts debate about which skills and jobs may or may not be automated and disappear, there is an increasing emphasis on higher order skills, which are more difficult to programme just because they require more flexibility and diversity.

Recent market research by LinkedIn Learning finds that creativity was the most demanded "soft" skill by companies in 2019 and the second most demanded skill after "cloud computing" skills (Petrone, 2019a[17]; 2019b[18]). The company identified the most demanded skills by analysing which skills people hired at the highest rates displayed in their profile. According to Accenture Research, given the current and coming acceleration of man-machine collaboration, a new skill set has become more important and will become increasingly more important in the future in almost every single role in the economy: a combination of complex reasoning (including critical thinking in the study), creativity, socio-emotional intelligence and sensory perception. The analysis of the US Department of Labor's O*NET database showed that creativity was the skill whose importance and demand increased the most in science and engineering roles between 2004 and 2017, and that its importance has increased in all roles of the economy. This is also true for complex reasoning (including critical thinking) (Accenture, 2018[19]). Finally, in a forecasting exercise of the demand for skills in all sectors of the economy in the United States and in western Europe, the McKinsey Institute finds that the demand for high-level cognitive skills such as creativity and critical thinking skills will increase by 2030: according to their forecasts, the demand for creativity will increase by 40% and 30% in the United States and western Europe, respectively, and the demand for critical thinking and decision making will increase by 17% and 8% (Bughin et al., 2018[20]).

All in all, there seems to be a consensus that creativity and critical thinking will become more important in people's professional life, and in much higher demand in the labour market in the decades to come.

Creativity and critical thinking for personal and social well-being

Beyond the economic argument, higher order skills such as creativity and critical thinking matter because they contribute to people's well-being and to democratic societies. They are at the top of Bloom's taxonomy for their level of complexity and demand (under the terms "create" and "evaluate"); they can also be seen as high level human needs or aspirations, in Maslow's tradition (under the term "self-actualisation"). While these hierarchies or taxonomies can be (and are often) criticised for many reasons, the key messages they capture is that complex intellectual and practical tasks contribute to individual well-being.

One of the strong arguments for and interests in creativity lies in the feeling of focus and well being that it creates, according to positive psychologists. Csikszentmihalyi (1990[21]; 1996[22]) famously described the state of "flow" that often comes with creativity, and, generally speaking, challenging tasks. Flow refers to "a state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will continue to do it even at great cost, for the sheer sake of doing it" (Csikszentmihalyi, 1990[21]). Csikszentmihalyi and Schneider (2000[23]) showed that these optimal moments can be experienced by adolescents in school when they perform certain learning tasks. Schneider et al. (2020[24]) go one step further and show that this experience can also be used to support learning as good curricular materials can induce "optimal learning moments". One particularity of the "flow" analysis is that it represents well being in the moment, rather than as an enduring state of happiness. Research on creativity has also focused on other types of association between creativity and well being, usually understood as positive emotional states. Research shows that positive affects enhance creativity, but that everyday creativity also creates positive effects that are likely to be sustained in the days following its occurrence – so that psychologists increasingly argue that creative moments in one's everyday life contribute to people's and society's well being (Richards, 2010[25]; Conner, DeYoung and Silvia, 2017[26]; Kaufman, 2018[27]; Perach and Wisman, 2019[28]).

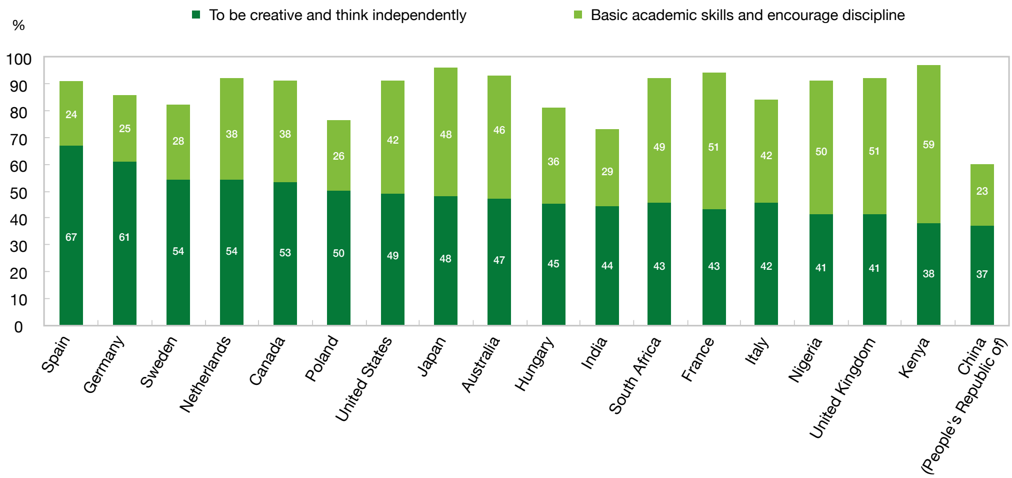
Critical thinking also plays a role for individual well-being, but is more often seen as an essential pillar of the functioning of modern democracies. The ancient philosophical tradition saw it both as a way to have a good and happy life (Hadot, 1995[29]) and as means toward a good government. Nowadays, in modern democracies, people are expected to exercise their critical thinking as an integral part of being a citizen, with the ability to make an independent and well-grounded opinion to vote, weigh the quality of arguments presented in the media and other sources of authority. In a digital world in which a multiplicity of facts, views, theories, and assumptions compete, critical thinking has become even more important. And in the same spirit, many see creative thinking as a key skill to overcome current social challenges, be they global or domestic in nature.

Creativity and critical thinking as consensual learning outcomes

Many discussions about the identification and development of so-called 21st century skills also include creativity and critical thinking as part of their list of key skills to acquire for the future. Most curricula in OECD countries include in one form or another critical thinking and creativity as expected learning outcomes. Their importance in education and higher education has become consensual worldwide (Fullan, Quinn and McEachen, 2018[30]; Newton and Newton, 2014[31]; Lucas and Spencer, 2017[32]). The role of education in the development of critical thinking is also increasingly acknowledged in many countries, where a majority of the population believes that schools should help students to become "independent thinkers" rather than to simply transmit knowledge (Figure 2.2).

Figure 2.2. Most societies support the fostering of creativity and critical thinking in education

It is more important that schools in our country teach…



Source: Pew Research Centre, Spring 2016 Global Attitudes Survey.

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Creativity and critical thinking: How they relate to other skills

While creativity and critical thinking are crucial for innovation and labour market needs, other supplementary skills are equally important. Our conceptual framework distinguishes three overlapping categories of "skills for innovation" (Figure 2.3): 1) technical skills (know-what and know-how); 2) creativity and critical thinking skills (critical thinking, imagination, creativity); and 3) behavioural and social skills (persistence, conscientiousness, self-esteem, communication, collaboration). These three skills sets need to be developed together.

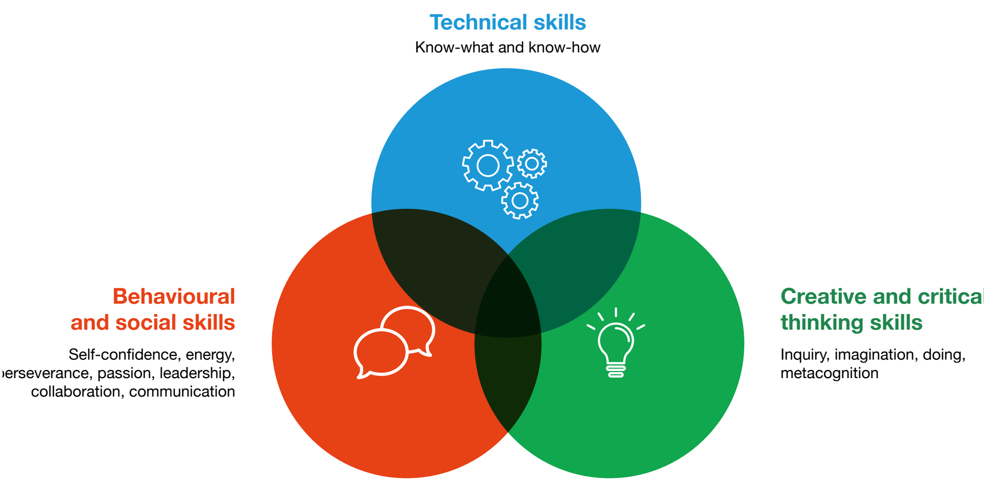
Typically, technical skills in a subject correspond to content (or declarative) knowledge and to procedural knowledge: knowing that, and knowing how. Technical skills, for example, refer to knowledge about maths or science formulas, and when and how to apply them; knowledge about music chords and theory, and how to apply them by performing or composing. By definition, technical skills should be acquired in any subject or field of study, from mathematics, science and language arts to visual arts, music, craft or everyday life activities (cooking, politeness, etc.). In formal education, great emphasis is given to technical skills: these are the ones that national exams and teacher tests and assignments typically assess.

Social and behavioural skills (or socio-emotional skills) are another category of skills. Emotional skills emphasise their self-regulative aspect (as they can typically not be observed) whereas behavioural skills emphasise their actual external expression (that can typically be observed). Drive and energy, passion, self-confidence and self-esteem, resilience, growth mindset, grit are examples of those skills, which may be nurtured through role modelling and encouragement. Social skills refer to collaborative and communication skills, which also build on behavioural skills.

Finally, creative and critical thinking skills are the third category. Before delving into their definition and theory in the next section, let us make three remarks to help understand the framework.

In these three categories, technical skills as well as creative and critical thinking skills both belong to "cognitive" skills, whereas social and behavioural skills correspond to "conative" skills. Creative and critical thinking skills are often described as "higher order" skills because they are cognitively more demanding. Therefore, one could consider them as the top level of the technical skills in a domain (even though, in our framework, they go beyond "knowing" about the domain).

Figure 2.3. Skills for innovation: Three skills categories



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These three categories build on one another and overlap. Technical skills in a domain cannot be acquired without effort, persistence, and a certain level of self-confidence. The ability to communicate and collaborate in a domain relies on some level of technical skills in this domain. In fact, communication in a domain builds on technical knowledge (knowing and understanding the concepts and lexicon of a domain is a key dimension of technical skills). Think of some subjects (such as law): communication and collaboration with other professionals cannot happen without some level of technical skills. In fact, a significant amount of the technical skills in any domain consists of making "communication with peers" possible (even though people can be more or less skilled in communication). Creativity and critical thinking skills build on technical skills. One cannot be creative in a domain without knowing the domain to some extent (as random originality does not count as creativity). One cannot be a critical thinker in a domain without knowing the domain (and preferably a few others).

Finally, let us note that the three categories of skills are domain-specific (rather than domain general). People should develop all these skills sets in different domains or subjects: in reading and writing, mathematics, coding, science, history, visual arts, music, etc. While some of the skills acquired in one domain may be useful in another, they will typically not transfer from one domain to another (see Detterman and Sternberg [1993[33]]; Bransford and Schwartz [1999[34]]). Strong technical skills in mathematics do not guarantee strong technical skills in literature, and vice versa; creative skills in music do not guarantee creative skills in history. At best, some of the behavioural and social skills and the creative and critical thinking skills may become a "habit of mind", a disposition that makes it easier to develop then again in a new domain.

While some subjects may offer more possibilities to develop one's creativity and critical thinking skills than others, one should not presume this will happen automatically. Because in its highest form the arts exemplify creativity, people often assume that arts education automatically develops students' creativity. This may be true or not. This will probably only happen if, say, music or visual arts, are taught in a way that intentionally emphasises creativity (Winner, Goldstein and Vincent Lancrin, 2013[35]). Similarly, philosophy is a subject that cultivates critical thinking, but it is actually possible to teach it in a purely dogmatic way. Creativity and critical thinking should thus be developed in all domains, which will reinforce those skills and turn them into a disposition that can be more easily reactivated when one learns new subjects.

Definitions, theories and dimensions of creativity and critical thinking

What do we mean by creativity and critical thinking, and how do they relate? This section will go through the definitions and research literature on creativity and critical thinking and highlight some relationships between the two concepts. The dimensions of creativity and critical thinking that have been emphasised as part of the project will also be noted.

Creativity

In the economic and labour market contexts presented above, creativity generally refers to "coming up with new ideas and solutions". Creativity is about producing new business solutions, new companies, and new technical solutions. It is also about great new songs, books, scientific theories, TV series, food, etc. Creativity can manifest itself in all domains, and all societies have their emblematic and recognised creative entrepreneurs, scientists, artists, architects, chefs, etc.

There is a long-standing interest in creativity in the western world. While it was initially related to religion and the creation of the world, since the romantic era the emphasis has shifted to individual creativity (e.g. Nietzsche). However, individual creativity has not always been socially valued. The mastery of technical skills was seen more as an "imitative" model. This is one of the narrative threads of the novel My Name is Red (Pamuk, 2001[36]), which also highlights that excellence in imitative mastery can only be recognised if there is some level of creativity in the imitation, one that only the other masters or experts will notice.

While the topic has been studied from different perspectives (Steiner, 2001[37]), most of current creativity research arguably comes from the field of psychology. Many definitions of creativity exist. Treffinger et al. (2002[38]) analysed 120 different ones, and noticed that they agree on the main features of creativity. Studies on creativity focus on the person, product, process (Runco, 2004[39]; Glaveanu, 2011[40]); come from a variety of theoretical lenses (Sternberg and Lubart, 1999[41]; Runco, 2007[42]); and include more or less emphasis on the social environment or context in which creativity happens (Csikszentmihalyi, 1996[22]; Amabile, 1996[43]; Florida, 2002/2012[4]).

Sternberg and Lubart (1999[41]) proposed a simple definition of creativity: "creativity is the ability to produce work that is both novel (i.e. original, unexpected) and appropriate (i.e. useful, adaptive concerning tasks constraints". Appropriateness recalls that creativity happens within a system or context with its standards and constraints; it is not just about doing something new. As Dennett (2013[44]) puts it: "Being creative is not just a matter of casting about for something novel – anybody can do that, since novelty can be found in any random juxtaposition of stuff – but of making the novelty jump out of some system, a system that has become established, for good reason". People sometimes refer to creativity as "thinking out of the box", acknowledging that creative ideas or actions are assessed against a box, and may indeed stretch or violate the system in an appropriate way – either changing the borders of the box or creating a new one.

A popular variant is to define creativity as the production of something novel and valuable. We prefer the neutrality of the word "appropriate" (or "effective", as per Runco and Jaeger [2012[45]]) to "valuable", because it better differentiates innovation and creativity, two concepts that are closely related, and sometimes used interchangeably. In economics, innovation refers to the introduction of a creative product or process that has a market value contributing to a firm or country's economic performance (Yusuf, 2009[46]). While creativity requires social confirmation, that is, external authorities or experts agreeing on whether the creative product or process can be deemed original and appropriate (Csikszentmihalyi, 1996[22]; Amabile, 1996[43]), it does not require market viability. One can easily agree that inventors are creative, even though their inventions may fail to become a commercially viable innovation. Creative people may fail to get their creations widely adopted, even though their peers acknowledge their creativity; by definition, innovators are supposed to push their innovations to the market and have a certain level of social success.

This distinction matters in an education context where creativity should not be measured against commercial or social value. In this case, teachers (and possibly the learners' peers) are the experts who recognise the novelty and appropriateness of the solution. The degrees of creativity can also vary. Some productions can be considered as novel to the world, to a given society or to given people. In education, one would generally expect that creativity is not about being new to the world, but just new to the student or going beyond what could be expected of them. Anyone can be creative at a certain level.

Sternberg and Lubart (1995[47]) go against the myth that only "gifted" or "exceptional" people can be creative. Most other writers on creativity claim the same, and Csikszentmihalyi has introduced the idea of a little-c (ordinary) and big-C (exceptional) creativity to emphasise the idea that anyone can be creative in everyday life. Any skill can be performed at differing levels of virtuosity, and while the greatest creators show what outstanding creativity looks like, people can produce things at different levels of creativity (Csikszentmihalyi, 1996[22]; Craft, 2001[48]). As (at least most) other skills, creativity is not binary, but a continuum that can be experienced at different levels of proficiency.

Several books on creativity base their theories on the biographies or interviews of successful creative people; that is people who have created something novel that has become part of the world culture (be it scientific, artistic, technological, etc.) (e.g. Csikszentmihalyi [1996[22]]; Gardner [1993[49]]) – people such as Einstein, Feynman, Turing, Skłodowska-Curie, Beckett, Borges, Proust, Monk, Billie Holiday, Charlie Parker, Louise Bourgeois, Hepworth or Chanel. This may give the impression that only extraordinary people can be creative. (Most of this people, it should be noted, have spent years of practice in their field to gain expertise and master it.) Furthermore, perhaps coincidentally, many psychologists who have worked on creativity have also worked on "gifted" or "precocious" students, adding to the tendency to associate creativity with "giftedness". In fact, rather than limiting "giftedness" to a high intelligence quotient, the idea should be broadened to include skills such as creativity.

Clarifying that creativity can be expressed by anyone at different levels of proficiency matters for teachers, students and parents. In educational contexts, limiting creativity to the great creators admired by humankind is limiting, and nurtures a "set" rather than a "growth" mindset (Dweck, 2006[50]). Children and adolescents are unlikely to equal exceptional creators, but they can gradually develop their creativity, as is the case for all other skills they acquire as they grow up. And some of them will eventually be added to the list of admired creators.

Emphasising both process and output, Lubart (2000[51]) defines creativity as "a sequence of thoughts and actions that leads to novel, adaptive production." What is this sequence? Creativity research has explored the cognitive processes involved in creativity. Guilford (1950[52]) emphasised two processes leading to creativity: divergent thinking (generating many ideas) and convergent thinking (choosing and developing a good one). Torrance (1970[53]), distinguished four aspects of the creativity process: fluency (having many relevant ideas), flexibility (having different types of relevant ideas), originality (having statistically novel ideas) and elaboration (being able to elaborate one's ideas). Most standardised tests of creativity or creative potential (e.g. Torrance, Wallach-Kogan, Guilford, Getzel Jackson, Mednick, Runco) decompose the creative process along similar lines and focus on some of its aspects. The test of creative potential used within the OECD project assessed the divergent-exploratory and convergent-integrative skills of students (see Lubart, Besançon and Barbot [2011[54]]).

Beyond these aspects usually tested by tests of creative potential, scientific research on creativity has decomposed the creative process in a series of human skills. Building on some of the categorisation proposed by Lucas, Claxton and Spencer (2013[55]), we summarise the macro-processes they involve under the following headings: inquiring, imagining, doing and reflecting.

Inquiring. One of the dimensions of the creative cognitive process is close to scientific inquiry. Torrance (1966[56]) highlights the importance of identifying problems, gaps in knowledge, missing knowledge and elements in the creative process. Because creativity cannot happen without knowledge about the field or problem investigated, looking for information, finding the problem and understanding its different possible dimensions is one of the important aspects of the creative process. This can take different forms, depending on the problem, from feeling and empathising with people (possibly customers) to a more objective approach of observing, describing and analysing from different possible perspectives what the issues and problems at stake are. Curiosity and unconventional connections between different knowledge and problems matter in the creative inquiry process.

Imagining. Imagination refers to the ability to see and play with ideas and things in one's mind. This exercise allows people to break away from conventional reality and pursue novel ideas and invent new stories, anticipate the future, pursue different scenarios, envision counterfactuals, simulate consequences of different ideas and solutions, etc. In the context of creativity, imagination is about a free and playful generation of ideas, theories and assumptions, with a certain level of intentionality. This can take the form of an independent generation of multiple ideas or the association of ideas, either by seeing actual or sometimes metaphorical connections (Mednick, 1962[57]; Runco, 2009a[58]). Being able to push ideas to their limits, or to explore unconventional ideas or even seemingly absurd ideas without much actual risk, is one of the cognitive processes that creativity may involve.

Doing. Creativity implies the creation of something novel and appropriate, based on one's inquiry and imagination. This is typically the convergent or integrative part of the creative process. This output production can take different forms based on the domain: it can be a product, a performance, an idea, a physical or mental model, etc. It implies the selection of some of the ideas that have been imagined and inquired, and thus some level of reflection and audacious decision making to meet the two main aspects of creativity. While products can be associated with the final stage of the creative process, the creative process can also include some tinkering process of trial and error, or the development of prototypes and models at different stages of the process.

Reflecting. Finally, intentionality and reflection are key aspects of creativity. Intentionality distinguishes creativity from random novelty, and sometimes from small children's spontaneity. The level of intentionality and reflection can vary with age, but also with one's level of creative proficiency. As noted above, reflection also occurs at different stages of the creative process as one decides which ideas to select and how to move forward.

While these different aspects of creativity do not necessarily come in a definite order, or are solicited at different points in the creative process, they can easily be related to the Design Thinking method (see Chapter 3 for more information on this pedagogy), which codifies the innovation or creativity process and aims to turn it into an art (Kelley, 2001[59]). For educational purposes, the d.school at Stanford University summarised the innovation process in five steps that can be looped: empathise, define, ideate, prototype, test.

A final take on creativity consists of looking at specific personal attitudes or dispositions. This is why creativity is sometimes associated with a social and emotional (or behavioural) skill. Psychologists have studied attitudes that are associated with being more "creative". Csikszentmihalyi (1996[22]) attributes ten personality traits to outstandingly "creative people", portrayed as: 1) physically energetic, with a taste for rest and quietness; 2) smart and naïve; 3) playful and responsible; 4) full of imagination and fantasy but rooted in reality; 5) both introvert and extravert; 6) humble and proud; 7) more sensitive and less gender-stereotyped; 8) both "traditional and conservative" and "rebellious and iconoclast"; 9) both passionate and objective about their work; 10) both suffering and enjoying more than others. According to him, creative people are characterised by contrasting personality traits, rather than a clear set of traits. Recent research on personality traits (usually measured by the Big Five model) and creativity theoretically and empirically associated the trait of "openness to experience" as a disposition for creativity (McCrae, 1987[60]).

In sum, creativity is a sequence of thoughts and actions that produces something that knowledgeable people in a domain recognise as original and appropriate in a certain context. (In a few instances, social confirmation can come late as the "peers" or "knowledgeable people" could not or did not want to accept the truth or beauty of what was created, which was recognised well after the death of the creator, but those are relatively rare cases that can arguably be ignored when the focus is education.) Creativity can be relative, and in an educational context teachers may be those knowledgeable people seeing that some product is original and appropriate (for a student of a certain age and knowledge). Here are a few examples of creative actions: producing or proposing something that is significantly different from existing solutions; producing or proposing something that is significantly different from what one has done before; finding an unusual way to solve a given problem. By contrast, while they are valuable in many other ways, the following actions are not creative: reproducing something someone or oneself has done (although this may require being very skilled, and is a strong way of learning and acquiring mastery); finding the solution to a complex problem in a usual way; producing something that is novel but inappropriate; or producing something that one finds novel but nobody else does.

Critical thinking

Critical thinking can be a step in the creative process or not: convergent thinking does not necessarily have to adopt a "critical" stance (Runco, 2009b[61]). Critical thinking mainly aims at assessing the strength and appropriateness of a statement, theory or idea through a questioning and perspective-taking process – which may in turn result (or not) in a possibly novel statement or theory. Critical thinking need not lead to an original position to a problem: the most conventional one may be the most appropriate. However, it typically involves the examination and evaluation of different possible positions.

Critical thinking is usually traced back to the dialectic method of Socrates and of its followers who sought the truth based on questioning, on identifying and challenging statements and their underlying hypotheses to see whether they held water. One of the philosophical schools that put a radical version of critical thinking at the core of its philosophy is scepticism (also known as pyrhonnysm). The Sceptics emphasised the limits of human knowledge and maintained that "suspending our judgment" was ultimately the appropriate stance towards existing theories. This form of radical scepticism was taken seriously by philosophers and its discussion and critique have led to the foundations of many philosophical theories of knowledge and science since the 17th century. Descartes and his successors attempted to create a hierarchy of beliefs and evidence, while others theorised the limitations (and functioning) of the human brain (e.g. Hume and Kant). The philosophy of enlightenment indeed revived the idea that common beliefs could be criticised and challenged and that knowledge, science and free thinking could lead to better societies – a philosophy for example illustrated by the Diderot and D'Alembert *Encyclopédie*.

In education, research on critical thinking usually refers to Dewey (1933[62]) as a key milestone or first famous user of the word in English (although most of the time he talked about "reflective thinking"): "The essence of critical thinking is suspended judgment; and the essence of this suspense is inquiry to determine the nature of the problem before proceeding to attempts at its solution". Critical thinking would thus be an initial scepticism allowing for inquiry, better understanding of the problem at hand before proposing a solution. Critical thinking can easily be linked to the two speeds of thinking highlighted by Kahneman (2011[63]): while fast thinking is successful for most daily situations, it includes several systematic biases of the mind that lead humans to give "irrational" or "wrong" solutions to even relatively simple analytical problems; slow thinking is the reflective and analytical thinking that attempts to remedy some of the biases of the human (fast) thinking, including confirmation bias (that speeds up the thinking process) and usually leads to a right or rational solution to a problem (should one have the relevant technical knowledge to solve it). At its best, critical thinking is one of the different forms of thinking slow, although it is not limited to finding the "right" answer to a problem, but also includes "determining" its nature.

Applied to education (and higher education), the theory of critical thinking has been developed by philosophers such as Ennis (1996[64]; 2018[65]), Facione (1990[66]) and McPeck (1981[67]) (see Davies and Barnett [2015[68]] and Hitchcock [2018[69]] for an overview of the literature). Hitchcock (2018[69]) summarises most conceptions by defining critical thinking as "careful goal-directed thinking" – another version of Ennis' definition: "reasonable reflective thinking focused on deciding what to believe or do" (Ennis, 2018[65]). In many cases, definitions of critical thinking emphasise logical or rational thinking; that is, the ability to reason, assess arguments and evidence, and argue in a sound way to reach a relevant and appropriate solution to a problem. This is also typically what standardised assessments of critical thinking tend to assess. However, critical thinking arguably goes beyond good analytical thinking, and includes a dimension of "critique" and "perspective taking", not so much in the sense of taking someone else's perspective, but in the sense of "perspectivism" in philosophy (as developed by philosophers such as Leibniz and Nietzsche):

looking at things from different perspectives. All perspectives or ways of seeing things may not be equivalent, some may be stronger than others, but they can all be valid and derived from rational or "good" thinking (and thus "true").

This view has been well illustrated in modern epistemology by Foucault (1966[70]) with his "epistemes" historically accepted knowledge) or Kuhn (1962[71]) with his "paradigms". When supplementing Karl Popper's falsification theory, perhaps Lakatos (1980[72]) provided one of the best illustrations of what critical thinking and its perspectivist dimension may look like in science. Scientists do indeed have different theories to explain natural (or social phenomena). Their "research programmes" embody these different views or perspectives. Lakatos noted that a scientific "research program" (that is, a theory) is composed of a "hard core" (of assumptions and procedures) and a "protective belt" (of secondary assumptions and procedures). Typically, scientists never challenge the "hard core" of their research programme, but rather change the secondary assumptions and theories to accommodate facts that do not fit with it. In the normal regime of a research programme, there is indeed not time to challenge assumptions. Challenging the "hard core" of a research programme, that is, its assumptions and ways of thinking, may lead to a better understanding of its framework; in some cases, this may lead to another "research programme" with a different set of assumptions – an occurrence of creative thinking. Within disciplines, a variety of research programmes often compete, even though some may be more widely accepted or successful in explaining relevant phenomena than others. Some disciplines can be seen as competing "research programmes" departing from different sets of values or assumptions about what matters and theories to explain observed facts (for example, economics and sociology).

Critical thinking is thus not merely limited to finding the right or appropriate solution after a reflective thinking process within a specific theory, paradigm or discipline. It is not just about having a critical look at the secondary belt of assumptions to find a way to adapt the theory. From time to time, it is also about being able and willing to challenge the core assumptions of theories, paradigms or accepted knowledge; about recognising the possible value of other perspectives or "research programmes"; assessing their possible strengths and weaknesses; and recognising that all theories or research programmes have their unproven "assumptions", and thus, possible limitations and biases – as reasonable and aligned with empirical perceptions or "fast thinking" as they might be. In addition to rational or logical thinking, critical thinking thus includes two other dimensions: 1) the recognition of multiple perspectives (or possibility to challenge a given one); and 2) the recognition of the assumptions (and limitations) of any perspective, even when it appears superior to all other available ones.

What are the cognitive processes or sub-skills involved in critical thinking? To establish a parallelism with creative thinking, we summarise the underlying macro-processes under the same headings as creativity: inquiring, imagining, doing and reflecting.

Inquiring. Determining and understanding the problem at hand, including its boundaries, is a first important dimension of a critical thinking inquisitive process. Sometimes this includes wondering why the problem is posed in a certain way, examining whether the associated solutions or statements may be based on inaccurate facts or reasoning, and identifying the knowledge gaps. This inquiry process partly concerns rational thinking (checking facts, observing, analysing the reasoning), but includes a more "critical" dimension when it comes to identifying the possible limitations of the solution, challenging some of the underlying assumptions and interpretations, even when facts are accurate. In many cases, inquiring involves acquiring knowledge, verifying knowledge, and examining the components of the problem in detail as well as the problem as a whole.

Imagining. In critical thinking, imagination plays an important role as the mental elaboration of an idea – but any thinking involves some level of imagination. At a higher level, imagining is also about identifying and reviewing alternative, competing world views, theories and assumptions, so as to consider the problem from multiple perspectives. This allows for a better identification of the strengths and weaknesses of proposed evidence, arguments and assumptions, even though this evaluation also belongs to the inquisitive process. Imagination also plays a role in thought experiments, which can be a strong component of any good thinking, but also a way to explore alternatives and make a point when experimentation is not possible (Dennett, 2013[44]).

Doing. The product of critical thinking is one's position or solution to a problem (or judgment about others' position or solution). This mainly implies good inference, a balancing act between different ways of looking at the problem, and thus recognition of its (possible) complexities. As any good thinking, critical thinking implies the ability to argue and justify one's position rationally, according to some existing perspectives and socially recognised ways of reasoning, or possibly some new ones.

Reflecting. Finally, even though one may consider one's position or way of thinking superior to some alternatives, perhaps just because it embraces a wider view or is better supported by existing evidence, critical thinking implies some self-reflective process about the perspective one endorses, its possible limitations and uncertainties, and thus a certain level of humility and openness to other competing ideas. While one does not have to embrace ancient scepticism and suspend one's judgment in all cases, this may sometimes be the most appropriate position.

In the same way that creativity can be approached as a disposition or "personality trait", critical thinking has been studied as a disposition or attitude. In fact, teaching and learning critical thinking in multiple disciplines is about developing this attitude, which can then be demonstrated as a skill. Barnett (2015[73]) distinguishes different forms of "criticality": critical reason (applied to knowledge), critical self-reflection (applied to self) and critical action (applied to the world). Vardi (2015[74]) highlights three dispositions involved in critical thinking: 1) self-regulation (self-discipline and self-management); 2) having an open, fair and reasonable mind, a preparedness to identify and face one's own biases, and a preparedness to reconsider one's own views where warranted; 3) being committed to ongoing self-improvement and being ready to develop one's knowledge. In the same spirit, Thomas and Lok (2015[75]) analyse the dispositions or personal attitudes that support the development and application of critical thinking skills: being open-minded and fair-minded; being truth-seeking and curious; avoiding cultural- or trait-induced bias and dichotomous black and white thinking. Synthesising the research literature on critical thinking, Hitchcock (2018[69]) categorises critical thinking dispositions as follows: attentiveness, habit of inquiry, self-confidence, courage, open-mindedness, willingness to suspend judgment, trust in reason and truth-seeking.

In sum, critical thinking is a slow thinking process involving analytical thinking, looking at problems from different perspectives, and being willing to challenge assumptions and conventional ways of thinking before reaching a position. Critical thinking does not necessarily end in a critique of the most widely accepted position on a topic, which may indeed be the strongest one based on existing evidence. It requires having mere opinions (rather than convictions) about facts, theories and assumptions. Here are a few examples of critical thinking actions: questioning and evaluating ideas and solutions before making one's opinion; carefully considering several possible alternatives to take one's decision; fully considering different arguments or views before rejecting (or accepting) them; suspending one's judgment before one has time to inquire and while one is inquiring; fighting one's "confirmation" bias (as well as other ones); accepting that there is not enough evidence to conclude firmly and remaining indecisive because of the uncertainty. By contrast, while they can be valuable, the following actions cannot be considered an expression of critical thinking: finding the solution of a well-specified complex problem (this is just problem solving that may or may not require any critical thinking); accepting the first idea that comes to mind (fast thinking); repeating without further examination what existing theories or "authorities" or local cultural views say (dogmatism, ethno-centrism); refusing all conclusions whatever they are as a matter of principle, based on the possible remaining uncertainties, or refusing a position on the grounds that it is widely accepted socially.

Commonalities between creativity and critical thinking and educational implications

Creativity and critical thinking are two distinct but related higher order cognitive skills. As such, both require great mental effort and energy and are cognitively challenging. They are related in that they involve some similar thought processes, but their goals differ. Creativity aims to create novel, appropriate ideas and products. Critical thinking aims to carefully evaluate and judge statements, ideas and theories relative to alternative explanations or solutions so as to reach a competent, independent position – possibly for action.

The research on creativity and on critical thinking do not actually overlap much, even though critical thinking sometimes plays an important role in creativity, and vice versa. School curricula and educational rubrics are, however, prone to group them together and to talk about "creative and critical thinking". In the same spirit, Lucas and Spencer (2017[32]) include critical thinking (as well as problem solving) under the concept of "creative thinking". In some cases, this conflation leads to nuances and differences getting lost, but this also highlights that some educational tasks may allow expanding and practicing sub-skills that are important for both.

Many of the cognitive processes involved in creativity and critical thinking share commonalities. Both require prior knowledge in the domain of application. The sub-skills that need to be deployed for each competence involve imagining, inquiring, doing and reflecting. Creativity puts more emphasis on imagining (brainstorming, generating ideas and alternatives), while critical thinking puts more emphasis on "inquiring", including its more analytical and systematic dimension (understanding and decomposing the problem, etc.). Critical thinking is mainly inquisitive, a detective way of thinking; creative thinking is imaginative, the artist way of thinking. However, critical thinking involves imagining alternative theories, counterfactuals, reasons, and results in an action (making a judgment); creativity requires making judgments and decisions about the alternative ideas generated in the imaginative process, and more fundamentally to examine the assumptions of existing solutions and conventions before its own act (creating something novel and appropriate).

Both creativity and critical thinking require a certain level of openness and curiosity. Both may lead to challenging authority, values or accepted norms, and this is what may make them both valuable and sometimes challenging. Critical thinking requires scientific integrity; creativity requires discipline and judgment. When education is conceived as the mere transmission of socially accepted knowledge, there is little room for creativity and critical thinking. On the other hand, like most other skills, creativity and critical thinking only have to be exercised at some points: even if this were concretely possible, a world in which people were all the time creative or all the time critical would be very hard to live in. Chances for cumulative knowledge and learning would become scarce, and the lack of accepted conventions would make life in society difficult. Students also need to learn when and about what they can or should think creatively or critically. In an educational context, both creative and critical thinking pursue the deeper understanding of knowledge and solutions, and thus deeper learning. Developing creativity and critical thinking is actually a way to improve learning and get students to acquire more expertise in a domain – whether it leads to the proposition of new knowledge and solutions or not.

Even though one can describe them at the conceptual level in a domain-general way, both creativity and critical thinking are mainly domain-specific in practice: they require knowledge about a field or context to be practiced, and usually being a strong creative or critical thinker in one domain does not imply any transfer of those skills to another domain. In both cases, the research literature overwhelmingly emphasises their "domain-specificity", even though, again, at a certain level of generality they can be described as domain-general (Barbot, Besançon and Lubart, 2016[76]).

It was long believed that creativity was domain-general, but virtually all creativity researchers now agree that it is actually mainly domain-specific (Baer, 2015[77]). Two types of arguments are generally put forward.

The first is theoretical: if creativity requires a solution to be appropriate to a certain domain (subject or task) and recognised by experts in the domain, one needs to have some knowledge and even expertise in this domain. One needs some level of expertise about music, mathematics, visual arts, science, literature or cooking to be creative in those domains.

The second type of argument for domain-specificity is empirical. First, while some people from the Renaissance such as Leonardo da Vinci have shown that one can excel and be creative in several domains, creativity research shows that this represents only a tiny proportion of the population. (In the classic age, when knowledge was less advanced and specialised, philosophers like Descartes, Leibniz and Pascal contributed creatively to philosophy, mathematics and science. Some mathematicians contributed to philosophy [e.g. Poincaré]. Some writers proved to be creative in painting or drawing [e.g. Blake, Hugo or Michaux], in filming [e.g. Duras] or in composing [e.g. Nietzsche]; some composers also proved creative in painting [e.g. Schönberg] or in writing [e.g. Schumann], but these are again notable exceptions.) A study of everyday creativity among university students found that only 1.4% of the sample were involved in several types of creative activity (Ivcevic and Mayer, 2006[78]). Were creativity domain-general and easily transferable, there would be many more "polymaths". Empirical studies also show little correlation between the creativity scores of the same subjects in different domains, as assessed by experts in those domains (Baer, 2010[79]; Silvia, Kaufman and Pretz, 2009[80]). Finally, recent studies highlighted differences among creative types, arguing that creativity in different domains does not necessarily mobilise the same personality traits and even skills (Ivcevic, 2007[81]), while others even suggest that it is task-specific (Baer, 2015[77]).

The research community on critical thinking also leans towards the domain-specificity of critical thinking (Dominguez, 2018[82]). In an exchange with Ennis (1989[83]), McPeck (1981[67]; 1990[84]) convincingly argued that critical thinking can only be experienced in a domain in which one has a certain level of knowledge and expertise, and argued that transfer to other domains is difficult to imagine, and has failed to materialise empirically even in a very narrow understanding of critical thinking as formal and informal logic (Evans, 1982[85]; Glaser, 1984[86]). To our knowledge, empirical testing of whether strong critical thinkers in one domain (say, philosophy) have similar higher performance in other domains (say, ancient poetry, music or cooking) has not been carried out. But one can assume that the results would be similar to those for creativity.

The implications of the domain-specificity of creativity and critical thinking are straightforward for education. This does not mean that one cannot describe or talk about those skills in similar ways for all domains or subjects at the conceptual level. This does not mean that similar patterns cannot be recognised in all domains. However, this implies that creativity and critical thinking have to be acquired and experienced as part of the learning in the subjects rather than as a special class on creativity or on critical thinking. If creativity or critical thinking were domain-general, without having a dedicated class to develop those skills, we could also leave the teaching of creativity to arts teachers, and the teaching of critical thinking to philosophy or science teachers – then it would be transferred to all other skills. Their domain-specificity implies that transfer would be hypothetical and that all teachers must feel in charge if these skills are to be consistently developed (even as a mere disposition).

In terms of summative or standardised assessment, this also implies that performance in one domain or one task should not be generalised to people's creativity or critical thinking in general. Performance in technical skills in science is not necessarily a predictor of performance in technical skills in literacy, and the same applies to creativity and critical thinking.

Using rubrics to improve teaching, learning and assessment

There is overall a common understanding among researchers on the key dimensions of creativity and critical thinking. However, transferring the concepts to a consistent educational application requires further translation. This is where rubrics intervene. Rubrics are a way to simplify, translate and construct a social representation of what creativity and critical thinking look like in the teaching and learning process. They aim to create a shared understanding of what creativity means in the classroom, and share expectations among teachers, and among teachers and students. The rubrics' function is to simplify the big concepts of creativity and critical thinking so that they become relevant to teachers and learners in their actual educational activities. They also allow teachers to monitor and formatively assess whether their students develop those skills. Rubrics are a metacognitive tool that helps make learning visible and tangible, and teaching intentional.

Rubrics belong to relatively common teaching and assessment tools in the English-speaking world. In many other countries, teachers are unaware they even exist. Outside the educational context, the closest approximation to a rubric is a "qualifications framework". The Common European Framework of Reference for Languages can be seen as a kind of rubric about technical linguistic skills: it describes different levels of fluency in a language – and specific educational objectives. Usually, rubrics are mainly designed as a formative assessment tool: they make the assessment criteria visible and explicit to both the teachers and the students. "An instructional rubric is usually a one- or two-page document that describes varying levels of quality, from excellent to poor, for a specific assignment. It is usually used with a relatively complex assignment. […] Although the format of an instructional rubric can vary, all rubrics have two features in common: 1) a list of criteria, or "what counts" in a project or assignment; and 2) gradations of quality, with descriptions of strong, middling, and problematic student work" (Andrade, 2000[87]). Well, most rubrics do, but in some cases the levels of proficiency are not fully articulated.

Rubrics have become increasingly used in recent years as an assessment tool that can serve both formative and summative assessment purposes for complex skills and multidimensional tasks and performances, which many associate with open-ended tasks (Busching, 1998[88]; Arter and McTighe, 2001[89]; Perlman, 2003[90]; Reddy and Andrade, 2010[91]). The use and effects of rubrics have also been increasingly researched, both in terms of assessment characteristics (reliability, validity) and in terms of learning and teaching outcomes. However, as of 2019, research on rubrics use remains a relatively modest corpus: the latest review by Brookhart and Chen (2015[92]) reviewed 63 studies (see Jonsson and Svingby [2007[93]], Reddy and Andrade [2010[91]], and Panadero and Jonsson [2013[94]] for previous reviews, sometimes with a different emphasis).

While one of the objectives of the development phase of the OECD project was to provide meaningful, articulated thresholds of performance to teachers and students, the reliability or validity of the use of the OECD rubrics for assessment purposes could be empirically tested in a further validation phase of the work. According to Brookhart and Chen (2015[92]), research shows that scoring rubrics can lead to acceptable levels of consistent and reliable judgment (that is, agreement on judgment both among raters and over time), when they are clearly designed and their users get sufficient training. Validity, that is, the extent to which the rubric assesses what it is supposed to judge, got strong support, even though Brookhart and Chen (2015[92]) note that the range of validity tests used should be expanded in the future.

The possible formative use of rubrics by teachers and students has made them more attractive in recent years, given the recognised importance of continuous feedback and formative assessment in effective teaching and learning (OECD, 2013[95]). They also make it clear that summative and formative assessments can be integrated and do not need to rely on different assessment tools (Looney, 2011[96]). Rubrics scaffold formative assessment and, as a result, enhance student learning and improve teaching. Panadero and Jonsson (2013[94]) give an account on how better transparency in assessment criteria and in grading have been theorised to improved performance. Different research strands have shown that improved academic performance could be mediated via:

- increased transparency in expected skills acquisition and better understanding of teacher expectations
- reduced anxiety about learning and increased task completion (decreased task avoidance)
- more structured teacher feedback, and student reflection about the received feedback
- enhanced student planning of their work and self-regulation in learning.

Most of the studies have indeed found a positive effect of rubrics on those learning enhancers.

In one word, rubrics support metacognitive teaching and learning; that is, the use of intentional strategies helping students to reflect on their learning and become better at self-regulating it. Those strategies have been shown to be effective to improve students' learning outcomes in mathematics and science (Mevarech and Kramarski, 2014[97]) but to also consistently improve learning in other subjects: they rank 13 out of 138 reviewed pedagogical interventions (with an effect size of 0.7) in the meta-analyses carried out by Hattie (2009[98]), and rank 2nd (effect size around 0.6 equivalent to a 7-month boost of learning) out of the 35 broad strategies examined through meta-analyses of randomised controlled trials by the English Education Endowment Foundation in its Teaching and Learning Toolkit (EEF, 2018a[99]; 2018b[100]). (Interestingly, in terms of impact on learning, creativity programmes rank 17th out of the 138 types of interventions examined in Hattie's meta-analyses.)

In the frame of the OECD project, rubrics were developed to be used as a metacognitive tool to help teachers to be more intentional and consistent in giving students opportunities to develop some of the skills underlying creativity or critical thinking. Defining which sub-skills or dimensions of creativity and critical thinking were the most relevant was in that respect as important as the definition of progression levels that would allow one to assess their acquisition. Assessment was clearly just one possible use of the rubric, and two types of rubrics were iteratively developed during the project: conceptual rubrics and assessment rubrics.

Conceptual rubrics

The OECD rubrics were not designed in relation to any specific types of assignment but rather to embrace a wide variety of assignments and situations. While the original plan was to develop one rubric, we ended up developing a portfolio of rubrics. Different types of rubrics serve different purposes. We called "conceptual rubrics" those that merely clarify "what counts" or "what teachers and students should particularly keep in mind". (Initially they also had non-articulated "levels" of proficiency for each descriptor.) The rubrics evolved and had different versions over the course of the project. This chapter presents the final ones. Based on the feedback from the field work, several types of conceptual rubrics were developed: two domain-general rubrics that could be used and adapted to any subject; a set of domain-specific rubrics that uses the vocabulary and refers to common pedagogical activities within specific subjects (mathematics, science, music, visual arts, and language arts).

A balancing act in developing rubrics lies between simplicity and complexity. To be useful, rubrics have to be teacher-friendly (and possibly student-friendly), and have a language that is easily understandable by different types of teachers. On the one hand, the descriptors of the different key ideas have to relate enough to the concepts as understood by experts in creativity and critical thinking. On the other hand, the descriptors have to be simple enough to be easily understood by teachers and students, and have to relate to skills and activities that are meaningful in a school setting. Ideally, one would easily memorise some of their language so that it becomes internalised. Informed by the "five habits of mind" rubric developed by Lucas, Claxton and Spencer (2013[55]); by a review of other existing rubrics and educational descriptions; and by project coordinators' and teachers' feedback during the action research, the final OECD rubrics capture different dimensions of both creativity and critical thinking through four high-level and easily memorable descriptors: imagining, enquiring, doing, reflecting. Each of those active words is then associated with some descriptor(s) for creativity and for critical thinking.

Two domain-general conceptual rubrics were developed: a "comprehensive" rubric and "class friendly" rubric (see Tables 2.1 and 2.2). Feedback from the piloting of the initial rubric with teachers in the nine countries of the first round showed that, while some teachers preferred to work with a more complex and comprehensive description that can match more situations, others preferred a simpler rubric highlighting fewer skills. Instead of going for one of the two approaches, the participating project teams decided that two versions of the rubric should be developed. Teachers may use them for different purposes or in different ways.

Table 2.1. OECD rubric on creativity and critical thinking (domain-general, comprehensive)

	CREATIVITY Coming up with new ideas and solutions	CRITICAL THINKING Questioning and evaluating ideas and solutions
INQUIRING	• Feel, empathise, observe, describe relevant experience, knowledge and information • Make connections to other concepts and ideas, integrate other disciplinary perspectives	• Understand context/frame and boundaries of the problem • Identify and question assumptions, check accuracy of facts and interpretations, analyse gaps in knowledge
IMAGINING	• Explore, seek and generate ideas • Stretch and play with unusual, risky or radical ideas	• Identify and review alternative theories and opinions and compare or imagine different perspectives on the problem • Identify strengths and weaknesses of evidence, arguments, claims and beliefs
DOING	• Produce, perform, envision, prototype a product, a solution or a performance in a personally novel way	• Justify a solution or reasoning on logical, ethical or aesthetic criteria/reasoning
REFLECTING	• Reflect and assess the novelty of the chosen solution and of its possible consequences • Reflect and assess the relevance of the chosen solution and of its possible consequences	• Evaluate and acknowledge the uncertainty or limits of the endorsed solution or position • Reflect on the possible bias of one's own perspective compared to other perspectives

Note: This rubric is meant for teachers/faculty to identify the student skills related to creativity and to critical thinking that they have to foster in their teaching and learning, not for assessment.

Table 2.2. OECD rubric on creativity and critical thinking (domain-general, class-friendly)

	CREATIVITY Coming up with new ideas and solutions	CRITICAL THINKING Questioning and evaluating ideas and solutions
INQUIRING	Make connections to other concepts and knowledge from the same or from other disciplines	Identify and question assumptions and generally accepted ideas or practices
IMAGINING	Generate and play with unusual and radical ideas	Consider several perspectives on a problem based on different assumptions
DOING	Produce, perform or envision a meaningful output that is personally novel	Explain both strengths and limitations of a product, a solution or a theory justified on logical, ethical or aesthetic criteria
REFLECTING	Reflect on the novelty of the solution and of its possible consequences	Reflect on the chosen solution/position relative to possible alternatives

Note: This rubric is meant for teachers/faculty to identify the student skills related to creativity and to critical thinking that they have to foster in their teaching and learning, not for assessment.

While it is still a simplification, the "comprehensive" rubric provides more details and a richer description of the different sub-skills involved in creativity and critical thinking. Teachers who preferred this rubric found it more helpful to think about the concepts of creativity and critical thinking – arguing that the "class-friendly" rubric was too elusive or left too much implicit. Another reason the comprehensive rubric was appreciated comes from its possible multidisciplinary use: teachers developed some of the sub-skills in their subject, and tried to develop the others in a more generic way, outside the subject that they taught. For example, maths teachers in Hungary designed a co-operative learning maths activity that would allow their students to learn geometrical properties and vocabulary by looking at a figure from different perspectives, the whole picture being perceived by bringing together each group's partial information. While incorporating some objectives of the rubric in the maths learning, they chose a topic that would allow students to develop empathy towards other students in their community (adding to the lesson a dimension of the rubric in a non-maths way).

We called the simpler rubric a "class-friendly" rubric because one of the requests from some other teachers was to have a simpler rubric they could easily share with and discuss with their students. The idea was thus to provide them with a rubric that would be less cognitively demanding, covering fewer situations. As some aspects of the "comprehensive" rubric had to be left out, the class-friendly rubric deliberately highlights the skills that are (believed to be) less often nurtured within school systems, and thus required stronger reinforcement. For example, critical thinking combines the ability to make sound rational judgments and the ability to take perspective. In the class-friendly rubric, the ability to take perspective was emphasised more than the ability to make sound rational judgments, based on the idea that the first dimension is more strongly associated with critical thinking than the second, and more routinely practiced in schools. The class-friendly rubrics were developed after the first year of implementation of the project in school, so that only (the initial version of) the comprehensive domain-general rubric was available during the first year of work with schools.

Some teachers also felt that rubrics that related more closely to the kinds of educational activities they do in their subject would be more helpful, and it was thus decided to develop a set of rubrics that would be "domain-specific" and translate the class-friendly rubric for specific subjects. We eventually developed iteratively five rubrics for science, mathematics, music, visual arts and language arts (see Annex 2.A1).

Assessment rubrics

Beyond a better understanding of the skills that one should develop, rubrics can also be used to assess student work. In fact, this is usually their main use in countries where they are popular. They usually have descriptors of different levels of proficiency for each of their dimensions, either attached to a specific assignment or to an unspecified one.

Initially, teachers in the field were asked to propose some of those descriptors based on their experience with their students. The first rubrics piloted in the field had a column reminding teachers that different levels of proficiency could and should be attached to each dimension. As country teams were also asked to collect examples of student work, the ambition was to reach an international convergence on the articulation of those levels by comparing the different examples of student work and the expectations of teachers across the international network. Perhaps because the action research protocol was already heavy, these plans only partially materialised.

In many of the school and teacher networks involved in the project, there was actually a reluctance to use the rubrics as assessment tools – and even to assess creativity and/or critical thinking in the same way as technical skills in a subject would be assessed. As the rubrics have four broad headings for each competence (creativity and critical thinking), under a classical format the assessment rubric on creativity would be a 4x4 or 4x5 matrix if one stayed at the level of the headings (inquiring, imagining, doing, reflecting) – so 16 - 20 descriptions of proficiency levels. (With the comprehensive rubric, this would have been a 6x4 or 6x5 matrix if one wanted a descriptor for each sub-skill: 24 - 30 descriptions). To assess performance in each competence, teachers or students would thus have to tick four to six cells. This is quite common with scoring rubrics. For example, the VALUE rubrics on creative thinking developed by the US Association of American Colleges and Universities (AAC&U) have 6 dimensions and 4 levels of progression (24 descriptors) and those on critical thinking have 20.

Scoring assignments with assessment rubrics can be time consuming, or perceived as such, in spite of all the advantages they have in terms of formative assessment and consistency and reliability of the assessments. This is even more the case when other dimensions than creativity and critical thinking also have to be assessed, notably the acquisition of the technical skills (knowledge and know-how) in the taught subject(s), and the assessment is seen as an add-on to the "usual" assessments. Given that in many countries teachers had no prior experience using rubrics, they considered the task of using one as an assessment tool too time consuming and intimidating.

Rather than covering all the sub-skills and dimensions of our conceptual rubrics, the OECD assessment rubrics propose an overall progression for each of the two competences (creativity and critical thinking). The country teams thought it would be more user-friendly and likelier to be used by teachers. Moreover, this also makes it easier to combine the assessment of creativity or critical thinking with other learning outcomes, for example technical skills in some subjects or socio-emotional skills, to form a final scoring rubric with four to six dimensions. While creativity and critical thinking are the focus of this book, they are merely two among other important skills students should acquire.

Having fewer dimensions makes the assessment rubric more compact, but each of the descriptors of levels then tends to become more multidimensional. As a result, it does not articulate the different progression levels of enquiring, imagining, doing and reflecting explicitly – even though there are obviously different levels of proficiency attached to those activities as they relate to creativity or critical thinking. However, it makes the rubric easier to combine with the scoring of other learning goals articulated by other rubrics.

Assessing the final student work (product)

Usually, assessment or scoring rubrics serve to evaluate a student assignment or a project. For example, Andrade (2000[87]) presents a rubric to write and assess a "persuasive essay" in domestic language (English in that case) classes. We developed two assessment rubrics with that same objective: defining quality levels of creativity and critical thinking demonstrated in student work. While some teachers and co-ordinators were initially uncomfortable with the idea of assessing the creativity and critical thinking in student work without having witnessed the learning (or production) process, this is actually a common form of assessment in education. When it comes to technical skills in a subject (know-what and know-how), teachers feel no difficulty in assessing the level of mastery of specific learning outcomes in science, mathematics, language arts, music, visual arts or any other subject by merely looking at some student product. Once assessment criteria are being clearly articulated, assessing learning outcomes or competences such as creativity and critical thinking follows the same process.

The two assessment rubrics on creativity and critical thinking were built on the same principle (Tables 2.3 and 2.4). They both have four proficiency levels. The two lower levels were intentionally defined so that they would not correlate with the "technical skills" in the subject of the assignment. The initial level of progression ("dormant") suggests that the student work demonstrates a good level of mastery of the technical learning outcome in the subject, but not in creativity or critical thinking. The lower level describes a lack of effort to demonstrate those skills in the assignment. The second level ("emergent") describes a relatively low level in these skills, but an attempt to demonstrate them. They are deliberately combined with a possibly lower level of mastery in the technical skills in the subject (that is, the other learning goals of the assignment).

If creativity in a domain was always correlated with the technical skills in this domain, there would be no point in assessing it separately. The same is true for critical thinking. It would be more economical to merely assess technical skills, as they would also give all the relevant information about students' creativity and critical thinking skills. High performance in technical skills in mathematics, science, humanities or the arts does not in itself guarantee high levels of creativity or critical thinking in these domains – although they might be correlated.

The top two levels of progression more classically point to a certain achievement in both the technical skills and creativity or critical thinking, and just vary in degree. Indeed, both creativity and critical thinking should provide an "appropriate" solution to the problem so that good levels of creativity and critical thinking should also demonstrate the expected technical mastery, though possibly in non-expected ways. For critical thinking, the third level ("excellent") shows a good understanding of the problem, presents an argued position that is compared to one alternative perspective and understands the assumptions of the proposed position. The fourth level ("outstanding") differs by comparing to more than one alternative perspective, provides sound evidence and is self reflective. For creativity, Level 3 ("excellent") shows a certain level of imagination, appropriateness and originality given what one would expect the student to do or know. Level 4 goes one step further, with more imaginative and personal features touched upon by the work and even greater appropriateness of the solution to the task.

While the project teams could initially not agree with any explicit labels on the progression levels – they were initially just referred to as Levels 1 to 4 – at some point they asked to also have titles attached to the levels. There are different views in the literature on whether labels for levels are helpful or not. Finding good labels for the lower levels proved difficult and subject to more negotiation. We chose "dormant" for the lowest level as a way to express that students may have the competence but did not demonstrate it in their work. (Some colleagues suggested labelling the first level negatively, for example "careless", to make it an incentive to at least try to get to the next level, but most teams opposed to this proposal.)

Table 2.3. OECD assessment rubric: Creativity

	Level 4: Outstanding	Level 3: Excellent	Level 2: Emergent	Level 1: Dormant
PRODUCT	The student work: • is highly imaginative, showing many instances of personal features and risk taking (formulation, technique, composition or content) • fully meets the requirements of the task • goes beyond the knowledge and rules expected to be mastered by the student in more than one aspect.	The student work: • is imaginative, showing some examples of personal features (formulation, technique, composition or content) • meets the requirements of the task • goes beyond the knowledge and rules expected to be mastered by the student in one aspect.	The student work: • is personal in some of its features (formulation, technique, composition or content) • meets some but possibly not all the requirements of the task • is in line with the knowledge and rules expected to be mastered by the student.	The student work: • meets the requirement of the task but • reproduces existing examples, with little personal perspective on formulation, content, technique or composition.
PROCESS	The work process: • shows a willingness to examine carefully a variety of ideas as well the ability to make meaningful connections with other ideas or domains. • generated several unusual or radical ideas and pushed some to their limits before making the final choices. • shows a clear awareness of the areas of personal novelty and risk that were pursued, and of why the final choices were made.	The work process: • shows a willingness to brainstorm ideas and examines carefully the chosen idea. • generated one unusual or radical idea and pushed it to its limit before making the final choices. • shows a clear awareness of the areas of personal novelty or risk that were pursued.	The work process: • shows a willingness to think or act beyond one's first idea, but connections made between ideas or domains lack consistency or remain superficial. • fails to explore selected ideas with depth. • shows little awareness of the areas of personal novelty or risk that were pursued.	The work process: • is limited to the exploration of imitative patterns or to the examples presented by the teacher or expected to be familiar.

Notes: The class-friendly assessment rubric for creativity is supposed to assess a task targeting the acquisition of some learning outcome in a discipline or more. It is not meant to assess a "creativity" exercise, but any exercise in which students have space to develop their creative thinking skills. "Product" refers to a visible final student work (for example the response to a problem, an essay, an artefact of a performance). The criteria are meant to assess the student work even if the learning process is not observable by the rater or was not fully documented. "Process" refers to the learning and production process observed by the teachers or documented by the students: the process may not be entirely visible in the final product as some interim ideas or aspects of the process may not be reflected in the final student work. Typically, the process could show a greater level of acquisition of the skills than the product. Levels 1 to 4 correspond to a continuum. Level 1 corresponds to little effort to exercise one's creativity, whether the technical requirements of the task are met or not. Level 2 corresponds to some effort, even if the technical requirements of the task are met or not. Level 3 corresponds to both an output that shows some level of creativity and some technical mastery. Level 4 combines both a high level of creativity and technical mastery.

Table 2.4. OECD assessment rubric: Critical thinking

	Level 4: Outstanding	Level 3: Excellent	Level 2: Emergent	Level 1: Dormant
PRODUCT	The student work: • presents a specific personal position to a clearly formulated problem • relates this position to alternative theories or perspectives within or outside the discipline • justifies the position with good evidence • acknowledges the assumptions and limitations of the chosen position.	The student work: • presents a personal position to a clearly formulated problem • relates this position to one alternative theory or perspective within or outside the discipline • justifies the position with some evidence • acknowledges the assumptions of the chosen position.	The student work: • presents a position to a problem that is not clearly formulated • relates this position to one alternative theory or perspective within the discipline • provides little evidence or acknowledges only minimally the assumptions and limitations of the chosen position.	The student work: • presents a commonly accepted position to a problem • justifies it with sound evidence, but • fails to question its assumptions or consider other possible perspectives on the problem.
PROCESS	The work process: • considers several ways of formulating and answering a problem • challenges several common positions or ideas about the problem • shows a clear understanding of the strength and limitations of the chosen and alternative positions • shows an openness to the ideas, critiques or feedback of others when relevant.	The work process: • considers one other way to formulate and answer the problem • challenges one common position or idea about the problem • shows a clear awareness of the areas of personal novelty or risk that were pursued.	The work process: • shows the willingness to go beyond one's initial way to formulate and answer the problem, but • does not clearly identify the assumptions of the examined theories or practices or their strengths and weaknesses.	The work process: • shows little willingness to explore other positions or theories than the most commonly accepted one • shows no willingness to question the assumptions of the chosen position, theory or practices.

Notes: The class-friendly assessment rubric for critical thinking is supposed to assess a task targeting the acquisition of some learning outcome in a discipline or more. It is not meant to assess a "critical thinking" exercise, but any exercise in which students have space to develop their critical thinking skills. "Product" refers to a visible final student work (for example the response to a problem, an essay, an artefact of a performance). The criteria are meant to assess the student work even if the learning process is not observable by the rater or was not fully documented. "Process" refers to the learning and production process observed by the teachers or documented by the students: the process may not be entirely visible in the final product as some interim ideas or aspects of the process may not be reflected in the final student work. Typically, the process could show a greater level of acquisition of the skills than the product. Levels 1 to 4 correspond to a continuum. Level 1 corresponds to little effort to exercise one's critical thinking, whether the technical requirements of the task are met or not. Level 2 corresponds to some effort, even though the technical requirements of the task are not met. Level 3 corresponds to both an output that shows some level of critical thinking and some technical mastery. Level 4 combines both a high level of critical thinking and technical mastery. It should be noted that Level 4 may correspond to a conventional position, to the extent that it is well understood and related to other ones.

Assessing the student work process (process)

Just having a rubric to assess final student work did not seem sufficient – or right – to teachers and local project leaders. Promoting creativity requires tolerance to experimentation and failure, so that just celebrating success in the final output may overlook the actual creative skills acquired through the process. Promoting critical thinking requires tolerance to failure too, and some level of risk taking, but also the acknowledgment that the final position may look conventional while being the result of strong critical thinking (conventional ideas may have gone through strong selection and critical thinking processes before they became conventional): this may or may not be well documented in the final product.

While final products say something about students' learning and skill acquisition, they do not tell the whole story about the learning process. It could actually be that the final product does not fully reflect the learning, and that teachers' assessments would differ if they had documentation about the whole process rather than just the final output. While the acquisition of creativity and critical thinking should ultimately be demonstrated in students' work, it may indeed be the case that students have actually exercised some of the sub-skills emphasised in the rubric in relation to either creativity or critical thinking, but that it does not fully show in their final output – either because they have not taken a final decision that would demonstrate it (in the case of creativity), or that they do not fully articulate their reasoning for it in their final position (in the case of critical thinking). As mentioned above, both the research literature on creativity and on critical thinking distinguishes product and process, and highlights their somewhat different properties or skills.

While distinguishing product and process may raise philosophical questions and could be seen as superfluous – a product being a "crystallised" or "solidified" process (Whitehead, 1929[101]; Storper and Salais, 1997[102]), it may create confusion should there be some misalignment between the assessment of process and product. Could a well-done process lead to a not-so-good product? Or could an excellent product be the result of a not-so-good process? Both scenarios are actually possible, but this challenges an assumption of traditional "assessment" (that the final product summarises enough of the learning process to be a reliable measure of it).

The two "product" and "process" approaches correspond to two different assessment situations, depending on what the assessor can actually see and assess (or wants to). Assessing the learning process implies that the assessor(s) could see it (or a documentation about it, for example through a portfolio).

There is nonetheless a similar logic between the product and process dimensions of the scoring rubric. In the case of creativity, the lowest level of proficiency ("dormant") refers to a production process during which students did not try to go beyond what was familiar to them, either thanks to their teachers or their community. Level 2 ("emergent") shows some effort to search and go beyond one's first idea, but not really appropriate connections between ideas, selection of ideas, depth in the research or risk taking. Level 3 ("excellent") shows actual brainstorming, careful examination of the ideas, and playing with at least one radical or unusual idea, with good understanding of the students of what personal novelty means to them. Finally, Level 4 ("outstanding") refers to the careful examination of multiple ideas, meaningful connections across ideas, the generation and serious exploration of several unusual or radical ideas, and strong intentionality and awareness about the process and its novelty or risk taking for the students.

In the case of critical thinking, Level 1 ("dormant") corresponds to a production process during which students did not explore alternatives, challenge assumptions, and quickly jumped to conclusions and a position. Level 2 ("emergent") corresponds to more attempts to explore alternatives, suspend judgment and be careful in one's thinking, but a partially inappropriate understanding of the framing of the problem. At Level 3 ("excellent"), students manage to consider and understand another way of looking at the problem, are able to challenge some aspect of it (or see why it could possibly be challenged), and are self-aware of the strengths but also possibly limitations of their position. Finally, at Level 4 ("outstanding"), students went further and explored several rather than just one alternative theory or formulation of the problem, challenged several positions, and showed an openness to feedback and critiques in addition to their own understanding of the strengths and limitations of their position.

Development of the OECD rubrics: The convergence process

The development of the rubrics went through a thorough development process based on a "rapid prototyping" model. An initial rubric was prototyped, tested in the field, modified and re engineered several times as feedback from the country teams was obtained. This was done over a two-year time period.

The initial version of the rubric was designed based on a literature review on creativity and critical thinking, on a review of existing rubrics on creativity and critical thinking within OECD countries and beyond, and extended to a review of how these skills are described in various country curricula.

The vocabulary and structure of the initial rubric built on rubrics or operational definitions of creativity and critical thinking developed in 17 countries. The list of the most structured rubrics on which the initial rubric was built at the start of the project is available as a web annex.

In terms of language, the rubric reused as much as possible the language of the "five habits of mind" that Lucas, Claxton and Spencer (2013[55]) developed during a collaborative project of Creativity, Culture and Education (CCE) and the OECD Centre for Educational Research and Innovation (CERI) on progression in student creativity in school. The language of the rubric (including inquisitive, imaginative, disciplined, collaborative, persistent) was indeed field-tested and well accepted by teachers in England, even though the rubric as a whole was seen as too complex for a complete use. Much of its phrasing building on the common concepts of the literature was also reused: making connections, challenging assumptions, playing with possibilities (ideas), etc. A lot of this wording can also be found in one way or another in the many rubrics that were reviewed and analysed to develop the initial version.

The first version of the OECD rubric was submitted for review to the project co ordinators and experts and revised until a consensus was reached that it was good enough as a starting point. Most of the editing concerned language rather than concepts, mainly to accommodate the connotations of the English words to the native English speakers in the teams. As many of them could not agree on those words, a first lesson of the process was that the ideas of the rubric were more fundamental than the actual wording, and that building a "common language" did not imply that all should use the same words. Many of the initial edits consisted of adding terms to be more comprehensive, noting for example that "observing" is just one means of inquiry and can be supplemented by other ways of perceiving the world (for example, empathising, feeling, etc.).

In contrast to some other rubrics, it was deliberately chosen not to include social and behavioural skills or dispositions related to creativity, and to focus the rubric on skills that were essential to creativity and critical thinking. Several versions of the rubric included a note requiring to also try to develop and monitor social and behavioural skills that are related to creativity and critical thinking but not explicitly mentioned in the rubric: collaborate, communicate, persist (self-control), self awareness (self-confidence). While the two last dispositions were seen as important for creativity, some teams found that they were not easily observable or not "objective" enough to be part of the main text.

Collaboration and communication were excluded from the main text because, while desirable and important, they were not considered as essential to creativity or critical thinking, or already included in the other dimensions. In theory, creativity and critical thinking can be performed individually or collaboratively, even though it needs some level of social acknowledgment. Collaboration is a powerful amplifier in brainstorming or ideating, but it is fair to say that it is a strong amplifier of learning in general – and not just acquiring creativity and critical thinking skills. As for communication, the "doing" dimensions of the OECD rubrics already acknowledged some level of appropriate communication. In the final version, these comments were dropped for the sake of simplicity. In practice, most pedagogical activities and lesson plans developed by teachers or project co-ordinators in the field included a collaborative learning dimension and some level of explicit communication about the work done (see Chapter 4).

As mentioned above, the process of going from one rubric to a portfolio of rubrics mainly implied a simplification of the language and an emphasis on the dimensions of creativity and critical thinking that were (perceived as) less commonly developed in primary and secondary education. Some important dimensions disappeared in the process, assuming that the simper language would still also convey or remind teachers and students of the details of the comprehensive rubric. Eventually, teachers using the rubric should internalise the ideas and make the actual wording less important.

How teachers and teams used the rubric(s) in the field

Teaching and learning creativity and critical thinking skills does not require a change of curriculum. This is one assumption of the project. Changing teaching (which includes assessment) should be sufficient to change the learning process and create opportunities for developing creativity and critical thinking, whatever one is supposed to learn. Indeed, (almost) anything can be learnt in different ways. This may involve changing the tasks proposed to students, but not necessarily a change in the subjects or domains learnt.

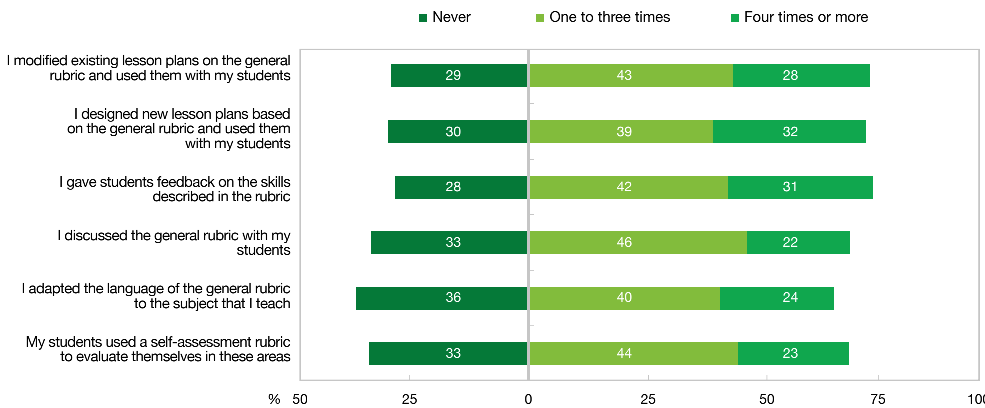
Let us say in passing that curriculum does, however, matter – or, more precisely, the way a curriculum document is written. Reviewing countries' curricula to see whether creativity and critical thinking were an objective, and how they were translated into practice, led to the realisation that most curriculum documents embrace creativity and critical thinking as learning outcomes and competences students should acquire, this typically remains in the "aspirational" or introductory part of the curriculum. Typically, the more practical description of the curriculum exclusively focuses on a closed problem with one correct solution, technical skills, and leaves little, if any, room to a phrasing that would allow teachers to consider that giving students opportunities to develop their creativity or critical thinking in the process would be possible. Governments and local authorities taking creativity and critical thinking seriously should thus review the way their learning objectives are phrased and give teachers a few examples of how they could be developing simultaneously technical skills as well as creativity and critical thinking skills.

Participants in the project were not asked to change their curriculum. They were encouraged to use the rubrics to design and review their lesson plans (without changing the technical skills students should acquire); to assess their students (and share with the OECD their progression levels); to design new rubrics more adapted to their context if need be; to discuss creativity and critical thinking with their students; to keep in mind the sub-skills they should aim their students to develop.

Overall, about seven in ten teachers reported some use of the project rubrics in the different ways mentioned above (so that three in ten did not use it after it was presented to them in the induction workshops that they all attended; see Chapter 5). This represents a high adoption and use level of the rubric overall. Figure 2.5 presents the different uses by team (when sufficient information is available).

Figure 2.4. How and how frequently teachers in the intervention used the OECD rubrics

Percentage of teachers using project rubrics in the last six months



Notes: Non-weighted percentages. Weighted averages available in Table 6.11a (Chapter 6).

StatLink https://doi.org/10.1787/888934002604

Using the conceptual rubrics to design and improve their teaching

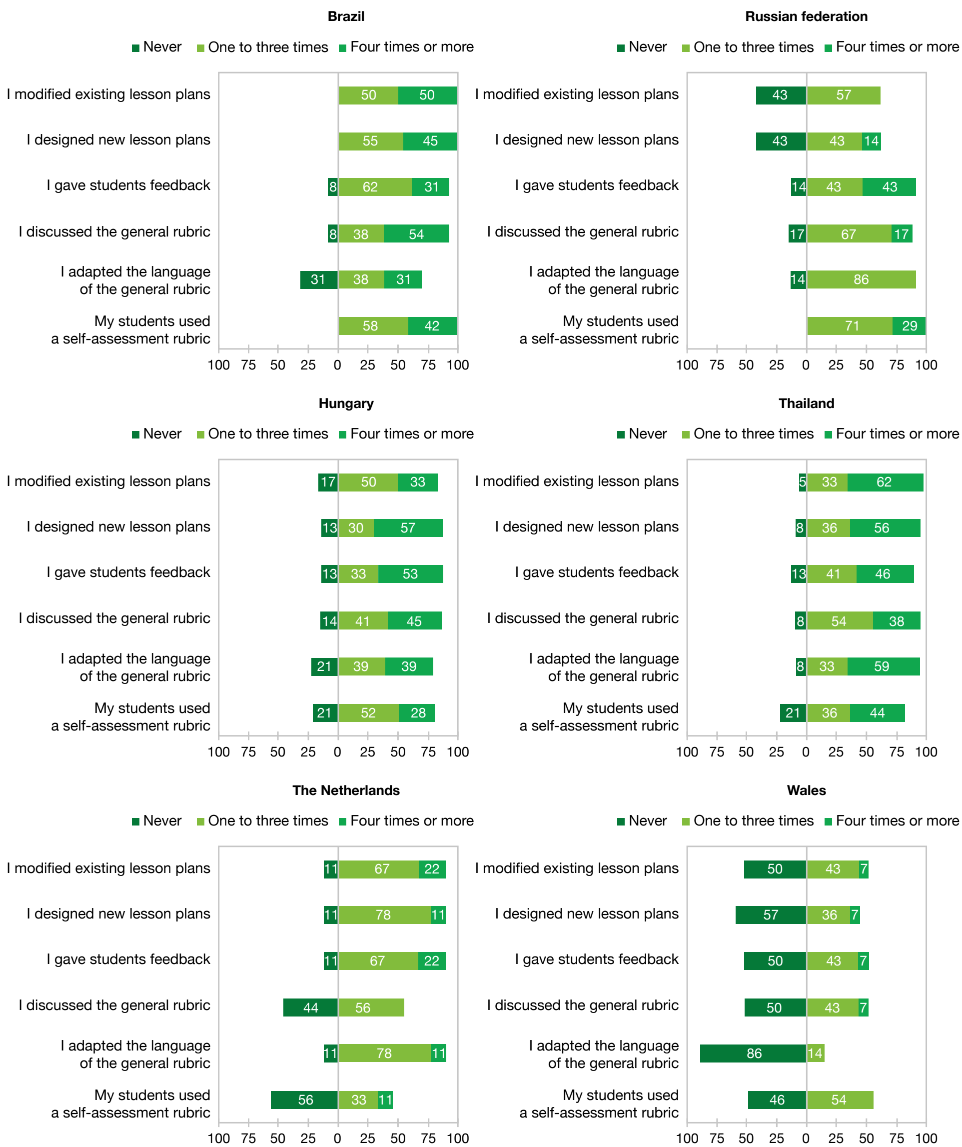
Local teams and teachers were asked to use the rubric as a way to design new courses, lesson plans or pedagogical activities or as a way to modify and improve existing lesson plans. Seventy per cent of the teachers (in the intervention group) report that they did over a six-month period of time, at almost an equal rate for both uses (Figure 2.4). About 30% of them did so more than four times, which is relatively frequent considering that they are mainly supposed to be used during the design of a multi-period course.

Depending on the subject of the lesson and the other learning outcomes they want to achieve, using an OECD conceptual rubric while designing a lesson helps teachers to build in it some assignments or tasks giving students the opportunity to develop at least some of the sub-skills of creativity or critical thinking. Some lessons may just develop a few sub-skills, while others could cover the full range, with an emphasis on either creativity or critical thinking (or both). Existing lessons could be modified according to the same process, adding just one opportunity to develop a sub-skill here and there, thanks to small changes to the lesson or its pedagogical delivery.

After decomposing their lessons or entire course or project into steps, teachers can identify when students were given the possibility or were requested to practice some of the skills identified in the rubric. The rubrics aim to help teachers be more systematic and intentional about the teaching and learning of creativity and/or critical thinking. The examples of lesson plans provided to the project teachers included a mapping of the different steps of the lesson against the sub-skills of the conceptual rubrics. Teachers were requested to do the same for their own lesson plans, at least those they submitted to their local project co-ordinator before possible further transmission to the OECD. As presented and discussed in Chapter 4, the conceptual rubrics had to be supplemented

Figure 2.5. How and how frequently intervention teachers used the OECD rubrics, by team

Percentage of teachers using project rubrics in the last six months



Notes: Non-weighted percentages. Weighted averages available in Table 6.11a (Chapter 6).

StatLink https://doi.org/10.1787/888934002623

by other lesson design criteria for teachers to develop lesson plans that were actually aligned to the ideas of the rubric. Building a professional language around creativity and critical thinking actually requires more than just good definitions and descriptors of the skills to develop.

Although this was not really requested, teachers also spontaneously discussed the conceptual rubric with their students. The rubric was thus used to make them better understand what creativity and critical thinking entailed, what it meant, and thus to foster a deeper understanding of those learning goals.

Designing one's own rubric and tools

While the OECD rubrics were at the core of the development phase of the project and of its international protocol, several related rubrics were actually used by the country teams, including local adaptations of the OECD rubric. There were three different ways of departing from the OECD rubric in the countries and teams that participated in the project.

The first way was not to use the OECD rubric, but a related one. Some school networks were already working with another rubric (e.g. Wales or one school in Boston using the "Studio Thinking" rubric developed by Hetland et al. [2013[103]]). They felt that using a second rubric would be possibly confusing for teachers or disruptive. The "Studio Thinking" rubric was arguably more focused on the visual arts habits of mind than the initial domain-general OECD rubric. And the "five creative habits of mind" rubric was commonly used by Creative Partnerships programmes. As there was indeed some alignment between those rubrics, this departure from the project protocol was fine for a development project – but it would raise issues of "fidelity of implementation" in a validation or efficacy study.

A second way was to use the OECD rubric alongisde others. In Hungary, the school network implementing the Creative Partnerships pedagogy proposed an interesting alternative: the team used both the comprehensive domain-general OECD rubric and the "five creative habits of mind" rubric, but for different purposes. The "five creative habits of mind" rubric was used as an observation tool for the classroom dynamics, while the OECD rubric was used to prepare, review and identify possible gaps in pedagogical activities. The team in Thailand did more or less the same. In the first year of implementation, teachers were only exposed to the "five habits of mind" rubric during the professional development, but then used both in the field; in the second year, they used both rubrics during the professional development and in the field. In fact, this use of multiple rubrics on the ground made it clear that having a portfolio of rubrics rather than just one rubric was appropriate and could work with teachers – assuming there is a clear understanding of the different purposes of the different rubrics.

Thirdly, some teams used the OECD rubric as a generative tool, that is, a basis for designing other local rubrics. In Brazil, part of the professional learning consisted of revising the self-assessment rubrics for students that were designed by the local coordintaors by (strictly) following the dimensions of the OECD rubric. By doing so, the participant teachers got to work and internalise the dimensions of the rubric, in addition to creating a new tool that their students could use and that would allow them to really emphasise creativity and critical thinking in parts of their teaching. In principle, this is a very strong way for local teachers to have ownership of the materials and internalise the skills highlighted in the rubric.

In the United States (Vista Unified District, near San Diego, California), the project co-ordinators and participating teachers used the conceptual rubric to develop a scoring rubric as well as a student-friendly self-assessment rubric that integrated creativity and critical thinking and the personalisation agenda of the school district. The progression levels were thus tied to the increasing learning autonomy of the students. The development process led teachers to step back, to really try understand what creativity and critical thinking meant, and how to assess them. It is one of the few teams that actually used the rubric as a scoring tool. The rubrics designed by the US team are presented as examples in Annex 2.A2.

Finally, in India and the Russian Federation, the local teams developed other tools such as checklists, self-assessment and peer assessment derivatives taking the ideas or wording of the initial OECD rubric as a starting point. This approach supplemented the use of the rubric by the project co-ordinators and teachers in school, and provided students with easier access to it.

Local adaptations of the rubrics were allowed during the project, acknowledging that they should mainly be about wording rather than substance. In practice, they are unavoidable: imposing the use of a single rubric with no flexibility or room for local adaptation would likely lead to less use and ownership of the rubric and of its ideas. Fostering their students' creativity and critical thinking is usually just one of many learning objectives for teachers and schools, and it may be more convenient for teachers to have fewer tools rather than more. Adaptation is also a form of ownership and understanding, and an adapted rubric may be better understood.

On the other hand, local derivatives and redesigned rubrics risk actually missing the key elements of the rubric that was designed collaboratively – even when it apparently keeps most of the wording. Sometimes, the most crucial (and perhaps challenging) elements can be removed (e.g. the perspectivist dimension of critical thinking), which not only implies less alignment with the original rubric, but also with the ideas or approaches of creativity and critical thinking supported in the project. In that respect, local adaptations can also be problematic.

Using the rubric for assessment

The initial project plan foresaw the design of the progression level during the first year of the field work, based on teachers' use of the conceptual rubric and the experience of their student work to propose progression levels. The process was supposed to be a co-ordinated bottom-up approach, with teachers and teams proposing their progression levels. Apart from the cases mentioned above, this did not happen. No assessment rubric was shared with the teams the first year of the field work. In practice, the OECD assessment rubrics were designed and agreed upon too late in the process to be sufficiently used by teachers in the field.

However, it is noteworthy that the conceptual rubrics were used to give feedback to students about their work, and thus as a formative assessment tool. Rather than using the conceptual rubrics as a scoring tool, teachers used them to give more frequent feedback to their students on all the different sub-skills described by the rubric: 72% of the teachers involved in the project report having done so at some point, including 40% reporting having *often* done so.

The use of a self-assessment rubric or tool by the students was also common across country teams – with 67% of the teachers reporting having done so (including 23% having *often* done so). This was, for example, the case in the US Vista team, where students were asked to self-assess their work on a task, also based on their autonomy towards the teacher (see Annex 2.A2.). All the self-assessment rubrics were designed by the local teams.

While country teams were initially asked to provide example of assignments and tests that would include an assessment of their students' creative and critical thinking skills, in practice teachers and team co-ordinators did not do so during the development phase of the project.

Summary and conclusion

In this chapter, we have shown that creativity and critical thinking are essential skills for tomorrow's society and economy:

- Innovation will play an increasingly important role in OECD economies and societies, and people having a highly innovative job are 3.9 more times as likely to report that creativity is important in their job than those who do not, and 3 times as likely to say so for critical thinking.
- Most studies on the future of jobs show that creativity and critical thinking have become in increasingly high demand in the US and western European economies, both in the past decade and in forecasts. Because of the ongoing automation and digitalisation of OECD economies, skills such as creativity and critical thinking that appear to be more difficult to automate than others are given a premium by employers.
- While creativity and critical thinking are essential to the economy, they are a source of personal well-being for individuals as human beings enjoy challenging tasks – and a key ingredient of sound democracies in a digital era that allows for more ideas and facts, including fake ones, to be considered by populations.

The importance of creativity and critical thinking appears to be well acknowledged in OECD (and other) countries' curricula. The main challenge to see them effectively taught and learnt lies in clarifying what they mean in an educational context and how teachers can actually teach and assess them. The OECD has thus worked with school and teacher networks in 11 countries over two school years to develop a common understanding and teacher-friendly language on what they mean in school.

In spite of the lively dissent that characterises any intellectual community, there is a strong consensus about what creativity and critical thinking mean and entail. Those two higher order cognitive skills are distinct but related as they involve similar cognitive processes to different ends.

- Creativity is the production of a novel and appropriate product (solution) or idea. In an education context, it does not have to be novel to the world, but just to what is expected to be known, and teachers can be the "experts" recognising students' creativity.
- Critical thinking is the careful evaluation of ideas, statements and actions relative to other alternatives based on accepted ways of reasoning in the problem's domain. It combines rational thinking and perspectivism; that is, the questioning of specific assumptions, conventions and accepted theories. The result of critical thinking can be conventional.
- At the conceptual level, creativity and critical thinking can be described as involving four categories of cognitive macro-processes: imagining, inquiring, doing and reflecting.
- While creativity and critical thinking can be described in general ways at the conceptual level, their exercise is domain-specific, which means that they have to be experienced in all subjects taught in school rather than being delegated to one or more subjects in the hope they would then transfer to all subjects. This implies that their teaching and learning requires a holistic change in educational methods.

One difficulty for teachers to develop their students' creativity and critical thinking skills lies in the apparent complexity and fuzziness of what creativity and critical thinking mean. Rubrics are one way to make those ideas readily accessible for teachers in a school environment: they describe what counts and should be developed and monitored in teaching and learning, as well as how the acquisition of those skills can be assessed. The OECD has developed a portfolio of rubrics supporting teachers to become more intentional and systematic in teaching creativity and critical thinking in different subjects. Those are simplified versions of what creativity and critical thinking mean when tailored to an educational context.

- OECD conceptual rubrics on creativity and critical thinking describe what skills teachers should try to develop in their students as they plan or revise their lessons and develop appropriate tasks. They propose descriptors of those skills under four headings: inquiring, imagining, doing and reflecting. Some of those conceptual rubrics are domain-general (applicable and to be adapted for all subjects) others are domain-specific (using the language and common activities of the subject taught).
- OECD assessment rubrics on creativity and critical thinking describe levels of progression or proficiency of creative and critical thinking skills. Teachers can use them for formative and summative assessment. Students can also use them to self-assess their own progress in these domains.

All OECD rubrics have been designed based on the research literature, a thorough international review of existing rubrics, and official descriptors of creativity or critical thinking in curricular and policy documents, and on a two-year field-testing of the wording with teachers in the field in 11 culturally diverse countries. The rubrics have been designed and iteratively revised through a quick prototyping processs.

They were meant to be used by teachers working in real-life settings in different ways: designing and revising lesson plans so that they give students the opportunity to develop their creativity and critical thinking skills; assessing student work and progression in the acquisition of these skills; generating new aligned rubrics adapted to their local context or self-assessment tools.

- The field work showed that, beyond their presentation of the rubric, on average seven in ten teachers did use the OECD rubrics for those purposes. The rubrics have thus proven to be useful and well adopted by teachers in most of the countries in which the project was implemented.
- Work also showed that while rubrics represent a key scaffolding tool for teachers to develop a common professional language about the meaning of creativity and critical thinking in their teaching practice, rubrics were not enough and needed to be supplemented by other tools making it visible and tangible what it means in practice to give students occasions to develop these skills as part of their disciplinary learning. Professional development, inspirational lesson plans and other quality checklists need to supplement rubrics and definitions to better translate creativity and critical thinking into teaching (and learning) practice.

In conclusion, rubrics appear to be a strong tool to influence teaching and learning in real-life settings and make abstract concepts such as creativity and critical thinking tangible and visible to teachers. While they do not work as stand-alone scaffolding tools for teachers, they clarify and simplfy the meaning of creativity and critical thinking and help teachers to become more intentional, systematic and consistent in the development and assessment of these key skills in their teaching.

Notes

1) See https://tinyurl.com/oecd-ceri-cct

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Annex 2.A1. OECD domain-specific rubrics on creativity and critical thinking

Table 2.A1.1 Class-friendly rubric (Science)

	CREATIVITY Coming up with new ideas and solutions	CRITICAL THINKING Questioning and evaluating ideas and solutions
INQUIRING	Make connections to other scientific concepts or conceptual ideas in other disciplines	Identify and question assumptions and generally accepted ideas of a scientific explanation or approach to a problem
IMAGINING	Generate and play with unusual and radical ideas when approaching or solving a scientific problem	Consider several perspectives on a scientific problem
DOING	Pose and propose how to solve a scientific problem in a personally novel way	Explain both strengths and limitations of a scientific solution based on logical and possibly other criteria (practical, ethical, etc.)
REFLECTING	Reflect on steps taken to pose and solve a scientitific problem	Reflect on the chosen scientific approach or solution relative to possible alternatives

Notes: This rubric identifies the main relevant sub-skills related to creativity and critical thinking that students should develop as part of their maths education. It is not meant to score students or provide them with a continuum of skill progression.

Table 2.A1.2. Class-friendly rubric (Maths)

	CREATIVITY Coming up with new ideas and solutions	CRITICAL THINKING Questioning and evaluating ideas and solutions
INQUIRING	Make connections to other maths concepts or to ideas from other disciplines	Identify and question assumptions and generally accepted ways to pose or solve a maths problem
IMAGINING	Generate and play with several approaches to pose or solve a maths problem	Consider several perspectives on approaching a maths problem
DOING	Pose and envision how to solve meaningfully a maths problem in a personally novel way	Explain both strengths and limitations of different ways of posing or solving a maths problem based on logical and possibly other criteria
REFLECTING	Reflect on steps taken to pose and solve a maths problem	Reflect on the chosen maths approach and solution relative to possible alternatives

Notes: This rubric identifies the main relevant sub-skills related to creativity and critical thinking that students should develop as part of their maths education. It is not meant to score students or provide them with a continuum of skill progression.

Table 2.A1.3 Class-friendly rubric (Visual arts)

	CREATIVITY Coming up with new ideas and solutions	CRITICAL THINKING Questioning and evaluating ideas and solutions
INQUIRING	Make connections to other visual arts concepts and media or to conceptual ideas in other disciplines	Identify and question assumptions and conventional rules in a piece of visual art (content, style, technique, colour, composition, etc.)
IMAGINING	Play with unusual and radical visual arts ideas when preparing or creating a piece of visual art	Consider several perspectives on the content, technique or expression of a piece of visual arts
DOING	Create visual art that shows expressive qualities or personally novel ways to engage a subject matter	Explain both strengths and limitations of a piece of visual arts justified by aesthetic, logical and possibly other criteria
REFLECTING	Reflect on steps taken in creating a piece of visual art and on its novelty compared to conventions	Reflect on the chosen expressive choices of a visual arts piece relative to possible alternatives

Notes: This rubric identifies the main relevant sub-skills related to creativity and critical thinking that students should develop as part of their visual arts education. It is not meant to score students or provide them with a continuum of skill progression.

Table 2.A1.4. Class-friendly rubric (Music)

	CREATIVITY Coming up with new ideas and solutions	CRITICAL THINKING Questioning and evaluating ideas and solutions
INQUIRING	Make connections to other musical styles, concepts or conceptual ideas in other disciplines	Identify and question assumptions and conventional rules in a musical performance, composition or analysis
IMAGINING	Play with unusual and radical ideas when preparing to perform, compose, orchestrate or analyse a music piece	Consider several perspectives on a musical performance, composition, interpretation or analysis
DOING	Perform, compose or analyse music with expressive qualities or relating to personally meaningful subject matter	Explain both strengths and limitations of a performance, a composition or an analysis of a music piece
REFLECTING	Reflect on steps taken to create performances, compositions or analyses of a music piece	Reflect on the chosen way of performing, composing or analysing a music piece relative to possible alternatives

Notes: This rubric identifies the main relevant sub-skills related to creativity and critical thinking that students should develop as part of their music education. It is not meant to score students or provide them with a continuum of skill progression.

Table 2.A1.5. Class-friendly rubric (Language arts)

	CREATIVITY Coming up with new ideas and solutions	CRITICAL THINKING Questioning and evaluating ideas and solutions
INQUIRING	Make connections to other ideas and knowledge in language art or other domains	Identify stylistic and substantive choices of a given text and the effects it produces on the reader
IMAGINING	Generate and play with unusual and radical narrative ideas or formal language techniques within a defined frame	Consider several substantive or stylistic perspectives on a given text or the writing of a text
DOING	Write (or analyse) a text with a content or style that is personally novel	Explain strengths and limitations of a given text justified on stylistic and substantive criteria
REFLECTING	Reflect on the originality of one's or someone else's text	Reflect on alternative ways of writing or interpreting a given text

Notes: This rubric identifies the main relevant sub-skills related to creativity and critical thinking that students should develop as part of their language arts education. It is not meant to score students or provide them with a continuum of skill progression.

Annex 2.A2. Examples of rubrics used or designed by project teams in participating countries

Table 2.A2.1. Continuum of critical and creative thinking for teachers (US [Vista] team)

Thinking process elements	Holistic and abstract - Student driven	Analytical - Student driven	Divergent and convergent - Student and teacher collaboration	Sequential - Student input around teacher focus	Concrete - Teacher driven
Imagining *The ability to think of things that are new or those that are not (yet) realised.*	Student *applies*, evaluates and *elaborates* on current skills and knowledge, and expands and/or connects ideas, concepts, objects, applications or texts independently, to disparate or novel ideas or subjects.	Student independently *applies* current skills and knowledge and expands concepts/ ideas to form a new idea, concept, object, applications or tests.	Student *applies* current skills and knowledge to expand on teacher-given model to form a similar idea, concept or object with intermittent help or guided prompting.	Student *modifies* or rearranges teacher-given model to form an idea, concept or object with some guided and/ or teacher prompting.	Student imitates models provided by teacher to form an idea, concept or object with teacher guidance and prompting.
Inquiring *The act of asking for information and investigation.*	Student *connects* seemingly disparate or novel parts to independently develop, synthesise, and evaluate question(s) and protocols which drive the process to *engage in novel investigation, practice* and outcomes.	Student independently *analyses* ideas, concepts, questions and processes to develop valid and applicable *question(s)* and protocols related to a topic. Student independently discovers information and answers which *drive their investigation, practice* and outcomes.	Student is able to *create, ask* and *apply* question(s) with guided prompting from teacher and/or peers, to guide investigation, guided practice and/or outcome.	Student *modifies/rearranges* teacher-provided question(s) with teacher prompting, or *recalls* information to *inform* investigation, *guided practice* and/or outcome.	Student *copies* and *imitates* teacher-provided questions to guide investigation, *guided practice* and/or outcome.
Planning *The ability to set up a detailed idea to do or achieve something.*	Student independently brainstorms, *re-evaluates*, develops and *connects* multiple perspectives within a flexible and fluid *plan* or process resulting in a student-desired/*predetermined outcome.*	Student independently brainstorms a flexible *sequence* of events/ steps that leads to a student-desired or *predetermined outcome.* Student re-evaluates *plan* throughout process and *articulates* thoughts behind changes.	Student brainstorms a *flexible sequence* of events/steps that leads to a *student-desired* or *predetermined* outcome with minimal teacher guidance. Student re-evaluates plan throughout process and articulates most thoughts behind changes.	Student *prepares* a *sequence* of steps, with some teacher guidance.	Teacher guides student to *prepare* a list of steps.
Generating *to produce something.*	Student *creates* independent and novel *investigations*, applications, objects or ideas to produce, create and *connect* student process and outcomes with disparate or unique connections.	Student *creates* independent *applications*, objects, products or ideas to produce, create and connect process/ plan to outcome.	Student creates *independent* application, object or idea to produce a process, create and connect parts of process/plan to an outcome with intermittent teacher guidance.	Student *imitates* most portions/sections to produce a process and/or create an outcome with some teacher prompting that is *connected* to a general goal.	Student *copies/imitates* all teacher modelled applications, objects or ideas to produce/ copy possible outcome with teacher guidance/ prompting, that may/ may not be *connected* to a goal.
Conveying meaning *Conveying the intent, meaning or message through a process to a specified audience.* *Ideas are communicated*	**Conveying meaning** Student *conveys meaning* and *intent* in connection with both process and outcome. Skills and knowledge *connect* and *elaborate*, extending beyond given subject matter. **Making thinking visible** Meaning and intent are visible, *articulated* and *communicated* through a-given or unique mediums.	**Conveying meaning** Student *conveys meaning* and/or *intent* of the process and outcome. Skills and knowledge *connect* and are *applied* from the given subject matter. **Making thinking visible** Meaning and intent are visible and *communicated* through medium, documentation and/or interview.	**Conveying meaning** Student *conveys meaning* and/or *intent* of most of the process and outcome. Skills and knowledge *connect* and are *applied* from aspects of the subject matter. **Making thinking visible** Meaning or intent is visible or *communicated* through medium, documentation or interview with limited teacher collaboration.	**Conveying meaning** Student *conveys* some *meaning* and/or intent of the process and outcome. Skills and knowledge *connect* and are *applied* from teacher suggestions from the subject matter. **Making thinking visible** Meaning or intent is slightly visible or *communicated* through given medium, documentation or interview.	**Conveying meaning** Student *conveys* limited *meaning* and/or *intent* of the process and outcome. Skills and knowledge *connections* and/or *applications* are provided by teacher. **Making thinking visible** Meaning or intent is limited or not visible or *communicated* through given medium, documentation or interview.

Note: Italicised words are associated with critical thinking (note of Vista team). This rubric was developed by the Vista Unified District teachers in the United States as part of OECD project.
Source: Vista Unified School District.

Table 2.A2.2. Student self-assessment continuum of critical and creative thinking (US [Vista] team)

Thinking process elements	I think and connect independently	I think independently	I begin to think independently with the help of others	I need someone to help me often	I need someone to help me at all times
Imagining *I think of new ideas or things.*	I use my ideas to create something new that connects with other ideas. I share my ideas.	I use my ideas to create something new and share these with others.	With a little help, I use my ideas and others' to create something new and then share.	With some help, I copy parts of others' ideas and change a few to create something new and share.	I copy the ideas of others with help to create something.
Inquiring *I ask questions.*	I create questions throughout the process and I connect between different ideas or the parts of what I'm learning.	I create questions related to the topic. I discover questions and answers to guide my next steps.	I add to or change the teacher's questions to discover and apply new information.	I change parts of the teacher's questions to help me discover information.	I use the same questions the teacher asks to discover information.
Planning *I make a plan.*	I make my own plan and think and share my steps. I plan and explain the beginning, middle and end with flexibility, knowing it may change.	I make my own plan and think and share my next steps. I plan, explain and share the beginning, middle and end.	I make a plan with little teacher help and I think and show my next steps. I plan, explain and share parts of the beginning, or middle, and/ or end.	I change some of the teacher's plan to help me discover or create and share something.	The teacher makes a plan with me to discover or create something.
Doing or generating *I make my ideas seen. I produce something.*	I create or produce my own ideas that are new and make different connections outside of what everyone else is doing.	I create or produce my own ideas.	I create or produce my ideas with a little help.	I copy or produce some of the others' ideas.	I copy or produce others' ideas.
Conveying meaning *I explain my ideas in some way.*	I share and show what I learned and explain how my thoughts connect to my work and other ideas.	I share and show what I learned and explain how my thoughts connect to my work.	With a few suggestions, I share or show what I learned and explain my thoughts.	With some suggestions, I share or show some of what I learned and what it means.	People help me share or show what I learned or what the ideas mean.
Reflecting *I think about my thinking, my process and work.*	I discuss and share about how and why I created my work, and how it connects to the original plan and other ideas. I think and share how to improve or change my ideas. What did I do? What does it connect to? Do I change anything? Why or why not? What are my next steps? What has changed? Why?	I discuss and share about how and why I created my work with my plan, and how to improve or change my ideas. What did I do? How did I create the idea or object? Does it meet the plan? Should anything be changed? Why or why not?	I discuss and share what and how I created the idea or object and if it met my plan. What did I do? How did I create the idea or object? Does it meet the plan? Why or why not?	I discuss and share my answers to the teacher's questions about my idea and how I created it. What did I do? How did I create the idea or object?	I answer the teacher's questions about what and how I created. What did I do?

Source: Vista Unified School District; 2017 VUSD OECD Team.

Chapter 3

Eleven signature pedagogies related to the fostering of creativity and critical thinking

This chapter presents eleven signature pedagogies that are aligned with the OECD rubrics on creativity and critical thinking and could inspire schools and teachers on how to nurture their students' creativity and critical thinking in mathematics, science, visual arts, music and interdisciplinary projects. Signature pedagogies refer to structured pedagogical models that can be applied to pedagogical activities, projects or education as such. They go beyond pedagogical techniques that all teachers should master in addition to conventional teaching based on lecturing. Some of those pedagogies have been used by the country teams participating in the OECD project.

Signature pedagogies: What are we talking about?

Some pedagogies are more prone than others to develop students' creative and critical thinking skills, depending on the discipline and its standards of expertise and excellence. Shulman (2005[1]) developed the concept of "signature pedagogy", capturing the idea that some pedagogies are philosophically more structured and holistic than smaller pedagogical techniques that can be integrated into any type of pedagogy, including traditional or mixed pedagogies. The "signature pedagogies" we refer to in this chapter correspond to holistic pedagogies that propose a teaching and learning philosophy as well as a holistic pedagogical approach based on specific processes and techniques. They contrast to the improvements of existing pedagogies that are presented in Chapter 4, and merely adapt extant pedagogical approaches, whatever they may be.

Apart from Montessori education, the signature pedagogies presented in this chapter do not correspond to a full schooling model, although they may embrace a teaching and learning approach in a specific subject. All were selected because they are aligned in some way to the teaching and learning of creativity and critical thinking skills, in addition to developing technical skills as well as social and behavioural skills. Some of them are pedagogies that were adopted by the country teams participa ting in the OECD project: Creative Partnerships was adopted by the Hungarian, Thai and Welsh teams; project-based learning and research-based learning were used by the French teams; Orff Schulwerk was used by the music teachers in the US Vista team; CREATE was developed as part of the OECD project. Other signature pedagogies presented in this chapter are simply associated with the teaching and learning of creative and critical thinking skills, in addition to usual technical skills in school disciplines.

Some of the presented pedagogies give more room to develop creativity, while others emphasise critical thinking. All require a good learning environment (OECD, 2013[2]; 2017[3]) and exemplify the criteria for good lessons that are presented in Chapter 4. While there is not much literature linking critical thinking to particular learning environments, many combine some elements usually associated to the nurturing of creativity or more active learning. Those include to a greater or lesser extent: a culture of intrinsic motivation; respectful relationships and quality dialogue between children and adults; flexible use of space and time; a balance of independent work and opportunities to collaborate; a balance of freedom and structure; the acceptance of non-conformity; and, usually, the creation of an artefact or performance (Beghetto and Kaufman, 2010[4]; Cardarello, 2014[5]; Davies et al., 2013[6])

1. CREATIVE PARTNERSHIPS (ALL SUBJECTS)

Main features of the pedagogy

Creative Partnerships is a pedagogical approach that promotes partnerships between creative practitioners and schools. It was initially implemented in schools in the United Kingdom in the early 2000s but has spread to other countries in recent years.

The programme promotes changes in teaching methods by engaging creative practitioners, typically artists or people working in the creative industries, as actors and advisers in the teaching process. Creative practitioners intervene in schools around a pre-identified problem and work with teachers to develop projects or new teaching techniques that would address the problem building on their creative experience as non-teachers – and without taking the teacher's responsibility away from them.

The interventions involve initial training for teachers and school staff as well as for creative practitioners, and are implemented within traditional classroom teaching or through specific out-of-class projects. Each Creative Partnership project is unique and adapted to the school's individual context and the collaborating teachers and creative agents. Yet, the common goal of all interventions is to place creativity at the heart of the learning process across the different domains and change not only students' learning experiences, but also teachers and schools as a whole.

New innovative and creative practices aim at deeply transforming teaching and learning in schools. The perspectives brought by creative professionals broaden and enrich how teachers teach the curriculum, and help students to develop a more comprehensive set of skills. The development of skills related to creativity, for instance, is an explicit goal of the programme, that uses the "Five creative habits of minds" rubric as part of its tools (Lucas, Claxton and Spencer, 2014[7]): new teaching methods should stimulate students to become imaginative, inquisitive, disciplined, collaborative and persistent in all subjects of the curriculum.

The Creative Partnerships approach also promotes the monitoring of the learning environment and stimulation of a "high-functioning classroom" in teaching and learning (Collard et al., 2016[8]; Lucas, Claxton and Spencer, 2013[9]; Lucas and Spencer, 2017[10]). In high-functioning classrooms, teachers transform their practices and design lesson plans so that students face challenges related to real-life experiences. Lessons need to engage students physically, socially, emotionally and intellectually; they need to place students at the centre of the learning process by putting students' own experiences, observations and questions on the front burner. This approach moves students' educational development from a model of acquisition of knowledge known by others, to a model where students have more agency in their learning (Galton, 2007[11]).

As much as possible, the high functioning classroom aims to exhibit the following features (as opposed to those of a "low functioning" classroom):

- Role of the teacher: challenging (rather than guided).
- Nature of activities: authentic (rather than contrived).
- Organisation of time: flexible (rather than bellbound).

- Organisation of space: workshop (rather than classroom).
- Approach to tasks: group (rather than individual).
- Visibility of processes: high (rather than hidden).
- Location of activities: mobile (rather than static).
- Self as a learning resource: central (rather than ignored).
- Emotions: acknowledged (rather than ignored).
- Inclusiveness: all (rather than some).
- Role of the learner: self-managing (rather than directed)

How it is supposed to foster creativity and critical thinking

Creative Partnerships develops students creative and critical thinking skills by making the learning process more creative and giving students more agency in their learning. The use of the "Five habits of mind" rubric as a metacognitive (and sometimes formative assessment) tool by teachers and students makes the teaching and learning of creative dispositions more intentional. Many dimensions of the rubric are aligned with the OECD rubrics on creativity and critical thinking (see Chapter 2).

Related evidence

The evaluation of the Creative Partnership programme in the United Kingdom (Ofsted, 2006[12]) brought some promising results. Using various quantitative and qualitative data sources (survey data, administrative data, classroom observation, analysis of pupils' work, etc.), the report highlighted the impact of the programme in changing teaching and learning in schools. The evidence suggests an advancement of pupils' creative attributes: improved capacity to improvise, take risks, show resilience and collaborate with others. Schools participating in Creative Partnerships also revealed improvements in pupils' academic achievements in various domains such as literacy, numeracy, and information and technology, as well as an increase in students' enjoyment during classroom learning. The study also indicates an improvement in teachers' understanding about creativity and creative teaching.

A recent quasi-experimental study of the impact of a Creative Partnerships pilot in Hungary found a positive effect of the programme on the self-image of participating students, on their social competence, as well as on progress in reading and mathematics (Collard et al., 2016[8]).

For more information

For more information on the Creative Partnerships programme, refer to *Creative Partnership: Initiative and Impact* (Ofsted, 2006[12]), *Creating Creative Learning Environments by Creative Partnerships Programme* (Collard et al., 2016[8]) and https://www.creativityculture education.org.

2. DESIGN THINKING (ALL SUBJECTS)

Main features of the pedagogy

Design Thinking is a business method developed for the engineering of new or improved products and processes, inspired by Simon (1969[13]), and aiming to make innovation an art following specified approaches (Kelley and Littman, 2001[14]). This method has been turned into a pedagogical approach in "innovation courses" in both university and schooling. Design Thinking consists of engaging students in learning experiences in which they think and act like designers and thus develop their creative and critical thinking skills.

Design Thinking is an interdisciplinary approach to teaching and learning in which students have to develop an innovative solution to a complex real-world problem by going through certain design processes. Like professional designers, students are asked to generate multiple solutions and subsequently analyse, evaluate and progressively improve these. The approach is student-centred and process-oriented.

Design Thinking instruction is comprised of three core features: 1) a flexible learning space; 2) teamwork; and 3) a systemic approach on problem solving. This pedagogy emphasises students' exploration, openness to new ideas and sharing of knowledge. Design Thinking can be either implemented in short sessions in a specialised field or in long interdisciplinary projects carried out over several weeks.

The design process involves several phases in which students expand and consolidate ideas (Rhinow, Noweski and Meinel, 2012[15]):

- Understanding and observation (expansion): Students assess the conditions and boundaries of the problem. They develop empathy and understanding of the people and context of the situation so they can adapt their actions to the current set of needs.
- Synthesis (consolidation): Students define the problem and the context faced in order to produce meaningful ideas. They gather the many perspectives to the problem, interpret and synthesise them in order to produce relevant insights and actionable solutions. In particular, this phase requires students to apply critical thinking and interpretation skills.
- Ideation (expansion): Students imagine and generate ideas in order to solve the problem. They need to brainstorm with the team; apply creative and collaboration skills.
- Prototyping (consolidation): Students experiment and work on transforming their ideas into tangible and physical products.
- Testing (expansion): Students put their ideas and solutions generated through the process into action. They receive feedback from their teachers, peers and possibly others.
- Iteration: The Design Thinking process has an iterative nature; students move from one phase to another (in no particular order). They sometimes need to repeat the whole process or certain stages of it.

Initially, the problem is ill-defined: students must identify it, frame it and diagnose the corresponding set of needs. This is a distinctive feature of Design Thinking, setting it apart from other pedagogical approaches such as Project-Based Learning. During the design process, students need to make use of analytical and strategic thinking in order to effectively apply their thoughts and actions. They need to recognise the complexity of the problem, take risks and show resilience. Students therein need to acknowledge that they are likely to make mistakes and be able to go forward

How it is supposed to foster creativity and critical thinking

Design Thinking is meant to develop students' creative and critical thinking skills in an applied way. The activities and cognitive processes it involves align with the OECD rubric (see Chapter 2). One Design Thinking rubric designed by the d.school at Stanford University for school education describes the learning process in the following sequence of actions: empathise, define, ideate, prototype, test. A set of corresponding rubrics was also developed. This is clearly aligned with the dimensions of creativity and critical thinking emphasised by the OECD rubric: students are asked to inquire through different means, depending on the problem, to imagine innovative and multiple solutions, including through the brainstorming technique, to produce an artefact and prototype, and then reflect on their process, before possibly starting it again.

Related evidence

The literature on Design Thinking as a pedagogy is expanding, but remains mainly focused on higher education. Some of it focuses on the impact of Design Thinking on creativity and creative self-confidence, and a lot shows the creative results of Design Thinking workshops, allowing the readers to apprehend the level of critical thinking that went into the Design Thinking process, and of creativity of the output (e.g. Plattner, Meinel and Leifer, 2016a[16]; Plattner, Meinel and Leifer, 2016b[17]; Horii, 2015[18]; Hölttä-Otto, Conner and Genco, 2012[19]).

For more information

More information on the Design Thinking pedagogy can be found in *Transforming Constructivist Learning into Action: Design Thinking in Education* (Rhinow, Noweski and Meinel, 2012[15]), *What Is Design Thinking and Why Is It Important?* (Razzouk and Shute, 2012[20]), *Design Thinking: An Educational Model towards Creative Confidence* (Rauth et al., 2010[21]). A book series on *Design Thinking Research* edited by Plattner, Meinel and Leifer (2012[22]; 2016a[16]; 2016b[17]; 2018a[23]; 2018b[24]) presents the latest research on Design Thinking in teaching as well as in organisations. See also https://dschool.stanford.edu.

3. DIALOGIC TEACHING (ALL SUBJECTS)

Main features of the pedagogy

The dialogic teaching pedagogy builds on the power of language to nurture students' thinking and stimulate their learning and understanding.

Dialogic teaching is a model of instruction that fosters continuous and controlled dialogue between students and teachers, as opposed to traditional teacher-centred, presentation-based methods of instruction. It involves talk that goes beyond questioning-answering that has a knowledge transmission function foremost. Dialogic pedagogy encourages students to narrate, explain, analyse, speculate, explore, evaluate, discuss, argue, etc. It also requires students to learn to listen to their peers, think about what they are saying, give them time to think and respect their viewpoints. On the other hand, teachers use classroom talk to better recognise students' needs, adapt their teaching practices to these and assess them accordingly. In this sense, both student and teacher talk are essential in dialogic teaching: although student talk stimulates and expands pupils' learning, teacher talk is crucial to encourage, facilitate and stimulate classroom talk and thus students' higher order thinking. Teachers need to develop a high level of awareness of their speech level and interactions with students, including how it stimulates their self-confidence, level of thinking, and creative and critical questioning.

Dialogic teaching encourages the exchange of ideas and information and requires: interactions (that encourage to think), questions (that invite for further enquiry), answers (that are justified and built upon), feedback (that informs and advances thinking), contributions (that extend the line of thinking), exchanges (that link to previous ideas and add to the understandings), discussion and argumentation (that challenge), professional engagement with subject (that takes talk beyond the conventional), and classroom organisation (that enables the realisation of all previous actions mentioned).

Teachers may organise classroom talk in five different ways: 1) whole class teaching; 2) group work (teacher-led); 3) group work (student-led); 4) one-to-one between teacher and student; or 5) one-to-one between student pairs. Within these organisational settings, there are endless possibilities for pedagogies around talk and dialogue. Five core principles describe dialogic pedagogies (Alexander, 2017[25]):

- Collectivity: Students address learning tasks together.
- Reciprocity: Students listen to each other, share ideas and consider alternative perspectives.
- Support: Students express their ideas freely, without fear of being wrong and they support one another to reach mutual understandings.
- Cumulation: Students build ideas from others' oral contributions, which adds to a coherent line of thinking.
- Purposefulness: Classroom talk is open and encouraged, but it is also planned and framed in order to achieve specific learning objectives.

Beyond these principles, every classroom is anchored in a specific context with its specific socio-cultural characteristics. Teachers should refine and tailor their talk pedagogies to the given circumstances while always bringing discussion and dialogue to the forefront. It is noteworthy, though, that dialogic pedagogies can also include repetition, recitation, instruction and exposition.

How it is supposed to foster creativity and critical thinking

Dialogic teaching mainly puts an emphasis on critical thinking, by supporting students to question, speculate, exchange, respect each others' different views on different issues, and thus encourage critical thinking, the understanding of how problems can be framed differently by different people, and of one's own possible biases or perspectives on a problem. Because of its focus on the quality of speech and dialogue between teachers and students, dialogic teaching also creates a positive environment for nurturing creativity: it creates a learning environment in which teachers create an environment that allows students to take risks, where they can play with unusual ideas, work collaboratively with others, etc. The only dimension of the OECD rubric that the pedagogy does not necessarily support is the creation of a meaningful student output (doing): inquiring, imagining and reflecting will typically be fostered by dialogic teaching, be it from a creativity or critical thinking perspective.

Related evidence

In an efficacy study commissioned by the English Education Endowment, this pedagogy showed strong efficacy: the trial found consistent, positive effects in English, science and maths for all children in Year 5, equivalent to about two months of additional progress. The result was similar when looking only at children from low socio-economic backgrounds (eligible for free school meals in England) (EEF, 2017[26]).Creativity and critical thinking were not yet included in the learning outcomes.

For more information

For more resources on dialogic teaching, a pedagogy developed by Robin Alexander but that has a few other cousin pedagogies based on the quality of questions and dialogue, please refer to *Towards Dialogic Teaching: Rethinking Classroom Talk* (Alexander, 2017[25]), *Essays on Pedagogy* (Alexander, 2008[27]: 72-172 and 184-191) and *https://www.robinalexander.org.uk/dialogic-teaching*.

4. METACOGNITIVE PEDAGOGY (MATHS EDUCATION, ALL SUBJECTS): CREATE

Main features of the pedagogy

Using rubrics as an instrument for fostering creativity and critical thinking is inherently a metacognitive approach; that is, an approach that makes teachers and students reflect on their teaching and learning, and ensure that they have explicit steps and questions to regulate their learning.

Mevarech and Kramarski developed a metacognitive pedagogy called IMPROVE to train students to apply self-addressed metacognitive questions during maths and science problem solving (see Mevarech and Kramarski, 2014[28]). Mevarech adapted this approach to design scaffolding questions aligned with the OECD rubric on creativity and critical thinking (see Chapter 2) so that students become more aware of their learning processes when it comes to developing their creativity. CREATE is about applying the following scaffolds: comprehend the core problem and task and decompose it into sub-problems; reconstruct connections to generate new ideas; explore, explain and experiment; add ideas/strategies/methods/technologies; true-but…; evaluation.

The acronym CREATE is meant to assist teachers and students in applying these self-addressed scaffolding questions corresponding to the different rubrics.

- **C**ore problem and sub-problems: What is the problem all about? Can you decompose the core problem into sub-problems? Can you look at the problem from different perspectives within a domain and/or between domains?
- **R**econstruct connections to generate new ideas: Reconstruct as many ideas as possible; reconstruct ideas of different kinds; reconstruct original (unusual) ideas; think how this problem is similar to or different from what you already know about this problem/phenomenon/task; integrate other disciplinary perspectives; shift perspectives.
- **E**xplore, explain and experiment: How can you justify your claim? What is needed, what are the givens and what are the options? Explore and play with unusual ideas; experiment: How can you test, prove your hypotheses, suggestions?
- **A**dditional strategies, methods, technologies: Reflect on your suggestions and see if you can solve the task by using different methods, technologies, resources.
- **T**rue-but: What are the reservations or exceptions of your suggestion/solution? Does the solution satisfy the necessary/desirable requirements? Look again at the needs, constraints and data, and reflect on what you have done so far to improve your suggestions; question the assumptions.
- **E**valuation: Self- and group evaluation of the whole process and the product: Does the solution make sense? Can you solve it in a different way?

How it is supposed to foster creativity and critical thinking

The prompts developed by Mevarech correspond to the development of key sub-skills of creativity, aligned with the research literature and the OECD rubrics on creativity and critical thinking. The main modus operandi of the pedagogy is to support students in their monitoring of creativity and of critical thinking, and in supporting students to develop these habits by proposing related tasks, notably ones that are complex, unfamiliar and non-routine, that are usually ill-defined and/or have multiple solutions. CREATE can be applied in maths, science, and other domains.

Related evidence

To analyse the effects of CREATE, Mevarech and Taieb (forthcoming[29]) designed a study in which students were randomly assigned into an experimental group who solved complex, unfamiliar and non-routine maths tasks by using the CREATE questions, and a control group who studied the same problem traditionally. All students were pre- and post-tested on the Torrance Creativity test. The tentative findings show that the experimental group significantly outperformed the control group on all factors of creativity: fluency, flexibility and originality. Other ongoing studies by Mevarech and colleagues point to similar encouraging results.

These findings indicate that creativity can be promoted in schools by implementing metacognitive pedagogy embedded in complex, unfamiliar, non-routine maths tasks. Questioning assumptions, shifting perspectives, looking for additional ideas, integrating methods from different disciplines, etc., are all useful tactics for solving creatively a wide range of problems. Using the acronym CREATE helps students to use meta-creative strategies and develop a related habit of mind.

For more information

For more information on metacognitive pedagogies in mathematics, see *Critical Maths for Innovative Societies: The Role of Metacognitive Pedagogies* (Mevarech and Kramarski, 2014[28]).

5. MODERN BAND MOVEMENT (MUSIC EDUCATION)

Main features of the pedagogy

Promoted by the Little Kids Rock foundation, the Modern Band movement has significantly changed music education in the United States in the past decades by means of integrating popular music into music instruction in schools. This is one example among many programmes around the world that promote the learning of music through popular music (Till, 2017[30]).

Two distinctive features characterise Modern Band pedagogy: repertoire and instrumentation. Modern Band classrooms have a popular music repertoire; that is, music that students listen to on their own and with others. These classrooms thus cover a wide range of contemporary music genres: for example rock, pop, reggae, hip-hop, rhythm & blues, electronic dance music, as well as other contemporary styles as they arise. The repertoire keeps pace with changes in current pop music. Secondly, Modern Band classrooms incorporate instrumentation that is typically used in pop music: guitar, bass, drums, piano, voice and technology – although other instruments can be added when playing, composing and improvising. By focusing on music that is familiar to students' everyday life, Modern Band helps to bridge the gap that can exist for students between "school music" and "regular music."

While the movement promotes popular music and the use of its instrumentation as cultural and compelling assets for music education, it does not provide systematic guidelines. In some ways, it follows the spirit of Orff Schulwerk (see p.113), but focuses on a different repertoire and instrumentation (given that Orff Schulwerk typically emphasises domestic folk music as its repertoire). Unlike much of traditional music education, students taught through a Modern Band pedagogy learn to perform, compose and improvise music.

The Modern Band programmes draw upon a teaching method called "Music as a Second Language". Developed by Little Kids Rock founder Dave Wish, this teaching methodology is built upon the principle that all humans are naturally musical beings just as they have a natural instinct for speech. Students therefore, should learn music in the same way they learn a second language – by learning how to speak the language before using notation, and by having opportunities to practice it through performing, composing and improvising (Powell and Burstein, 2017[31]). By working in small ensembles, students have the opportunity – and obligation – to collaborate, share ideas and compromise as they create their own unique renditions of popular songs or create brand new musical works.

Modern Band organises music instruction around a student-centred repertoire (pop music), nurtures a comfortable learning environment, enhances intrinsic motivation, utilises comprehensible resources, and introduces students to improvisation and composition in the early stages of their musical development. In a Modern Band context, the learning experience occurs through learning by doing, with music knowledge and skills being acquired with little consciousness of the process.

How it is supposed to foster creativity and critical thinking

The Modern Band pedagogy provides space for students to explore, experiment, improvise and create – or, in the language of the OECD rubric (see Chapter 2), to inquire, imagine and do. It gives students agency to actually become a musician and a strong motivation to do so. The focus on music improvisation and composition gives students room to develop their creativity. There is little intentional focus on critical thinking or, more generally, on reflection, in the official descriptions of this pedagogy. This could easily be added by interested teachers.

For more information

More resources on the Modern Band approach can be found at: *www.littlekidsrock.org* and in *The Routledge Research Companion to Popular Music Education: "Popular Music and Modern Band Principles"* (Powell and Burstein, 2017[31]) and "*Modern Band" As School Music: A Case Study* (Byo, 2017[32]). See more broadly *The Routledge Research Companion to Popular Music Education* (Smith et al., 2017[33]) for related approaches.

6. MONTESSORI (ALL SUBJECTS)

Main features of the pedagogy

The Montessori pedagogy is a comprehensive model of schooling developed over the first half of the 20th century by Maria Montessori and her collaborators and practiced in an estimated 20 000 schools on 6 continents. The model posits successive stages or "planes" of development: birth to 6, 6-12, 12-18 and 18-24. These correspond to periods of schooling with learning environments and curricula designed to respond to the needs and characteristics of each stage.

Montessori's signature feature is a learning environment explicitly prepared to respond to the cognitive, social and physical needs of children at specific stages of development. At all levels, classrooms are designed to encourage movement, choice, exploration, self-correction and deep investment in multiple strategies for problem solving. Other essential features include:

- Open seating plans with clusters of tables and chairs, organised around carefully structured "areas" of study (language, mathematics, science, history, arts and so on), which are fully equipped with scientifically derived sets of didactic materials.
- Mixed-age student groupings: birth to three, three to six, six to nine and so on.
- Large class sizes (25-35 students or more), designed to encourage independence, voluntary social interaction and a sense of community that is not dominated by adult control.
- Teachers trained in the theory and practice of the model, including use of Montessori materials. Training is comprehensive and intense and is typically delivered over 12-36 months.
- Large (two to three hours) periods of uninterrupted work, designed to encourage deep exploration and natural cycles of engagement, refreshment and re-engagement.

How it is supposed to foster creativity and critical thinking

Although Montessori does not isolate creativity as an explicit outcome, the model is congruent with key elements that recent research identifies as supporting the development of creative potential. Those elements include:

- flexible use of space and time
- respectful relationships between children and adults
- a culture of intrinsic motivation
- a balance of independent work and opportunities to collaborate
- acceptance of non-conformity
- a balance of freedom and structure.

To gain a deeper understanding of the intersection between Montessori learning environments and the development of creative potential, it is necessary to attend to both inputs – quality of learning environments – and outcomes for learners in these environments. Even though it puts a strong emphasis on structuring the learning environment, the Montessori pedagogy then provides students with a lot of agency in choosing how they learn and provides them room to explore and inquire, to play with unconventional ideas, and produce meaningful artefacts.

Related evidence

A 2017 evaluation of Montessori education in South Carolina found that Montessori students exhibit greater creative potential in mathematical thinking than their peers in traditional school settings. Montessori students were able to generate significantly more and significantly more original mathematical ideas than their traditional school counterparts (Culclasure, Fleming and Riga, 2018[34]).

Studies of Montessori outcomes also report significant links between high fidelity Montessori implementation and performance on a range of executive function measures (Diamond and Lee, 2011[35]), social interactions, engagement, learning outcomes (Lillard et al., 2017[36]) and also sometimes creative outcomes. For example, compared to a group of Montessori applicants who attended other schools because of a lottery admission process, Montessori students wrote more creative essays at the end of primary school (Lillard and Else-Quest, 2006[37]). In France, studies found that students in Montessori learning environments performed better than those in traditional schools on a variety of creativity measures (Besançon and Lubart, 2008[38]; Besançon, Lubart and Barbot, 2013[39]).

For more information

The Montessori Method by Maria Montessori (Montessori, 1912[40]) provides a detailed description on the Montessori philosophy and approach to education. More information can be found in *Montessori: A Modern Approach* (Lillard, 1972[41]) or on the Association Montessori Internationale website at: https://montessori-ami.org/.

7. ORFF SCHULWERK (MUSIC EDUCATION)

Main features of the pedagogy

Developed by Carl Orff and Gunild Keetman, this pedagogical model for learning and teaching music has significantly gained ground across music education around the world. It is explicitly focused on creativity and "learning through play" and aims to unleash students' creative potential, whatever their level of musical "talent".

The Orff Schulwerk is an active, learner-centred approach to music education. Children are led through a discovery learning process of exploring, experimenting, selecting and creating. It is a student-centred and process-oriented form of instruction: the focus is entirely put on the process of music making, notably singing in group, improvising and composing.

The model promotes music education as a multidimensional activity in which the students engage through movement, singing, playing, dancing, etc. Students are given the space to develop their artistic potential, while they gain confidence, improvise, create and express themselves. Teachers on the other hand, act as facilitators, guiding the students throughout their learning process. For this process to be effective, teachers need to create a comfortable environment where students' natural behaviour of play is the stream to start and encourage their interest and aptitude in music. They need to provide students with comprehensive resources to stimulate their learning. In particular, Orff lessons are associated with a wide range of percussion instruments such as marimbas, xylophones or metallophones. The use of these instruments is grounded on the belief that percussive rhythm is a natural form of human expression and thus the best way to nurture a natural learning environment.

The Orff Schulwerk method does not provide systematic guidelines for instructors, but rather some principles. In fact, educators are expected to provide a creative education and design their own learning environment. In the United States, the method identifies four phases in students' musical development (Shamrock, 1986[42]): 1) exploration (preliminary play with materials and space, discovery of the possibilities in terms of sound and movement); 2) imitation (developing basic skills in rhythmic speech, movement, playing an instrument, etc.); 3) improvisation (extending the skills developed to the point of initiating and creating new patterns and combinations); 4) creation (combination of different materials and components, start natural or rhythmic speech, movement, singing, and playing instruments).

At all levels, students' development of music literacy is flexible: each student should learn at his or her own level of understanding and talent. The Orff Schulwerk model promotes an inclusive approach to music education and considers that all students can be composers. Given the pedagogical freedom, teachers are able to design their own music lessons and adapt them to the students' age and skills. Yet, when taught effectively, these music classrooms can function with a great diversity of students when musical tasks are differentiated in a functional manner. While instruction is individualised, the Orff Schulwerk pedagogies promote a collective playful environment inclusive of all students at different stages of development and attainment. Interaction, co-operation and social skills are fundamental pillars of this pedagogical approach.

How it is supposed to foster creativity and critical thinking

The Orff Schulwerk method places creativity at the core of its philosophy. In a documentary, Orff stated: "Every human being has an innate part of creativity … My educational objective has always been to identify and reveal this creator who lies dormant in each of us". The Orff Schulwerk provides a lot of space for students to explore, experiment, improvise and create – or, in the language of the OECD rubric (see Chapter 2), to inquire, imagine and do. More than other music activities, the focus on music improvisation and composition gives students room to develop their creativity. There is a less intentional focus on critical thinking as part of the method, with a low emphasis on assessment or on structured discussions about one's work. Teachers could, however, easily integrate activities around critical thinking as part of the method if they so wish.

Related evidence

There is some evidence of a positive relationship between Orff instruction and students' interest, attitudes and enjoyment in music education (Siemens, 1969[43]). There is still little research on the impact of the Orff pedagogy on students' creative thinking skills. Through a quasi-experimental design, (Fang et al., 2009[44]) explored the effects of Orff pedagogies on students' creativity over a one-year school programme. Comparing 30 music students who learnt through the Orff music instruction, and a control group who followed the traditional music curriculum, the Orff group showed significantly greater improvements in all dimensions of their creative thinking skills as measured by the Torrance Creativity test (flexibility, fluency and originality). More studies with larger sample sizes would need to confirm this promising preliminary result.

For more information

For more details on the Orff Schulwerk pedagogy refer to *Music for Children* (Orff and Keetman, 1950 - 1954[45]), *Orff Schulwerk: An Integrated Foundation* (Shamrock, 1986[42]), *Orff-Schulwerk in the New Millennium* (Goodkin, 2001[46]) and https://aosa.org.

8. PROJECT-BASED LEARNING (SCIENCE EDUCATION, ALL SUBJECTS)

Main features of the pedagogy

Project-Based Learning is a student-centred, cross-disciplinary method of instruction that has emerged as a prominent strategy to develop learners' in-depth understanding of academic content along with a wide range of skills.

This pedagogical model is built around three principles: 1) learning is context-specific; 2) learners are actively involved in the learning process; 3) learners achieve a common goal through social interactions and the sharing of knowledge and understandings (Cocco, 2006[47]). While it is often used in science education (and medical sciences in higher education), other subjects can also be taught with a Project-Based Learning approach.

Project-Based Learning consists of challenging students with real-world problems and in organising learning through structured collaborative projects that will make students acquire content and procedural knowledge as they try to solve them collaboratively. The design of these projects has five distinct characteristics (Krajcik and Blumenfeld, 2005[48]):

- Driving question: Projects focus on questions or problems that drive students to acquire the main concepts of the course. The driving question provides context and relates to real-world concerns and real-life challenges so that students are engaged in meaningful learning experiences.
- Situated inquiry: Project-Based Learning is an inquiry-based approach to learning where students acquire and develop knowledge and skills by investigating the driving question.
- Collaboration: Students collaborate with their peers and teachers to investigate the driving question.
- Use of technology tools to support learning: Students make use of technology tools to support their investigations (for collecting data, communication with others via network, etc.). These tools expand the possibilities for learning.
- Creation of artefacts: Students conclude their projects by reflecting their understanding, knowledge and response to the driving question into a final and concrete artefact. This product can be presented in different forms (reports, videos, sketches, models, etc.).

Through a rigorously scaffolded self-directed, hands-on learning process, Project-Based Learning enables students to acquire a deeper understanding of academic concepts and develop an extended set of skills. The authentic and real-world nature of the problem bridges the gap between classroom learning and real-life experiences and, as such, fosters pupils' motivation, engagement and interest in learning. Projects are largely designed and built by the students; their investigations carried out autonomously. As students inquire, they often use content knowledge and skills from different areas and subjects. In particular, Project-Based Learning requires that students mobilise and develop different skill sets: research skills, decision-making skills, critical thinking skills, problem solving skills, collaboration skills, etc.

The final stage of the process is a key step to any successfully implemented project: students' new understanding of and response to the driving question must materialise in a final concrete artefact. Whatever the level of success, the mere creation of this artefact contributes to give a realistic and tangible dimension to the Project-Based Learning experience.

How it is supposed to foster creativity and critical thinking

Project-Based Learning in science has a strong emphasis on critical thinking, but also develops some aspects of students' creativity. Inquiring; understanding the nature of the problem; making, challenging and revising (at least one's) assumptions or theories; comparing the strength of alternative evidence; arguing; justifying one's solution or product; reflecting on one's positions and those of others; all those dimensions of critical thinking of the OECD rubric are inherently part of Project-Based Learning. The strongest contribution of Project-Based Learning to the development of creative skills lies in the final artefact developed by students. Many creativity sub-skills are also usually developed in the teaching and learning process, notably observation and ideation.

Related evidence

The research literature shows extensive evidence on the positive impacts of Project Based Learning on academic achievement and attitudes towards learning (Chen and Yang, 2019[49]; Akinoğlu and Tandoğan, 2007[50]; Baş, 2011[51]; Kaldi, Filippatou and Govaris, 2011[52]). Recent research shows that Project-Based Learning can have positive effects on students' engagement and interest in science education (Schneider et al., 2016[53]; 2020[54]). There is, however, little research on the impact of Project-Based Learning on students' creative and critical thinking abilities.

The 2012 evaluation of the implementation of Project-Based Learning in the state of West Virginia (Ravitz et al., 2012[55]) highlighted the positive effects of Project-Based Learning professional development and implementation in teachers' perceived ability to teach and assess 21st century skills. The study compared two groups of teachers of similar characteristics, one expected to use Project-Based Learning after having participated in professional development (44), and another group who had not participated in the professional development programme and so was not expected to use it (42). Data collected on teacher practices and perceptions show that teachers implementing Project-Based Learning report more teaching and assessment of 21st century skills overall, with similar patterns across disciplines.

For more information

For more resources on the Project-Based Learning pedagogy, consult *The Cambridge Handbook of the Learning Sciences, C.19-Project-Based Learning* (Krajcik and Blumenfeld, 2005[48]), *A Review of Research on Project-Based Learning* (Thomas, 2000[56]) and the Buck Institute for Education website at: https://www.pblworks.org.

9. RESEARCH-BASED LEARNING (SCIENCE EDUCATION)

Main features of the pedagogy

Traditionally developed in higher education, the research-based approach has spread across primary and secondary classrooms promoting the undertaking of a research project as a learning and teaching strategy at all levels.

In this pedagogical approach, students learn about methods and procedures, and through the research process. Teachers need to plan, deliver and assess students' work over these research processes, while providing students with a hands-on responsibility as actual researchers.

Students endorse the role of researchers and are initiated to research concepts, methods and ethics and take part in research-based activities during which they inquire about problems or questions in a scientific way. Students learn scientists' way of thinking and working, and conduct their research project following usual research practices:

- Scientific inquiry around a specific question;
- Research of previous work on the topic/literature review;
- Design of an experimental protocol;
- mplementation of the research protocol;
- Organisation and data analysis;
- Validation of results and conclusions to the scientific question;
- Communication of results.

Since research is fundamentally a collaborative exercise, students carry out their investigations in collaboration with peers. This makes social interaction and collaboration two very important dimensions of this teaching method, giving space for the development of collaborative and communication skills.

During students' research projects, teachers act as tutors and supervisors. Students are expected to become self-directed and motivated learners. The conduct of their research project requires students to apply various competencies: pose a question that can be answered through scientific inquiry, question, describe, formulate hypotheses, make use of knowledge, experiment, model, exchange ideas, form arguments and make conclusions.

The research project also allows students to acquire technical knowledge about a topic and one or more fields of science, and to develop the ability to critically analyse and reflect, organise and plan, collect and analyse data, and establish conclusions regarding a question. It also enables students to experience authentic and meaningful learning and to experience the limits and constraints of science (time, budget, knowledge gaps, etc.).

A final very important emphasis of research-based instruction is to teach students the ethics and process of scientific research: science is evidence-based (as opposed to opinion-based), collaborative, requires intellectual integrity (results must be validated). Mistakes are an integral part of the research process and the learning interaction.

How it is supposed to foster creativity and critical thinking

This pedagogical approach in science mainly emphasises critical thinking, but also leaves room for students' creativity. The initial stage when students have to find a research question requires creativity: the research question should ideally be not only novel to them, but to the science community. To that effect, they will have to discover what is already known, and observe, play with ideas, and formulate a research question that can be scientifically investigated with easily available resources. Most of the research process will then typically develop their critical thinking skills: challenging their assumptions, looking at the problem from different perspectives, taking an evidence-based position and reflecting on its strength as they communicate their results.

For more information

Find more details on research-based education see *Teaching Research Methods: Learning by Doing* (Aguado, 2009[57]) and the website of the French-based programme *Les Savanturiers – École de la Recherche* at: https://les-savanturiers.cri-paris.org.

10. STUDIO THINKING (VISUAL ARTS EDUCATION)

Main features of the pedagogy

The findings documented in *Studio Thinking 2: The Real Benefits of Visual Art Education* (Hetland et al., 2013[58]) have influenced visual art classrooms in the United States, and around the world.

The Studio Thinking framework outlines four studio structures and eight studio habits of mind that are used in high-quality, thinking-centered visual arts classrooms. The four studio structures (demonstration-lecture, students-at-work, critique and exhibition) describe the interactions of time, space and relationships between teacher and students during class.

These art classrooms have only a very brief instructional period (demonstration-lecture) before students get to work, during which time the teacher circulates to talk with individual students to learn about their thinking, give advice and pose questions to help students dig deeper in their creative process (students-at-work). Visual art classrooms also include a period of critique, during which students reflect – they evaluate both what pleases and bothers them in their work and recall the process used in creation. Students have the opportunity to practice giving and getting constructive feedback during time specifically dedicated to this purpose. Visual art also provides the unique opportunity for students to publicly exhibit their works.

The second part of the Studio Thinking framework are eight broad thinking dispositions, or habits of mind, that are taught during thinking-centred visual arts classrooms. These are: 1) develop craft (technique and studio practice); 2) engage and persist (finding passion and sticking with it); 3) envision (imagining and planning); 4) express (finding and showing meaning); 5) observe (looking closely); 6) reflect (question and explain and evaluate); 7) stretch and explore (play, use mistakes and discover); and 8) understand art worlds (domain and communities). As outlined in *Studio Thinking from the Start: The K-8 Art Educator's Handbook*, teachers use these habits of mind systematically and in dozens of different ways in teaching, planning and assessing – they use the studio habits as the centre of formative assessment, talking with students about their progress in using each habit; they create curricula that use the studio habits explicitly; they use studio habit language consistently so students become well-versed in talking about their art making in terms of thinking habits

How it is supposed to foster creativity and critical thinking

The Studio Thinking approach is mainly aligned with creativity dispositions, but also develops some aspects of critical thinking in the assessment of one's work and others'. While students are given a lot of agency to conduct their work, the systematic emphasis on and assessment through the Studio habits leads to a more intentional development of some creative habits of mind. Many of those habits are aligned with the dimensions on creativity of the OECD rubric (see Chapter 2): students have to produce something, to observe, to imagine, to play with unusual ideas (stretch and explore). Other habits such as "finding meaning", "question, explain and evaluate", or "understand art worlds" should develop some aspects of critical thinking in the arts.

For more information

More resources can be found in *Studio Thinking 2: The Real Benefits of Visual Art Education* (Hetland et al., 2013[58]), *Studio Thinking from the Start: The K-8 Art Educator's Handbook* (Hogan et al., 2018[59]) and at: www.studiothinking.org.

11. TEACHING FOR ARTISTIC BEHAVIOR (VISUAL ARTS EDUCATION)

Main features of the pedagogy

This grassroots movement to teaching visual arts has been growing exponentially over the past decade, mainly in the United States, but also in select schools around the globe. Teaching for Artistic Behavior (TAB) is a pedagogical approach based on student agency and choice structured around three fundamental pillars:

1. Children are the artists.

2. The classroom is their studio.

3. What do artists do?

In the Teaching for Artistic Behavior approach, students develop their own projects: they struggle to find inspiration, envision an idea, design a plan of action, reflect on their progress, persist through difficulties, evaluate the work as it proceeds and see the project through to completion. They do the research, the exploration, create the artwork, then reflect on and revise it, before deciding when it is finished and, to some extent, whether it is successful.

A TAB classroom is different from a traditional art classroom in that students have only a short period of teacher-directed instruction (in order to learn new techniques, materials or follow a mandated curriculum). They then spend the rest of their class time in self-directed art making.

TAB classes are structured in terms of time and presentation of materials and techniques. In terms of time structure, most classes begin with a teacher-directed demonstration of about ten minutes, followed by work time, and end with a sharing session. As for presentation of materials, "studios" – such as drawing, painting, sculpture or fibre studios – are opened week by week so that children are slowly exposed to different elements of the room, which eventually opens in full.

Some teachers choose to adapt principles of TAB to adapt the level of choice that is left to the students; others set requirements for large, polished works that must be finished, and many require artist statements in which students reflect on their process.

In these classrooms, walls, books, posters and peers do the teaching. As teachers circulate around the room to speak individually with students, learn about their thinking and help with individual challenges, children learn from posters and other resources around the room, or from their more experienced peers (Douglas and Jaquith, 2009[60]; Jaquith and Hathaway, 2012[61]).

How it is supposed to foster creativity and critical thinking

By following their own line of inquiry, students take ownership of their learning, engage deeply with their work, and demonstrate both divergent and convergent creative thinking processes as they independently invent solutions to problems like assembling their sculpture to stand straight, mixing just the right colour for their painting or searching for the perfect object to add texture to their clay piece (Douglas and Jaquith, 2009[60]; Jaquith and Hathaway, 2012[61]).

This pedagogy relates to "research-based" learning in science education: one gives students the responsibility to be scientists, the other, to be artists. Teaching for Artistic Behavior puts more emphasis on creativity than on critical thinking. The "imagination" and "inquiry" dimensions of creativity are supposed to result from the combination of the agency given to students and from the creative nature of the artistic process, which involves both imagination and inquiry. There is a strong focus on "doing" something that is personally interesting and challenging, and on "reflecting" critically on one's artistic process. The latter is also one dimension of critical thinking.

For more information

More resources can be found in *Engaging Learners through Artmaking* (Douglas and Jaquith, 2018[62]), *The Learner Directed Classroom* (Jaquith and Hathaway, 2012[61]), 2012), *The Open Art Room (Purtee and Sands*, 2017[63]), at: www.teachingforartisticbehavior.org and in the dozen Facebook groups that teachers use to support each other in professional learning communities.

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Chapter 4

Creativity and critical thinking in everyday teaching and learning

This chapter presents a framework to support teachers in the design of classroom activities that nurture students' creativity and critical thinking skills as part of the curriculum. Developed collaboratively by participants in the OECD-CERI project, the framework is composed of a portfolio of domain-general and domain-specific rubrics and a set of design criteria to guide teachers in the development of lesson plans that create opportunities for students to demonstrate their creativity and critical thinking while delivering subject content. Teachers across teams in 11 countries worked to adapt their usual teaching practice to this framework and to develop lesson plans in multiple subject areas. The chapter presents a selection of exemplar lesson plans across subject areas and concludes with some key insights.

A framework to design learning experiences that nurture creativity and critical thinking

What strategies are effective to foster creativity and critical thinking in primary and secondary education? Teachers do not always feel well equipped to answer this question. There is a lack of a common professional understanding of what these skills look like in formal education settings and, more particularly, of how they can be embedded into curriculum delivery. Some educators fear that putting an emphasis on these skills will come at the expense of subject matter knowledge, assuming that the activities devoted to content instruction cannot at the same time nurture creativity and critical thinking. Others fear that the pedagogical approaches better suited to foster these skills, such as project-based or inquiry-based learning, are too time-consuming and difficult to accommodate within regular teaching as they usually rely on extended activities and non-traditional ways of organising classroom activities. Many simply lack a workable model of what creativity and critical thinking are in practice and the necessary pedagogical confidence to cultivate them in their school context.

Most of these concerns stem from false dichotomies between knowledge and skills or knowledge and dispositions that fail to see how these are intertwined rather than competing learning goals. Educators need models that make visible how learners can mobilise their disciplinary knowledge in new and uncertain contexts by using their creativity and critical thinking; that is, the positive interplay between subject matter knowledge and higher order thinking skills.

The OECD-CERI project therefore attempted to create a shared social and professional representation of what it looks like to teach, learn and assess creativity and critical thinking in formal education settings. It brought together teams of teachers, researchers and pedagogues in 11 countries to develop exemplars of lesson plans or units of work that portray different strategies to foster students' creativity and critical thinking as part of their teaching of subject matter knowledge. As a result of this initiative, the OECD has produced a repository of rubrics and lesson plans that can inspire teachers, school leaders and curriculum developers across countries to create more space for creativity and critical thinking skills in their school systems without sacrificing the acquisition of technical skills in the disciplines. These resources are available through the project's mobile application and website.

These materials were developed through an iterative and collaborative process. With the help of a group of experts, the OECD-CERI team produced an initial set of rubrics that provided a common terminology and understanding of major sub-dimensions of creative and critical thinking processes. Teachers across teams in 11 countries trialled these rubrics for a variety of purposes, from framing and designing instruction plans to structuring discussions with peers and students (see Chapters 2 and 6). An initial set of examples of lesson plans was also developed and shared with the local project co-ordinators. As the implementation progressed, feedback from fieldwork made it clear that more guidance was needed to translate ideas from the rubrics into classroom activities. A set of design criteria to further assist teachers in their own adaptation and production of lesson plans was thus developed. In turn, lessons from trialled lesson plans complemented research to help identify some of the key features of the teaching and learning environments where creativity and critical thinking can flourish. The rubrics, the design criteria, the examples from lesson plans and insights from research about supportive learning environments provide a guiding framework for schools and teachers seeking to nurture students' creativity and critical thinking within their national curricula, through incremental or more radical changes in teaching practice.

The rubrics

The OECD rubrics on creativity and critical thinking describe the sub-skills involved in these thought processes and actions. Rather than attempting to establish a one-size-fits-all definition of what student creativity and critical thinking look like, the OECD developed a portfolio of rubrics that maintain strong conceptual consistency while allowing derivatives for different purposes and specific subject areas. The core set includes a domain-general, comprehensive rubric; a domain-general teacher-friendly version; five teacher friendly derivative rubrics for mathematics, science, visual arts, music and language arts; and two assessment versions that describe levels of progression for products and processes where students deploy these skills in a school context. Project participants produced additional derivatives of the rubrics, for instance, linked to the tasks of specific lesson plans, as well as related tools that depart from and complement the core OECD-endorsed materials.

The structure and language of the OECD-CERI rubrics are informed by a review of the research literature and by selected standards and rubrics for creative and critical thinking developed by educational organisations in different countries. They are also informed by the five-dimensional model of creative thinking of Lucas, Claxton and Spencer (2013[1]) and by insights from its field trial in English schools. The OECD rubrics distinguish four sub-dimensions or basic components of both creativity and critical thinking skills, namely inquiring, imagining, doing and reflecting (see Chapter 2 for a more in-depth discussion).

Taken together, the four sub-dimensions come to represent the macro-processes involved in creativity and critical thinking. However, the rubrics are not meant to prescribe a sequence of steps and the implied order may be altered either because a task guides learners towards a different sequence, or because different learners engage differently with a given task. The rubrics emphasise the importance of attending to both generative and evaluative thinking processes. In school contexts, this is essential to move beyond narrow notions and measurements of creativity that focus solely on originality and neglect appropriateness: evaluative, convergent thinking processes are precisely those that require learners to activate subject knowledge within task constraints and which can provide a stronger connection to curricular content (Cropley, 2006[2]; Baer, 2011[3]). In addition, the reflecting sub-dimension opens a door to using metacognitive pedagogies to develop creativity and critical thinking by encouraging teachers and students to step back and think about how they use these skills in a school context (Mevarech and Kramarski, 2014[4]).

The rubrics articulate shared sub-dimensions for the two complex cognitive skills. While these illustrate common elements of underlying thinking macro-processes, the differences in how inquiring, imagining, doing and reflecting are articulated between creativity and critical thinking may also capture possibilities for interplay. For instance, Pringle and Sowden (2017[5]) find that that shifts between associative and analytic thinking predicted creativity in design processes.

While aiming to reflect key insights from the research literature, the main goal of the rubrics remained nonetheless to provide a simple language that teachers can use to better embed creativity and critical thinking into their regular practice. The rubrics were field-tested and improved to provide a vocabulary that teachers and learners can use to identify and target manifestations of creativity and critical thinking across the curriculum. This process also involved translating domain-general skills descriptors into domain-specific versions of the rubrics that articulate what creativity and critical thinking would look like in five main subject areas: science, mathematics, visual arts, music and language arts.

As of 2016, over 50 countries worldwide had recognised skills beyond literacy and numeracy across the subjects of their national curricula, creativity and critical thinking being the most commonly identified alongside communication; these skills may be integrated into curricula as subjects in their own right, embedded into content in different subject areas or through interdisciplinary subjects (Care, Anderson and Kim, 2016[6]). While some curricular frameworks treat creativity and critical thinking as cross-curricular skills, in other cases they appear located in a set of specific subjects: for creativity, these usually include art, design or music, whereas critical thinking is more commonly embedded into science or philosophy.

The conceptual framework underlying the rubrics sees creativity and critical thinking as skills to be developed within specific fields or school subjects – but with the potential to become thinking "dispositions" or "habits of mind" as they are more frequently and systematically practiced across subject areas (Costa and Kallick, 2002[7]). There are two major assumptions under the notion of disposition: first, that individuals can cultivate and learn behaviours that exemplify these skills and, second, that sustained practice leads to their routine deployment in a range of different contexts. This also implies that, ultimately, the cultivation of creativity and critical thinking in schools aims at developing these skills for a broader range of real-world settings (Lucas, 2019[8]).

In inviting teachers to incorporate creativity and critical thinking into the teaching of subject content, the rubrics align with a large body of research that shows how, rather than developing in a decontextualised vacuum, the ability to engage in creative and critical thinking processes applies to specific domains and tasks (Box 4.1). In an education context, the domain-specific manifestation of creativity and critical thinking skills comes with an important implication: it challenges the traditionally held view that creativity and critical thinking can only be developed in specific disciplines. Such a belief is behind the conventional assumption that teaching for creativity equates to embedding "artistic" tasks into other subject areas. It also underlies a narrow understanding of critical thinking as a synonym of analytical or logical thinking. In opposition to these views, the OECD rubrics align with the notion that creative and critical thinking skills can be developed in any subject matter and that their development relies fundamentally on adequate pedagogical and assessment approaches, rather than on subject-specific content. Therefore, the rubrics move away from the traditional idea that arts education is the natural (or sole) territory of creativity development, and that mathematical and scientific reasoning and other forms of logical inference are the only vehicles of critical thinking. Instead, the rubrics promote the recognition that the development of creativity and critical thinking has a place in all subjects and interdisciplinary approaches of the school curriculum.

Importantly, the rubrics ensured consistency and alignment between the materials trialled and refined by teams in different countries without imposing a narrow selection of pedagogical approaches. Lesson plans developed in alignment with the rubrics proposed a range of specific techniques to embed creativity and critical thinking into curriculum delivery. These drew on the pedagogical knowledge of experts associated with the project as well as on the methods that participating teachers were already implementing prior to the intervention. This non-prescriptive approach leaves teachers ample freedom to choose the most appropriate teaching methods for their students and specific teaching environments.

Box 4.1. "Creative in what?" Arguments for domain-specific creativity

A common feature to creativity and expertise is that both require context. Just as describing someone as an expert appears incomplete without specifying his or her domain of expertise, answering the question "Are you creative?" makes little sense without specifying a context: "Creative in what?" As a thinking skill that cannot be decontextualised and that requires a certain level of knowledge within a domain, a domain-specific conception of creativity challenges the competing theory of domain-generality (Baer, 2015[9]; Baer, 2016[10]).

Creativity research increasingly acknowledges that "creative potential involves partly a generalised ability, partly a set of domain-specific abilities, and partly a set of task-specific abilities" (Barbot, Besançon and Lubart, 2016[11]). Arguments for the domain-specificity of creativity highlight that the nature of the creative work varies across domains (e.g. music, chemistry or advertising) and, at a more granular level, as a function of specific task demands within a domain (e.g. composition and performance within music). The different abilities that different people bring to a task also result in unique configurations of resources for creative work. Empirically, the domain-specificity of creativity finds support in the fact that expert creativity ratings of products in different domains tend to be poorly correlated. By contrast, ratings of products within a domain are often modestly but positively correlated. Put differently, creativity achievements in one domain appear to be weak predictors of creativity in other areas (Baer, 2016[10]). The literature also shows that creativity training relying on authentic tasks within the domain at hand tends to be more effective than training based on domain-general tasks. A meta-analysis of over 70 studies concludes that the use of domain-based performance exercises is the factor most consistently associated with the effectiveness of creativity training programmes (Scott, Leritz and Mumford, 2004[12]).

Design criteria to guide teachers in the development of lesson plans

In addition to the conceptual rubrics, the second element of the framework is a set of design criteria to assist teachers in the adaptation of existing, or the design of new, lesson plans in which the goal of developing student creativity and critical thinking skills is compatible and supports curricular content delivery. Feedback from early stages of fieldwork made it clear that rubric descriptors were often not sufficient to assist teachers in the complex task of creating space in their classroom activities for the behaviours and thought processes reflected in the rubrics. To respond to this challenge, we proposed a list of principles that would define classrooms activities and assignments that encourage students to exercise and demonstrate creativity and critical thinking skills.

The criteria operationalise the concepts of the rubric and thus provide additional guidance for teachers to visualise the features of teaching and learning activities aligned with the rubrics. The criteria take also into account aspects related to student engagement and teacher friendliness, since the goal was to facilitate actual implementation with diverse groups of students and ensure that teachers with different backgrounds and constraints could find pointers for incrementally adapting their instructional and assessment practices.

While they represent a non-exhaustive list of potentially useful principles, the eight criteria seek to align lesson plans with a focus on creativity and critical thinking with some of the major principles underlying effective learning, as established in a growing knowledge base (e.g. Sawyer (2006[13]); Dumont, Istance and Benavides (2010[14]); National Academies of Sciences, Engineering and Medicine (2018[15]). These dimensions include learner motivation and engagement, cognitive activation and connections to relevant subject content, opportunities for formative assessment, and a co-piloting of the learning process shared by teachers and students.

The design criteria are as follows:

1. Create students' interest to learn. Motivating activities increase possibilities for learning. Motivation to learn is fostered by experiences that students value and which generate in them a sense of belonging and purpose (National Academies of Sciences, Engineering and Medicine, 2018[15]). Lesson plans should hence be designed to stimulate students' curiosity and engagement, for instance by addressing "big questions" or topics related to students' own interests. These strategies seek to increase students' intrinsic motivation, so that they are genuinely interested in learning rather than simply expecting extrinsic rewards. This principle usually implies starting the activities by formulating a big question, by presenting a challenge or "provocation", or by putting students in an unusual and unexpected situation. These can serve as motivational triggers for students to stir to action and find creative and critical solutions to the problems they are confronted with. Equally important is to return to these initial questions several times as the activity unfolds, either to regain focus or to revisit the original challenge in light of new information or early attempts to solve them. Driving questions are exciting and important for learners when they encompass worthwhile content that is meaningfully anchored in a real-world situation; these type of questions are a hallmark of Project-Based Learning (Krajcik and Blumenfeld, 2006[16]) (see Chapter 3).

2. Be challenging. Often, lack of engagement in classroom activities comes from learning goals and tasks that students find too easy or unfit to display their ability and achievements. Setting challenging goals that students find accessible and worthwhile of their effort is thus a way of maintaining their engagement. Finding the right level of cognitive challenge implies also finding an adequate match with progression through curriculum contents, as well as students' age and maturity. Activities that push learners to reach just above their capacity without overloading them create conditions not only for effective learning, but also for assessment that is sensitive to learners' strengths and weaknesses (Wiliam, 2010[17]).

3. Develop clear technical knowledge in one or more curriculum domains. Any creative or critical thinking process relies on content knowledge, as there is no such thing as content-free thinking. Improving the creativity and critical thinking skills of students therefore implies also helping them to acquire content or disciplinary knowledge. At the same time, stimulating deep thinking about a subject is the best way to teach content knowledge because it results in higher levels of cognitive activation for learners: the active and meaningful processing of information is the best ally of learning, and thus an emphasis on content knowledge does not conflict with an emphasis on higher order thinking skills (Beghetto, Baer and Kaufman, 2015[18]). Lesson plans and classroom activities designed to engage students in creative and critical thinking processes therefore also deliver curriculum content in one or more domains, involving both content and procedural knowledge.

4. Include the development of a visible product or artefact. Learning sciences research indicates that students learn better when they develop external representations of their constructed knowledge, whether such products are abstract or material (Scardamalia and Bereiter, 2006[19]). Making visible the learning process is also a first step towards the assessment of creative and critical thinking skills. Different stages of a work process will result in more or less "final" products. Some can show the culmination of the work process, such as staged performances, artwork portfolios, full product designs, research reports, and scientific or mathematical models that students put to a test. Others may instead reflect intermediate steps of the process, such as sketches and prototypes, outlines of essays, a list of hypotheses or preliminary models tackling a scientific question. Ideally, lesson plans and activities would further involve an iterative development and refinement of products, for instance by asking students to generate and compare multiple versions of a solution or artefact. Emphasising the visibility of student products serves to make creativity and critical thinking processes more observable, thereby facilitating formative assessment. Lesson plans can encourage students to document the different stages of their thinking rather than only its final output. Documenting work process is not only crucial to assess students' progression in the mastery of creative and critical thinking skills, but also shifts the focus away from final products and helps students become more aware of the value of their personal learning path.

5. Have students co-design part of the product or solution. Activities and tasks that channel work into a single pattern and lead to a set of similar expected outputs across a group of students do usually little to promote their creative and critical thinking skills. Instead, products need to reflect a substantial level of student autonomy in the choices leading to products or solutions to the task at hand. In other words, products of a lesson plan that create space for creativity and critical thinking should in principle not all look alike but, instead, reflect a variety of possibilities. Letting students co-design products and solutions means that lesson plans should maintain a substantial degree of openness and room for student agency, which is not only compatible with, but also supported by, the presence of well-defined boundary conditions for collaborative experimentation and play. The human brain is primed for interaction, and opportunities to co-construct knowledge exploit more meaningfully the social and collaborative nature of effective learning (Wiliam, 2010[17]).

6. Deal with problems that can be looked at from different perspectives. The lesson plans are expected to propose open-ended problems and exploratory tasks that foster student inquisitiveness and imagination. Designing problems that have several possible valid solutions implies valuing novelty and usefulness rather than simply accuracy and conformity to pre-defined solutions and procedures. It also involves favouring tasks that do not require the use of a specific and unique technique or procedure for their solution. Subjects related to the arts, the social sciences, or language and literacy skills may appear to lend themselves more easily to these types of problems, but in fact open tasks able to accommodate more than a single solution can be designed in any area of the curriculum. While conventionally a lot of teaching of mathematics has relied on routine problems that require the application of ready-made algorithms, innovative approaches in mathematics and science education increasingly favour complex, unfamiliar and non-routine tasks. Typically, such tasks invoke both formal as well as real-life situations, involve the co ordination of previous knowledge and experiences, embed information in non explicit forms, require students to search for additional information, and allow multiple valid solutions or multiple patterns of inference to reach the correct solution (Mevarech and Kramarski, 2014[4]). More generally, open problems require students to come up with their own interpretations of the task requirements. Moreover, they deal with a relatively vast universe of possible answers – that is, they make room for multiple valid answers, as long as these are adequately justified on subject-pertinent criteria.

7. Leave room for the unexpected. Rigidly scripted lessons may be effective in scaffolding students' acquisition of content knowledge, but they can also transmit to students the impression that their personal ideas are not worth exploring and sharing. Stressing again the idea of openness, this principle relates to designing activities and tasks for which neither teachers nor students could know all the possible answers in advance, or where final student outputs are difficult to anticipate, with the aim to strengthen students' sense of ownership of the learning process and their disposition to take risks in their proposals and venture into unknown territory. Even if a lesson plan involves the teaching and learning of commonly adopted techniques or solutions to a problem, it can also encourage an exploration and discussion of unexpected paths and answers. This requires, on the part of teachers, a deliberate effort to follow-up on unexpected and off-track student ideas to explore their creative potential, rather than to dismiss them (Beghetto, 2013[20]). A willingness to give up on the idea of clearly defined sequences and end points for lesson plans is a first step for seizing unscripted opportunities for exploring student creativity and critical thinking.

8. Include time and space for students to reflect and to give and receive feedback. Moments and conditions for reflection are conceived as a way to help students become aware of the steps they have taken in the course of the activity, and thus of their own progress and of possibilities for further improvement. Students may put physical artefacts (e.g. posters, drawings, 3D models) on display in the classroom so that others can take a look and provide comments, or they may just discuss their ideas with peers or give a presentation to the class describing their work and justifying their choices or the position they take in a debate. From teachers, this demands careful lesson time management and making sure that all students have the chance to engage in the sharing of their learning. In addition, time and opportunities are needed for students to use the feedback that they receive to improve their work iteratively, which means that time for reflection should ideally not only be planned at the end of an activity, but in its intermediate stages as well. This design principle also contributes to changing negative perceptions of "mistakes" into opportunities to learn. Formative feedback is a pillar of effective learning, and opportunities for formative peer- and self-assessment can not only support students towards improving their work, but also activate them as instructional resources for one another and as owners of the learning process (Wiliam, 2010[17]; OECD, 2013[21]).

What could it look like? Examples from lesson plans across subject areas

The OECD rubrics and design criteria provide a consistent language and a set of quality guidelines to help teachers move from the implicit to the explicit in their efforts to develop students' creativity and critical thinking. However, making these skills more visible and tangible for teachers and learners also requires more practical illustrations of how they can be integrated into everyday classroom activities while teaching some learning outcomes of their local curriculum. Showing how to foster the skills described in the rubrics into teaching and learning across different subject areas is the major purpose of the repository of exemplar lesson plans developed during the OECD-CERI project. These lesson plans are meant to provide teachers with examples and inspiration to change their teaching practice to create opportunities for students to exercise at least some creativity and critical thinking sub-skills.

Teachers participating in the international network were invited to trial and refine lesson plans inspired by the rubrics and design criteria. Across teams, the pedagogical intervention involved two forms of work around lesson plans. On the one hand, lesson plans developed by expert pedagogues were distributed to teachers for adaptation to their local contexts. On the other hand, teachers were provided with blank templates for developing their own lesson plans, either by adapting materials that they were already using or by designing new activities from the ground up.

The template reproduces the typical teacher-friendly format and structure of lesson plans but introduces a series of novel elements to bring forth opportunities to develop creativity and critical thinking. The template's cover page provides standard information about the unit of work, including the targeted student age group, the subject area(s) and the specific subject content covered, a generic description of the proposed activities and tasks, the approximate number of lesson periods required for carrying out the activity, and a set of keywords to help teachers assess, at a glance, the fit with the curriculum they have to teach. Importantly, the front page also lists the specific sub-dimensions of the OECD rubrics for creativity and critical thinking that the lesson plan focuses on, and provides a description of products and processes that teachers can assess in relation to these skills. This is formulated to reflect the outputs and thinking processes that students would ideally engage in when demonstrating high levels of creativity and critical thinking, thus setting a goal for "what it looks like" in the specific context of the lesson plan.

Lesson plans then propose a sequence of steps for instruction. This includes a breakdown of the lesson periods and, in relation to each of the steps, a description of the expected roles of the teacher and student and an explicit formulation of both the subject content and the opportunities to exercise and assess students' creativity and critical thinking skills. Last but not least, the template reproduces a class-friendly version of the OECD rubrics mapping the steps of the lesson onto specific creativity and critical thinking sub-dimensions, so that teachers can easily see or reflect on the skills that are targeted by the different tasks.

Using this template in combination with the rubrics and design criteria, teachers and experts across 11 countries developed over 100 lesson plans with an explicit focus on creativity and critical thinking. These materials reflect a range of development processes. In some cases, teachers adapted existing units of work. In others, they crafted new activities from scratch. Similarly, some lesson plans reflect early attempts at pedagogical (re)design building solely on teachers' prior knowledge, whereas others result from teachers going through a dedicated professional development programme which presented the project rubrics and provided examples of teaching strategies and techniques to nurture students' creativity and critical thinking. A third category of lesson plans are those commissioned to expert pedagogues.

Lesson plans collected throughout the project were then curated and peer reviewed with the goal to select activities that could be portrayed as exemplars and made accessible on line to teachers worldwide. The curation involved copy editing, harmonising the layout and improving the clarity of instructional sequences in alignment with the rubrics and the design criteria. Further, a group of international experts and practitioners engaged in a peer review exercise to provide feedback on the quality of the activities, their alignment with the conceptual framework and their usability.

Discussions about the quality of selected lesson plans reflected a diversity of views on usability. Some project participants noted that exemplar lesson plans represented a clear departure from the dominant teaching culture of their countries, and that local teachers required clear instructions and descriptions of instructional steps in order to implement the activities. Others emphasised the goal of enabling teachers to (re)design their own lesson plans and thus that exemplars represent mainly a source of inspiration with ample room for local adaptation. Overall, the diverse set of activities developed under the project spans on a continuum in terms of practical guidance for implementation.

Table 4.1. Distribution of OECD repository of lesson plans for creativity and critical thinking by key characteristics

	All	Primary	Secondary
Total	80	41	39
By subject			
Science	14	4	10
Maths	19	13	6
Visual arts	18	6	12
Music	12	8	4
Interdisciplinary	12	6	6
Other	5	4	1
By duration			
1-2 lesson periods	18	15	3
3-6 lesson periods	44	20	24
> 6 lesson periods	18	6	12
By focus			
Creativity	29	17	12
Critical thinking	8	6	2
Both	43	18	25
By openness			
Open	31	15	16
Mixed	44	23	21
Directive	3	3	2

The selection process resulted in a final set of 80 curated lesson plans. As shown in Table 4.1, the activities are evenly distributed between primary and secondary levels of education and over three-quarters address one of the four main subjects of the intervention, namely science (14), mathematics (19), visual arts (18) and music (12), which broadly reflects the levels and domains chosen by different teams for the pedagogical intervention. A smaller number of activities call into play knowledge and techniques from other subjects (5) or adopt an interdisciplinary approach (12). In terms of duration, about half of the activities are designed to span three to six lesson periods, with shorter activities being concentrated in primary education and longer, project-type activities being more common at the secondary level. Notably, over half of the activities focused on the joint development of creativity and critical thinking skills, which speaks to a broad belief about the compatibility of this approach. Amongst lesson plans with a narrower focus, most chose to emphasise opportunities to demonstrate and assess creativity rather than critical thinking. Lastly, when categorised according to how much control of the learning process is in the hands of students (openness), most of the lesson plans give an intermediate (44) or large (31) level of student autonomy, while only a few (5) expect teachers to play a more directive role. This is consistent with the focus on task-openness and student self-directed learning present in the design criteria collaboratively developed by project participants. The lessons plans also represent a continuum in terms of content and approach. Indeed, it appeared that depending on their current practice, teachers could be more or less attracted to different levels of openness of the lesson tasks and pedagogical approach. As for the rubrics, it was decided to accommodate for the variety of views and teaching practices across countries.

The curated lesson plans and the template are available through the project tablet application; the digital toolkit for educators can be downloaded for free, thus contributing to an expanding global bank of resources for the development of creativity and critical thinking skills in young learners. Alongside the rubrics, the project lesson plans are primarily meant to inspire teachers across countries by showing how these skills can be better integrated into their regular teaching practice as learning goals compatible with the acquisition of content knowledge in different areas of the curriculum. As discussed in the sections below, their content analysis provides valuable insights on at least three areas. First, the lesson plans uncover a variety of teaching strategies to promote creativity and critical thinking that may be applied across subject areas. Second, they illustrate the nature of the tasks that create opportunities for students to exercise and demonstrate these skills in the context of school subjects. Third, they provide examples of how the concepts and language of the rubrics can be articulated in relation to specific subject content.

Techniques that support creativity and critical thinking

An emerging knowledge base exists about innovative pedagogical practices for fostering higher order skills. While the modes of teaching that support transfer are typically more challenging to implement than those merely supporting knowledge retention, higher order skills can be developed in specific subject domains and do not necessarily require radically novel instructional practices (Greiff et al., 2014[22]; Schwichow et al., 2016[23]).

The collected lesson plans reveal a series of teaching techniques that can be implemented across disciplines and which can explicitly promote inquiring, imagining, doing and reflecting as defined in the rubrics. For instance, teachers can use brainstorming to help students exercise the divergent thinking aspects of their creativity. Brainstorming can develop students' tolerance for ambiguity as it invites them to formulate multiple ideas on a topic while avoiding the premature dismissal of lines of thought, thus connecting with the inquiring and imagining sub-dimensions of creativity. Similarly, asking students to formulate metaphors invites them to engage in analogical thinking and helps to establish relationships across questions in different disciplines, which also draws on the inquisitive aspect of creativity.

Other techniques have a stronger bearing on critical thinking. As an example, teachers may use tasks that demand from students the definition of conditions for failure, for instance with regard to scientific or design problem. Identifying conditions in which an experiment or proposal will not hold is a way to figure out, by opposition, the necessary conditions for its success, which bears on the inquiring and doing sub-dimensions of critical thinking. A complementary method is to identify constraints on the traditional solutions to a problem, as a first step to helping students imagine possible alternative outcomes once these limiting conditions have been removed.

The rubrics and the design principles provided the conceptual backbone that guided teachers in different countries in their design of new pedagogical activities, but this framework was wide enough to encompass different pedagogical approaches and teaching techniques. One of the key findings of the project is that the teaching methods to develop creativity and critical thinking can take many different forms and can thus enrich a variety of teaching practices. Even if the collected pedagogical activities are all aligned with the rubrics and the design principles, they differ in length, teaching techniques and overall pedagogical strategy. Different choices reflect the diversity of students' needs, motivations, difficulties and other factors of the learning environment, such as the spaces in which teaching and learning take place, the available resources and the support of school leaders.

The examples presented in Table 4.2 by no means exhaust the list of teaching methods that can contribute to fostering creativity and critical thinking skills, but simply reflect many of those commonly featured in the lesson plans developed during the project. A more comprehensive list of teaching and learning methods for developing creative thinking is provided by Lucas and Spencer (2017[24]).

Table 4.2. Examples of teaching techniques to promote some aspects of creativity and critical thinking skills

Technique	Prompts for students
Brainstorm	Your ideas on this topic/question (X) are needed! A lot of ideas have to be considered before we agree on a few. So for now, the more the better! There are no bad ideas: any idea has the potential to become the next great solution/invention/product. It is forbidden to criticise other people's ideas. Every student has to speak at least once. And then a "second round" of brainstorming on the same topic (a day later). Select some ideas to work on. All ideas are recorded on a board.
Connections	Imagine connections between this object/concept and another three that you can think of [independent links]. Alternatively, work out how this object/concept links a set of three others [network links]. Alternatively, find ways of linking these ten random objects.
Define conditions for failure	What alternative proposals would fall short of the desired outcome? What could go wrong if we followed these alternative ideas? What could be done to ensure a greater chance of success next time?
Define the problem/ question	How would you describe the problem? Describe the "needs" or interests that make this situation a problem. What is the central problem/dilemma? Can the problem be broken down in smaller sub-problems/questions? Identify the main and secondary components of the problem/question.
Identify constraints	What constraints exist when finding a solution to the problem/question? In what respect do these factors limit our ability to solve the problem? How different would the outcome be in the absence of these limiting conditions?
IMPROVE	Identify the type of problem and make connections to your previous knowledge: how is the problem similar to or different from problems that you have solved in the past? What strategies can be used to solve the problem? Can you solve the problem in a different way?
List impossibilities	What solutions or proposed ideas are completely out of the realm of possibility? (as an opportunity to challenge assumptions).
Outline alternative hypotheses	What are all the potential explanations for this issue/problem/question?
PATENT method	Problem: What is the problem? Argument: What is your core argument? Thinking: How can you justify your claim? Experiment: How can you prove that your suggestions work? Necessary and desirable requirements: Does the solution/product satisfy necessary requirements? Does the solution/product satisfy desirable requirements? Explain your reasoning. True, but...: What are potential reservations/exceptions/objections to your solution/argument/product?
Pros and cons	What are the benefits or disadvantages of a proposed solution/idea? Once a solution/ idea is proposed, what occurs as a result? What are the negative and positive outcomes of the solution?

Technique	Prompts for students
Rationale for order of solutions	What is the rationale for the solution as proposed? Could the solution be proposed/justified in a different way?
Reverse engineering	Tell a well-known story backwards: start from the end and make it unfold back to the beginning. Highlight moments where the story could have taken different directions.
Role playing	Put yourself in the place of character/person X1, and say and do what your think he/she would feel/think/do in situation Y/how he/she would respond to question Y/what solution he/she would propose for issue Y. (Combine with role rotation and reflection.)
SWOT method and comparison with priors	Write down your first reactions to this topic/idea/argument (X). Now, take time to examine its Strengths, Weaknesses, Opportunities and Threats: What are its main merits? Are there weak points where it does not hold together? If this idea/solution/argument was true, what could we do next building on it? What would be the risks or problems that come with it? How do these compare with your previous reactions? Do they challenge your prior ideas?
Test and assess hypotheses	Now that a solution has been proposed, how can you demonstrate that it would lead to the desired outcome? How can that outcome be simulated? Can you design an experiment to test your hypothesis? What type of evidence would we need to know if the hypothesis works or not?
Using and suggesting metaphors	Think of other situations/relationships that are similar/analogous to that which is observed. Connect this problem/question with similar problem/question in another subject/discipline.
Waiting time	Stop and think for several minutes before answering to develop more intuitive/deeper responses.

Importantly, experience from the project suggests that these and similar techniques can be gradually incorporated by teachers, in a piecemeal fashion and small stages rather than in an attempt to depart drastically from established practice. A major advantage of a gradual transition towards innovative practices for fostering student creativity and critical thinking is to provide a scaffold for teachers to gradually modify their professional routines as they become more comfortable with the uncertainty brought about by more flexible tasks. Even short exposures to these practices may help teachers observe how students respond to more complex and open-ended tasks and whether they are able to collaborate effectively with peers. Based on these observations, teachers can anticipate strategies to support students, such as by asking additional questions to guide the inquiry process or creating supportive conditions for students to share and develop unconventional ideas in their work.

For all this to happen, teachers' knowledge of and confidence in pedagogical techniques remains crucial. Professional development around these pedagogical approaches can play a major role in this respect, especially as teaching for creativity and critical thinking is rarely an element covered in initial teacher preparation programmes. Similarly, school leaders have an important role to play. A school culture open to innovation might give teachers more freedom to experiment with unconventional lesson structures, to collaborate with other teachers to come up with interdisciplinary activities and to propose pedagogical interventions extended in time. In contrast, teachers working in an unfavourable environment for pedagogical innovation will generally have fewer incentives and less support to try out a broader set of teaching techniques.

Tasks that invite creativity and critical thinking

One of the major obstacles to the development of creativity in a variety of school subjects is the belief that creativity only flourishes through the arts. One common practice is indeed to introduce arts-related content and tasks to render activities in other subject areas such as science or mathematics more "creative". Whereas this approach may certainly have some benefits and can contribute to student engagement and even artistic creativity, it does not intentionally nurture domain-specific creativity in the main taught subject and cannot be seen as the only strategy used to foster creativity and critical thinking across the curriculum. Conversely, critical thinking is too often associated to disciplines emphasising logic (maths or philosophy) or to science. Teachers may thus fail to use the potential of non-scientific subjects to develop students' critical thinking (Claxton, 1999[25]).

The lesson plans developed during the project show that, while tasks that train creativity and critical thinking skills share some general features, there are also discipline-specific problems that support the practice of these skills. On the one hand, tasks that create opportunities to engage in creative and critical thinking have a generic open nature: almost invariably, the tasks are engaging, complex and open-ended. On the other hand, tasks need to develop disciplinary technical skills and be solidly anchored in subject content or cross-cutting issues. Based on the project lesson plans, Table 4.3 presents examples of problems and driving questions that can trigger student inquiry and imagination in subject-specific ways.

In science units, driving questions often had to do with the explanation of observed or experienced physical phenomena or with environmental challenges for which there is yet no widely accepted solution. Explaining physical phenomena is typically a scientific task that requires creative scientific skills such as choosing an appropriate experimental method, identifying relevant data patterns and interpreting them. This way, asking students to figure out what causes gravity or evaporation can make them embark in a self-directed exploration of scientific concepts. Working on socio-scientific issues also provides rooms to look at scientific problems from different perspectives and consider alternative theories and assumptions.

In mathematics, the literature highlights the use of problems that either have multiple solutions or explicitly require students to reach the unique right solution through multiple paths (Levav-Waynberg and Leikin, 2012[26]). Creative mathematical expressions can also be enhanced by open tasks relying on well-structured opportunities for class dialogue that signal to students that non-conventional ideas can be taken seriously (Schoevers et al., 2019[27]). Mathematics lesson plans developed by the project reveal different strategies to foster autonomous thinking and student creativity. An example is a task requiring students to calculate the perimeter of a geometrical figure in as many ways as possible. "Ill-structured" problems are another kind of task used in the collected activities to foster student agency in mathematics. These involve relatively loose or incomplete definitions of the problem space (initial state, goal and constraints), so that students cannot only choose the methods they use to solve it, but also the precise question that they try to answer. An example is to propose a destination for a school trip, plan itineraries and travel arrangements within a set budget.

Type of task	Driving question or problem	Student tasks
Science activities		
Explain a physical phenomenon	Why do you feel colder when you are wet than when you are dry when you are sitting by the pool?	Students find an answer to a scientific question by applying the scientific method (e.g. experiments, data analysis).
Solve an environmental problem	How can we reduce air pollution?	Students identify the causes of a problem and propose a solution. May require taking into account conditions for success going beyond the scientific sphere (e.g. socio-economic constraints).
Design an artefact	How can we build a tornado-proof structure?	Students are asked to design an artefact fulfilling certain constraints.
Challenge a theory	Can you imagine an alternative taxonomy to classify living beings?	Students challenge a theory or scientific construct by comparing it to competing theories or constructs.
Imagine scientific counterfactuals	What would the world look like if the theory of plate tectonics did not apply?	Students engage in counterfactual reasoning to imagine what the implications would be if certain conditions were changed, for instance, if a scientific theory did not apply.

Table 4.3. Examples of tasks per discipline to foster creative and critical thinking skills

Type of task	Driving question or problem	Student tasks
Mathematics activities		
Ill-structured mathematical problem	Find a possible destination for this year's school trip.	Students solve an authentic problem that mirrors real-world situations. The problem leaves room for interpretation and the data provided are inconclusive so students will have to define the problem space, take into account different alternatives and justify the choices made.
Multi-solution tasks	Calculate the perimeter and the area of a figure in at least three different ways.	Multi-solution tasks have one single answer but different methods can be used to reach it.
Visual arts activities		
Merging different art forms	Produce a contemporary piece of graffiti inspired by cave art.	Students deconstruct art forms into their different components (e.g. technique, themes) and produce a personal piece of art combining elements from different art forms.
Challenging art theories	Is graffiti a legitimate art form? Can functional objects be considered art?	Students consider whether traditional definitions of art hold in view of unconventional pieces of art.
Conveying emotional or aesthetic experience	Choose objects that represent you and put them together so that they make up a face or figure.	Students produce a visual representation of their inner self.
Interdisciplinary activities		
Synergies between artistic disciplines	Imagine how a classic poem or other literary text would sound to a rap beat.	Students analyse a piece of art through the lenses of a different artistic discipline (e.g. a painting through the lens of literature, a musical piece from the perspective of visual arts).

Type of task	Driving question or problem	Student tasks
Synergies between science and arts	Produce a humorous print about cell structure for a t-shirt.	Students play with scientific concepts through the techniques of artistic disciplines, e.g. metaphors, poetry, imagery and visualisation.
Design problem involving art and technology	Design a fashion accessory that can be used as bicycle lightning.	Students design an artefact that has to fulfil both functional and aesthetic constraints.

In lesson plans for visual arts, one example of prominent strategy was to ask students to analyse and compare different artistic styles and to produce a new piece of art combining elements from two or more styles. For instance, students were encouraged to produce a contemporary piece of graffiti inspired by cave art. A special case is that of interdisciplinary activities, which allow students to engage with tasks beyond subject matter boundaries. Examples from the collected lesson plans include inviting students to interpret a piece of art through the lens of a different artistic discipline or design an artefact that has to fulfil both functional and aesthetic constraints that correspond to two different fields.

An important lesson learnt from the project is that one of the key conditions for the successful implementation of activities with opportunities for creative and critical thinking is to create a caring and non-threatening environment where students are willing to take the risk of sharing their personal ideas (Beghetto, 2009[28]). This environment presupposes a series of teacher attitudes and beliefs, such as a positive attitude towards mistakes and a belief in the malleability of students' skills and knowledge. It also requires discernment and the ability to lead good dialogues and conversations with students and classes. This approach helps students develop a growth mind-set according to which intelligence, ability and performance are not fixed, but can be further developed through training (Dweck, 2006[29]). Students with a growth rather than a fixed mind-set will persist longer and this might contribute to the success of the creative process.

A practice to this end is using mistakes or failures to trigger reflection and thus as opportunities for learning, helping students to see misunderstandings as a chance for improvement rather than as a failure. For instance, the teacher induction programme of the Dutch team discussed a practice that consists in displaying the "most beautiful mistake" that occurs while attempting to solve a mathematics problem, and from which the entire class would learn something. This can be done in the context of calculation by means of estimation, which neither relies on precise procedures nor results in clear answers and which students who are weak in algebra tend to find difficult. Spelling out how mistaken assumptions can be refined is a learning opportunity. Another example from this team was to choose a question that the teacher herself cannot resolve, as a way to make it clear to students that the thinking process behind a mathematical problem can be as important as its answer. Other lesson plans attempted to nurture a risk-free environment through mindfulness techniques that make students more aware of their self-image, emotions and goals. This approach can help learners to value more their own perspectives on the questions and issues addressed in their schoolwork and thus prepare them to dare to propose and share new and unexpected ideas.

Exemplar lesson plans by subject area

The lesson plans showcased below illustrate in more detail how the four major sub-dimensions of the OECD rubrics on creativity and critical thinking – inquiring, imagining, doing and reflecting – can find a translation in lesson plans that follow specific curriculum content, usually within disciplines. Each example comprises a brief description of a proposed teaching sequence as well as a discussion on how the unit fosters students' creativity and critical thinking while delivering subject content. The accompanying tables highlight how the creativity and critical thinking dimensions of the class-friendly rubrics can be applied to those particular activities

Science lesson plan: Evaporative cooling

The lesson plan *Evaporative cooling* is a science activity for secondary education that illustrates inquiry-based science teaching. The activity shows how scientific creativity and critical thinking can be nurtured while acquiring content and procedural knowledge about the scientific ideas of intermolecular forces and energy transfer during phase changes of matter. The lesson plan starts with a driving question that acts as an anchoring point in students' experience and immediate context: why do we feel colder when we are wet than when we are dry when we are sitting by the pool? Students are then asked to find an explanation for this sensation that they have already experienced. Throughout the activity, students work on the scientific concepts and terms required to describe, understand and explain the phenomena of evaporation and temperature change.

Evaporative cooling exemplifies activities that implement a project-based learning approach in science, in which students take on the role of the scientist conducting observations, seeking explanations for the observed natural phenomena, constructing and revising models, and justifying their reasoning according to the scientific method. This approach encourages students to take control of their own learning and nourishes all four dimensions of the science-version of the project rubrics, as shown in Table 4.4.

Table 4.4. Creativity and critical thinking in the science lesson plan *Evaporative cooling*

	Inquiring	Imagining	Doing	Reflecting
Creativity in science: rubric descriptors	Make connections to other scientific concepts or conceptual ideas in other disciplines.	Generate and play with unusual and radical ideas when approaching or solving a scientific problem.	Pose and propose how to solve a scientific problem in a personally novel way.	Reflect on steps taken to pose and solve a scientific problem.
Critical thinking in science: rubric descriptors	Identify andv question assumptions and generally accepted ideas of a scientific explanation or approach to a problem.	Consider several perspectives on a scientific problem.	Explain both strengths and limitations of a scientific solution based on logical and possibly other criteria (practical, ethical, etc.).	Reflect on the chosen scientific approach or solution relative to possible alternatives.
Examples of implementation from the lesson plan	Making connections between experiences of being cold while wet and scientific concepts. Identifying and questioning ways to observe and measure evaporation and temperature change.	Generating an initial model to explain the phenomenon of being cold while wet based on prior knowledge and other possible explanations. Making assumptions and exploring different theories to explain patterns in their data.Reviewing models and assumptions and identifying different perspectives to explain the phenomenon.	Proposing explanatory models of evaporative cooling (from initial representations to computer-based models). Explaining both strengths and limitations of the proposed explanations for evaporation. Acknowledging potential bias, uncertainty about model parameters or limitations of the explanation.	Peer evaluation of the different models based on the rubric followed by final revision of their own model. Presentation of the reviewed models to the class and final reflection. Assessment of the unit at the end of the activity to reflect on what has been learnt.

Source: Own elaboration based on lesson plan developed by experts at Michigan State University (United States) for the OECD-CERI bank of pedagogical activities for creativity and critical thinking.

The activity also offers an example of how students can develop, in an iterative fashion, visible products that serve as a strong basis for assessment of work processes, as proposed in the design criteria. In the framework of the lesson plan, students develop several explanations of evaporation processes. They start by building a simplified model of the phenomenon on the basis of their intuition and previous knowledge. After a series of experiments to test the evaporation rate of different liquids and the correlation with temperature change, students build a more complex model integrating new concepts and relations amongst them (such as the positive correlation of temperature change with evaporation rate). As a final step, students are invited to produce a computer-based model that they will be able to test using a simulation software. The observations made through this simulation enable students to further refine their initial model. This iterative approach not only develops students' knowledge, but also teaches them that through reflection and revision of their work they can move from a basic to a more thorough understanding of a physical phenomenon.

Mathematics lesson plan: A world of limited resources

The lesson plan *A world of limited resources* is a mathematics activity for primary education. It requires students to apply mathematical reasoning to address problems faced when having to share, fairly and accurately, a limited quantity of resources. The activity is divided into two parts, each drawing on a fictional scenario. First, students work in small groups to consider how a generous financial gift to their school could be divided fairly amongst the school community. This task involves discussing different criteria for a fair distribution and using mathematical operations and tools such as division, fractions and percentages. In the second scenario, the teacher asks students to divide the school playground between different age groups using rations, a specific area of mathematics knowledge and their problem solving skills. Besides mathematical reasoning, this second stage requires students to think about how to measure and divide the playground area based on a count of students and their distribution across age groups.

All the dimensions of creativity and critical thinking as represented in the class-friendly rubric for mathematics are nurtured during this activity, as shown in Table 4.5. Students develop their creativity as they seek to generate solutions to a real-life problem related to their immediate environment and think critically when considering the relative merits of alternative solutions, as there is not a single valid answer to the problem. Finally, the activity allows building the students' mathematical knowledge as they are required to learn and apply a variety of measurement and calculation methods.

Table 4.5. Creativity and critical thinking in the mathematics lesson plan
A world of limited resources

	Inquiring	Imagining	Doing	Reflecting
Creativity in science: rubric descriptors	Make connections to other maths concepts or to ideas from other disciplines.	Generate and play with several approaches to pose or solve a maths problem.	Pose and envision how to solve meaningfully a maths problem in a personally novel way.	Reflect on steps taken to pose and solve a maths problem.
Critical thinking in science: rubric descriptors	Identify and question assumptions and generally accepted ways to pose or solve a maths problem.	Consider several perspectives on approaching a maths problem.	Explain both strengths and limitations of different ways of posing or solving a maths problem based on logical and possibly other criteria.	Reflect on the chosen maths approach and solution relative to possible alternatives.
Examples of implementation from the lesson plan	Building awareness of the use of division and fractions to address issues of fairness and equity in the distribution of limited resources. Exploring different ideas and approaches to define a fair distribution.	Generating several ideas to solve the distribution problem and understand their implications in mathematical language. Examining different mathematical approaches to distribute resources (ratios, absolute and decimal numbers, percentages, etc.) and selecting the most appropriate to solve different problems.	Proposing a solution for a fair distribution of resources combining criteria of mathematical accuracy and equity. Presenting and evaluating the different solutions to identify the plurality of criteria and ways to share limited resources.	Final discussion during which the teacher prompts students to reflect on what they have learnt and how they used creative and critical thinking to elaborate their solution for a fair distribution of limited resources.

Source: Own elaboration based on lesson plan developed by experts from Creativity, Culture and Education and Hidden Giants (United Kingdom) for the OECD-CERI bank of pedagogical activities for creativity and critical thinking.

Visual arts lesson plan: Graffiti: Perceptions and historical connections

The lesson plan *Graffiti: Perceptions and historical connections* encourages secondary education students to investigate and experiment with graffiti art, from both socio-cultural and artistic perspectives. Students are first asked to explore different attitudes towards this form of art and to develop and express their own viewpoint. They are then encouraged to analyse how graffiti art is related to other art forms, such as cave art. This analysis leads to the production by students of a piece of art combining characteristics from both art forms. They are given the choice between producing a piece of graffiti art using the techniques of cave art or a piece of cave art using the techniques of graffiti.

The lesson plan therefore involves the production of a personally novel piece of art, and a reflection on different beliefs and value judgments towards different forms of art. By doing so, the activity introduces students to content in art history and encourages them to use, and learn about and use different visual art techniques. Table 4.6 shows how the lesson plan helps students develop the four dimensions of creativity and critical thinking that are formalised in the visual arts rubric.

Table 4.6. Creativity and critical thinking in the visual arts lesson plan
Graffiti: Perceptions and historical connections

	Inquiring	Imagining	Doing	Reflecting
Creativity in science: rubric descriptors	Make connections to other visual arts concepts and media or to conceptual ideas in other disciplines.	Play with unusual and radical visual arts ideas when preparing or creating a piece of visual art.	Create visual art that shows expressive qualities or personally novel ways to engage a subject matter.	Reflect on steps taken in creating a piece of visual art and on its novelty compared to conventions.
Critical thinking in science: rubric descriptors	Identify and question assumptions and conventional rules in a piece of visual art (content, style, technique, colour, composition, etc.).	Consider several perspectives on the content, technique or expression of a piece of visual arts.	Explain both strengths and limitations of a piece of visual arts justified by aesthetic, logical and possibly other criteria.	Reflect on the chosen expressive choices of a visual arts piece relative to possible alternatives.
Examples of implementation from the lesson plan	Making connections (e.g. between ancient forms and new forms of art/ graffiti). Exploring the technical characteristics and the socio-cultural background of graffiti art and cave art (e.g. colours, materials, shape, text, imagery, purpose, motivation, context).	Envisioning an artistic output by playing with the techniques and materials used in graffiti art and cave art. Thinking about how to combine these in a single piece of artwork. Interpreting pieces from different art movements (ancient and new) and comparing them using multiple perspectives: aesthetic, technical, socio-cultural, representational.	Producing a piece of contemporary graffiti based on a piece of cave art, or a piece of cave art based on a piece of contemporary graffiti. Identifying the weaknesses and strengths of own and others' perspectives on graffiti art (based on aesthetic or socio-cultural grounds).	Presenting an initial sketch of the envisioned graffiti or cave paining and revising it based on feedback. Justifying own opinion on graffiti art while acknowledging the uncertainty of the endorsed opinion.

Source: Own elaboration based on lesson plan developed by Welsh teachers for the OECD-CERI bank of pedagogical activities for creativity and critical thinking.

Music lesson plan: Musical poetry

Musical poetry is a music activity for primary students. It starts with a presentation by the teacher of the concepts of dynamics and tempo, with examples and definitions, followed by a whole class discussion. In a second stage, students work on a poem previously selected by the teacher based on its contrasts and rhythmic potential. They imagine the type of musical soundscape that could accompany the poem, considering different timbres and sound effects as well as tempo and dynamics. During this process, the teacher frames a discussion between students about the qualities that different sound effects and tempos could bring to the poem. Subsequently, students compose a musical soundscape to accompany the poem and perform their compositions for the rest of the class. After each performance, all students fill out a listening worksheet on what they heard and discuss the different choices made by their peers to identify what they liked and what could be improved by choosing different musical elements.

As described in Table 4.7, the different dimensions of creativity and critical thinking represented in the music version of the rubrics are nurtured during the Musical poetry activity. Students can exercise their musical creativity in composing and performing by experimenting with a variety of timbres and dynamics and connecting these to literature and poetry. In addition, they are asked to listen critically to the compositions of other students and evaluate the expressive qualities of multiple rhythms and sound effects.

Table 4.7. Creativity and critical thinking in the music lesson plan *Musical poetry*

	Inquiring	Imagining	Doing	Reflecting
Creativity in science: rubric descriptors	Make connections to other musical styles, concepts or conceptual ideas in other disciplines.	Play with unusual and radical ideas when preparing to perform, compose, orchestrate or analyse a musical piece.	Perform, compose or analyse music with expressive qualities or relating to personally meaningful subject matter.	Reflect on steps taken to create performances, compositions or analyses of a musical piece.
Critical thinking in science: rubric descriptors	Identify and question assumptions and conventional rules in a musical performance, composition or analysis.	Consider several perspectives on a musical performance, composition, interpretation or analysis.	Explain both strengths and limitations of a performance, a composition or an analysis of a musical piece.	Reflect on the chosen way of performing, composing or analysing a musical piece relative to possible alternatives.
Examples of implementation from the lesson plan	Articulating connections between emotion in the poem and musical expression. Questioning and discussing conventional rules related to musical expressions.	Generating ideas on different rhythms and timbres and playing with those ideas. Exploring a variety of ideas about what can be expressed with changes to sound effects and dynamics.	Composing and performing a musical performance to accompany a poem. Explaining why final choices have been made and how they relate to the poem. Discussing strength and limitations of different musical expressions.	Discussing, reflecting on and critically evaluating different musical ideas and performances. Reflecting on the novelty of compositions, performances and choices made by others regarding dynamics and tempo.

Source: Own elaboration based on lesson plan of the OECD-CERI bank of pedagogical activities for creativity and critical thinking.

Interdisciplinary activity: My region: What if?

My region: What if? is an interdisciplinary activity for secondary education that leads students to a deep investigation of historical processes. The activity is immediately relevant to students since it focuses on historical events in the students' own region. Students are divided into groups and asked to learn about a past historical period by doing research on the living conditions of a specific social group, with each group focusing on a different social stratum or community. They are then invited to present their findings to the class through role play, for instance in the form of a video or news report. In a third stage, they identify an historical event that brought about important changes in the fields of arts, science or technology and they imagine alternative scenarios assuming that this particular event had not taken place. The activity ends with a foresight exercise in which students come up with proposals for promoting changes in their region.

Every sub-dimension of the creativity and critical thinking project rubrics is also addressed by this activity, as described in Table 4.8. Since the activity invites students to explore an historical period through the perspective of a specific social group, it conveys the idea of history as an interpretive process rather than as objective truth and thus prepares the ground for students' personal interpretation of historical facts. Students carry out their inquiry about the historical period from the perspective of their chosen social group. They then make connections between different domains, by exploring the chains of causality between the socio-political conditions and the scientific and the artistic developments of the historical period they explore. By asking students to come up with alternative courses of history, the activity makes them engage in counterfactual thinking, a valuable tool for innovation and for critically assessing historical events and how they are interpreted.

Table 4.8. Creativity and critical thinking in the interdisciplinary lesson plan
My region: What if?

	Inquiring	Imagining	Doing	Reflecting
Creativity in science: rubric descriptors	Make connections to other concepts and knowledge from the same or from other disciplines.	Generate and play with unusual and radical ideas.	Produce, perform or envision a meaningful output that is personally novel.	Reflect on the novelty of a solution and of its possible consequences.
Critical thinking in science: rubric descriptors	Identify and question assumptions and generally accepted ideas or practices.	Consider several perspectives to a problem based on different assumptions.	Explain both strengths and limitations of a product, a solution or a theory justified by logical, ethical or aesthetic criteria.	Reflect on the chosen solution/ position relative to possible alternatives.
Examples of implementation from the lesson plan	Making connections between historical events and arts or technology. Understanding the context of historical events and current characteristics of regions, analysing and addressing knowledge gaps through research. Investigating an historical period, empathising with the assigned social groups and identifying some defining features.	Playing with scenarios and thinking counterfactually: imagining alternative scenarios if the historical event had not taken place. Considering new sequences of historical events from a different point of departure.	Considering what the economic consequences would have been if the historical event had not taken place. Creating a performance to present the results of their research. Replicating the exercise with a foresight perspective by looking at how the future might be and the challenges to overcome.	Presenting the imagined alternative scenarios, appreciating their novelty and reflecting on ways to improve them. Students assessing the scenarios elaborated by their peers based on a rubric provided by the teacher. Final discussion on the value of scenario-building and counterfactual reasoning.

Source: Own elaboration based on project bank of pedagogical activities for creativity and critical thinking. Lesson plan developed by the CERI team for the OECD-CERI project.

A shift in mind-sets: A balance between structure and openness

A major theme from interviews and focus groups with teachers is how the best lesson plans and activities proposed in the context of the intervention implied a departure from traditional pedagogical conventions and teaching practices, particularly from the notion that instruction should lead students' thinking towards a clear and pre-determined path. Many of the project activities invited new roles for both teachers and learners – not only in relation to cognitive tasks, but also amongst themselves. In several instances and teams, project participants formulated this idea as achieving a balance between structure and openness.

According to teacher accounts, the most successful activities in stimulating students' creativity and critical thinking downplayed the teacher's influence and created opportunities for students to solve problems independently. Another relevant feature were tasks that allowed addressing topics related to students' own interests. Openness was thus described as the possibility to accommodate the directions that students chose to take with a project or task, and thus as a partial relinquishing of teachers' control over it, and as space for developing learner awareness and metacognition about the choices or actions in their work.

However, teachers also stressed how greater openness comes with a stronger need to make learning goals and conditions for action visible to students. Activities that are less directive in their development require clearly set parameters from the start, which in turn demand substantial preparation and clear language on the part of teachers. Structure, thus, is not neglected but enhanced in a sense: the greater openness comes within well-defined goals and expectations. Teachers praised lesson plans with a solid anchoring in subject content and links to curriculum, and where the teacher remained responsible for setting problems and tasks for students.

These themes are also common to education and psychological research. Davies et al. (2013[30]) find that a high level of learner control over their learning and classroom activities characterises creative environments in education. The evidence suggests that creativity is enhanced when learners are supported to take risks and make their own choices within safe and flexibly framed structures, and when expectations about the activity's objectives are clear to them. Creativity-fostering conditions include also opportunities to work collaboratively and to engage in peer and self-assessment, which relates to the metacognition dimension. Similarly, the role of adequate boundary conditions for student tasks echoes the recognition, by cognitive psychology, of the positive influence that constraints can have on creative problem solving and idea evaluation (Medeiros, Partlow and Mumford, 2014[31]; Medeiros et al., 2018[32]).

Experts working with the Dutch team noted how most of the activities proposed to teachers represented a departure from the standard didactic contract; that is, the implicit set of reciprocal obligations traditionally assumed by teachers and learners (Brousseau, 2011[33]). Within such a contract, typical expectations include that problems posed to students will have a unique correct solution, that solving problems requires using solely the information presented to students (and all of it), or that solutions stay within the taught content. Teachers from the Dutch team noted the strong conceptual component of some project activities, which they saw as a call for making concepts and learning goals within the rubrics clear to students from the onset. In turn, teachers linked openness to tasks promoting a greater activation of students and to expanded criteria for assessment. The role of teachers in exemplar activities would thus focus on defining boundary conditions for challenges and tasks; within those, students would then be asked to experiment and come up with their own solutions.

In the Brazilian team, some teachers described the project activities as balancing focus between content and space for students to reflect and act in diverse ways. Local team co ordinators emphasised that the rubric was mainly used for formative assessment purposes, and that making desired learning goals visible gradually became a key element of teacher professional development plans. Teachers were encouraged to design activities that served as a window for students' thinking and provided a clear definition of what is expected from them, in a way that students could easily understand, as well as frequent opportunities for student self-assessment. Teachers perceived a positive effect in the autonomy of students that engaged in these activities, and an improvement in their metacognitive thinking that often transferred to other subjects.

In the US (Vista) team, teachers reported a shift in their pedagogical approach that translated into more questions being asked to students that did not lead to or guide them towards a single valid answer, and in creating more open-ended work that spurred diverse outcomes. For some teachers, this came with the realisation that controlling much of the outcome was "safe teaching", but often not conducive to student ownership of learning or to higher level thinking skills. Teachers reported that students were excited to take part in learning activities where their ideas could be heard, instead of just answering a question. Many teacher testimonials describe the redesigned lesson plans as empowering for students.

In the Russian team, project co-ordinators noted that the main change triggered by the intervention was an alteration of teaching styles, which became less directive and authoritative than usual and led teachers to engage more often in discussions with students. Co-ordinators linked this to the pedagogical activities tested during the project, while wondering whether these behaviours could spill over to more conventionally structured lessons.

In the Thai team, teachers described their role in the project activities as facilitating student conversations and reminding the class about the real objective of the lessons, rather than guiding student thinking. Many teachers thought that this established a more respectful and mature relationship with students that was not part of their teaching culture. In the same vein, a student testimonial describes the regular classes as "all about teachers' perspective", while "activities with the new format let us think by ourselves".

In the Hungarian team, teachers' evaluations underlined the introduction of new ways of working, talking, thinking and assessing in the classroom. The most successful lessons used space both within and outside the classroom in flexible ways and involved physical activity for children, which resulted in improved concentration. They also consistently included time for effective reflection, allowing children to elaborate about elements of the work done in smaller groups for the benefit of the whole class, and ensuring that teachers had a good grasp of how much learning had taken place and of any concepts that would need to be reinforced later. Teachers and supporting creative practitioners also stressed that the lessons they planned and delivered together challenged students to negotiate both within and between groups in order to solve problems collaboratively.

The innovative lesson plans and activities proposed during the intervention also required students to adapt their learning strategies. This adaptation was not without difficulties and took time. Several teams reported that students felt confused about tasks without a single correct answer. They also were sometimes frustrated as they were asked to devote more time to planning and reflection than they were used to. Over time, however, reports suggest that students became more autonomous in their learning and felt more comfortable with student-centred activities. A gradual transition to new teaching practices through small adjustments of existing practices therefore needs to accommodate both teachers' and students' learning curves. Several teams encouraged such a strategy of incremental changes: rather than modifying the whole structure of their lesson plans, teachers started by introducing minor adaptations to their lesson plans, for instance by including a space at the end of the lesson for students to reflect on their work. These small changes can be the starting point for new teaching and learning practices where students take greater ownership of the learning process, including in a collective way

Key insights

The teacher-friendly framework and exemplar lesson plans developed during the project helped teachers to embed creativity and critical thinking into everyday teaching.

The OECD succeeded in providing a teacher-usable framework for the design of learning experiences that promote students' creativity and critical thinking alongside subject-specific content and skills. The core elements of this framework are a set of rubrics and design criteria for lesson plans. In both their domain-generic and domain-specific versions, the rubrics provide a teacher-friendly language to describe the behaviours and thought processes in which learners engage as they apply their creativity and critical thinking skills. The rubrics distinguish four sub-dimensions that underlie both creative and critical thinking processes, namely inquiring, imagining, doing and reflecting. The design criteria further to assist teachers in the adaptation of existing, or the creation of new, lesson plans that embed opportunities for students to use their creativity and critical thinking skills while working on curricular content. By complementing the concepts of the rubric, the criteria provide more pedagogical guidance for teachers to visualise other features of classroom activities that invite thought processes and outputs requiring creativity and critical thinking. The criteria seek to align lesson plans with many of the principles of effective learning established by research in the learning sciences, including motivation, cognitive activation, self-regulation and opportunities for formative assessment.

Within this framework, teachers and experts in teams across 11 countries developed close to 100 lesson plans in different domains with a focus on creativity and critical thinking. These work units can inspire teachers internationally by making visible the kind of approaches and tasks that place creativity and critical thinking as learning goals compatible with the delivery of content knowledge across the curriculum. These activities propose a variety of teaching techniques without prescribing any particular pedagogical approach, therefore showing that teaching for creativity and critical thinking can encompass a wide range of instruction methods. However, the experience of project participants highlights that the successful implementation of lesson plans hinges critically on creating non-threatening environments where students feel safe to take risks in their thinking and expressions, which in turn presupposes a positive attitude towards mistakes and learner empowerment on the part of teachers.

Creativity and critical thinking have domain-specific applications, but can be fostered in all disciplines through the right type of tasks

Different disciplines offer different opportunities for the development of creativity and critical thinking. Indeed, the lesson plans developed in the course of the project show that creativity and critical thinking look differently across disciplines and that there are discipline-specific tasks to develop these skills. However, while bringing to light the domain-specificity of creativity and critical thinking, the materials developed during the project show that tasks to train and demonstrate creativity and critical thinking skills in education share some general features. These tasks are engaging and have a deliberate open nature where students are encouraged to explore multiple solutions to problems within parameters that clarify goals and yet remains relatively flexible with regard to the concept space and techniques that students can call into action. Exemplar lesson plans remain anchored in relevant subject content while posing complex problems that make students stretch their perspective to solve them. Importantly, as they are found across the four main subjects of the intervention – science, mathematics, visual arts and music – they clearly show that creativity and critical thinking are not the monopoly of specific disciplines; neither are the arts the sole territory of creativity nor science and maths the only way to stimulate critical thinking.

For most teachers and students, focusing on creativity and critical thinking required a challenging redefinition of roles

The experiences of teams in different countries reveal that both teachers and students were challenged by the setting of creativity and critical thinking as explicit learning goals and the implementation of new teaching and assessment approaches.

Feedback from teachers clearly indicated that the intervention required them to depart from more traditional and "safe" teaching practices, and specifically from scenarios where teachers could easily anticipate or shape students' thinking processes and outputs. At the same time, many teachers were challenged by the need to describe newly expected learning outcomes to students in a clear and articulate manner – and to plan teaching and learning sequences accordingly. A recurrent theme in teachers' reflections was how teaching for creativity and critical thinking, at least as formulated in the framework of the project, required them to achieve a greater balance between structure and openness in their teaching. Similarly, students needed to adapt their learning strategies, and many of them felt confused as activities eliminated the certainty that comes with single-solution problems.

This points to the importance of teachers' pedagogical knowledge of and confidence in using certain teaching and learning methods as a key part of what is needed to cultivate learners who can think more creatively and critically. These are methods which enable students to become engaged in challenging real-world problems, take ownership of their learning, co-design materials, be playful and open-minded, take risks, and reflect on the processes of their thinking. Teachers' content knowledge remains another key component of the professional competence needed to teach for creativity and critical thinking. For mathematics teachers, for example, being able to present students with problems that can be solved in different ways (e.g. using different methods to solve a quadratic equation or to find a square root) implies that teachers themselves know about the existence of these different methods. Teachers will draw on content knowledge to anticipate students' responses and to make sense of the solutions that they had not anticipated. Preparing teachers for the delivery of these skills might thus imply not only providing them with training on general pedagogical methods, but also making sure that they have a strong technical competence in the domain that will enable them to effectively guide learning within the boundaries set by student-centred tasks.

Notes

1) The OECD Learning Framework 2030 stresses these interconnections through the concept of competency, which involves the joint mobilisation of knowledge, skills, attitudes and values to meet complex demands. The framework puts the focus on how these elements interact and can develop simultaneously rather than in competition with each other. The framework distinguishes various forms of knowledge. Disciplinary knowledge remains important as the raw material from which new knowledge is developed, together with the capacity to think across the boundaries of disciplines. Epistemic knowledge, such as knowing how to think like a mathematician, historian or scientist, also enables students to extend their disciplinary knowledge. Procedural knowledge, in turn, involves understanding the series of steps or actions taken to accomplish a goal; some procedural knowledge is domain-specific, some is transferable across domains. The framework also posits that, for applying their knowledge in unknown and evolving circumstances, students need a broad range of skills, including cognitive and higher order skills (e.g. creative thinking, critical thinking or learning to learn); social and emotional skills (e.g. empathy, self-efficacy or collaboration); and practical and physical skills (e.g. using new technology devices). The use of this broader set of knowledge and skills is in turn mediated by attitudes and values (e.g. motivation, trust or respect for diversity).

2) See https://tinyurl.com/oecd-ceri-cct

3) As of September 2019, out of a total of 106 activities, 63 had been developed by teachers and local team co ordinators, 36 had been commissioned to experts, and 7 had been developed by the OECD-CERI team and experts.

4) The peer review involved 27 teachers and researchers from 9 countries. On average, each lesson plan was reviewed by two reviewers. An evaluation grid was designed which operationalised the design criteria defining good lesson plans. Evaluators were asked to score multiple criteria on a four-point Likert scale. They were also encouraged to provide comments on how they would improve the lesson plans. The results reveal that evaluators considered most of the lesson plans to be of good quality and to fulfil the criteria of the evaluation grid. On a scale from 1 to 4, the average score was 3.2, with 75% of the lesson plans receiving an average score above 3. Across subjects and evaluation criteria, average scores were all in the range 2.5-3.5, with science activities and the usability criterion receiving lower average scores than other categories. Suggestions for changes from the peer review were used to further develop the lesson plans..

5) This categorisation took into account, for instance, whether lesson plans included a substantial production component that required students to take decisions when guidelines given by teachers allow multiple courses of action or lines of thought.

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Chapter 5

Teacher professional development plans

This chapter discusses the undertakings and experiences of the different teams taking part in the OECD-CERI project with regard to the development of teachers' ability to foster and assess creativity and critical thinking. Local team co-ordinators relied on three types of measures to design their professional development strategies: teacher training, individual follow-up, peer dialogue and collaboration. Seeking support from school and system leaders was also key to provide teachers with good conditions for professional learning. The extent to which teams relied on these measures varied as their relevance and effectiveness depended on the specificities of local contexts.

Introduction

Changing teaching practices requires some support. All country teams participating in the OECD-CERI project were requested to have a minimal professional development plan, and were encouraged to support teachers throughout the implementation of the project. Most of them seized this opportunity and documented how they supported the professional learning of the participating teachers.

This chapter presents and reflects on the strategies they have developed to enhance teachers' ability to foster and assess creativity and critical thinking in the classroom. Adapted to their context, those professional development strategies were very different from one team to the other. As participants had a large degree of freedom to design their strategies, the variability allows several preliminary lessons to be drawn.

This chapter builds on reports prepared by team co-ordinators to provide contextual information on their experience with the project as well as qualitative findings arising from their own observations and from participants' feedback (teachers, school and system leaders, or students). After discussing the professional development measures implemented by teams participating in the project, it highlights the main lessons from the teacher professional development plans implemented by the country teams to support participating teachers to foster their students' creativity and critical thinking.

Teacher professional development plans: the key ingredients

During the OECD-CERI project, country teams implemented strategies for the professional development of teachers to foster creativity and critical thinking in the classroom based on several measures. At a minimum, teams were required to introduce the project materials, objectives and suggested pedagogical approaches to teachers by organising a one-day induction training session at the beginning of the project. Apart from this common condition, co-ordinators were free to design the professional development plans of their choice depending on their interests, capacity and local context.

The large majority of local team co-ordinators opted for more extensive professional development plans than the minimum requirement. In addition to introducing the project's ideas and tools, they designed strategies to support teachers in implementing new pedagogical activities in the classroom and stimulate reflection on their professional practice.

As part of their professional development plans, local team co-ordinators relied on three types of professional development measures: training, individual follow-up, and peer dialogue. A fourth key element of their strategy was to seek support from school and system leaders, a favourable condition for the implementation of the three other measures.

The different aspects of the team professional development plans are discussed in the next sections. Illustrations of specific practices implemented by teams during the intervention complement the discussion with practical examples drawn from the experience of different teams with the project.

Training

The literature on teacher professional development emphasises that training programmes are useful to formally provide teachers with the knowledge necessary to enhance their professional skills (Hoban and Erickson, 2004[1]). Yet, this measure is also criticised for considering teachers as passive recipients of knowledge rather than active contributors to their own professional development, and for being too disconnected from teachers' everyday practices (Avalos, 2011[2]; Clarke and Hollingsworth, 2002[3]; Borko, 2007[4]). In that respect, critics call for the design of training programmes that are embedded in teachers' daily work and immediate context (Opfer, 2016[5]; Kraft, Blazar and Hogan, 2018[6]; OECD, 2019[7]).

In the frame of a project about changing one's teaching practice, teachers can immediately practice or try to implement the learning of the training, so that the training remains close to teachers' daily practice. Most teams develop training programmes that were closely connected to teachers' professional reality and useful to enhance their ability to foster creativity and critical thinking in the classroom. However, training programmes implemented by teams differed with regard to their format, their intensity and frequency, their approach to teachers' learning and their activities.

Different training formats for different contexts

Training programmes were a central component of all professional development plans implemented in the framework of the OECD-CERI project. However, the format of training programmes differed greatly between teams. Some relied on a unique induction session held before the start of the intervention, while others organised multiple training sessions during the project. The purpose of induction sessions was to introduce the project to teachers, raise their awareness of its goals and provide them with the information necessary to ensure a proper implementation of the intervention. Additional training sessions sought to further expand teachers' understanding of approaches or methods that could help them to translate the goals of the project in their teaching practices.

Induction sessions can be an appropriate solution for the professional development of teachers when they already have a strong motivation to change their teaching, as well as a solid knowledge base on the practices to implement. However, in practice induction sessions alone were seldom sufficient to fulfil the professional development needs of the project. The goals of the intervention were often new to teachers, as well as rubrics as a pedagogical tool and some of the related practices. A unique session could spark interest but would usually not lead to teachers taking ownership of the ideas and use the rubrics, unless some other opportunities for learning were provided. Usually, teams that implemented a unique session on creativity and critical thinking were implementing a signature pedagogy for which teachers would be accompanied (see Chapter 3 for a more detailed discussion of signature pedagogies). However, training was most valuable when it consisted of several sessions held at regular intervals and continued to include a focus on the creativity, critical thinking and the project materials.

During the project, training programmes proved meaningful in two main respects. On the one hand, they were useful to introduce the ideas of creativity and critical thinking and the project materials to teachers. On the other hand, they provided teachers with opportunities to actively explore new pedagogical approaches and reflect on their teaching.

Taking ownership of the project's ideas and tools

In the majority of participating teams, the ideas of creativity and critical thinking were introduced to teachers using the OECD rubric and the set of pedagogical activities that were initially developed. In a few cases, the "five creative habits of mind" rubric (Lucas, Claxton and Spencer, 2013[8]) was used instead of the OECD rubric. Team co-ordinators also used different types of supplementary tools or approaches to guide teachers and make them envision a classroom in which students develop their creativity or their critical thinking, such as the "high functioning classroom" model (CCE, 2012[9]). Teams therefore trained and accompanied teachers to master the rubric (or the alternative tool) for various educational purposes: to adapt and design pedagogical activities, to make the concepts of creativity and critical thinking explicit for students, to undertake summative or formative assessments, etc. (see Chapter 2 for a more detailed discussion of the rubrics).

The process of acquainting teachers with the rubric and its implication for professional practice was challenging and often gradual. Several teams followed a systematic approach to foster teachers' acquisition of knowledge. At first, they introduced small changes in teachers' practices. In some teams, teachers worked on short pedagogical activities designed by external experts and tried out a range of new practices in the classroom to identify what worked best with their students. Other teams chose to start from school textbooks and progressively introduce changes into existing lessons. As teachers' understanding of the project improved, changes became increasingly substantial until they could design entirely new lesson plans. Although these mechanisms did not rapidly translate into a significant transformation of teaching practices, co-ordinators reported that they were helpful to secure participants' acquisition of new knowledge to innovate in their teaching. Gradual approaches to ensure teacher mastery of the new tools provided by or developed during the project are illustrated in Box 5.1, with examples of plans developed by teams in Brazil and the Netherlands.

Box 5.1. Plans and actions to introduce the project's ideas and tools to teachers in Brazil and the Netherlands

At the beginning of the project, most teachers in the Brazilian team had limited explicit reflection about how to foster students' creativity and critical thinking. The use of rubrics for teaching and assessment was also new to them. To address this challenge, co-ordinators chose to implement a professional development strategy inducing a slow-paced learning process, advancing step-by-step and starting with making minor changes to existing activities to get teachers accustomed with the innovative methods and secure their engagement.

Second, they developed a range of support material (booklets, video clips, etc.) to help teachers take ownership of the rubric and the innovative approaches promoted by the project. Third, since the principle of the rubric as a tool for formative assessment was new to teachers, they were invited to experiment with this method during training sessions through exercises on stylised rubrics specifically created for that purpose. Co-ordinators reported that this process proved very useful to build teachers' comprehension of the project's tools and methods.

In the Netherlands, although teachers already had some experience with the teaching approaches put forward by the project, the methods of the project and the rubrics were still new to them. Co-ordinators therefore planned the intervention as a system of steps intended to support teachers' acquisition of new knowledge and tools.

During the first training session, the rubric was introduced through an interactive workshop during which teachers engaged in discussions on some fundamental questions of the project such as: Are creativity and critical thinking complex skills? Can they be taught in school settings? Do they have levels of progression? etc. This discussion allowed teachers to start taking ownership of the goals of the project and question several preconceived ideas they had on creativity and critical thinking.

Thereafter, co-ordinators structured the intervention into three main stages to facilitate the progressive development of teachers' professional abilities to implement new practices. At first, teachers implemented lesson plans developed by education specialists. In a second stage, they designed new activities based on a common theme. The goal was to preserve some degree of comparability between activities to facilitate discussion and collective reflection during training sessions. In the third stage, teachers were invited to develop new activities with complete pedagogical freedom (i.e. theme not imposed). After each stage, teachers had the opportunity to reflect on their practices with the help of external experts.

Lectures and workshops

The type of training activities was a third important aspect of training programmes. Training sessions could either take the form of lecture courses or collaborative workshops. While the lecture-type instructional methods were sometimes preferred for induction sessions, follow up training sessions generally consisted of workshops.

Lecture courses were useful to transmit the project's ideas and tools to teachers. Yet, teams reported that most teachers had difficulties envisioning how these could translate into their teaching practices. In that respect, interactive workshops requiring teachers to engage in discussion and collaboration proved particularly useful. Besides encouraging engagement in learning, interactive workshops stimulated peer exchange and teachers' reflection on their teaching practices. In order to create the best conditions for dialogue, some teams divided participants into small working groups. This allowed everyone the opportunity to take part actively in the workshops and to work with peers teaching similar subjects at a similar educational level.

Several teams managed to trigger teachers' participation in their learning by designing appropriate training activities. The scheme implemented in Spain, described in Box 5.2, provides a good illustration of a training programme that fostered teachers' active exploration of new pedagogical approaches and reflection on their professional practice.

Box 5.2. Linking content to professional practice and collaborative workshops to foster teachers' active learning in Spain

The training programme implemented in Spain consisted of five training sessions spread throughout the intervention. Its central focus was the development of pedagogical activities and their implementation in the classroom. After each training session, teachers were given assignments to prepare at home and to experiment with their students. Once completed, the trainer used the results of assignments to design the next training session. The trainer thereby started each session by presenting the main problems encountered by teachers in their assignments as well as successful strategies to overcome them before introducing the next steps of the work. This way, training was embedded in teachers' professional practices and the successive stages allowed for a gradual improvement of their professional skills.

Furthermore, co-ordinators reported that an unanticipated shift occurred during the third training session when the trainer gave every teacher ten minutes to present their experience with the implementation of pedagogical activities to foster creativity and critical thinking in their classroom. After each presentation, other participant teachers gave feedback to the presenters, highlighted the successful accomplishments and suggested areas for improvement. This scheme encouraged teachers to share their views on effective practices and problems faced while getting inspiration from comparable experiences. The trainer subsequently observed an improvement in the quality of teachers' activities between those who attended the third training session and those who did not. In view of this result, the trainer decided to repeat the collaborative process during the following training sessions.

Individual follow-up

During the project, individual follow-up consisted of several mechanisms to support and mentor teachers in the delivery of new lessons making more space for students' creativity and critical thinking. Overall, the aims of individual follow-up measures were aligned with those of the training activities: to sustain teachers' awareness and motivation for the intervention on the one hand, and to extend their understanding of the goals of the project and the ways to reach them, on the other. Nonetheless, follow-up activities differed from training sessions, as they were continuous rather than occasional. Moreover, they focused on teachers individually, not as a group. In this regard, individual follow-up provided teachers with opportunities for continuous and personalised learning. Finally, they usually took place in teachers' schools, which was seldom the case of the trainings.

Different structures for teacher follow-up

The intensity and conditions of individual follow-up varied across teams. At a minimum, co ordinators communicated with teachers remotely and upon request. In the majority of teams, however, teacher follow-up was more structured. Some took advantage of the qualitative data collection protocol of the project to conduct interviews and classroom observations and provide teachers with guidance on their teaching. A number of teams also followed and supported teachers through online platforms.

A valuable measure implemented in teams comprising a large number of teachers was the recruitment of facilitators to follow-up with teachers. These facilitators were often teacher trainers or school-based pedagogical counsellors. They provided teachers with feedback and acted as intermediaries bridging the gap between teachers on the one hand and co ordinators and system authorities on the other.

The profile and background of professionals in charge of teacher follow-up was an important aspect of these measures. Individual follow-up was particularly beneficial when undertaken by stakeholders from outside the school context. With such external support, teachers not only conferred with colleagues sharing a similar mindset, but were also challenged to adopt new ways of working. Moreover, they had access to specialist expertise they would not have benefited from otherwise. Box 5.3 provides several examples of measures implemented by teams during the project for the follow-up of teachers by external stakeholders.

Box 5.3. The accompaniment of teachers in Hungary, India, the Netherlands and Wales

Several teams participating in the project provided individual follow-up to teachers. The Indian team, for example, collaborated with experts from the National Council of Educational Research and Training (NCERT). At first, these experts designed pedagogical activities for teachers to work with in the classroom. In the following stages, NCERT experts accompanied teachers individually in the development of new activities to foster student's creativity and critical thinking.

In the Netherlands, local team co-ordinators ensured that every teacher had two dedicated contact persons: a researcher from the co-ordinating team and an expert in didactics in their field (mathematics, sciences or visual arts). This mentoring scheme provided teachers with individual guidance on aspects related to both the specific goals and activities of the project, as well as to the appropriateness of their teaching practices as a whole.

In Wales and in Hungary, the accompaniment of teachers was at the core of the professional development strategy. The intervention was structured around the close collaboration between teachers and artists directly within the classroom to implement innovative pedagogical activities. External educational facilitators oversaw this collaboration and made sure that the intervention remained aligned with the fundamental purposes of instruction. The presence of artists allowed new ways of working to be introduced in participating schools and gave teachers the opportunity to develop their creative skills. The confrontation between the professional norms of teachers and artists also led to teachers' reflection on their professional practice and fostered learning. There was indeed a clear division of labour in the strategy adopted by these teams such that the artist remains an artist and does not act as a substitute for the teacher.

Responding to teachers' individual needs

Individual follow-up provided teachers with opportunities for personalised learning and guidance adapted to their own situation and needs. In some teams, individual follow-up allowed teachers to acquire additional knowledge and methods that were not directly part of the project's tools and approaches but that proved valuable to foster students' creativity and critical thinking. For example, a number of teams accompanied teachers in the improvement of their instructional and classroom management skills, which in turn enhanced their capacity to implement new teaching practices. As illustrated in Box 5.4, such methods can be useful to foster creativity and critical thinking in the classroom.

Box 5.4. Fostering instructional and classroom management skill in the Netherlands and Thailand

During the project, a number of teams built on the development of teachers' instructional and classroom management skills as a way to enhance their confidence and ability to try new teaching approaches. These skills gave teachers the capacity to set clear learning goals, establish a teaching strategy to reach them, recognise successes and failures, and identify areas for improvement. The examples of Thailand and the Netherlands are particularly interesting as local co-ordinators reported significant advances in teachers' professional ability to foster creativity and critical thinking after perfecting more generic teaching methods. In both countries, the resources of the pedagogical toolkit, namely the rubrics and pedagogical activities, were at the centre of this process.

The Thai team implemented an extensive training and follow-up plan to strengthen teachers' understanding of the meaning and potential uses of the rubric. Co-ordinators emphasised that this process ultimately provided teachers with more rules and procedures through which they developed the habit of setting learning goals with students and implementing a system of steps to reach these goals. In addition, participating teachers reported that experimenting with new teaching approaches using the rubrics enhanced their satisfaction and confidence with their work.

In the Netherlands, the development of teachers' instructional and classroom management skills occurred through the implementation of new activities designed by external experts in the classroom followed by subsequent reflection on their teaching. According to teachers, particularly those in the visual arts, the new activities were an "eye opener", as the tools and methods promoted to foster creativity and critical thinking equipped them with more knowledge to guide student learning, and increase the structure in their teaching. By putting the new approaches into practice, teachers enhanced their ability to set clear learning goals in advance, to provide students with specific milestones in their learning, and to connect these to relevant teaching methods and activities.

The benefits of strengthening instructional and classroom management skills extend beyond fostering students' creativity and critical thinking. By the end of the intervention, participating teachers in Thailand and the Netherlands reported that they had developed a better understanding of how to nurture the learning process by adopting these teaching techniques in all their practices.

Individual follow-up likely had a significant impact on the professional development of teachers. This was particularly emphasised by teams in which teachers were less familiar with the goals and practices promoted by the project. In such circumstances, co-ordinators often reported that teachers needed to be both motivated and mentored to assimilate the new concepts, handle the pedagogical toolkit of the project and implement new teaching practices. To that end, close accompaniment of teachers in their daily practices proved valuable as a supplement to training sessions that, by nature, could not ensure the same continuous development of their professional abilities.

Peer dialogue

The participation of teachers in professional networks through which they can discuss and share ideas with their peers has been identified in the literature as an innovative and highly effective form of professional development (Trust, Krutka and Carpenter, 2016[10]; Bolam et al., 2005[11]; OECD, 2019[7]). Within collaborative networks, peer dialogue allows teachers to collectively advance their knowledge, provide each other with support that is appropriate to their needs and collaborate to innovate in their practices (Paniagua and Istance, 2018[12]).

During the OECD-CERI project, the support teachers benefited from peer dialogue was similar to the one provided by individual follow-up as it was continuous and personalised. In contrast, this support did not come from stakeholders from outside the profession, but from teacher colleagues. It thus constituted a useful complement to follow up by external experts as it allowed teachers to share and acquire more tacit types of knowledge that were directly related to their professional practice and context.

Local teams relied on different means to promote peer dialogue. In all cases, these strategies proved useful to provide teachers with support and foster their engagement in the project.

Different ways to stimulate peer dialogue

Teams participating in the project encouraged peer dialogue in different ways. Some used training sessions as a forum for discussion allowing teachers to collaborate and exchange ideas. Others encouraged collaboration between teachers working in the same school or site through local meetings and workshops to design new pedagogical activities. In a few cases, intra-school peer dialogue emerged spontaneously as teachers collaborated to develop new teaching activities. This phenomenon even reached teachers who were not involved in the project through a contagion effect from the innovative practices of teachers participating in the intervention.

A number of teams also relied on virtual platforms as a tool for communication and collaboration among teachers. Web-based technologies offered new opportunities for peer dialogue, in particular when participants were geographically far apart from each other.

In advanced stages, peer dialogue and collaboration can lead to the emergence of professional learning communities. These are highly interactive communities where teachers meet or connect regularly to exchange ideas, solve problems and collaborate on teaching strategies. Box 5.5 describes measures implemented by the Brazilian team to promote the emergence of a professional learning community.

Box 5.5. Promoting the emergence of a professional learning community in Brazil

Peer dialogue and collaboration were systematically encouraged through most of the activities for professional development implemented by the Brazilian team. Training sessions, for example, were organised in the form of hands-on workshops during which teachers collaborated on adapting the rubric or designing pedagogical activities.

In addition, co-ordinators built up a network of facilitators, called "multipliers", to foster collaboration between teachers. At the beginning of the intervention, multipliers organised workshops within schools to disseminate information about the project. As teachers started to implement new practices, multipliers observed lessons, exchanged with teachers and principals, and took note of their actions. By visiting more and more schools, they became able to identify best practices and share them among teachers from different sites.

In the following stages, multipliers invited teachers to present their experience to their peers in other schools when they identified good opportunities for knowledge exchange. This exercise scaled-up the process as more and more teachers, after seeing examples of presentations, asked to present and discuss their own experiences. In the words of the project co-ordinators, teachers became "energised" and a "contagious growth mindset was spread among the group". According to co-ordinators, multipliers played a key role in the process of building a professional learning community across schools.

Lastly, co-ordinators developed an online platform to promote collaboration between participants. They invited teachers, school authorities and multipliers to post ideas, material and questions on the platform and to provide other users with answers, comments and feedback on their requests. At the beginning, co-ordinators and multipliers provided most of the user inputs on the online platform. As the intervention moved forward, teachers developed the habit of sharing practices and giving each other feedback, thereby diminishing the dependence of the platform on the co-ordinating team.

Supporting teachers and fostering engagement

In several teams, peer dialogue provided teachers with both practical and emotional support. From the practical point of view, peer dialogue allowed teachers to find solutions to common problems as well as to share knowledge, experience and best practices. It also helped to challenge preconceived ideas and negative assumptions by confronting teachers with evidence grounded in their professional reality. From the emotional point of view, peer dialogue enabled teachers to overcome natural fears or embarrassment when facing new approaches and adopting less familiar practices.

Peer dialogue also proved valuable to foster teacher learning and to facilitate reflection on their teaching. Box 5.6 illustrates the experience of the Vista District team (United States) where peer dialogue gave rise to an advanced process of collective reflection.

Box 5.6. Peer dialogue to foster collective reflection among teachers in the Vista District (United States)

Collective reflection on teaching practices was an important driver of teacher professional development in most of the teams participating in the project. To that end, co-ordinators often used the pedagogical toolkit – the rubrics and activities – to ask teachers to reconsider their teaching practices and challenge some of their professional routines. In this regard, the experience of the Vista District team was particularly interesting.

In the Vista District, teachers' reflection was originally stimulated by their hesitation to work with the international rubric, which they did not perceive as an operational framework with direct applicability in their teaching context. Interestingly, this situation did not translate into a low engagement in the project. Rather, it sparked discussion among teachers who ultimately designed their own set of rubrics, which they called "continuums". These locally adapted rubrics were then used to develop new teaching activities and to assess students. Once activities had been implemented in the classroom, student work was collected and reflected upon during meetings. The goal was to identify, within the lessons, the elements making student thinking concrete and visible and, thereby, to find ways to improve teaching practices. Subsequently, "continuums" were again discussed and refined based on the lessons learnt.

According to co-ordinators, the project gave rise to a gradual shift in teachers' mindset. The collective development and application of "continuums" drove their professional development by stimulating them to think and develop a deeper understanding of creativity and critical thinking, to relate this reflection to their own teaching practices, and to determine how to cultivate these skills with different learners.

Although measures stimulating peer dialogue can prove very interesting for the professional development of teachers, they often need to be closely monitored. Several team co-ordinators highlighted the necessity to take into account the emotional dimension of teachers' engagement in the intervention and paid much attention to providing teachers with a positive, respectful and caring environment. They pointed out the importance of preserving, throughout the intervention, teachers' inclination to share ideas and support each other by building a respectful model of interaction in which they can openly discuss without fear of being judged. Creating these conditions required continued efforts from local team co-ordinators.

Support from school and system leaders

A substantial body of literature has recognised the importance of support from school and system leaders for the professional development of teachers. These stakeholders have the ability to create a culture of innovation within schools and systems, as well as to break down barriers to teacher professional development (Darling-Hammond and McLaughlin, 1995[13]; Day et al., 2010[14]; OECD, 2018[15]; OECD, 2019[7]).

During the project, most of the teams reported that support from school and system leaders represented at least an important precondition – and at best a powerful lever – for the professional development of teachers. The level of support from educational leaders determined the amount of resources (time, funding, administrative support, etc.) and the potential incentives provided to teachers who engaged in the pedagogical intervention.

Teachers in participating teams benefited from varying levels of support from the school administrations. At a minimum, school principals were informed about the intervention and gave their approval for its implementation. In several teams, school and system authorities committed beyond providing a mere agreement to actively supporting the project. Some team co-ordinators actively sought support from school and system leaders by involving them in the planning and local implementation of the project. As illustrated in Box 5.7, the experience of the Brazilian team provides a good example of this type of initiative.

The support from educational leaders sometimes led to the introduction of incentives to foster teachers' engagement in the project. These incentives took various forms. Some team co ordinators offered financial compensation for the extra time teachers invested in the project. Others provided a budgetary incentive for participating classes to fund a class outing of their choice. In a third instance, co-ordinators delivered a certificate of professional development to participating teachers at the end of the intervention.

Although incentives can be useful, the project also showed that they are not a panacea to foster the engagement of schools and teachers in an innovative intervention. Several teams reported that trust-based relationships and a tradition of co-operation between co-ordinators and schools proved to be a more influential driver of school participation than financial incentives.

Similar observations were made with respect to teachers. In the teams that offered an equal financial incentive to all participants, teachers' propensity to innovate in their teaching nonetheless differed. Highly motivated teachers spontaneously became group leaders, designed their own lesson plans and played a central role during collaborative activities. On the other side, several teachers participated less actively during group work and only implemented pedagogical activities designed by external experts. Although this observation is not surprising, it highlights the importance of teachers' intrinsic motivation for the success of innovative pedagogical interventions.

Box 5.7. Engaging school and system leadership in Brazil

In Brazil, the implementation of the project was led by a non-governmental association active in the field of education, the Ayrton Senna Institute (Instituto Ayrton Senna, IAS), in partnership with the state and municipal departments of education and the state's industry federation.

As part of their strategy to facilitate the implementation of the intervention and the professional development of teachers, IAS co-ordinators sought to ensure a large amount of support from educational leaders through active communication and exchanges. They organised meeting and school visits with education authorities from different levels – from heads of schools to regional administrations – to prepare the implementation of the project, plan training sessions for teachers, analyse the results and discuss areas for improvement.

In some schools, the engagement of principals had a large impact on the intervention as they promoted the project, shared documentation, organised professional development workshops and provided regular assistance to solve practical issues. Regional educational leaders were also convinced by the new approaches. By the end of the project, they were considering ways to initiate a transformation of the whole evaluation system toward more formative assessment, and to integrate the use of rubrics in other teaching practices.

Overall, the project showed that teacher professional development benefited from active communication with school and/or system leaders to ensure their understanding of the goals of the project, their engagement in the process of change and their support toward teachers. At a minimum, teachers should get from their hierarchy the approval and the practical ability to engage in this type of project. Optimally, this support should translate into the implementation of specific measures to ensure that teachers have the right incentives and the best working conditions to foster their students' creative and critical thinking skills.

Lessons learnt

Several lessons can be learnt from the strategies that the participating country teams developed to advance teachers' abilities to foster creativity and critical thinking.

The first is that providing teachers with professional learning opportunities beyond the project materials (rubrics and lesson plans) is essential. In a sense, pedagogical resources are also key to professional change, but probably just a second best solution to support teachers compared to face-to-face training and learning opportunities.

A second lesson is that professional development plans can take many forms, depending on the teaching standards, beliefs of the teachers, but also support of school and systems leaders to the project. Country teams shaped their professional development based on three key elements: training sessions, individual follow-up with teachers, and opportunities for peer dialogue. Overall, four types of strategies were adopted. The first approach was limited to an induction session presenting the project ideas and tools to the participating teachers. The second approach consisted of a series of four to five one-day training sessions, providing room for teachers to further their understanding of how to foster their students creativity and critical thinking, but also to discuss how they tried to do it in practice in their classroom. The third approach added to the training sessions an individual follow-up of teachers, with experts visiting them at regular intervals to give them feedback and foster self-reflection on their practices. The fourth approach added to training sessions and follow-up mechanisms several measures to build a professional learning community. These included school-based meetings to design new activities and reflect on professional practice, school visits during which teachers discussed their modified lessons (or lesson plans) with their peers from other schools, and the development of a digital platform that would allow pedagogical facilitators and teachers to discuss their practice.

All those approaches have their benefits and their implementation partly depends on the budget available to teams, but it is noteworthy that none of them was particularly expensive. The only approach that was arguably not very effective was to limit professional development to an induction training session. While this could work with expert teachers who are very motivated, the competition of multiple other tasks usually made this approach less effective in sustaining teachers' engagement with the project ideas and materials.

Changing one's teaching practices takes time and is difficult. The appropriate duration of professional development programmes depends on teachers' initial understanding of the practices promoted by the project. However, most of the teams reported that a period of six months was seldom sufficient to develop teacher professional skills to foster their students' creativity and critical thinking. Moreover, teams that implemented two rounds of intervention highlighted that the second round continued to bring about important benefits for teachers' learning.

Several elements of the teacher professional development plans could be highlighted as interesting practice:

1. Adopting a gradual strategy seems to have led to a stronger engagement of teachers. For example, several teams participating in the project chose to "start small" by inviting teachers to implement minor changes in their teaching or experiment with activities designed by external experts. This process helped to keep teachers involved in the project and to encourage their professional development.

2. Relying on peer dialogue to provide teachers with support and feedback can be a powerful strategy to develop their professional abilities to foster creativity and critical thinking. During the OECD-CERI project, teams used several means to promote such a dynamic, in particular physical and online platforms to foster peer dialogue. Online platforms were useful to provide participants with flexibility to communicate and collaborate. Yet, they were always part of broader systems designed to facilitate collaboration among teachers through joint lesson design, collective reflection and other means.

3. Measures to enhance teachers' ability to foster creativity and critical thinking are not necessarily specific to this particular goal. Likewise, the benefits of professional development activities implemented during the project extended beyond teachers' capacity to foster creativity and critical thinking. For example, the acquisition of instructional and classroom management skills proved valuable to advance teachers' capacity to implement new pedagogies, assess the outcomes of their teaching and improve their professional practice. Such generic competences have the potential to benefit other types of teaching goals or practices.

The practical application of the new teaching approaches is where the learning happens the most. As teachers reflecting on their experience with the project reported, the improvement of their professional skills came mainly from "practicing in the classroom". Practice also appeared to stimulate teachers' self-efficacy and motivation. A number of teams reported that teachers' views and beliefs evolved markedly after acknowledging – sometimes with surprise – the change in students' results, behaviour and enthusiasm with learning. Wherever teachers perceived that pupils appeared to learn better and to have more pleasure in their work, these positive outcomes, especially when obtained with underperforming children or with students with behavioural disruptions, led to an increase in teachers' motivation and desire to continue working with the new teaching practices.

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Chapter 6

Teacher attitudes and practices around creativity and critical thinking

By drawing on questionnaire data and qualitative feedback from teams in 11 countries, this chapter explores beliefs and behaviours around creativity and critical thinking among teachers participating in the OECD-CERI project. Do these teachers feel prepared for nurturing creativity and critical thinking in their students? Do they share an understanding of how these skills materialise in school settings, and of how they translate into the language of specific subject areas? Do they have practical ways of assessing student creativity and critical thinking? To what extent do curricula and teaching workloads allow them to innovate towards these goals?

Introduction

Teachers are key to the success of any educational innovation. For creativity and critical thinking to be at centre stage in educational practice, teachers have to embrace and own this agenda. This is why teachers played a central role in the theory of action of the OECD-CERI project on fostering and assessing creativity and critical thinking skills in education. The project sought to gain a better understanding of what teachers believe and do when they teach for creativity and critical thinking, and to align their attitudes and practices with the evidence base on effective ways to foster these skills in the classroom.

By drawing on questionnaire data and qualitative feedback from teams in 11 countries, this chapter explores questions about participant teachers' beliefs and behaviours. Do they feel prepared for nurturing creativity and critical thinking in their students? Do they share an understanding of how these skills materialise in school settings, and of how they translate to the language of specific subject areas? Do they have practical ways of assessing student creativity and critical thinking? To what extent do curricula and teaching workloads allow them to innovate towards these goals?

Shaping teachers' attitudes and practices for fostering innovation skills

In recent years, many countries have embarked on a revision of what they think is crucial for students to learn in the rapidly changing environments of the 21st century (Care, Anderson and Kim, 2016[1]). Schools are being asked to prepare students for jobs that have not yet been created and for social and environmental challenges that are not yet fully anticipated. Future generations will need an expanded set of skills to participate fruitfully in social, economic and cultural life, and there is widespread consensus that creativity and critical thinking are among the key competences for equipping youth for the future.

While the recognition of creativity and critical thinking in curricular frameworks is important, the major challenge for education systems remains how to promote the teaching and learning environments that help to develop these skills alongside technical and socio-emotional skills in curriculum subjects. First and foremost, there is a need for a better and more widely shared understanding of what creativity and critical thinking mean in a school context, of how they materialise in different school disciplines, and of the instruction and assessment practices that create the space for students to develop and demonstrate them. For instance, recognition that creative thinking requires time to unfold and can be taught may motivate teachers to allow more time for their students to incubate creative ideas and to pattern time and instruction more deliberately (Csikszentmihalyi, 1997[2]). Overall, teachers need a better understanding of how to recognise creativity and critical thinking, of the conditions that encourage their development, and of how they can guide students to become more creative and critical thinkers. This common ground can become the basis for a more consistent teaching and learning of creativity and critical thinking skills in school systems internationally.

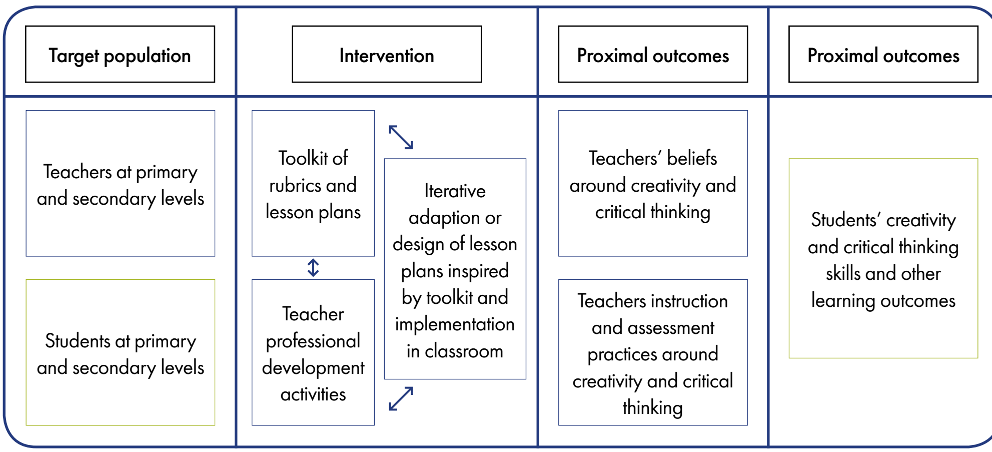
As a multi-faceted activity, teaching can take many different forms. This chapter is mainly concerned with "teaching *for*" creativity and critical thinking as embedded into curricular content, rather than with "teaching *about*" these skills (Jeffrey and Craft, 2004[3]). Teaching *about* creativity or critical thinking makes these skills the subject matter of teaching, for instance in a dedicated course, and falls outside of the current scope. However, teaching that aims to nurture student creativity and critical thinking (teaching *for*) can often itself display these skills, becoming a "teaching *with*". For instance, creative teaching can promote student creativity by modelling behaviours such as the willingness to take risks, learning from mistakes or seeking complexity, and may occur in any subject area (Beghetto, 2017[4]). Similarly, teachers that demonstrate critical thinking in their own practice provide a model for students to learn to question their own assumptions or acknowledge biases in their reasoning. The chapter therefore looks at teaching "*for*" and "*with*" creativity and critical thinking as complementary goals.

Teacher attitudes and practices as proximal outcomes of the intervention

Figure 6.1 presents the theory of action underlying the OECD-CERI project on fostering and assessing creativity and critical thinking skills in education (see Chapter 1). In its first phase, the objective was to develop internationally valid instruments and pedagogical resources that could be validated in an intervention as described by Figure 6.1. Teachers' attitudes and practices constitute outcomes of the intervention in their own right, while they constitute also mediators of the potential impact on students' creativity and critical thinking skills. Two complementary aspects of the project aimed at triggering attitudinal and behavioural changes in teachers. First, the use and iterative refinement of a portfolio of rubrics (see Chapter 2) and lesson plans (see Chapter 4). Second, teachers' professional development activities (see Chapter 5). Both elements were designed to help teachers articulate a language around creativity and critical thinking skills and to shape their views and interactions with students. School principals were also expected to play an important role in this change process by leading, encouraging and supporting teachers as they trialled the project tools and implemented the pedagogical intervention. Another central goal of this initial, development phase of the project was to design and pilot survey instruments that could be used in a validation or efficacy study, which implied trialling them in a real-life setting.

In this chapter, the attitudinal outcomes of main interest are teachers' beliefs about creativity and critical thinking as well as their sense of self-efficacy and preparedness for nurturing these skills in their students. Teacher behaviours under examination area set of classroom-based instruction and assessment practices that align with the OECD rubrics on creativity and critical thinking. Change in these areas was expected because the intervention introduced ideas and tools about teaching for creativity and critical thinking that are rarely integrated in teacher education programmes and that may have departed from the regular routines of many participating teachers, even though they voluntarily participated in the project[1].

Figure 6.1. Theory of action of the OECD-CERI project on creativity and critical thinking



Collecting information about teachers and teaching

This chapter draws on several sources to examine the frequency of and changes in a set of attitudes and practices for the cultivation of creativity and critical thinking in schools. First, it brings in information from interviews and focus groups with teachers as well as feedback from local team co-ordinators, both of which were synthesised in country team reports. These provide detailed descriptions of the local implementation of the intervention and of differences with regard to the regular teaching and assessment practices in the control schools. The team reports also discuss how teachers took ownership of the rubrics – often in collaboration with peers, the changes they introduced in their teaching, and the changes they perceived in students' engagement and outcomes.

Second, the chapter draws on responses to teacher questionnaires. These were administered in both intervention and control groups before and after the field trialling of the OECD rubrics and lesson plans[2]. The questionnaires collected information about teachers' target classes, regular teaching and assessment practices, views on creativity and critical thinking, and personal backgrounds. Additionally, once the fieldwork was completed, teachers in the intervention group responded to a battery of questions about their use of the rubrics, participation in the project activities and own assessment of impact.

Teachers' self-reports provide a privileged window into the experiences of the main agents of the intervention. As such, they constitute an invaluable source of information about the challenges of implementing school-based innovations for promoting creativity and critical thinking skills, as well as a reservoir of insights about their impact on a range of outcomes. Self-reports can nonetheless suffer from some shortcomings. Most notably, self reports are often subject to social desirability bias, thus potentially reflecting views that teachers consider desirable or expected from them rather than actual opinions; they may also reflect cross-cultural differences in response styles (van de Vijver and He, 2014[5])[3]. With the aim to mitigate these risks, the chapter also analyses data from students and school principals to triangulate teachers' accounts about the occurrence of different teaching practices.

Close to 800 teachers[4] participated in the project, including both intervention and control groups. Across teams, the average number of participating teachers[4] was 63, but sample sizes ranged widely, from less than 20 teachers in the French teams up to 159 teachers in the Thai team. Overall, a larger share of teachers was in intervention (57%) than in control groups (43%), while they were evenly distributed between primary (51%) and secondary (49%) education (Table 6.1)[5].

Prior to the start of the fieldwork, about half of the teachers involved in the project completed questionnaires (413), with equal shares from intervention and control groups and a slightly larger proportion of secondary level teachers (56%)[6]. Despite variation in the number of responses, the data permit to characterise teacher profiles and baseline levels for a range of attitudes and practices within most teams, as well as to analyse average values for the pooled sample. Importantly, across teams, 270 teachers completed questionnaires both prior to and after the intervention, representing almost two-thirds (65%) of the respondents at baseline (prior to the intervention) and a third (33%) of the total number of teachers involved in the project. These panel subsamples enable some analysis of changes in teachers' attitudes and practices; however, their size is too small to support causal inferences about the impact of the intervention[7]. The data can nonetheless convey a sense of the direction and magnitude of changes in teachers' attitudes and practices, at least for the Hungarian and Thai teams for which there are a larger number of teacher responses to questionnaires[8].

Profile of participating teachers

A comparison of teachers' responses to the questionnaires and data from international surveys suggests that project participants broadly shared the average demographic profile of the teaching workforce in their respective countries.

On average across teams, the proportion of female teachers was substantially larger than that of male colleagues (79% and 21%, respectively). This unbalance holds for all teams and is particularly pronounced in the Brazilian, Indian and Russian teams, where less than one in ten teachers was male (Table 6.2). Project participants represented an experienced pool of teachers. On average across teams, almost two-thirds of participating teachers had more than ten years of teaching experience by the time they joined the project. In all but one team, this proportion is equal to or higher than 50%, and in five teams it was over 80%. By contrast, only 5% of teachers across teams had less than two years of teaching experience (Table 6.2). In terms of qualifications, most teachers in teams within OECD countries had completed a higher education degree, whereas teaching certificates or other forms of post-secondary non-tertiary degrees were the most common qualifications for teachers in Brazil, India and the Russian Federation. All these figures are consistent with international statistics on the teaching workforce.

Responses to questionnaires further suggest that teachers in intervention classes faced more classroom management challenges than teachers in control classes (Table 6.3). In virtually all teams, intervention teachers reported more often that they had to wait a long time for students to quiet down at the beginning of their lessons, and that it was difficult to keep students concentrated. Conversely, a greater proportion of teachers in the control group reported that students in their classes took care to create a pleasant learning atmosphere. This may have influenced the conditions of the intervention, as low levels of student discipline and co-operation can reduce opportunities for implementing innovative pedagogies. Evidence from the OECD Teaching and Learning International Survey (TALIS) shows a positive and consistent correlation between positive class climates and the percentage of class time dedicated to actual teaching and learning (OECD, 2014[6]; 2019[7]).

Teacher attitudes towards creativity and critical thinking

Personal attitudes and belief systems help individuals to plan, execute and evaluate their own and other people's actions. Educational research views attitudes, motivations and beliefs as important components of teachers' professional competence alongside their content and pedagogical knowledge (Guerriero, 2017[8]). Attitudes and beliefs aligned with effective approaches to nurturing creativity and critical thinking can inform more consistent teaching behaviours, while myths and misconceptions may lead teachers in the wrong direction. Understanding teachers' beliefs about creativity and critical thinking is hence important to design pedagogies and training programmes that help teachers embrace more explicit and systematic approaches to develop these skills.

Teachers' self-efficacy in teaching for creativity and critical thinking

Teacher self-efficacy refers to the perceptions that teachers have of their capacity to plan and implement specific teaching practices and to bring about desired outcomes in their students (Bandura, 1997[9]; Tschannen-Moran and Hoy, 2001[10]). The importance of self efficacy beliefs is thus predicated on their potential to influence teachers' actions and effort. Research has documented positive links between teachers' self-efficacy and a range of outcomes, including self-reported and student-reported use of specific teaching behaviours and willingness to adopt innovations (Klassen and Tze, 2014[11]; Zee and Koomen, 2016[12]).

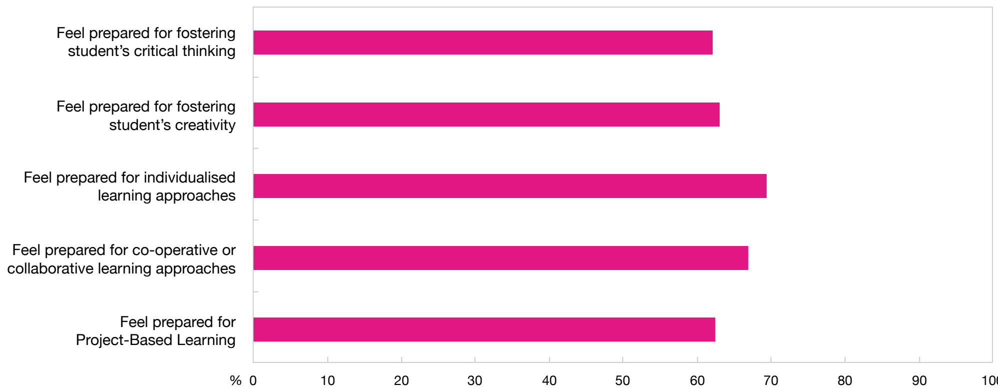
Teachers' creative self-efficacy can encompass both perceptions about their ability to teach creatively and to facilitate creativity in learners (Rubenstein et al., 2018[13]). As a motivational belief, creative self-efficacy can give teachers a sense of agency and control for enacting creativity fostering practices in the classroom. Creative self efficacy is also correlated with teachers' perceptions of the value that society places on creativity, of the potential of students to become creative and of their own creativity (Rubenstein, McCoach and Siegle, 2013[14]).

The questionnaires developed for the OECD-CERI project covered two dimensions related to self-efficacy. The first is teachers' sense of preparedness for enacting student-centred pedagogies, including co-operative learning, Project-Based Learning and individualised learning approaches. Teachers who feel prepared to use these strategies can be seen as confident in their ability to employ a range of instruction and assessment practices aligned with the project rubrics (see Chapter 2) and several of the signature pedagogies proposed in the context of the intervention (see Chapter 3). The second dimension is self efficacy in relation to the development of higher order skills, explored through two items asking teachers about their preparedness for fostering student creativity and critical thinking skills specifically. This extends the traditional teacher self-efficacy framework to encompass the goals of 21st century education and serves as an indicator of teacher professional development needs for promoting creativity and critical thinking as part of a broader set of student skills.

Figure 6.2 shows teacher self-reported levels of preparedness among project participants at baseline. Across teams, close to seven out of ten teachers felt "well" or "very well" prepared for implementing collaborative as well as individualised learning approaches, whereas slightly more than half felt confident about carrying out Project-Based Learning activities. On average, around two-thirds of participating teachers reported a strong sense of self efficacy for fostering students' creativity and critical thinking skills, with percentages being largely similar between teachers in intervention and control groups, but masking large differences across teams (see Table 6.5). Moreover, these levels of self-efficacy among project participants appear consistent with evidence from TALIS 2018 indicating that, across countries, over four-fifths of lower secondary education teachers feel well prepared to help their students think critically, and that less than one in five perceive a high level of need for professional development for teaching cross-curricular skills or using individualised learning approaches (OECD, 2019[7]).

Figure 6.2. Teachers' sense of self-efficacy at baseline

Percentage of teachers who...



Notes: Percentages correspond to the sum of the response categories "Well prepared" and "Very well prepared". Non-weighted percentages Results by team and weighted averages in Table 6.5 (see Annex A).

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Teachers' ranking of vignettes about creativity and critical thinking

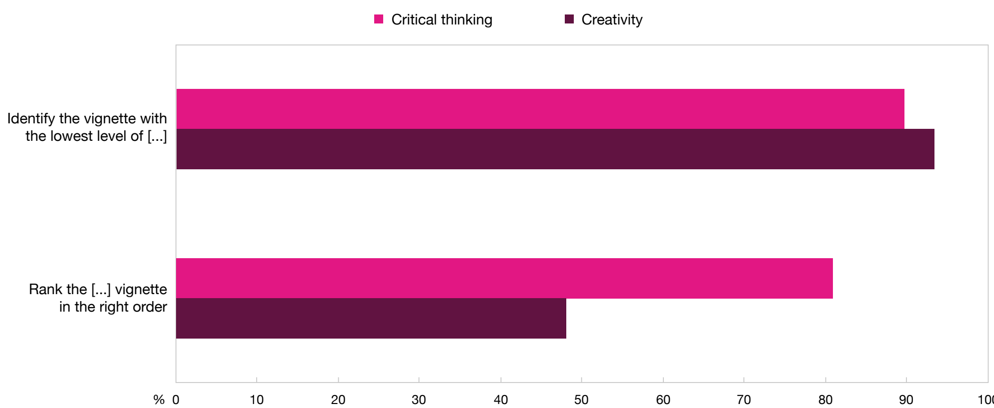
A different perspective into teachers' sense of preparedness comes from their rankings of the vignettes included in the questionnaires. These vignettes described, in alignment with the project rubrics, what different levels of creativity and critical thinking could look like in the context of specific school subjects. Teachers who ranked the vignette scenarios – which depicted low, intermediate and high levels of student proficiency in these skills – in the anticipated order can be seen as demonstrating an understanding of creativity and critical thinking that is consistent with the project framework[9].

As shown in Figure 6.3, at baseline and on average across teams, slightly less than 40% of the teachers ranked the scenarios of the creativity vignette in the expected order, whereas about 71% assigned the predicted levels of proficiency to the scenarios of the critical thinking vignette. The higher teacher accuracy in ordering critical thinking rather than creativity scenarios holds for ten out twelve teams for which these data are available (Table 6.5). Hence, results clearly indicate that, at least prior to the intervention, teachers across teams had a much more shared understanding of what low, intermediate and high levels of critical thinking would look like in a classroom than of an equivalent depiction of creativity. This may be due to curricula providing more consistent definitions of critical thinking than of creativity, making it easier for teachers to visualise the types of products and processes that reflect critical thinking in school.

Another finding from the analysis of vignette rankings is that, for both creativity and critical thinking, around nine out of ten teachers across teams correctly identified the vignette corresponding to the lowest level of proficiency in these skills. That is, a very large share of teachers placed the scenario depicting a low level of student creativity or critical thinking at the expected bottom of the ranking. This indicates that, whereas higher levels of proficiency may remain more problematic to characterise, especially in the case of creativity, common ground exists among teachers for identifying student work that is not creative or does not demonstrate critical thinking. The results therefore suggest that teachers can more easily pinpoint the lack of these competences than formulate what they actually look like in school. Importantly, no substantial differences exist at baseline between control and intervention teachers in their rankings of vignette scenarios (Table 6.5).

Figure 6.3. Teachers' ranking of vignettes at baseline

Percentage of teachers who...



Notes: Non-weighted percentages. Results by team and weighted averages in Table 6.5 (see Annex A).

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Teachers' beliefs about creativity and critical thinking

Teacher's pedagogical beliefs are another important factor in the attitudinal domain. Teachers come into the classroom with pre-existing conceptions about the nature of teaching and learning, which are typically shaped by pre-service training, professional development and prior interactions with students (Hofer and Pintrich, 1997[15]). Teachers' views on the merits of different strategies to support student learning, such as direct transmission or constructivist approaches, can influence their selection of teaching and assessment methods. For instance, teachers' use of instructional behaviours stressing choice and rationale rather than directives and time limits appears mediated by their beliefs about the effectiveness and cultural normativity of such practices (Reeve et al., 2014[16]). Another aspect of teacher attitudes relates to how they value different educational goals. Expectancy-value theory posits that individuals will more likely pursue objectives that they view as both achievable and personally valuable (Eccles and Wigfield, 2002[17]). Teachers' subjective valuing of learning goals and innovative practices can thus be important for their actual use of specific pedagogical approaches.

Data from baseline questionnaires reveal high levels of teacher support for constructivist pedagogies among project participants (Table 6.4). Across teams, more than 80% of teachers agreed, for instance, that their role is to facilitate students' own inquiry and that students learn best by finding solutions to problems on their own. These figures are consistent with prior reports from TALIS (OECD, 2014[6]) and perhaps unsurprising given the principles that informed the intervention and the voluntary character of teacher involvement. Reponses to novel items in the teacher questionnaires point in the same direction. For instance, more than 90% of teachers agreed with the notions that instruction should encourage students to try new solutions and answers, even if they are wrong, and that instruction should promote the expression of new ideas from students. By contrast, only about 36% of teachers across teams agreed that instruction is mainly about transmitting accepted knowledge to students, which is an example of a position openly challenged by the rubrics and activity design criteria proposed by the intervention. Interestingly, however, teachers also expressed a high level of agreement with the statement that assessments should be built around problems with clear, correct answers, which partly contradicts the model of open tasks with multiple solutions embodied in many of the lesson plans developed for the project (see Chapter 4).

Research has specifically investigated teacher beliefs about the nature of creativity and creative manifestations in school settings. Also referred to as implicit theories of creativity, these latent beliefs have practical implications for teaching if teachers use them, either intentionally or unconsciously, as the models against which they judge students' creative behaviour and performance (Sternberg, 1985[18]; Runco, Johnson and Bear, 1993[19]). Reviewing two decades of research in the topic, Andiliou and Murphy (2010[20]) distinguish three main categories of teachers' beliefs about creativity. A first group relates to the nature of creativity, including beliefs about its distribution in the population, its malleability over the life course, its domain specificity or the factors that define creative outcomes. A second cluster covers teachers' beliefs about the profile of creative individuals, including both their knowledge and personality traits. A third group concerns views about the potential for fostering creativity of various classroom environments and teaching strategies. The salience of these dimensions is also visible in more recent reviews by Mullet et al. (2016[21]) and Bereckzi and Kárpáti (2018[22]). Overall, the evidence suggests that, across countries, teachers tend to endorse a positive and democratic view of creativity; support the ideas that creativity can be nurtured in every individual and demonstrated in all school subjects; and increasingly support the view that teaching for creativity requires creative teaching. However, lack of time, overloaded curricula, inadequate training, standardised tests and lack of clarity regarding assessment are widely perceived as barriers to promoting creativity in the classroom across teachers in different countries.

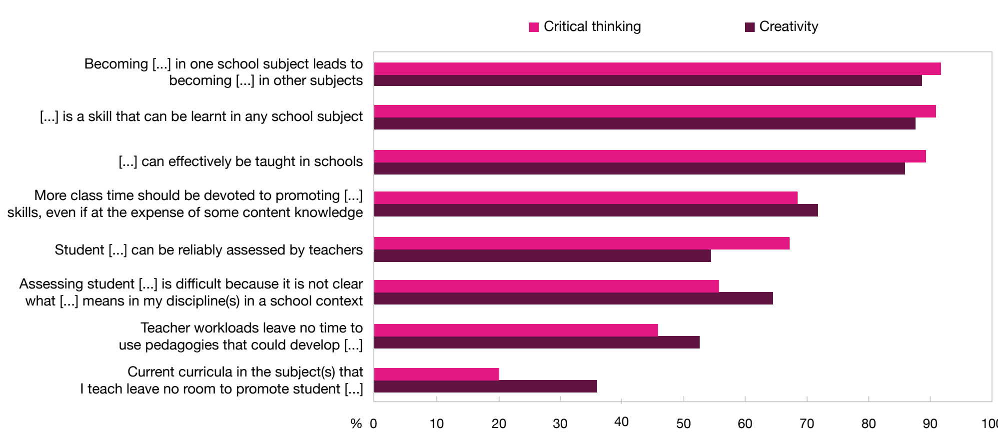
The research literature also documents a frequent misalignment between teachers' beliefs and scientific theories of creativity. A common misconception among educators is that creativity involves only originality, whereas researchers tend to stress the joint requirement of novelty and appropriateness for the task at hand [see, for example, Kaufman and Beghetto (2013[23])]. Relatively common among teachers are also a bias towards arts subjects [see, for example, Patson et al. (2018[24])], a negative perception (as misbehaviours) of student characteristics associated with creativity such as risk-taking or a preference for ambiguity [see, for example, Kettler et al. (2018[25])], or gender stereotypes in the definition of creative boys and girls [see, for example, Gralewski and Karwowski (2013[26])]. Discrepancies in beliefs about creativity can also exist between teachers and students [see, for example, Hong, Part and Rowell (2017[27])].

Teacher beliefs about critical thinking have received less attention, which may reflect a greater consensus around its dimensions and the dispositions of critical thinkers (Facione, 1990[28]). Research suggests that teachers often equate critical thinking with high intellectual ability, with the implication that their use of instruction activities with a stronger or weaker focus on critical thinking is largely mediated by their perceptions of students' ability (Zohar, Degani and Vaaknin, 2001[29]; Warburton and Torff, 2005[30]).

The teacher questionnaires of the OECD-CERI project were designed to explore many of the areas highlighted by prior research on teacher beliefs about creativity and critical thinking (Tables 6.6 and 6.7). Some items tapped into the malleability and domain specificity properties of these skills, as well as on perceived difficulties for their assessment. Others touched on teachers' valuing of creativity and critical thinking as learning goals in their own right, and on perceived barriers for their promotion in their everyday practice. Figure 6.4 presents results for a selection of these questions.

Figure 6.4. Teachers' beliefs about creativity and critical thinking in school

Percentage of teachers agreeing that...



Notes: The percentages correspond to the sum of the response categories "Agree" and "Strongly agree". Non weighted percentages. Results by team and weighted averages in Tables 6.6 and 6.7 (see Annex A).

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On average across teams, there is broad support among teachers for the notion that creativity and critical thinking skills are transferable across domains. Around nine out of ten teachers agree with the statements that these skills can be learnt in any school subject, and that becoming creative or a critical thinker in one school subject has positive spill-overs in other domains, for instance by helping students to become more inquisitive in different curriculum areas. In the case of creativity, this stands in clear opposition to the traditional view that creative work is the monopoly of the arts. Teachers in the Slovak team appear as the sole exception to this pattern.

Importantly, over 85% of teachers across teams agreed that creativity and critical thinking can be effectively taught in schools. This suggests widespread support for viewing these skills as malleable and amenable to teaching in school settings. This contrasts with the stereotype that creativity and critical thinking are innate talents that children may or may not bring to school, and implicitly opens a door for teachers and schools to assume an active role in promoting these skills. The majority of teachers within each participating team held this view, albeit at relatively lower levels among teachers in the Hungarian, Slovak and French Lamap teams.

The stature that teachers accord to creativity and critical thinking skills as learning goals and in relation to other, potentially conflicting objectives, can also have an effect on how actively they engage with innovations designed to promote these goals. A sign of endorsement for the importance of higher order skills is that close to 70% of teachers across teams agreed with the statement that more class time should be devoted to promoting creativity and critical thinking skills, even if this implied covering less subject content. Only teachers in the Russian team stand out with less support (17%) for this view.

Questions about the assessment of student creativity and critical thinking reveal that this aspect remains problematic for a majority of teachers. Across teams, just 54% of teachers agreed that student creativity can be reliably assessed in the classroom, and 64% subscribed to the view that it is difficult to identify creative outputs in the context of their school subjects. Teachers expressed somewhat less concern about the assessment of students' critical thinking: across teams, 67% agreed that teachers can reliably assess this skill, while 56% agreed that it is not clear what critical thinking means in their disciplines. Substantial variation exists across teams, especially concerning the difficulty of translating skill achievements into the language of school subjects. Overall, given the broad endorsement of the relevance of these skills, assessment stands out as the area where teachers perceive the greatest need for practical solutions, especially with regard to evaluating student creativity.

Items eliciting teachers' beliefs about barriers for teaching creativity and critical thinking also provide valuable insights. Across teams, only 36% of teachers shared the view that the curriculum that they are expected to teach leaves no space to promote student creativity, a percentage that decreases to 20% in the case of critical thinking. The pattern of results is largely consistent across teams and suggests that teachers did not perceive their respective curricular frameworks as a major obstacle for nurturing learners' creativity and critical thinking. Two exceptions are the high proportion of teachers seeing a clash between curriculum and creativity in the Thai team (86%), and with critical thinking in the Hungarian team (60%).

By contrast, there is a more negative perception about the time constraints that would prevent teachers from engaging in more systematic fostering of students' creativity and critical thinking.

Across teams, around half of teachers agreed with the statement that current workloads do not leave enough time to implement the pedagogies needed to develop creativity (53%) or critical thinking (46%); this was the most common among teachers in the French and Welsh teams. To some extent, therefore, teachers implicitly perceive that teaching for creativity and critical thinking calls for instruction and assessment strategies that require a different organisation of teaching time.

Insights from qualitative feedback

There is evidence that individual characteristics account for much of the variation in teachers' attitudes, which underlines the fact that educators in shared school- and country level contexts can hold rather different beliefs and motivations (OECD, 2014[6]). Feedback from local project co-ordinators suggests indeed that diverse teacher profiles and levels of engagement with the project existed within most of the participating teams. For instance, local co-ordinators in the Brazilian and Madrid (Spain) teams described three broad profiles among their teachers. A first group consisted of teachers who were sceptical about the feasibility of the project or saw it as yet another initiative that would translate into an additional workload for them; some of these teachers dropped out of the project at early stages, introduced only small qualitative changes in their practice and put minimal effort into the data collection. A second cluster of teachers believed in the proposal but had difficulty adapting their way of thinking and pedagogical practices, often unsure about the effectiveness of the proposed tools and approaches.

A third group saw the project as an opportunity to innovate and improve their practices and thereby their students' engagement and results; these tended to remain highly motivated after induction sessions and initial interactions with colleagues and to engage proactively with the tools and tasks presented to them. Reports from the Russian team indicate as well that teachers displayed very heterogeneous levels of involvement, often reflecting different school level desire for innovation. Diversity in pre-existing beliefs was also evident among teachers with substantial experience with innovative pedagogies. For example, some teachers in the French CRI team objected to the project rubrics on the argument that creativity and critical thinking could be trained appropriately in an intuitive way without an explicit formulation of these skills.

Changes in teachers' attitudes associated with the intervention

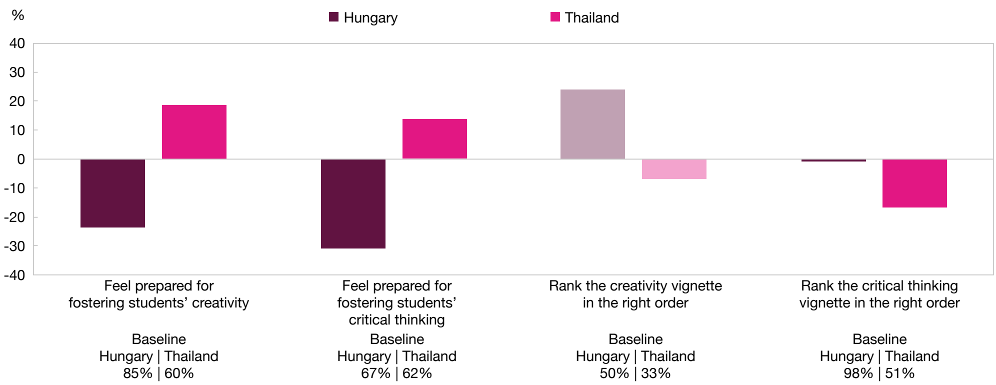
The teacher data in the Hungarian and Thai teams allow a first examination of the impact that the intervention of the OECD-CERI project had on participating teachers' attitudes about creativity and critical thinking. Figure 6.5 shows changes in Hungarian and Thai teachers' sense of self-efficacy and in the accuracy of their ranking of vignettes. The results, though, point to two rather different stories.

Among Hungarian teachers, the intervention appears to be associated with a significant drop in the percentage of teachers that feel confident in their ability to foster students' creativity and critical thinking, and with an increase in the share of those ranking creativity vignettes in the expected order. Contextual factors and baseline levels for these outcomes provide some pointers for interpreting the results. Most teachers in the Hungarian team had been involved in the local Creative Partnerships programme (see Chapter 3) before participating in the project and started it with a greater sense of preparedness than teachers in most other teams, especially with regard to their ability to promote student creativity (Table 6.5). The intervention, which exposed them to a different set of tools and formulations about what these skills entail in school settings, seems to have lowered their perceived self-efficacy. By contrast, the sense of preparedness increased among teachers in the control group. A potential explanation for these results is that the intervention led teachers to question previously held beliefs and assumptions by making them more aware of the difficulties involved in teaching for creativity and critical thinking, eventually making them feel more vulnerable. Psychology research has shown that awareness effects can result in a downward adjustment of personal self-efficacy, especially when complex tasks place greater demands on individuals' capabilities (Bandura, 1997[9]; Stajkovic and Luthans, 1998[31]). Increased requirements for creative skills can thus lead to lower reported levels of creative self-efficacy (Tierney and Farmer, 2011[32]). Qualitative feedback from project participants suggests this type of process may have occurred. Testimonials from interviews in the Brazilian team, for instance, brought to light the disappointment that some teachers felt in the course of the intervention as they realised the weaknesses of some of their previously held assumptions about how to develop student creativity and critical thinking.

A different pattern of results, however, can be observed among Thai teachers, for whom the intervention was associated with an increase in their sense of preparedness for promoting both creativity and critical thinking, as shown also in Figure 6.5. In the Thai team, increases in teachers' sense of preparedness are visible for all participant teachers, but to a greater extent among intervention teachers. Qualitative feedback connects these enhanced levels of confidence to the feedback that teachers received from local project co ordinators and training providers after the initial trialling of the project rubrics and lesson plans, which underlines the importance of monitoring and formative feedback to teachers about their efforts in implementing an innovation. Among Thai teachers, however, the data reveal a decrease in the accuracy of the ranking of the critical thinking vignettes, and no changes with regard to creativity vignettes.

Figure 6.5. Changes in teachers' self-efficacy and vignette rankings

Change pre-post between and control groups in the percentage of teachers who...



Notes: Figures show difference-in-difference estimates of the effect of belonging to the intervention group on the outcome of interest. Statistically significant differences at 0.2 are shown in darker tone. Full results in Table 6.5b (see Annex A). See Technical Annex for details.

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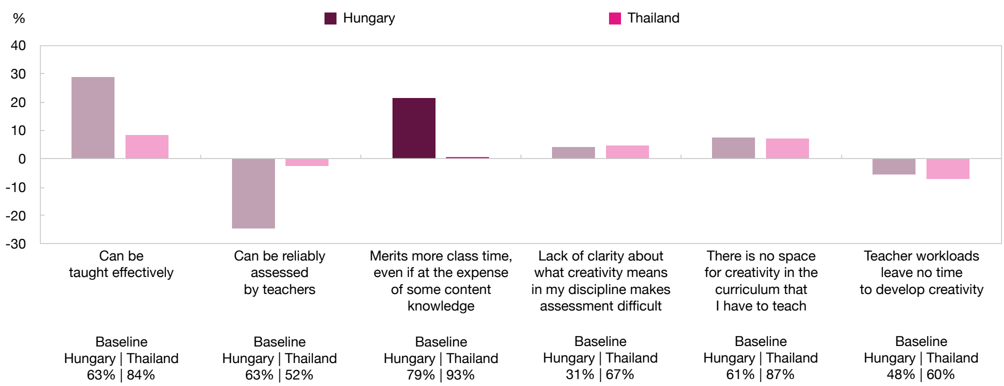
Based also on the panel subsamples for the Hungarian and Thai teams, Figure 6.6 and Figure 6.7 show changes associated with the intervention in teacher beliefs about creativity and critical thinking in school. While only a handful of these estimates reach statistical significance, the results provide an indication of how teachers who used the project materials and participated in professional development activities modified their views about the nature of these skills and about the conditions for making them a more integral part of their everyday practice.

In both teams, the intervention appears to have increased the share of teachers endorsing the view that student creativity can be effectively nurtured in schools. The increase is larger among teachers in the Hungarian team and driven entirely by changes in the intervention group, whereas it is smaller and largely due to changes in the control group in the Thai team. By contrast, there is small decrease in both teams in the proportion of teachers agreeing that they can effectively promote critical thinking in school. These results should be read in light of higher baseline levels of support for the malleability of critical thinking, and thus eventually as a sign of convergence in views about these two skills. It is also possible that, by emphasising aspects such as perspective taking and awareness of own bias, the intervention somewhat problematised teachers' pre-existing understanding of critical thinking more than relatively more diffuse prior notions of creativity.

Regarding assessment, the intervention seems modestly associated with more teachers sharing the view that assessing creativity and critical thinking is difficult, mainly due to a lack of clarity about what these skills mean in specific school subjects. Among teachers in the Hungarian team, this may also be linked to a heightened perception about a clash between the curriculum and aspects of critical thinking as articulated in the project rubrics. By contrast, results also suggest that the intervention increased positive views about the possibility of teaching for creativity and critical thinking despite regular teacher workloads. However, all these changes are small in magnitude and driven in some cases by shifts in the attitudes of teachers in the control rather than in the intervention classes. Besides, a noteworthy result among teachers in the Hungarian team is the increase in support for the view that creativity and critical thinking skills deserve more attention in school education, notwithstanding the difficulties that the project may have made more apparent. Among teachers in the Thai team, the subjective valuing of these skills did not decrease relative to its high level at baseline.

Figure 6.6. Change in teachers' beliefs about creativity in school

Change pre-post between intervention and control groups in the percentage of teachers agreeing that...



Notes: Figures show difference-in-difference estimates of the effect of belonging to the intervention group on the outcome of interest. Statistically significant differences at 0.2 are shown in darker tone. Full results in Table 6.6b (see Annex A). See Technical Annex for details.

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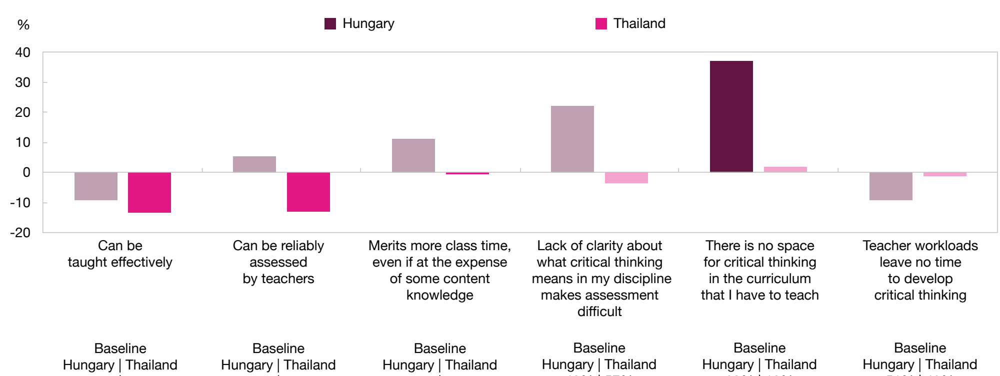
Figure 6.7. Change in teachers' beliefs about critical thinking in school

Change pre-post between intervention and control groups in the percentage of teachers agreeing that...



Notes: Figures show difference-in-difference estimates of the effect of belonging to the intervention group on the outcome of interest. Statistically significant differences at 0.2 are shown in darker tone. Full results in Table 6.7b (see Annex A). See Technical Annex for details.

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Teachers' instruction and assessment practices around creativity and critical thinking

The quality of teaching practices remains the largest school-based influence on student outcomes. This includes the strategies that teachers use to activate students' cognition, to assess their work and to provide feedback that enhances their learning. Complementing teachers' attitudes towards creativity and critical thinking, it is the actual instructional and assessment practices that they implement which allow imparting these skills to students.

Instruction and assessment supporting creativity and critical thinking

Research has shown that instructional practices grounded in collaboration, divergent use of knowledge and skills to transfer them to different settings, multiple approaches to problem solving, self-evaluation and independent learning help foster creativity (Cropley, 1995[33]; Hong, Hartzell and Greene, 2009[34]). In younger classes in particular, students learn by emulating creative behaviours of their teachers, even more so if the creative behaviours are explicitly rewarded (Soh, 2017[35]). Overall, as Lucas and Spencer (2017[36]) summarise, pedagogies centred on problem-based learning, learning communities in the classroom, a growth-focused outlook and playful experimentation coupled with systematic practice are of crucial significance in cultivating creativity.

Creativity-fostering instruction is often part of a broader environment. This includes flexible use of the physical environment and material resources, both outdoors and inside the classroom, as well as striking a balance between structure and play for students to take risks and decisions, as facilitated for instance by game-based learning approaches. From the students' perspective, flexibility means freedom to venture into multiple perspectives, while for teachers it involves the possibility, but also the expectation, to adapt instruction to the directions taken by the students (Davies et al., 2013[37]). In turn, assessment practices commensurate with the goal of developing creativity can either be student-centred – by means of formative assessment, self-assessment peer reviews and real-time feedback – or teacher-centred – by means of criterion referenced grading, performance tasks or rating of student artefacts (Lucas and Spencer, 2017[36]).

Certain teaching practices are also associated with the development of critical thinking skills. Drawing on Ennis' typology of approaches to integrating critical thinking in instruction (Ennis, 1989[38]), a meta-analysis by Abrami et al. (2008[39]) finds that a mixed approach in which critical thinking principles are taught as an independent track within a specific subject matter works best for students, whereas immersion methods that do not make such principles explicit underperform all other approaches. More specifically, genuine, real-world problems engage students more effectively in critical thinking and help to anchor their interest. Simulations, role play or game-based learning are some of the methods that facilitate applied problem solving. Discussions and debates in a class setting, both adversarial and co-operative, are also efficient levers of critical thinking. Pedagogies centred on authentic problem solving and dialogic learning appear particularly effective when used together with some amount of mentoring involved in the pedagogic mix (Abrami et al., 2015[40]).

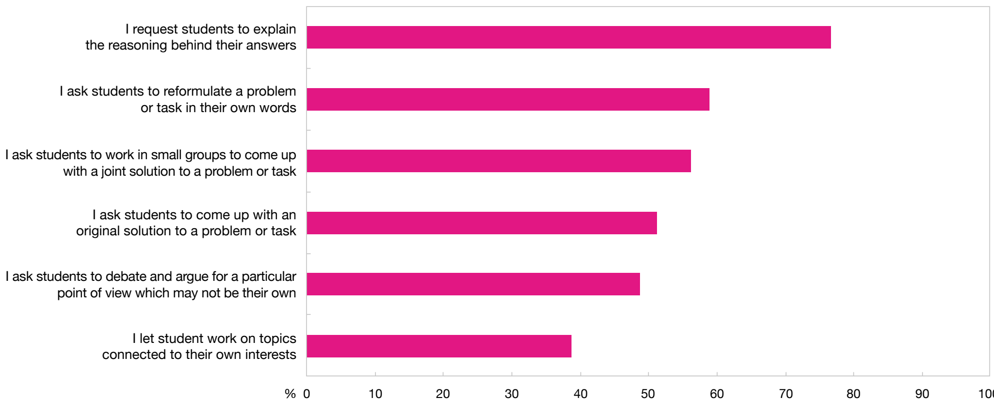
Infusing instruction and assessment with elements of critical thinking is a way of activating autonomous decision making in students and, more importantly, of enabling them to transfer their skills and behaviours to new problems and contexts (Holmes, Wieman and Bonn, 2015[41]). Studies show that explicit and persistent instruction and assessment of critical thinking can be embedded in regular course content and pursued across the curriculum (Marin and Halpern, 2011[42]; Cargas, Williams and Rosenberg, 2017[43]).

Questionnaire responses offer an opportunity to examine the instructional and assessment practices of teachers involved in the OECD-CERI project by providing information on the frequency with which teachers used a selection of practices over a specified period of time(10). Figure 6.8 shows the percentage of teachers declaring to use different instruction practices aligned with the project rubrics and certain related signature pedagogies (see Chapter 2 for a more detailed discussion of the rubrics and Chapter 3 for more information on the signature pedagogies) in at least 25% of their lessons prior to the intervention. Given an average of four hours of teaching to the target classes weekly, these percentages can be taken to reflect whether participant teachers used these practices at least once a week, or at least once every four lesson periods.

On average across teams, requesting students to explain the reasoning behind their answers appears as the most common of these practices at baseline, with 77% of teachers employing it once a week or more. By contrast, only about 40% of participant teachers were letting their students work on topics connected to their own interests, making it the least prevalent practice. In between, asking students to reformulate a problem or task in their own words and to work collaboratively to come up with a joint solution to a problem were being employed at least once a week by more than half of the teachers across teams.

Two practices are of particular interest given their close connection to descriptors in the project rubrics. Prior to the intervention, about half of the participating teachers reported asking students to debate from a perspective different from their own and to come up with an original solution to a problem or task at least once every four lessons. In both cases, teachers in the Indian and Spanish (Madrid) teams reported the highest levels of use of these practices. In the absence of external benchmarks, though, it is difficult to assess whether the frequency of their use among project participants is high or low. Nonetheless, these teacher self-reports suggest that basic strategies to stimulate students' creativity and critical thinking in the classroom were part of the teaching repertoire of at least half of the teachers involved in the project.

Figure 6.8. Teachers' instruction practices at baseline



Percentage of teachers using the following practices in at least 25% of their lessons

Notes: Non-weighted percentages. Results by team and weighted averages in Table 6.8 (see Annex A).

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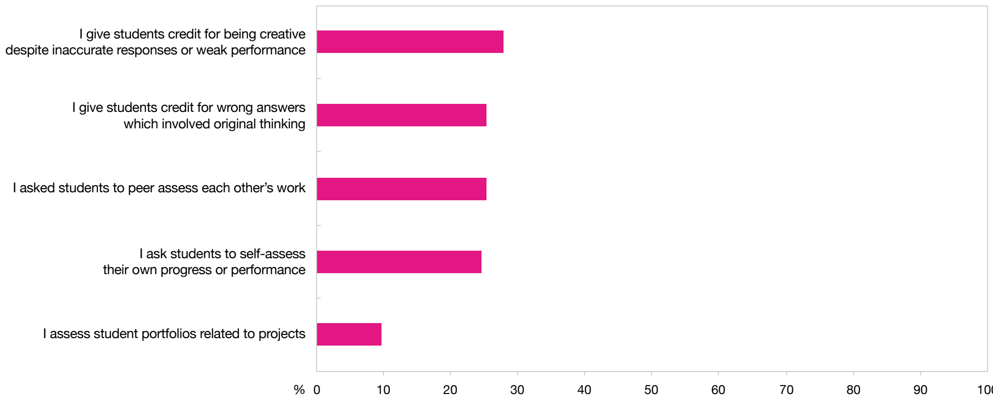
Figure 6.9 provides complementary evidence about the relative frequency with which participant teachers used, prior to the intervention, a series of assessment practices aligned with the project rubrics and the criteria for designing lesson plans with a focus on creativity and critical thinking. As in the case of instruction, the reporting threshold is set at 25% of the lessons with the target class, which typically amounts to employing the listed methods at least once a week. Some practices relate to a shift in the criteria for assessing student work beyond accuracy or conformity to expectation. On average across teams, around one in four participating teachers reported that commending students for being creative or demonstrating original thinking even when their responses or performance were inaccurate was something that they would normally do in at least 25% of their lessons. Two other practices involve extending assessment responsibilities to students, namely asking students to self-assess their own progress or performance and asking students to peer assess each other's work. Similarly, around a quarter of teachers declared using these practices at least once a week, on average across teams. By contrast, the assessment of student portfolios related to projects appears a less prevalent practice. Again, the dearth of comparable data makes it difficult to evaluate whether the reported frequency of use of these assessment methods and criteria is in line with external evidence. A tentative interpretation of these results is that the assessment approaches promoted by the project were marginal, but not entirely foreign to the regular practice of participant teachers.

Figure 6.9. Teachers' assessment practices at baseline

Percentage of teachers using the following practices in at least 25% of their lessons



Notes: Non-weighted percentages. Results by team and weighted averages in Table 6.10 (see Annex A).

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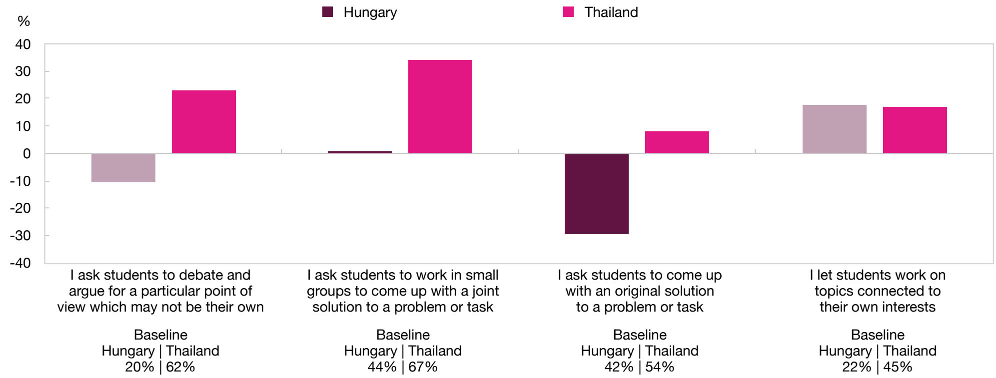
Changes in teachers' instruction and assessment practices

Using the panel subsample of teachers from the Hungarian and Thai teams, Figure 6.10 shows results on instructional changes associated with the intervention, with a focus on some of the practices more closely related to the project framework. As with changes in teachers' attitudes, different results are observed for the two teams. Among teachers in the Thai team, the intervention appears related to significant increases in three instruction practices aligned with the rubrics and design criteria for new lesson plans: asking students to argue for a position different from their own, asking students to engage in collaborative problem solving and letting students work on tasks in relation to topics of their interest. In the Hungarian team, the only significant change is a decrease in the proportion of teachers asking students to come up with original solutions to classroom tasks. However, and particularly for Hungarian teachers, patterns of change among control groups shed doubts on the reliability of these results. In turn, findings for changes in assessment practices show no clear direction, with mostly small and sometimes inconsistent estimates for the two teams (Table 6.10).

Figure 6.10. Change in teachers' instruction practices

Change pre-post between intervention and control groups in the percentage of teachers using the following practices in at least 25% of their lessons



Notes: Figures show difference-in-difference estimates of the effect of belonging to the intervention group on the outcome of interest. Statistically significant differences at 0.2 are shown in darker tone. Full results in Table 6.8b (see Annex A). See Technical Annex for details.

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Did students perceive any changes in teaching?

Teachers' and students' perceptions of teaching practices often complement each other rather than being redundant (Kunter and Baumert, 2007[44]). Student reports of their teachers' instruction and assessment methods therefore provide another perspective of classroom changes associated with the intervention. These data were collected by questions embedded in the various tests administered in the context of the project. Importantly, by virtue of the larger number of observations available, these student responses allow an analysis of changes in teacher practices in different subjects and levels of education, as well as a more robust estimation of impact based on the construction of synthetic indices from multiple items in test-embedded questions. Relative to teachers' own reports, these measures suggest more changes in teaching practices.

Among primary education teachers, overall indices of instruction show positive signs, suggesting that practices became more aligned with the project rubrics and design criteria. This holds for practices in science and mathematics courses among teachers in the Hungarian team, as well as for practices in visual arts and music among teachers in the Thai team. In both cases, baseline levels for these indices are similar between teachers in the intervention and the control groups and most estimates reach statistical significance. Positive changes for teaching practices in science and mathematics courses are also observed in the US (Vista) and Dutch teams, albeit baseline values call for caution in interpreting these results (Table 6.9a).

Among secondary level teachers, no significant changes in instruction are visible in science or mathematics. By contrast, visual arts and music teachers in the Dutch teams appear to have moved away from practices aligned with the rubrics while the opposite is true among teachers in the Slovak team (Table 6.9b). Chapter 7 discusses results based on student-level data in more detail.

Overall, results do not show consistent changes in teacher practices associated with the intervention. In a number of teams, however, the data suggest that primary level teachers modified their instruction methods in line with the project rubrics and signature pedagogies, and that such shifts occurred, in different teams, across the school subjects covered by the intervention. Apparently, this was less the case in secondary education.

Teachers' reports on the intervention

This section focuses on teachers' accounts of their experiences with the intervention proposed by the OECD CERI project. It relies on feedback collected during interviews and focus groups with teachers as well as on responses to a questionnaire module administered to teachers in intervention groups at the end of the fieldwork, amounting to 131 responses across teams. It also brings in the perspective of school principals, as captured in their own questionnaire responses.

Participant teachers and principals provided information on the nature and extent of the perceived changes in teaching, on the types and frequency of peer collaboration for project-related work, and on the impact of the intervention on students. By offering a glimpse into how these educators (re)organised their professional practice to make space for the development of their students' creativity and critical thinking, the data provide insights for the introduction and diffusion of similar pedagogical innovations.

Teachers' reports are framed by remarkably favourable overall evaluations of the intervention. On average across teams, when asked to consider all aspects of their participation in the project, 46% of teachers in the intervention groups evaluated their experience as "very positive" and another 50% considered it "positive", while less than 5% considered it negative. Teachers in the Brazilian and Thai teams expressed the most positive assessments of the intervention (Table 6.11 e).

Changes in teaching

Teachers' perceptions of the direction and extent to which they changed their practice over the course of the intervention are partly dependent on their previous familiarity with the proposed tools and approaches. Qualitative feedback provides a strong indication that, in the majority of teams, teachers had little experience with some of the components of the intervention. For instance, teachers in the Russian team noted the centrality of the teacher figure and a strict control of student activity in their typical lesson settings, as well as a high-stakes testing culture that leaves little space for formative assessment. Teachers in the Thai team reported very low familiarity with rubrics as well as the prevalence of teaching styles based on the transmission of subject matter content. In the Spanish (Madrid) team, teachers openly acknowledged that trying to develop student creativity or to connect subject content to students' own experiences were not explicit objectives in their regular teaching. In other teams, though, participant teachers described student-centred pedagogies and the use of rubrics as common elements of their teaching approach.

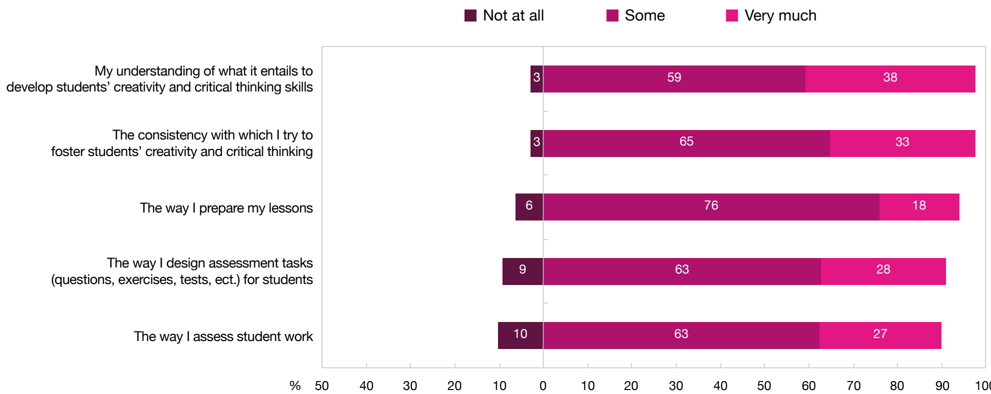
Figure 6.11 shows teachers' reports about the extent to which they modified their regular teaching practice in the context of the intervention; that is, as a result of a deliberate attempt to foster and assess students' creativity and critical thinking skills. The dimension of teaching where teachers reported greater changes is their understanding of what developing students' creativity and critical thinking skills entails. On average across teams, about 38% of teachers modified their views substantially in this respect, while another 59% reported more moderate changes. Teachers in the Brazilian, French CRI and Thai teams declared the largest changes in this area. Importantly, only less than 3% of teachers across teams reported not having changed their understanding of how to develop these skills in their students, which signals the success of the intervention in helping teachers to better discern what these skills entail in a school context. Moreover, about 33% of teachers across teams reported that they became much more consistent in their efforts to foster students' creativity and critical thinking, while another 65% declared a more moderate increase in their consistency and less than 3% of teachers reported no changes in this respect.

Intervention teachers also consistently agreed that they had modified the ways in which they prepared their lessons, designed exercises and assessed student work. Between 18% and 27% of teachers across teams considered that the intervention led to substantial changes in their practice in these areas, while only less than 10% declared having carried on with their established routines. In all dimensions, teachers in the Thai team reported the largest transformations of their practice, which suggests that the intervention represented a major change of their teaching culture.

Overall, less than 10% of teachers across teams reported a lack of impact on their pedagogical practices across these five areas (Table 6.11c). This indicates, on the one hand, a strong interest on the part of teachers to experiment with innovative tools and pedagogies around creativity and critical thinking, which comes in the context of an intervention that was supported by their school leadership and education authorities. On the other hand, it suggests that teachers generally saw that it was possible to integrate, incrementally, the project tools and pedagogies into their everyday practice.

Figure 6.11. Intervention teachers: Changes in teaching practices

Percentage of teachers reporting changes in pedagogy in the last six months



Notes: Non-weighted percentages. Results by team and weighted averages in Table 6.11c (see Annex A).

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Across various aspects of teaching, reports of moderate and small changes are more frequent than reports of more radical transformation. This is an expected result given the relatively short duration of the intervention in most teams, and a general preference for favouring adaptations of existing teaching materials and routines rather than full departure from established practice, in what can be seen as an incremental approach to innovation. For instance, the Dutch team proposed a three-step model in which teachers worked first with existing lessons to gain familiarity with the language of the project rubrics, then moved on to creating new lesson plans under the parameters of a common theme and lastly to designing new activities with no constraints. Likewise, teachers in the Russian team privileged the integration of concepts from the rubrics in lesson units that allowed for interdisciplinary approaches without requiring a curriculum shift. In the Brazilian team, local project co-ordinators asked teachers to work first on activities they had already implemented in their classrooms and that could easily accommodate a focus on creativity or critical thinking, with the aim to integrate a formative assessment of these skills into existing materials. Feedback from interviews and focus groups similarly points to a shared recognition that changes in teaching practices were modest in magnitude, but consistent in their direction. Testimonials in several teams emphasised the gradual shift in awareness that the intervention created. For instance, teachers in the US (Vista) team stressed how participation in the project helped them realise that they were previously prescribing and dictating much of the lessons, leaving little room for student creativity or deeper thinking. In the same vein, teachers in the Slovak team noted that changes in their thinking about the assessment of creativity and critical thinking led them to ask students new types of questions, as well as to allocate more time for classroom discussions.

Teachers' adoption and adaptations of the OECD rubrics were arguably an important driver of these changes in teaching practice. Teachers most commonly used the rubrics to modify or design new lesson plans and to give feedback to students on their progression with these skills. About 30%

of intervention teachers used the rubrics for these purposes four times or more over a period of six months, and about another 40% of teachers did so between one and three times. The project rubrics were less frequently used as a starting point for class discussions, as a student self-assessment tool, or as a template for adapting the domain-generic formulation of creativity and critical thinking into the language of specific school subjects. About 20% of the teachers engaged in these practices four times or more in the course of the intervention, whereas another 40% of the teachers reported having used the rubrics with these goals between one and three times over the previous six months. Teachers in the Brazilian, Hungarian and Thai teams reported the highest levels of engagement with the rubrics across all these potential applications (Table 6.11a). Teachers' adoption and uses of the OECD rubrics are discussed in more detail in Chapter 2.

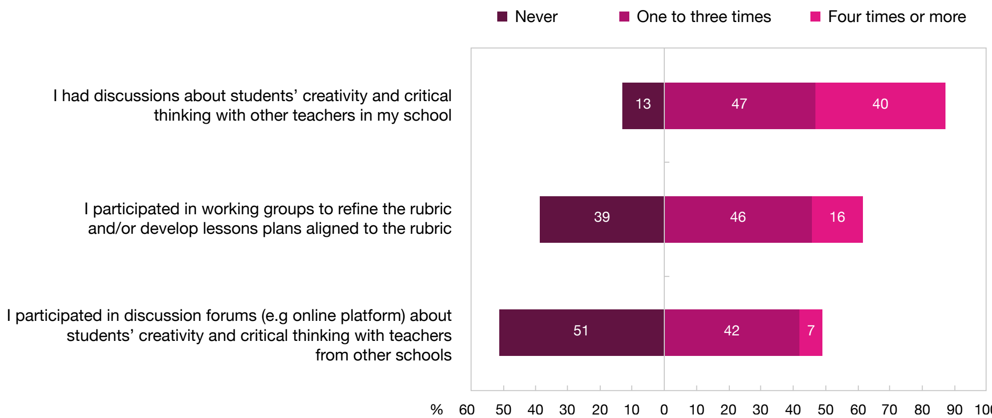
While school principals were not expected to engage with the rubrics in classroom activities, many of them had opportunities to review and discuss the rubrics with teachers in their schools. Principals' views about the project materials broadly align with teachers' positive evaluations. On average across teams, 89% of principals in the intervention schools agreed with the statement that the project provided access to valuable resources that otherwise would not have been available to their staff. Moreover, almost two thirds of principals in intervention schools considered it highly likely that their schools would use the project rubrics and lesson plans with other classes in subsequent school years (Table 6.12).

Changes in peer collaboration

Besides providing them with a range of innovative tools and ideas, the intervention created a substantial amount of exchanges among teachers about the development of creativity and critical thinking in education. Figure 6.12 shows the frequency of different forms of collaboration among teachers in the intervention groups. On average across teams, close to 90% of teachers reported having discussed how to nurture students' creativity and critical thinking with other teachers in their schools at least once over a period of six months, including 40% who engaged in discussions on this topic four or more times during the intervention. Moreover, around 60% of teachers participated in working groups to adapt rubrics to their subjects areas or to co-develop lessons plans aligned with the rubrics; in the Brazilian, Hungarian and Thai teams, over a quarter of teachers met colleagues for these purposes four times or more. The project was less successful in connecting teachers across schools, although 49% of the intervention teachers exchanged on these topics with peers in different schools, on average across teams. These discussions were often facilitated by online discussion platforms such as those established by the Brazilian and Dutch teams, but also by joint training sessions as organised, for instance, by the Thai team (Table 6.11b).

Figure 6.12. Intervention teachers: Collaboration with peers

Percentage of teachers reporting collaboration with peers in relation to the intervention in the last six months



Notes: Non-weighted percentages. Results by team and weighted averages in Table 6.11b (see Annex A).

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School principals also evaluated very positively the collaboration dynamics that the project sparked among teachers. Around 75% of principals in intervention schools estimated that the project led to collaboration between teachers in unusual and positive ways, and that the project provided professional development opportunities that their teaching staff would not have had otherwise. In addition, 53% of principals in intervention schools reported a high likelihood that their schools will incorporate lessons from the project to professional development activities in future years (Table 6.12).

Results about teacher collaboration in schools are important as they indicate that the project succeeded in activating professional learning communities around teaching for creativity and critical thinking in many of the participating teams. The data suggest that a large majority of the more than 400 primary and secondary education teachers that were involved in intervention groups across teams benefited from this professional learning. Intervention teachers not only had access to project materials, but also opportunities to adapt these to their local contexts and to engage in a collective reflection about how to foster and assess creativity and critical thinking skills in a school context.

Both individual characteristics and school-level organisational components play an important role in teachers' adoption of pedagogical innovations, and dynamic professional learning communities are a privileged vehicle for teacher peer learning and the pursuit of shared goals (Vieluf et al., 2012[45]). For teachers, these learning communities also represent an opportunity for continuous professional development, particularly when they support teachers in turning implicit ideas and occasional practices into more explicit and consistent teaching approaches

(Cordingley, 2008[46]). This is why an important component of the intervention was to provide a language for articulating more visibly and systematically the teaching and learning of creativity and critical thinking, as well as to create spaces for teachers to exchange and collaborate around these issues.

Team reports provide examples of various modes of teacher peer collaboration stemming from the intervention. For instance, in Brazil, where fieldwork extended over two school years, teachers who participated in the first year of the intervention played an active role as mentors of teachers who joined the project in the second year. The role of these mentors, who were recruited on the basis of their strong engagement, was to provide pedagogical advice and practical support to new participants based on their past experience, and to liaise with local project co-ordinators. In the US (Vista) team, a series of after-school professional development workshops were organised for teachers on their own campuses to share ideas, processes and outcomes. These workshops provided a safe space for the teachers to reflect on where they were in the process of teaching for creative and critical thinking. Teachers read and discussed research articles and shared their personal ideas in relation to the shift of teaching for critical and creative thinking. Chapter 5 further discusses opportunities for teacher peer learning in the context of professional development plans.

Changes in student outcomes

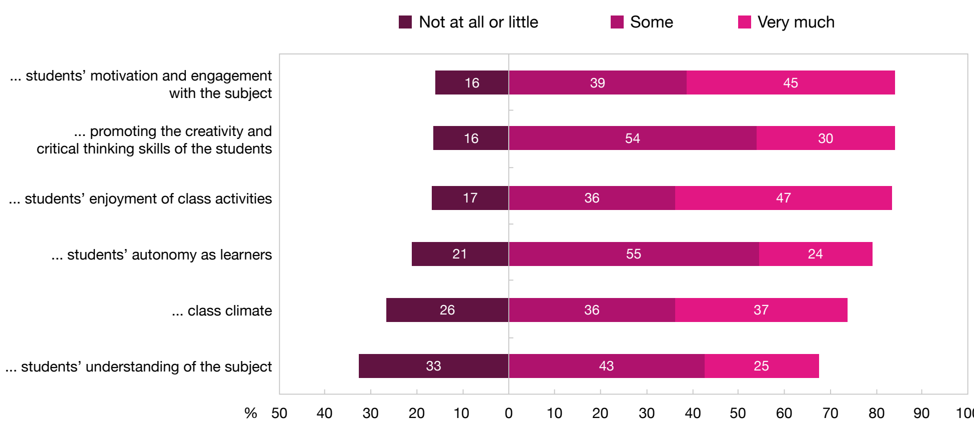
Teachers were also asked to describe, based on their own perception, the impact that the intervention had on a range of student outcomes. Figure 6.13 presents results for these questionnaire items. On average across teams, almost half of teachers reported a very positive impact on their students' motivation and engagement with the school subject and on their enjoyment of lessons, while more than a third of teachers reported moderate positive effects. Additionally, around three-quarters of intervention teachers reported a positive effect on the class climate, including 37% who perceived significant improvements.

Feedback from interviews and focus groups not only confirms a positive influence on student behaviours, but also that, as teachers in several teams observed, this mainly concerned low-performing or unengaged students. Teacher testimonials from the Brazilian, Indian, Russian and Slovak teams concur that student engagement increased as many of the activities trialled in the intervention gave students a greater sense of ownership, resulting in greater enjoyment and more positive classroom climates. Teachers in the US (Vista) team associated higher levels of student engagement to open tasks that helped students connect with their own interests and which allowed varied solutions. Students appeared to develop a more positive sense of their work as diversity in student outputs was explicitly welcome. Importantly, educators in several teams observed that these changes applied in particular to students who tended to shy away from volunteering ideas and solutions in more traditional lesson plans. For instance, teachers in the Brazilian team noted that low-performing students showed greater engagement with tasks where their ideas and proposal would not be judged as either correct or mistaken. Teachers in the Spanish (Madrid) team also reported more active classroom participation among students with learning difficulties in lesson plans developed and implemented as part of the project.

Teachers' evaluations of the impact of the intervention on students' understanding of subject content and on their creativity and critical thinking skills are also consistently positive, albeit less so than for behavioural outcomes. In both cases, around a quarter of teachers considered that the intervention translated into large improvements for students, and around half perceived moderate positive effects, on average across teams. Reports from principals of intervention schools confirm those of teachers. On average across teams, nine out of ten principals agreed or strongly agreed with the statements that the intervention helped expand learning opportunities for students and that it led to positive changes in their motivation and engagement (Table 6.12).

Figure 6.13. Intervention teachers: perceived changes in students

Percentage of teachers reporting collaboration that trying to foster and assess students' creativity and critical thinking in the last six months had a positive effect on...



Notes: Non-weighted percentages. Results by team and weighted averages in Table 6.11d (see Annex A).

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Lastly, about 80% of teachers agreed that the intervention promoted students' autonomy as learners, including about 25% of teachers who perceived a substantial improvement in this respect. Qualitative feedback indicates that teachers saw many of the lesson plans developed for the project as providing greater opportunities for students to solve problems independently than traditional lessons, and as giving the teacher a steering rather than a directive role. Chapter 4 elaborates on how the balance between structure and openness plays out in the project lesson plans.

Key insights

Creativity and critical thinking are increasingly visible in curricular frameworks around the globe. Yet, in most education systems, teachers lack clear guidance for embedding these skills in their everyday practice alongside content and procedural knowledge. To start with, educators and curriculum developers need more common ground in their understanding of how creativity and critical thinking manifest in the context of subject-based teaching and learning. Teachers also need support and safe spaces for adopting, gradually but consistently, the instructional and assessment approaches that encourage students to develop and demonstrate their creativity and critical thinking.

Findings from the OECD-CERI project show broad support among teachers in 11 countries for fostering students' creativity and critical thinking, and provide rich evidence that teachers are willing and able to experiment with innovative tools and approaches for developing these skills. While they were self-selected, participating teachers seem to have similar profiles to their country peers, at least when comparable representative statistics were available. Teachers across teams embraced the idea that creativity and critical thinking are malleable skills that can be developed in school and across the curriculum. However, teachers perceived major difficulties in assessing student progression in creativity and critical thinking skills and in proposing assessment criteria. While teachers' beliefs about creativity and critical thinking broadly mirror each other, results suggest that teachers perceive critical thinking to be better integrated into current curricula and easier to assess than creativity.

The fieldwork in the international network saw teachers testing and taking ownership of a variety of teaching tools and techniques aiming to promote creativity and critical thinking. Teachers across teams trialled the project rubrics and other materials for a variety purposes, from tweaking or designing lesson plans within their curriculum to providing more articulate feedback to students. Across these varied applications, the structure and vocabulary of the project rubrics complemented opportunities for professional development in helping teachers to move from the implicit and episodic to more explicit and systematic efforts to nurture creativity and critical thinking in their students.

The project also showed teachers' readiness to engage in professional learning communities for educational innovation. Across teams, more than 400 primary and secondary level teachers were involved in intervention classes, thereby gaining access to new materials and training opportunities. Most often, teachers experimented with such tools and ideas in collaboration with their peers, working together to adapt tools to their local context and exchanging with colleagues about their experiences in the classroom.

Teacher attitudes and practices changed, but not only in one direction. Most teachers report having gained a better understanding of what creativity and critical thinking skills entail in a school context and are now more consistent in their efforts to foster them. These changes are remarkable given the relatively short duration of the intervention, as are the positive changes that teachers consistently perceived in their students' engagement with the redesigned lessons. At the same time, many teachers felt vulnerable when gaining a greater awareness of the changes required in their regular practice – including in their relationship with students. By pushing teachers to engage with a more explicit formulation of creativity and critical thinking and with more consistent teaching approaches, the intervention also likely "problematised" many of the intuitive beliefs that teachers held about these skills and about their own capacity to foster them.

Notes

1) The project used a purposive sampling design, recruiting participant teams, schools and teachers mainly based on a shared interest in the project agenda. Participant samples are not meant to be representative of their education systems.

2) Local co-ordinators were responsible for translating the instruments, and for administering them in paper and pencil or digital formats, depending on the local circumstances.

3) These issues can occur when teachers use Likert-type response scales to indicate the importance they attribute to a given practice or their agreement with a given idea about teaching and learning. Construct validity and cross-cultural comparability may thus be partly compromised.

4) The number of individual teachers involved in the project was 728, of which 90 participated in two rounds of the intervention over two different school years in their respective teams (Hungary, India, Thailand and US Vista). The number of participant teachers reported in the statistical tables is 818 as this better reflects the number of classes involved in the project. Panel questionnaire data for these 90 teachers are treated as independent throughout the chapter after statistical analysis failed to reveal significant differences in their response patterns between the two school years.

5) All tables are available online; see Annex A.

6) Response rates were the highest in Thailand (91%), ranging between 40% and 60% for the majority of teams, and the lowest in the Slovak, Russian and US Montessori teams, at 25% or less. No questionnaires are available for the US (Vista) team.

7) The small size of the panel (longitudinal) teacher samples prevents robust difference-in-difference analyses. Once split for comparing the outcomes of teachers in control and intervention groups, the low number of responses does not afford enough statistical power to parse out genuine effects from random variation. As pre-post comparisons come with wide margins of uncertainty, results must be interpreted with caution. Even for the larger samples of the Hungarian and Thai teams, the questionnaire data from the first phase of the project cannot support strong causal inference about impact. See Technical Annex for more details on the methodology.

8) The decision to focus analyses of change exclusively on the Hungarian and Thai panel subsamples rests on several criteria. They are the only samples to: include at least 30 teachers completing both pre- and post-questionnaires; have a good balance of respondents between intervention and control groups (each within the 45-55% range); represent more than 50% of the total number of participating teachers in their teams; and represent over 80% of the number of teachers having completed pre questionnaires in their teams (Table 6.1).

9) The vignettes were designed and tested for the first time in the context of the OECD-CERI project. They serve to assess respondents' alignment with the conceptual framework of the project as embodied in the project rubrics, rather than with other expert or consensual definitions of creativity or critical thinking. The expected order of the vignette scenarios is defined by two conditions: 1) identifying the presumed hierarchical structure of the three scenarios in terms of levels of creativity or critical thinking; 2) identifying the top and bottom vignette examples as representing the highest and lowest levels, respectively. While not subject to a robust psychometric validation yet, the project vignettes represent a promising innovation for the study of creativity and critical thinking in a school context. For more details, see Technical Annex.

10) In the case of instruction practices, teachers reported the number of times they had used each specific practice over the past 4 weeks; in the case of assessment practices, the period extended to 12 weeks. In both cases, relative frequencies (percentage of lessons in which a practice is used) are calculated using information about the number of teaching hours per week.

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Annex A. List of tables available online

The following tables are available in electronic form only.

Chapter 6. Teacher attitudes and practices around creativity and critical thinking

Table 6.11 d. Intervention teachers: perceived changes in students
StatLink https://doi.org/10.1787/888934003250

Table 6.11 e. Intervention teachers: overall evaluation
StatLink https://doi.org/10.1787/888934003269

Table 6.12. Views from school principals post intervention
StatLink https://doi.org/10.1787/888934003288

Chapter 7

Effects of the project on students' outcomes and development of survey instruments

This chapter presents the most relevant effects of the OECD-CERI pilot project on students' outcomes and discusses the validation of the survey instruments. Furthermore, it introduces the initial findings of a class-level analysis, with a special focus on the most successful classes and the characteristics of their teachers, students and adopted pedagogical activities. Finally, it discusses the lessons learnt from the pilot phase. These are laid out by main topic and provide suggestions on how the survey operations and instruments can be improved in sight of the validation phase.

The OECD-CERI project

The OECD-CERI project brought together 13 teams from 11 different countries which recognised the importance of creativity and critical thinking for the future development of their students and partnered together in order to foster these skills with innovative pedagogical practices and a shared understanding of what creativity and critical thinking entail. The teams were from both OECD member countries (France [CRI and Lamap teams], Hungary, the Netherlands, the Slovak Republic, Spain [Madrid Community], the United Kingdom [Wales] and the United States [Montessori and Vista teams]) and from non member economies (Brazil, India, the Russian Federation and Thailand).

While the project mainly focused an intervention based on the development of pedagogical resources, a secondary objective was to develop instruments that would be used in a validation phase of the project. To this effect, the OECD developed and field trialled instruments for a quasi-experimental survey design, which consisted of selecting two samples of students and administering to them a set of questionnaires and tests for measuring several outcomes of interest (e.g. creative potential) and relevant explanatory variables (e.g. gender, age). One group was exposed to pedagogical practices aimed at fostering students' creativity and critical thinking (the intervention group), while the other one served as a reference (the control group). The administration of the questionnaires and tests took place twice for both groups of students: once before the intervention group started adopting the new pedagogies (at pre-), and once towards the end of the school year (at post-).

It is worthwhile highlighting what exactly defines the intervention group, as the juxtaposition between this group and the control group will represent the core of the analysis that will follow. The students in the intervention group were those whose teachers actively participated in professional development sessions organised for this project (see Chapter 5). These events provided teachers with common tools describing the main characteristics of pedagogical activities that would foster and assess creativity and critical thinking (see Chapter 2). Nonetheless, teachers in some teams were given complete autonomy concerning the practical development of the activities in terms of content and length. Therefore, not all students in the intervention group were exposed to the same pedagogical activities. Instead, all students in the intervention group had teachers who were part of dedicated professional development events and were exposed to pedagogical activities that were inspired by the principles discussed at these events.

The OECD developed most of the instruments and tests specifically for this project, which consisted of a student questionnaire, an achievement test in science and mathematics, and an achievement test in visual arts and music. All instruments were level-specific, meaning that those administered to primary students were simpler than those developed for secondary students. Furthermore, the project also adopted the EPoC test, a test developed by Todd Lubart, Maud Besançon and Baptiste Barbot which aims at measuring discipline specific creative potential in children and adolescents (Lubart, Besançon and Barbot, 2011 [1]). In this chapter, findings at student level will also rely on some of the data obtained through the teachers' questionnaires.

The part of the OECD-CERI project involving the students took place between November 2015 and July 2017, a period that included two complete school years for both the northern and the southern hemispheres. The involvement of the local teams differed across school years, school level and administered instruments, but overall it allowed answers to be collected from more than 17 000 students. Hereinafter, "Round 1" and "Round 2" will be used to distinguish the stages of the project including respectively the first and second year of data collection. The assessments at pre- and at post- were carried out in each of the two rounds, and while some teachers took part in both rounds (33 out of 380, 15 in the intervention group and 18 in the control one), the vast majority of students did not. In fact, only 40 students did, and their Round 2 data were excluded from the analysis for the purpose of this report.

This chapter presents the initial findings describing the effect of the new pedagogical activities on students. These findings only represent a short-term assessment of the effectiveness of the intervention with students, as an assessment of longer term effects was not part of this pilot. Investigating the relevant factors that would allow a deeper evaluation of the findings (e.g. teachers gaining confidence with the new pedagogies over time, students being more able to process and assimilate the new pedagogies and concepts over longer periods) would only be possible through an assessment of longer term effects.

In light of a possible validation phase, this pilot represented an important field test for the different survey instruments, the administration in real life settings and the subsequent comparability of the data across countries. In order to ensure a consistent implementation of the survey operations, the OECD distributed guidelines and recommendations for the administration of the instruments to all teams in the form of a research protocol. At the end of the pilot, the refined research protocol was one of the outcomes of the project in terms of the development of instruments. In terms of instrument selection, teams independently chose which instruments to administer to their participants, usually following the structure of their interventions (i.e. teams focusing on creativity and critical thinking in mathematics prioritised the test in science and mathematics over the one in visual arts and music). Successively, teams were in charge of translating all instruments into their national language(s) and administering them according to the research protocol. The OECD co-ordinated the data collection and was in charge of the data analysis.

The research questions

For the pilot stage of the OECD-CERI project, the research questions addressed in this chapter covered two broad areas: survey issues and students' outcomes. The survey issues concerned all the challenges faced for a successful development of the survey instruments and implementation of the data collection. The students' outcomes, instead, focused on the effectiveness of the intervention at student level, and the aim was to establish whether the findings were encouraging for certain teams, levels, topics or for any combination of these. At this stage, the pilot was meant to constitute a proof of concept: finding out if the intervention worked under certain conditions would represent the rationale for a subsequent validation study.

The different instruments that were developed for this pilot represented one of the key outputs. Almost all instruments were used in the field for the first time, so there were some crucial questions needed to be clarified:

- Did the instruments measure the concepts for which they were built?
- Were the instruments capable of measuring meaningful changes in these concepts despite the relatively short period between the pre- and post-assessments?
- Did the instruments capture all the relevant information for a meaningful analysis?
- Could the instruments be further refined and improved?

In terms of survey design and survey management, the biggest challenges were the heterogeneity of stakeholders involved in the project and the narrow period within which the survey was organised and run. This meant that there were limited occasions for training and support in the use of the instruments and that, in some instances, operational responsibilities were assigned to people with limited prior experience in survey management and data collection. However, it will be informative for the validation phase to get an indication of whether such a complex design could be handled by in house staff rather than outside contractors. Some key questions in this regard were:

- Were survey operations carried out according to the research protocol?
- Were survey instruments used as expected?
- Was data collection carried out according to the research protocol?

Finally, in terms of students' outcomes, the questions were those that underpin most experimental studies:

- What types of effects can be identified?
- What is the role of context?
- Are there differential effects across subgroups of students?

Development and validation of the instruments

As mentioned above, students were administered up to four different instruments: a student questionnaire, the EPoC creativity test, an achievement test in science and mathematics, and an achievement test in visual arts and music. Students completed all relevant instruments twice: before the beginning of the intervention (at pre), and after the intervention was concluded, or the school year approached its end, (at post), ideally an interval of six months between the pre- and post-measurements. The following paragraphs provide a brief description of the characteristics and content of each instrument.

The student questionnaire, which presented only minor differences between its pre- and post-versions, contained several item batteries that allowed building a series of indices of interest, such as the index of positive learning feelings (Dormann, Demerouti and Bakker, 2018[2]; Schneider et al., 2016[3]) or the index of learning dispositions related to creativity and critical thinking (Carr and Claxton, 2002[4]). The questionnaire also included some anchoring vignettes about creativity and critical thinking (King et al., 2004[5]), which allowed evaluating students' understanding of these concepts and self-perception in terms of their creativity and critical thinking. Furthermore, the questionnaire collected some background information on the students and their households (e.g. gender, education level of the household), and on the students' activities inside and outside of school.

The EPoC test was developed to measure creative potential in children and adolescents in different domains of creative thinking and production: artistic-graphic; verbal-literary; social problem solving; scientific, mathematics and music composition (Lubart, Besançon and Barbot, 2011[1]). The test required individuals to produce work (e.g. drawings, stories, problem solutions) which was then assessed in a standardised way. In each domain, there were two types of tasks: divergent-exploratory thinking and convergent-integrative thinking (creative synthesis). The final creative potential measure included both aspects of creativity. For each domain, two equivalent booklets were developed, called booklet A and booklet B, making it therefore possible to conduct a pre post comparison. The EPoC test required 40-50 minutes to be completed.

The achievement test in science and mathematics was built by the OECD with released items taken from two large-scale surveys: Trends in International Mathematics and Science Study (TIMSS, carried out by the International Association for the Evaluation of Educational Achievement [IEA]) for primary students, and the Programme for International Student Assessment (PISA, carried out by the OECD) for secondary students. The test contained open- and closed-ended items on science and mathematics, some embedded questions on students' interest in these subjects, and some questions about teaching practices in their science and mathematics classes. As with the EPoC test, two booklets of equivalent difficulty were developed in order to allow pre post comparisons. Each booklet included 20 items that contributed to the final score at primary level, and 18 items at secondary level. Students at both levels were given 45 minutes to complete the test. Henceforward, this test will be referred to as the STEM test.

The achievement test in visual arts and music was built in house by the OECD. The test contained only closed-ended items on visual arts and music, some embedded questions on students' interest in these subjects, and some questions about teaching practices in their visual arts and music classes. As with the STEM test, two different tests were developed for primary and secondary students, and in both cases two equivalent booklets were developed in order to allow pre post comparisons. Each booklet included 53 items that contributed to the final score at primary level, and 82 items at secondary level. Students at both levels were given 30 minutes to complete the test. Henceforward, this test will be referred to as the VAM test.

All scores and indices discussed in this chapter are country-, level- and discipline-specific. Scores were computed as simple weighted scores, and the weights depended on the proportion of respondents that correctly answered each item in the different countries, educational levels and items. For STEM scores, these proportions were obtained from the TIMSS and PISA survey data (IEA, 2011 [6]; OECD, 2006[7]; OECD, 2012[8]). For VAM scores, instead, they consisted of the proportion of respondents that correctly answered each item in the single countries. If any of the weights were not available, international item- and level-specific weights were used. More complex methods, such as Item Response Theory (IRT) models, were also investigated for computing the achievement scores. However, due to the high correlation between the IRT scores and the simple weighted scores, it was preferred not to use IRT scores in order to ease the interpretation of the results. The majority of the indices were built by means of separate team- and level-specific factor analyses, with the remaining ones obtained by taking the simple average of two items. In the case of the factor analyses, it was assured that configural invariance was respected among all teams and levels. Furthermore, scores and indices depended on the discipline in which the students received the intervention. For example, if a student received the intervention in mathematics, their final STEM score would include only their score to the questions in mathematics. However, if their intervention was in a subject different from mathematics and science, their final STEM score would include their scores to the questions in both mathematics and science.

Between Round 1 and Round 2, the OECD carried out an initial assessment of the instruments' characteristics. The questionnaire and the STEM test saw only minor changes, while several items were removed and replaced in the VAM test. Additional details about the item-selection procedures, the instruments, the way that scores and indices were derived, and the validity checks that were run on them can be found in the Technical Annex.

The study group

Size of the study's populations

The initial sample of the OECD-CERI project pilot included 20 273 students – 8 949 primary school students and 11 324 secondary school students. The smallest sample size was that of the French (CRI) team (354) and the biggest corresponded to the Thai team with 5 021 students. A few schools and classes dropped out before the project even started, which reduced the sample of participating students to 19 129 (8 358 in primary school and 10 771 in secondary school). Of the 19 129 students, 17 291 participated in at least one assessment included in the data collection. With the exception of the Indian team, which achieved a response rate of 64%, the response rate across all the other teams was, on average, 95%.

Based on the high response rates and on the available information concerning a large part of the non-completion mechanisms, the analysis will make the assumption that the response mechanisms for all instruments followed a "missing completely at random" (MCAR) distribution – for further details see the work of Rubin (1976[9]). This is equivalent to assuming that the attrition (or the nonresponse) did not concern some groups of students more than others, or that there was not a selection bias. In most cases of classes or schools dropping out during the project or before the beginning of the data collection, local teams promptly informed the OECD about these occurrences and provided explanations for these events. For example, a few teams reported classes or entire schools dropping out because they had committed to too many research projects and were asked by their governing boards to drop the majority of them. In many other cases, the reasons for the missingness of post data were rooted in operational hiccups and in the misuse of the instruments, which were independent of the characteristics of the students.

As far as the STEM and VAM achievement tests are concerned, the scores of some students were excluded from the analysis because their response rate to the items in the tests was not above an agreed threshold. Such a decision aimed at excluding those scores that were at risk of depending exclusively on the (low) effort put into taking the test rather than on the students' ability. The selected threshold was 70%, which was established at the lowest possible value while maintaining the consequent data loss within acceptable limits. This implies, for example, that if a student left 7 or more items out of 20 blank, then their score was not considered as reliable, and it was thus excluded from the analysis. The overall data loss for the STEM test was 8% for primary students and 6% for secondary students. For the VAM test, data loss amounted to 20% for primary students and 4% for secondary students. However, most of these data losses were registered by teams that also faced relevant operational issues.

Of the 17 291 students who participated in at least one assessment, 12 265 completed at least one instrument both at pre and at post, with 5 703 at primary level and 6 562 at secondary level (Table 7.1). This corresponded to an overall completion rate of 71%, with only a minor difference between the two educational levels: 75% among primary students and 68% among secondary students. The highest completion rate was observed for the French (CRI) team (98%), while the Indian team had the lowest completion rate (28%). In terms of pre and post available data for the single instruments, the teams collected 8 986 questionnaires (with a completion rate of 67%), 7 953 EPoC creativity tests (with a completion rate of 75%), 7 376 STEM achievement tests with less than 30% of missing values (with a completion rate of 62%) and 1 500 VAM achievement tests with less than 30% of missing values (with a completion rate of 50%).

Table 7.1. Number of students who completed an instrument at the beginning of the project and share of those who also completed the corresponding instrument at the end of it, by team

	Questionnaires	EPoC creativity tests	STEM achievement tests	VAM achievement tests	Any instrument
Brazilian team	1 119 (51%)	628 (90%)	981 (31%)	x	1 248 (62%)
British (Wales) team	791 (75%)	821 (89%)	725 (86%)	x	852 (91%)
Dutch team	852 (69%)	652 (56%)	487 (63%)	348 (75%)	874 (73%)
French (CRI) team	325 (96%)	204 (99%)	319 (97%)	x	345 (98%)
French (Lamap) team	207 (0%)	361 (97%)	201 (19%)	x	364 (97%)
Hungarian team	1 272 (89%)	1 214 (62%)	1 286 (87%)	x	1 534 (85%)
Indian team	999 (31%)	x	1 280 (25%)	x	1 793 (28%)
Russian team	860 (66%)	1 310 (64%)	1 547 (41%)	740 (0%)	2 122 (50%)
Slovak team	563 (63%)	619 (90%)	423 (61%)	457 (64%)	652 (88%)
Spanish (Madrid) team	467 (0%)	x	361 (74%)	x	670 (51%)
Thai team	4 333 (86%)	3 645 (85%)	3 426 (84%)	456 (99%)	4 590 (95%)
US (Montessori) team	90 (0%)	242 (38%)	169 (53%)	x	253 (37%)
US (Vista) team	1 621 (51%)	938 (41%)	774 (30%)	246 (45%)	1 994 (58%)
Total	13 499 (67%)	10 634 (75%)	11 979 (62%)	2 247 (50%)	17 291 (71%)

Notes: EPoC: Evaluation of Creative Potential; STEM: science, technology, engineering and mathematics; VAM: visual arts and music. STEM and VAM data only include those students who responded to at least 70% of the items included in the tests.

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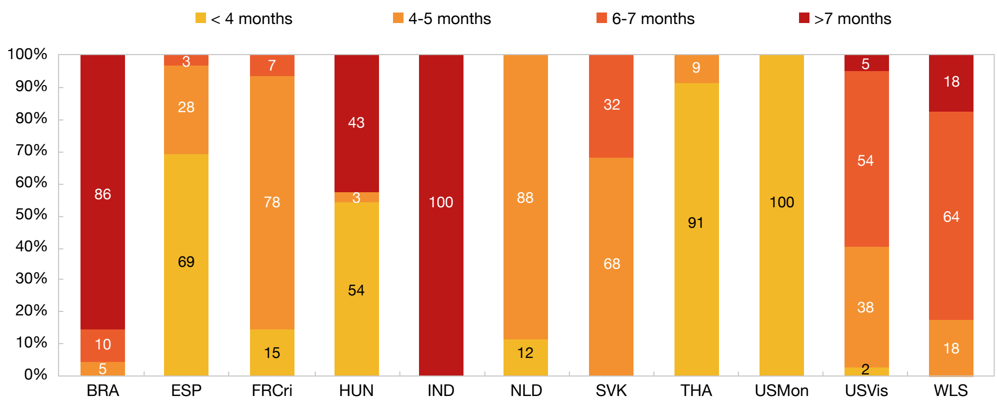
The intervention with students

The research protocol recommended that the intervention with students take place between the pre- and the post-measurements, and that six to seven months elapse between the two measurements. Unfortunately, few teams were able to stick to the recommendation of the research protocol. As Figure 7.1. shows, only four teams managed to have a time frame of six months or more between pre- and post- data collections for at least 50% of their students, while some have time frames of three months. Some teams do not appear in Figure 7.1. as this information was not available. No remarkable differences could be observed between educational levels.

Figure 7.1. Share of students by length of data collection's time frame and team



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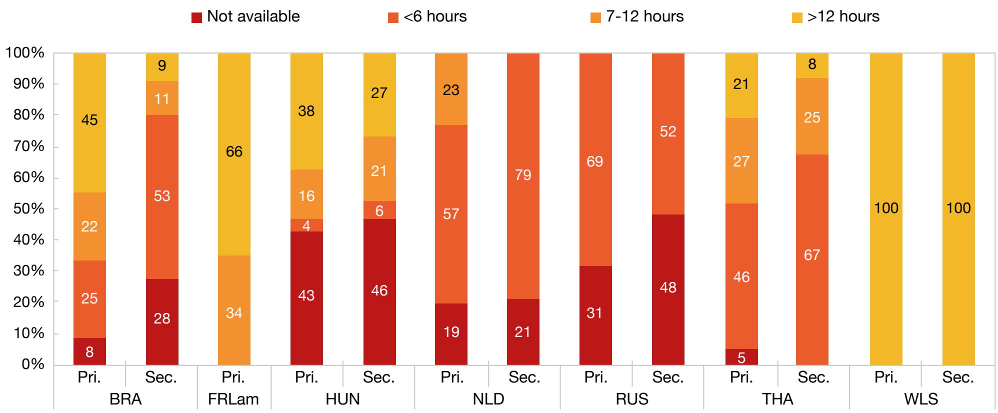
In the context of this chapter, the duration of the intervention refers to the number of hours spent by students on the new pedagogical activities. This is substantially different from, and much shorter than, the duration of the project for teachers. In fact, the intervention with teachers also included meetings of the professional development plan and any out-of-class time spent by teachers to reflect on the new instruments (such as the rubric; see Chapter 2) and to devise and develop the new pedagogical activities.

The research protocol did not contain any explicit recommendation in terms of the duration of the intervention with students, as the local teams had to adapt to very different school contexts. In fact, substantial differences could be observed among teams (Figure 7.2.). Interestingly, the duration of the intervention was longer at primary level for almost all teams for which there was data available. A possible explanation may be based on the number of teaching hours with the same class available to each teacher, which is much higher in primary school than in secondary school. Consequently, a higher number of teaching hours with the same class allows teachers greater flexibility in the organisation of their teaching activities, making thus primary school teachers more likely to dedicate more hours to the project than their secondary school counterparts. Other factors that likely played a role in this context were the different disciplines in which the interventions were carried out (with significant variations in their allotment of instruction time) and the different teaching cultures that exist at primary and secondary level.

Figure 7.2. Share of students by duration of the intervention with students, team and educational level



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Taken together, Figure 7.1. and Figure 7.2. show that, from the available data, less than four months passed between the pre- and post-measurements for about 24% of the students, and that the intervention lasted less than six hours for almost 55% of the students. This figure should be taken with caution, as teams did not always time the duration of the teachers' interventions with students, nonetheless it shows that students' exposure to the new pedagogies was relatively short. (Taken at face value, this average corresponds to 1% of the average instruction time for six months in the participating countries [data adapted from OECD (2018[10])]). This highlights the pilot nature of the study and is a reminder that the objective of this phase was not to measure the efficacy of the intervention, but to develop instruments and field trial them. As a result, even where there are enough data collected, the real impact of the intervention could be underestimated due both to the short period elapsed between the two measurements and the limited exposure of the students to it. In fact, even by allowing that the innovative teaching practices might trickle and permeate some of the remaining instruction time, at least 90-95% of instruction time would still be delivered through the established teaching practices.

Characteristics of the study population

This section discusses the main characteristics of the population that took part in the OECD-CERI project. In order to provide further context for the description of the different realities in which the single teams operated, PISA 2015 data (OECD, 2015[11]) were used as a reference value. While collected in 2015, which is two to three years before the data collection for this project, PISA 2015 data provide nationally representative estimates for some of the variables that were also collected in this pilot. By including them, readers can see how the samples participating in this project compared to their respective national populations. However, these comparisons should only be used as simple indications, as teams were not required to be working with nationally representative samples.

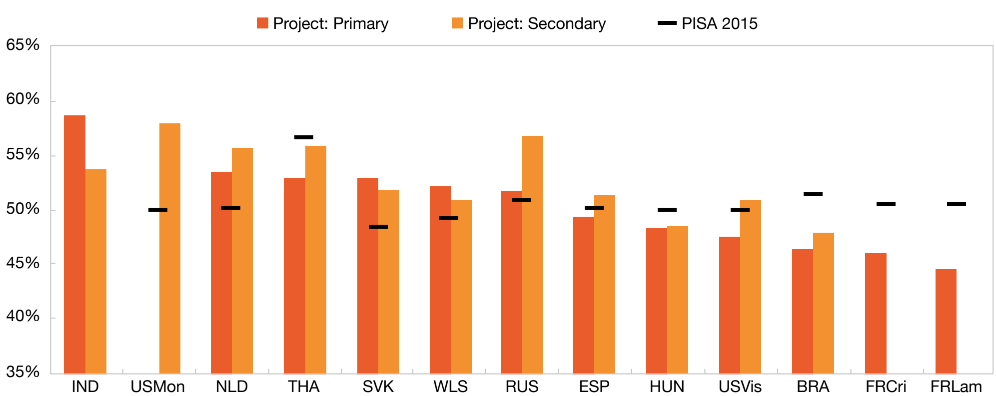
Age

The research protocol recommended local teams to include in their samples 3rd grade classes for primary students and 8th grade classes for secondary students. Nevertheless, the age of the students still showed some variation across the different teams. For primary students, the average age across teams was 8.8 years, with a minimum average of 8.0 years for the US (Montessori) team and a maximum average of 10.1 years for the Brazilian team. For secondary students, the average age across teams was 13.5 years, with a minimum average of 12.5 years for the Indian team and a maximum average of 14.1 years for the Russian team. A very small number of students in the sample belonged to high schools (216 – 174 for the Brazilian team and 42 for the Hungarian one). Due to the limited size of this group, these students were analysed as part of the secondary students.

Gender

The share of girls in the samples was relatively uniform across the participating teams, with a minimum of 45% observed in the French (Lamap) team and a maximum of 58% in the US (Montessori) team. Figure 7.3. presents the share of girls across the participating teams by educational level. This share was similar across the two educational levels for most of the teams, with the exception of the Thai, Russian and Indian teams.

Figure 7.3. Share of girls in the different samples and PISA 2015 reference data, by team and educational level



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Immigrant background

According to the PISA definition (OECD, 2015[12]), students are identified as having an immigrant background if both of their parents were born abroad (i.e. regardless of the student's country of birth). In this pilot, the share of students with an immigrant background varied significantly across teams, with a minimum of 1% for the Thai team and a maximum of 44% for the US (Vista) team (Figure 7.4.). For a few teams, the share was substantially higher than the PISA 2015 values, but having sample populations with similar characteristics to those of the respective national populations was not a requirement. Possible explanations for these differences could include, but are not limited to: the fact that teams participating in this project were working with more diverse realities in terms of immigrant background than the average schools in their countries; and a real increase in terms of magnitude of the population of students with an immigrant background, which in this project was measured three to four years after the data collection for PISA 2015.

Figure 7.4. Share of students with an immigrant background in the different samples and PISA 2015 reference data, by team and educational level

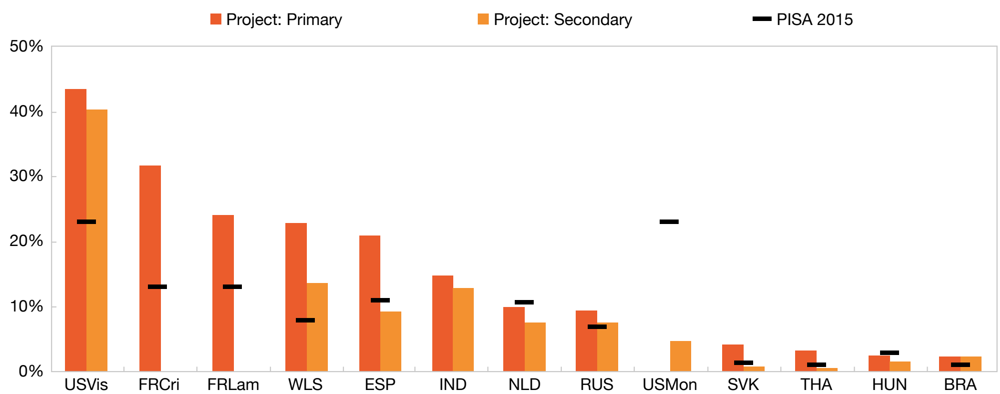

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Figure 7.4. highlights a very low presence of students with an immigrant background for some teams (less than 2.5%), at least according to the PISA definition. However, this definition exclusively takes into account the country of birth of the students' parents (as a couple). When using the information about the country of birth of the students and of each of the parents (collected through the project's student questionnaire), the data highlights several different student profiles, which differ even more when considering the information provided by the variable describing the main language spoken at home by the students. The options in this case were "Main language of the country", "Secondary language of the country" and "Foreign language".

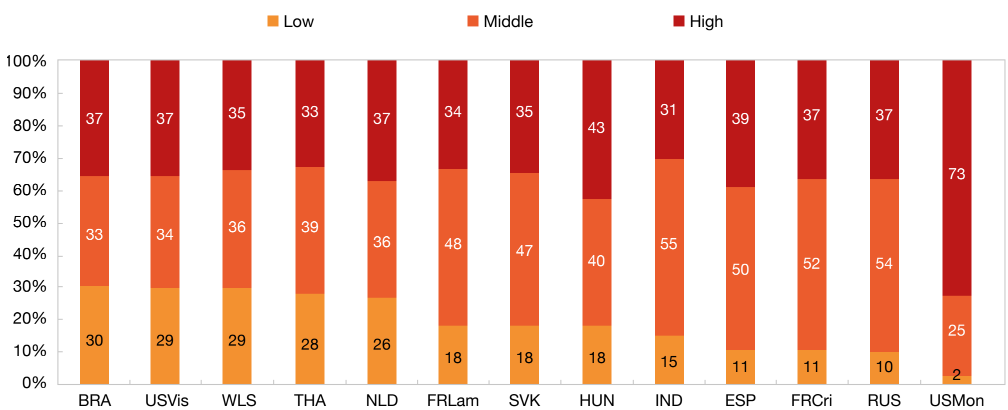
In order to have meaningful results for all teams, a new index describing the immigrant background of the students was built by using all the information provided by the variables about the country of birth of the students and their parents, and the language spoken at home by the students. The

Technical Annex illustrates the differences between the PISA variable and the new index. For the rest of the analysis, the variable used to describe the immigrant background of students will be the new index.

Socio-economic status

The socio-economic status index was built in a country- and level-specific way. At primary level, the index only included information about the possession of books of the households. At secondary level, it also included information about the highest level of education of the parents. The index divided the students into three groups according to their underlying socio-economic status (low, average and high) and aimed at including at least 15% of the students in the low and high categories for every country. Nonetheless, this was not always possible due to the underlying discrete nature of the data, and the shares of students in these two groups sometimes varied significantly across teams (Figure 7.5.). Students in the low category ranged from 2% for the US (Montessori) team to 30% for the Brazilian team, while those in the high category ranged from 31% for the Indian team to 73% for the US (Montessori) team.

Figure 7.5. Share of students with a low or high socio-economic status, by team



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Initial understanding about creativity and critical thinking

The student questionnaire contained two sets of anchoring vignettes that allowed investigation of the students' self-perception of their creativity and critical thinking (the language for primary students consisted of a simplified version of the one used for secondary students). For each skill, these vignettes described three characters with different levels of creativity or critical thinking. Students were first asked to evaluate the level of creativity or critical thinking of the characters (from "Not at all" to "Very much"), and then asked to identify themselves with one of the characters. This allowed assessing the extent to which the students had a correct understanding of these skills by looking at those who correctly ranked the different vignettes.[2]

Furthermore, it was possible to evaluate both their relative and absolute self-perception of creativity and critical thinking. The relative self perception was defined as the level of these skills that the students assigned to the character with whom they identified themselves. For example, if they believed that the character that they identified themselves with was "Very creative", then their relative self perception would result as "Very creative". The absolute self-perception, instead, was given by the a priori level of creativity or critical thinking of that character, as established when preparing the vignettes. If students identified themselves with the character with the lowest creativity, for example, then their absolute self-perception would result as "Little creative", regardless of level of creativity that they assigned to the character. If the students had a perfectly clear understanding of creativity and critical thinking, then the correlation between relative and absolute self-perception should have been close to 1.

Figure 7.6. shows the different baseline understanding of creativity that students had across teams based on the rankings of the vignettes. The average percentage of students that were able to correctly rank the three vignettes on creativity at the beginning of the project was about 40%, but the differences were substantial across teams, ranging from 61% for the Dutch team to 21% for the Indian team. With the exception of the Dutch case, though, the highest percentages were all around 45%, and no remarkable differences were observed between primary and secondary students.

Figure 7.6. Share of students who correctly ranked the vignettes on creativity at the beginning of the project, by team

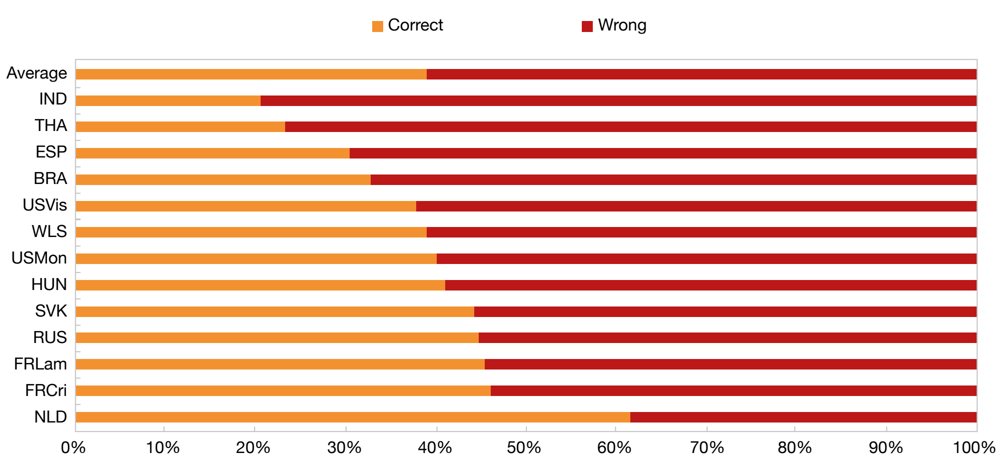

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Figure 7.7., instead, shows the shares of students correctly ranking the vignettes on critical thinking at the beginning of the project. Here, the highest percentage was observed in the US (Montessori) team (61%), while the lowest was in the Indian team (23%). The average percentage was about 40%, but substantial variation emerged between the primary and secondary levels: the average for secondary students was 47%, while that for primary students was only 30%. This difference and

the ones that emerged when considering the ranges of these percentages (a minimum of 28% and a maximum of 61% for secondary students versus a minimum of 17% and a maximum of 50% for primary students) suggest that primary students did not have a clear understanding of the different levels of critical thinking presented in the vignettes.

Figure 7.7. Share of students who correctly ranked the vignettes on critical thinking at the beginning of the project, by team

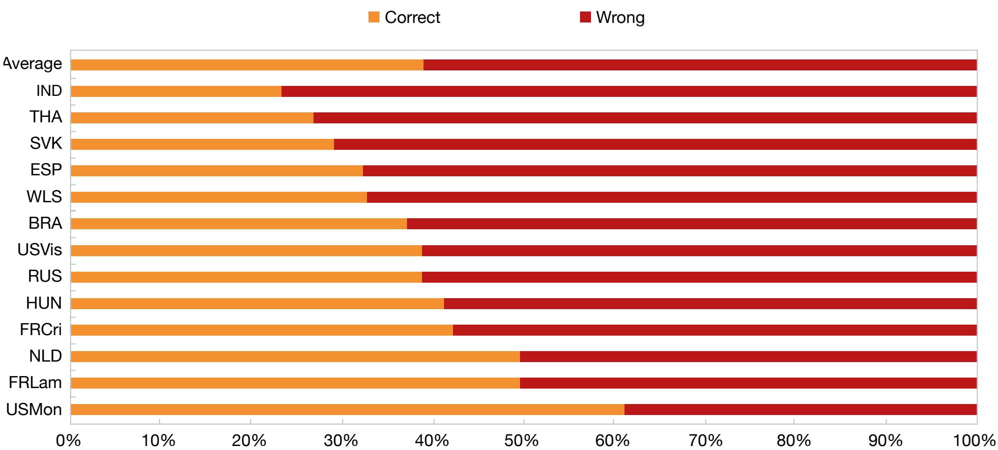

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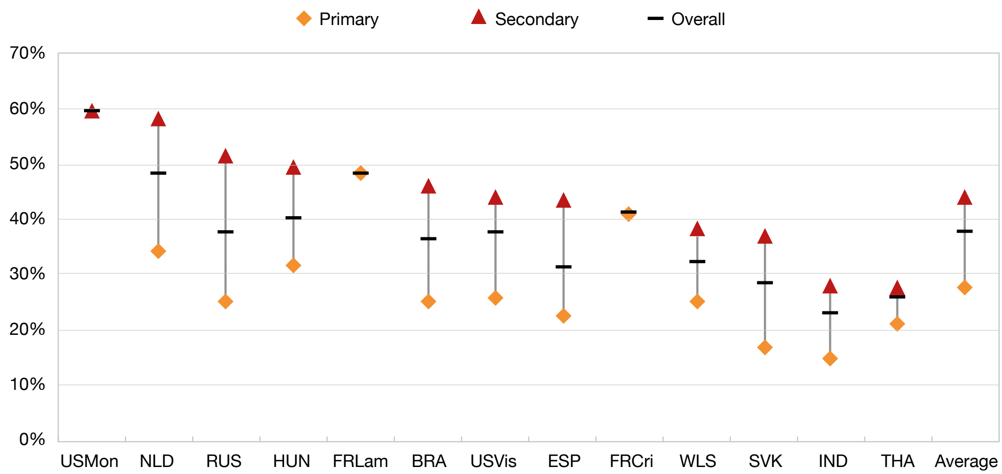
Figure 7.8. presents the same data as Figure 7.7. , but breaks the data down into primary and secondary students in order to show the differences between the responses of the two groups to the vignettes on critical thinking.

Figure 7.8. Share of students who correctly ranked the vignettes on critical thinking at the beginning of the project, by team and educational level



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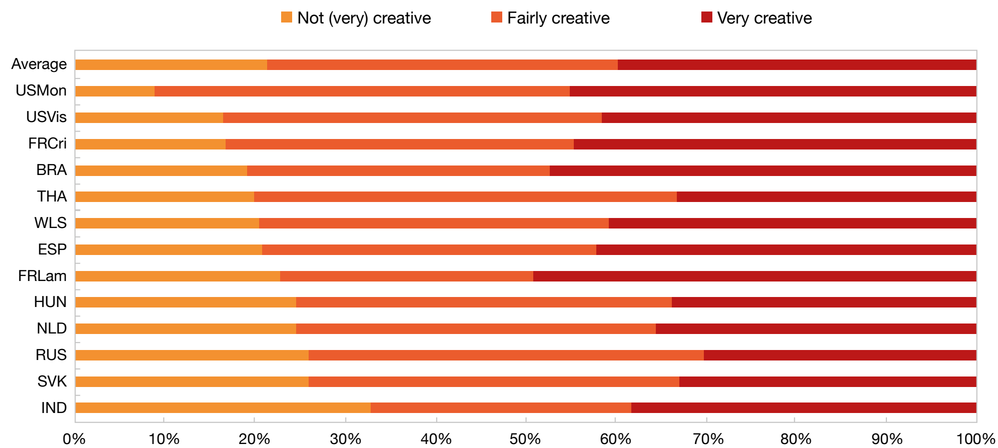
Students' self-perception of their own creativity and critical thinking

As mentioned earlier, vignettes can also be used to investigate the students' self-perception of their creativity and critical thinking. In terms of self-perception of their creativity (Figure 7.9.), the highest percentage of students identifying themselves as being very creative was registered in the French (Lamap) team (49%), while the lowest was in the Russian team (30%). Interestingly, the percentage of students at the other extreme, i.e. identifying themselves as not at all or not very creative, was similar for both teams (23% and 26%, respectively), while for other teams this percentage showed remarkable variations. The minimum was observed for the US (Montessori) team (9%), while the maximum was for the Indian team (33%). However, both the US (Montessori) and the Indian teams seemed to represent exceptional cases, as the share of students identifying themselves as not at all or not very creative varied between 17% and 26% for the other teams. The correlation between relative and absolute self-perception for creativity was around 0.3 for both primary and secondary levels of education.

Figure 7.9. Students' relative self-perception of their creativity at the beginning of the project, by team



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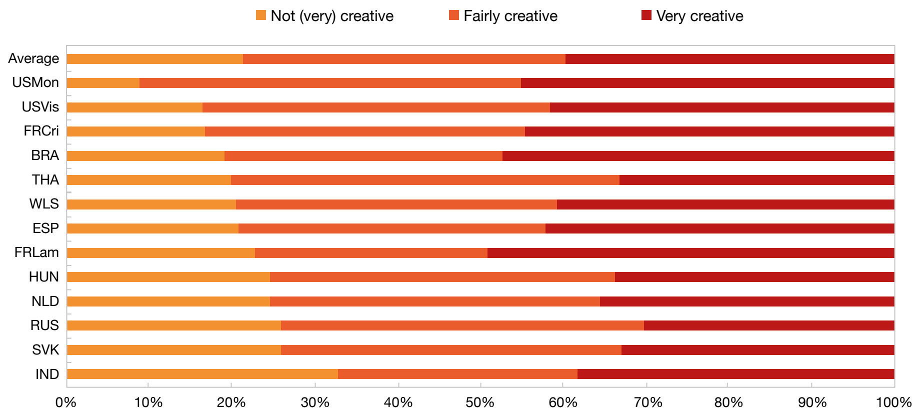
When considering the students' relative self-perception of critical thinking (Figure 7.10.), the highest percentage of those identifying themselves as being very critical thinkers was registered in the French (Lamap) team (46%), while the lowest was in the Slovak team (23%). A similar variation could be observed in the percentage of students identifying themselves as not at all or not very critical thinkers, which ranged from 18% for the US (Montessori) team to 42% for the Indian team. In the case of critical thinking, looking at the correlation between relative and absolute self-perception seems to confirm the analysis in the previous paragraphs, i.e. that primary students did not have a clear understanding of the different levels of critical thinking presented in the vignettes. In fact, while the correlation was around 0.3 for secondary students (the same value observed in the case of creativity), it was close to 0 for primary students. Possible explanations for this difference for primary students may lie in the simplified language that was adopted for their vignettes (which may not have been as effective as intended), in the natural development of children (as developmental psychology shows that abstract thinking tends to develop during adolescence) or in the presence of a more common understanding of creativity than of critical thinking between children and adolescents.

Figure 7.10. Students' relative self-perception of their critical thinking skills at the beginning of the project, by team



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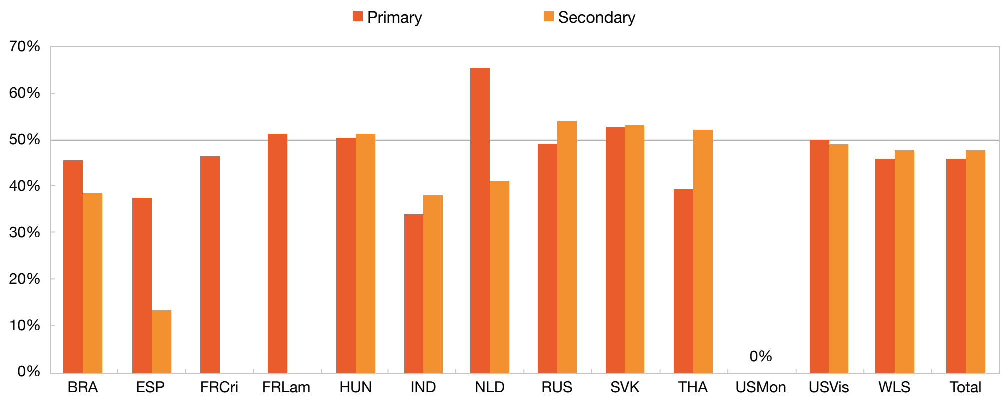
Control and intervention groups

So far, the descriptive analysis has looked at all the students who participated in the project altogether. As mentioned earlier, though, the project followed a quasi experimental design, which implied splitting students into two groups: those in the control group and those in the intervention one. The research protocol recommended recruiting control groups that were broadly comparable to the intervention groups, notably in terms of academic achievement and socio-economic status. Furthermore, it wanted control and intervention groups of similar size.

Significant differences between these groups emerged when their profiles were analysed by team and educational level. This was true for the underlying distribution of some of the main socio-demographic variables of interest and for the sample sizes of the two groups. Overall, out of the 7 620 primary students, 3 486 were enrolled in the control group, while 4 134 were part of the intervention group, leading to an average 46% share of controls. Across teams, though, this share varied between 34% and 66% (Figure 7.11.). On the other hand, the 9 657 secondary students were divided into 4 558 control students and 5 099 intervention students, which led to an average 47% share of controls. As in the case of primary students, the share of controls showed a stark variation across teams – between 13% and 54%. Most of the cases with a substantial unbalance between the two groups occurred due to issues of various kinds faced during the school recruitment process or data collection operations.

Figure 7.11. Share of control students, by team and educational level



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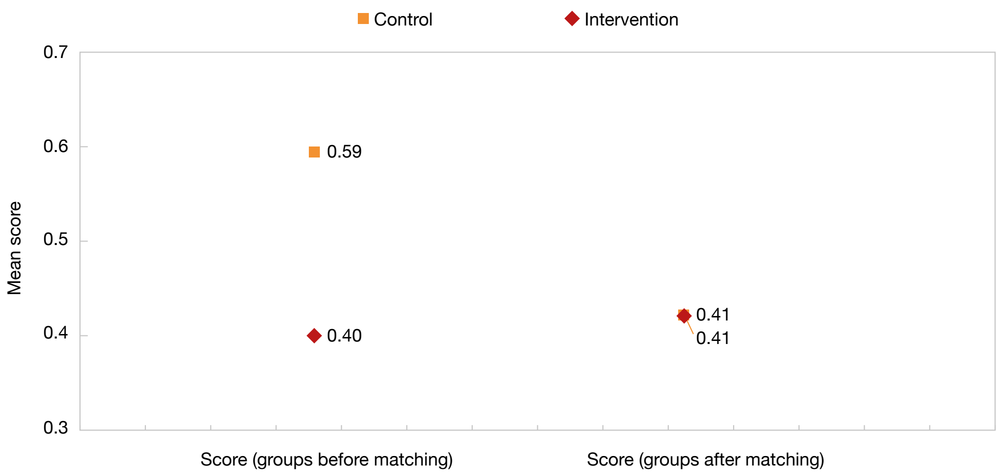
In terms of socio-demographic variables, local teams were encouraged to select schools, teachers and students from a variety of possible backgrounds when possible (e.g. in terms of school size, socio-economic status, achievement level), and to ensure that control and intervention groups would be broadly comparable. In spite of the teams' efforts, these recommendations proved difficult to achieve in practice and there were substantial differences between the two groups. In order to reduce their impact on the findings to a minimum, the first step of the analysis consisted of a propensity score matching (Rosenbaum and Rubin, 1983[13]). This technique realigns the baselines of the two samples by attributing different weights to the students in the control group. A specific set of weights was computed for each of the survey instruments. The weights for the questionnaire were computed in order to adjust potential imbalances in gender, socio-economic status and age. The weights for the tests, additionally, also adjusted potential imbalances in the baseline of their main variable of interest (namely the EPoC, STEM and VAM scores). Figure 7.12. shows an example of the effect of the propensity score matching.

Figure 7.12. Example of the effect of the propensity score matching on the STEM scores at the beginning of the project for primary students in the Thai team



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The objective of the propensity score matching was to obtain two groups of controls and interventions that, once weighted, can be assumed to be largely equivalent (at the beginning of the project). Its main drawback is that it implies some data loss if some students did not reply to any of the explanatory variables used for building the propensity scores. In this case, it becomes impossible to compute their propensity score, and they need to be excluded from the analysis. However, this would have ultimately happened anyway when running any analysis including the explanatory variables used for the matching. In order to minimise data losses, the propensity score matching included only the variables listed in the previous paragraph (mostly available for all students) and sometimes accepted minor imbalances between the groups rather than excluding a significant number of students from the analysis. As an indication, the data loss due to the propensity score matching amounted to 3% of the overall data for the questionnaires, 11% for the EPoC creativity tests, 6% for the STEM achievement tests and 4% for the VAM achievement tests. More information about this analysis can be found in the Technical Annex.

Measuring the effects of the intervention with students

The main objective of this pilot was to develop instruments for a possible validation phase of the study. This process included the actual collection and analysis of data, first to assess the validity of the instruments, but also to understand the effects of the intervention, even with a small statistical power.

The following sections discuss the results associated with being in the intervention group on students and the factors that affected these results in a consistent way across countries. The first section introduces the methods used for the analysis, while the second presents the results that were consistently observed across countries for all students. The focus then shifts to specific subgroups of students in order to explore whether the intervention had a differential effect for some sub-populations. All results account for the possible confounding effects of a set of 13 explanatory variables.

Methods

The results derived from a set of multivariate models that investigated the effect of the intervention with students in terms of pre post change for several outcomes of interest. All models were computed with cluster robust standard errors at school level, thus accounting for the hierarchical structure of the data. Furthermore, all models included a set of control variables, such as age, gender, socio-economic status, subject and the value of the outcome of interest at the beginning of the project. When available, the time between pre- and post- data collections and the duration of the intervention with students were also included among the control variables.

The analysis was limited to a discussion of the results in terms of the direction of the findings (positive or negative) due to the high heterogeneity in the fieldwork carried out by the different teams. The current pilot constituted a proof of concept, so the actual magnitude of the findings would have had only limited importance for the assessment of the effectiveness of the intervention with students. Hence, rather than focusing on the size of the different coefficients, the analysis focused more on the patterns that could be observed across different teams and educational levels.

The threshold for statistical significance was not set at the conventional level of 0.05. Initially suggested by Fisher in 1926, the threshold of 0.05 implies that out of 100 tries, the result of interest will be observed in at least 95 occasions. In other words, the conclusion would not be true in 1 out of 20 tries. As the same author pointed out, this threshold was deemed appropriate for establishing "experimentally established" scientific facts (Fisher, 1926[14]), which was not among the objectives of this pilot. Furthermore, as stated by the American Statistical Association in 2016, "scientific conclusions and business or policy decisions should not be based only on whether a p value passes a specific threshold" (Wasserstein and Lazar, 2016[15]).

As the same authors suggest to use the significance "as a tool to indicate when a result warrants further scrutiny", and in order to comply with the explorative and informative – rather than evaluative – nature of this report, the threshold for statistical significance was set at the level of 0.2, meaning that the results presented as statistically significant in this analysis would be observed in at least four out of five tries. All considerations about the need for a more restrictive definition of the statistical significance will be discussed in the context of the future validation study, if any, just like those on the magnitude of single effects. For information, the share of results discussed in Table 7.2. that were also significant at the level of 0.1 amounted to almost 80%, while the share was 65% for those discussed in Table 7.3.

This pilot provided a substantial wealth of data, collecting up to more than 2 000 variables for each of the participating students. For the purpose of this chapter, 36 outcomes constituted the focus of interest. Of these, 18 were taken from the questionnaire (8 of which from the section on vignettes); the remaining 18 were taken from the EPoC, STEM and VAM tests (6 outcomes from each). In order to select the most relevant explanatory variables, the effects of 29 variables on the outcomes of interest were initially explored. Of the initial 29 variables, 13 were retained, which included the time between pre-and post- data collections and 3 main groups of variables concerning, respectively, the students' background, their responses to the vignettes, and their teachers' practices and beliefs.

The final analysis consisted of team- and level-specific models investigating: 1) the effect of the intervention with students after controlling for the above-mentioned set of control variables; and 2) the effect of the interaction of the 13 explanatory variables of interest with the intervention (while still maintaining the control variables in the models). The number of models varied significantly across teams due to the differences in data availability. For point (1), they ranged from 34 for the Slovak team to 3 for the French (Lamap) team, while for point (2) they ranged from 413 for the Thai team to 36 for the French (Lamap) team. The Spanish and US (Montessori) teams were excluded from the multivariate analysis due to data availability issues. Table 7.2. illustrates the findings related to point (1).

Overall results of the intervention with students

The aim of this pilot was to implement new pedagogical activities that would benefit students on several dimensions concerning creativity and critical thinking: their creativity potential, their understanding of these concepts, the use of teaching practices related to these skills by their teachers, their learning dispositions and learning approach towards these skills, etc. Furthermore, it was important to measure the potential effects of this intervention with students in terms of more established metrics, such as scores in achievement tests focusing on STEM or VAM subjects.

For this to be true, students in the intervention group would need to show more improvements in the outcomes of interest than their counterparts in the control group. Additionally, it would be desirable for these findings to be consistent across countries, even if only limited to some subjects, topics, educational levels or other relevant variables.

The intervention with students seemed to have a positive effect: of all the 268 models, 25% showed a statistically significant positive effect while only 18% showed a significant negative effect, for a net total of 7%. The overall impact of the intervention was similar across educational levels, as the net totals were around 7% for primary and secondary students taken separately.

For primary students, the intervention seemed to be particularly beneficial in terms of scores in the achievement tests. More specifically, positive and significant effects were observed for:

- STEM test scores (for four teams out of nine)
- VAM test scores (for two teams out of three).

Table 7.2. Positive and negative statistically significant results associated with the effect of the intervention with students

Instrument	Index or item	Models with positive results	Models with negative results	Total models
STEM test	Teaching practices in STEM (P)	1	1	8
	Teaching practices in STEM (S)	3	0	6
	Interest in STEM (P)	2	3	9
	Interest in STEM (S)	2	2	7
	Score (P)	4	0	9
	Score (S)	1	1	7
VAM test	Teaching practices in VAM (P)	1	0	3
	Teaching practices in VAM (S)	1	0	2
	Interest in VAM (P)	0	0	3
	Interest in VAM (S)	2	0	2
	Score (P)	2	0	3
	Score (S)	2	0	2
Vignettes	Ranking CR vignettes (P)	2	0	10
	Ranking CR vignettes (S)	3	1	8
	Ranking CT vignettes (P)	0	0	10
	Ranking CT vignettes (S)	2	2	8
	Rel. self-perc. CR (P)	4	2	10
	Rel. self-perc. CR (S)	2	3	8
	Rel. self-perc. CT (P)	1	2	10
	Rel. self-perc. CT (S)	3	2	8
EPoC test	Overall score (P)	1	1	8
	Overall score (S)	3	0	6
	Convergent score (P)	2	3	9
	Convergent score (S)	2	2	7
	Divergent score (P)	4	0	9
	Divergent score (S)	1	1	7
Questionnaire	Learning dispositions (P)	1	0	3
	Learning dispositions (S)	1	0	2
	Positive feelings (P)	0	0	3
	Positive feelings (S)	2	0	2
	Single interest (P)	2	0	3
	Single interest (S)	2	0	2
	Parental engagement (P)	2	0	10
	Parental engagement (S)	3	1	8
	School belonging (S)	0	0	10
	Learning approach (S)	2	2	8
TOTAL	Primary students	34	24	130
	Secondary students	33	25	138
	All students	67	49	268

Notes: P = primary; S = secondary; CR = creativity; CT = critical thinking; Rel. self-perc. = relative self-perception. All models included a set of control variables, such as age, gender, socio-economic status, subject, the value of the outcome of interest at the beginning of the project, and, when available, the time between pre- and post- data collections and the duration of the intervention with students. The positive or negative results columns include those models for which the statistical significance of the intervention was less than 0.20.

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In both cases, none of the models showed a negative and significant effect of the intervention.

For secondary students, findings tended to be more scattered across the different variables of interest. Nonetheless, positive and significant effects were observed for:

- the use of teaching practices related to creativity and critical thinking during STEM classes (for three teams out of six)
- students' interest in VAM subjects (for two teams out of two)
- VAM test scores (for two teams out of two).

No negative and significant effects were observed for any of these variables.

In terms of scores in the EPoC creativity test, the intervention with students had mixed effects. Its effect among primary students was positive for four teams out of ten, but it was also negative for three of the remaining teams. For secondary students, instead, one team out of seven showed a positive intervention effect and three showed a negative effect. These heterogeneous effects persisted even when looking at EPoC subscores, as divergent and convergent scores presented similarly mixed results.

The time elapsed between pre- and post-measurements also had a positive impact on the amount of positive and significant results (not shown). The longer the time period between the pre- and post-measurements, the better the observed effects. Of the 227 models that included this variable, 33% showed a positive impact of longer time frames while only 15% showed a negative impact, for a net total of 17%. This effect was similarly distributed among primary and secondary students (net totals of 15% and 19%, respectively). This is in line with the recommendations of the research protocol and with the evidence of action research in education, which suggests the need of a sufficiently long time frame in order to be able to measure significant changes in the outcomes of interest. At primary level, EPoC scores were the outcome mostly associated with an improvement when the time between pre- and post- data collections was longer (for three teams out of eight). Longer time frames also seemed to have positive effects on a few indices for secondary students, such as learning dispositions related to creativity and critical thinking, positive learning feelings, and ability to correctly rank the vignettes on critical thinking. In all cases, these effects were measured in two or three teams out of seven, while no significant negative changes were observed.

Results for specific subgroups of students

When looking at the effects of the intervention with students on the different groups of students (Table 7.3.), the interest shifted to finding out whether some sub populations (e.g. girls) benefited particularly from the intervention. To do so, in each of the models presented in the previous section, the interactions between the intervention and the different sub populations of interest were included one at a time.

After considering all the outcomes of interest, the results showed that the following groups of students seemed to consistently benefit more from the intervention across countries:

- students whose teacher believed that creativity could be taught at school when the intervention started (net total of 9%)

- students who correctly ranked the vignettes on critical thinking at the beginning of the project (who showed positive differential results in 18% of the models and negative differential results in 11% of the models, for a net total of 7%)
- students who did not correctly rank the vignettes on creativity at the beginning of the project (net total of 6%).

Table 7.3. Positive and negative significant results associated with the effect of the intervention with students for the different subgroups of interest

Variable	Positive results	Negative results	Overall models	Percentage positive results	Percentage negative results	Net total	Net total (primary)	Net total (secondary)
Gender: Female	34	44	268	13%	16%	-4%	-5%	-2%
Socio-economic status: Low	41	43	265	15%	16%	-1%	-6%	6%
Socio-economic status: High	35	39	268	13%	15%	-1%	-4%	2%
Immigrant background (project definition)	52	33	261	20%	13%	7%	2%	13%
Relative self-perc. of CR at pre: Low	51	29	268	19%	11%	8%	3%	15%
Relative self-perc. of CR at pre: High	27	34	268	10%	13%	-3%	2%	-8%
Relative self-perc. of CT at pre: Low	38	44	267	14%	16%	-2%	-8%	5%
Relative self-perc. of CT at pre: High	35	49	266	13%	18%	-5%	-4%	-7%
Correct ranking of CR vignettes (at pre)	29	45	268	11%	17%	-6%	-6%	-6%
Correct ranking of CT vignettes (at pre)	48	30	267	18%	11%	7%	6%	8%
Longer time between pre- and post-data collections	39	61	220	18%	28%	-10%	-13%	-7%
Higher index of practice change	34	48	256	13%	19%	-5%	-3%	-8%
Teacher correct rank. of CR vign. (at pre)	17	16	81	21%	20%	1%	-6%	13%
Teacher correct rank. of CT vign. (at pre)	14	3	40	35%	8%	28%	42%	6%
Teacher believed CR could be taught (at pre)	15	10	56	27%	18%	9%	4%	13%
Teacher believed CT could be taught (at pre)	7	12	34	21%	35%	-15%	-39%	13%
Discipline of teacher: STEM (vs. VAM)	6	18	59	10%	31%	-20%	9%	-27%
Discipline of teacher: STEM (vs. other)	9	4	27	33%	15%	19%	x	19%
Discipline of teacher: VAM (vs. other)	12	17	62	19%	27%	-8%	-19%	15%

Notes: Self-perc. = self-perception; CR = creativity; CT = critical thinking; vign. = vignettes; rank. = ranking. "Overall models" indicates the number of instances in which it was possible to investigate the effect of the interaction between the intervention and each variable across the 13 teams and the 36 outcomes of interest. Besides the interaction between the intervention and each of the variables, all models also included a set of control variables, such as age, gender, socio-economic status, subject, the value of the outcome of interest at the beginning of the project, and, when available, the time between pre- and post- data collections and the duration of the intervention with students. The reference group for "Socio-economic status" and for the variables describing the relative self perception of the students' creativity and critical thinking at the beginning of the project is "Average". In the case of "Discipline of teacher", the category "Other" groups together all subjects other than STEM and VAM subjects.

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Furthermore, additional interesting positive results could be observed by looking at the two educational levels separately. In particular, in secondary schools, the intervention seemed to work better for:

- students with an immigrant background (net total of 13%)
- students who had a low, and then average, relative self-perception of their creativity at the beginning of the project (net totals of 23% and 8%, respectively)
- students who had a low, and then average, relative self-perception of their critical thinking at the beginning of the project (net totals of 12% and 7%, respectively)
- students whose teacher correctly ranked the vignettes on creativity at the beginning of the project (net total of 13%).

For primary students, instead, the intervention seemed to work better for:

- students who had an average relative self-perception of their critical thinking at the beginning of the project (net total of 9% for low self-perception and of 4% for high self perception)
- students whose teacher correctly ranked the vignettes on critical thinking at the beginning of the project (net total of 48%).

Surprisingly, the intervention seemed to have a negative effect at primary level for those students whose teacher believed that critical thinking could be taught at school at the beginning of the project (net total of 39%), while this effect was positive at secondary level (net total of 13%).

In terms of discipline, the interactions between the subject of the intervention and the intervention itself were often not available due to the survey design of the local teams (e.g. all teachers carried out the intervention in the same subjects, all control teachers belonged to one discipline and all intervention teachers to another one). However, 121 models were estimated, 53 for primary students and 68 for secondary students. It was observed that the intervention seemed to work particularly well in subjects other than STEM and VAM (mostly interdisciplinary interventions) for primary students (net total of 19%) and in VAM subjects for secondary students (net total of 42%).

For primary students, the positive effect of the intervention in interdisciplinary projects mostly concerned:

- parental engagement (in two models out of four)
- the students' positive learning feelings (in two models out of four)
- the students' understanding of creativity (ability to correctly rank the vignettes on creativity – in three models out of four)
- the students' curiosity (share of students learning only what they were interested in – which decreased in two models out of three).

For secondary students, instead, the most frequent positive effects associated with an intervention in VAM subjects concerned:

- the students' relative self-perception of their creativity and critical thinking (in two models out of four for both skills)
- the students' learning dispositions related to creativity and critical thinking (in two models out of four)
- the students' learning approach related to creativity and critical thinking (in two models out of four)
- the students' feeling of belonging in school (in two models out of four).

A snapshot of class-level analysis

An additional way to look at the data is to shift the attention from the students to the classes. By doing so, it is possible to use additional information originating from the teachers' questionnaires on the characteristics of the teachers themselves and of the learning environments, and to focus on it. Most of this information had to be otherwise excluded from the student level analysis due to the limited availability of teacher questionnaires.

By using single classes as units of interest for the analysis, it is possible to identify those that showed the most promising results and look at the commonalities between them. Furthermore, in some cases it was possible to link these data with those of the specific new pedagogical activities, thus providing readers with useful benchmarks both in terms of class characteristics and of specific interventions with students.

Methods

The class analysis focused only on a few variables of interest: EPoC, STEM and VAM scores; interest in STEM and VAM subjects; use of teaching practices related to creativity and critical thinking; proportion of students not only learning what they were already interested in; ability of the students to correctly rank the vignettes on creativity and critical thinking; and use of a learning approach related to creativity and critical thinking (only for secondary students). The analysis isolated the top 25% of classes in terms of change pre post for each of these variables – separately for controls and interventions and by level – and then compared this group with the rest of the classes in order to identify its distinctive characteristics.

Two important differences existed between the class level analysis and the student level one presented in the previous sections. The first was that the class level analysis was not carried out for each local team separately due to the wide variation in the number of participating classes for each of the teams. For the purpose of this exercise, carrying out the analysis for all teams together still allowed meaningful conclusions to be drawn from the data. The second difference was that the class level analysis considered variables that could not be included in the student level analysis. Some of the most relevant were: the number of teaching hours with the class per week, whether the teacher felt prepared for fostering students' creativity and critical thinking, the seniority of the teacher, and the class climate. The full list of explanatory variables used for the class level analysis can be found in the Note 5.

Overall, 753 classes participated in the pilot but, in order to ensure a minimal reliability of the estimators, only those with at least five students were included in the analysis. Therefore, the final sample consisted of 732 classes. Class-level data were either derived from the teachers' questionnaires or consisted of class-level averages based on the answers to the students' questionnaire. In the latter case, averages were estimated separately for each variable of interest and only if any of the following conditions was satisfied: the class had a response rate of at least 50%; or the class had at least ten valid answers.

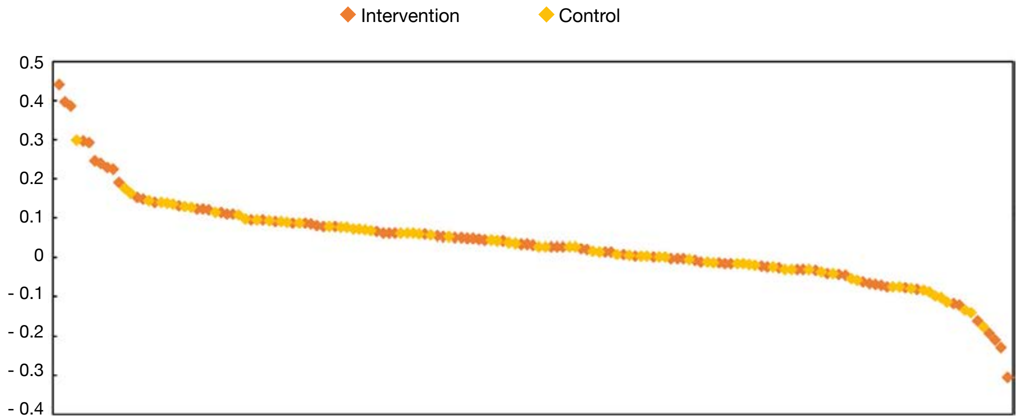
Effects of the intervention with students by outcomes of interest

By looking at the distribution of control and intervention classes in terms of pre post changes in the variables of interest, it was possible to pinpoint those variables for which the intervention with students lead to the most satisfactory results. This turned out to be the case of:

- STEM scores, at primary level (shown in Figure 7.13.)
- the ability to correctly rank the vignettes on critical thinking, at primary level
- the use of teaching practices related to creativity and critical thinking, at both levels.

In the case of Figure 7.13. , for example, the classes with the highest pre post changes appear on the left side of the chart, and here it is possible to notice how the intervention classes, i.e. the circles, outnumber the control ones, i.e. the crosses. Among the first 10 classes, for example, only 1 belongs to the control group, and only 6 control classes appear among the first 20 classes. This suggests a positive effect attributable to the intervention. The conclusions that could be drawn by simply looking at a series of figures like this one were broadly consistent with those that emerged from the student-level data analysis described in the previous sections.

Figure 7.13. Pre-post change in STEM scores at class-level, by group



Note: Classes are sorted by descending magnitude of pre-post change.

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Effects of the intervention on students by class profile

Primary students

In addition to the previous findings, the analysis highlighted that, at primary level, the interventions seemed to benefit those classes where the learning climate was challenging at the beginning of the project. When looking at the top performing classes, the share of those with a challenging learning climate was often more than double among the interventions than among the controls, and it was 78% higher on average.

Top performing intervention classes also showed slightly better performances in terms of STEM scores at the beginning of the project and higher socio-economic status than their control counterparts. In terms of teachers' profiles, most top performing classes had teachers with lower qualifications, were less senior, and felt less prepared for fostering students' creativity and critical thinking when the project started.

Secondary students

For secondary students, the intervention still seemed to benefit those classes with a challenging learning climate at the beginning of the project, but the difference was less remarkable than for primary students (only 28% higher on average).

A longer time between pre- and post- data collections seemed to be positively linked with better results, and for almost all outcomes of interest the top performing intervention classes had, at the beginning of the project, teachers who believed that creativity and critical thinking could be taught in schools more than what their counterparts did in top performing control classes.

Activity-level analysis

Finally, the design of the study makes it possible to look at the specific effects that some pedagogical activities seemed to achieve across the different teams. Those listed in Figure 7.14. were selected because they showed very positive results (in the top quartile) in more than five classes (except "Secret of community", which was only used in two classes but that in both cases had excellent results for all variables of interest available). The figure presents the overall profile of the activities, which includes their main characteristics, those of the classes where they were implemented and their most relevant results.

In some cases, local teams provided the OECD with detailed descriptions and lesson plans for some pedagogical activities implemented in the field. Most of these materials were included in the OECD repository of lesson plans, after they were peer-reviewed (Chapter 4).

Table 7.14. Profiles of the most successful pedagogical activities

Secret of community

Educational level	Primary
Developing team	Thailand
Country of implementation	Thailand
Overall duration of the activity	3 h 20m
Average class size (and number)	39.5 (2)
Share of low achievers in STEM	Not available
Share of high achievers in STEM	Not available
Average performance of school	High
Average performance of class	High
Average climate of classroom	Encouraging
Main results of the Activity	- Increase in EPoC scores - Increase in use of relevant teaching practices

Geometrical artwork

Educational level	Primary and secondary
Developing team	Russian Federation
Country of implementation	Russian Federation & Thailand
Overall duration of the activity	2h 30m
Average class size (and number)	26 (15)
Share of low achievers in STEM	37%
Share of high achievers in STEM	15%
Average performance of school	Middle-high
Average performance of class	Middle-low
Average climate of classroom	Mixed
Main results of the Activity	- Increase in understanding of creativity and critical thinking - Increase in interest (STEM) - Increase in learning dispositions

Detective Pytha

Educational level	Secondary
Developing team	Thailand
Country of implementation	Thailand
Overall duration of the activity	2h 30m
Average class size (and number)	37 (13)
Share of low achievers in STEM	35%
Share of high achievers in STEM	18%
Average performance of school	Average
Average performance of class	Middle-low
Average climate of classroom	Rather discouraging
Main results of the Activity	- Increase in interest (STEM) - Increase in use of relevant - teaching practices - Increase in learning dispositions

Animal breeding

Educational level	Primary and secondary
Developing team	Thailand
Country of implementation	Thailand
Overall duration of the activity	3h 20m
Average class size (and number)	36 (10)
Share of low achievers in STEM	19%
Share of high achievers in STEM	26%
Average performance of school	Average
Average performance of class	Average
Average climate of classroom	Mixed
Main results of the Activity	- Increase in interest (STEM) - Increase in use of relevant - teaching practices - Increase in learning dispositions

The class level analysis is an interesting alternative type of analysis, which allows deeper interpretations of the results and is more robust against data missingness. Furthermore, the main results emerged at student level could be found again also in this context. Consequently, it seems that this type of analysis should be an interesting avenue to explore in action research in education. For it to be fully informative, though, it would be recommendable to have a reasonable sample size of classes, allowing a separate class level analysis by country and educational level. This should be taken into account when planning the analytical strategy of a validation phase of the project.

Conclusions

Following the results of the data analysis, the feedback received from the local teams and the evidence that was collected on the behaviour of the instruments, this pilot seems to confirm that the adopted instruments and analytical strategy are appropriate to evaluate the effects of the intervention with students. As the previous sections showed, the instruments and the analytical strategy allowed capturing both positive and negative effects, and then identifying context related factors that influenced them. Furthermore, they allowed for some flexibility in the possible types of analysis, depending on whether the interest lied with students or classes.

The major findings that emerged from data analysis of this initial pilot are the following:

- The intervention with students seemed to have an overall positive effect: of all the models that were estimated, 25% showed a statistically significant positive effect while only 18% showed a significant negative effect, for a net total of 7%. This overall effect was similar across educational levels. If the specific effects are considered, these varied across levels:
    - for primary students, the effect of the intervention seemed to be particularly beneficial in terms of STEM and VAM test scores
    - for secondary students, it seemed to be particularly beneficial in terms of the use of teaching practices related to creativity and critical thinking during STEM classes, of the students' interest in VAM subjects and of VAM test scores.
- Some sub groups of students seemed to benefit particularly from the intervention, in a way that was fairly consistent across countries:
    - students whose teacher believed that creativity could be taught at school when the intervention started
    - students who correctly ranked the vignettes on critical thinking at the beginning of the project
    - students who did not correctly rank the vignettes on creativity at the beginning of the project.

- Finally, some additional positive effects varied significantly within teams in line with the high diversity of the local realities. These are detailed in Chapter 8.

The existence of common results suggests that engaging with teachers and local policy makers to actively foster creativity and critical thinking is possible, and that it can lead to significant and replicable improvements in several outcomes of interest for students. Furthermore, these results are particularly relevant due to the robustness of the findings, which accounted for the possible confounding effect of variables such as gender and socio-economic status.

The effect of the intervention with students seemed to be focused on the achievement test scores among primary students, for whom the results showed clearer patterns compared to secondary students. Two main factors may explain this: on the one hand, primary students might be more receptive to the more open pedagogies used by the teams due to their relatively little previous experience with other more established practices. On the other hand, primary school teachers spend much more time with the same pupils than secondary ones, and this might facilitate a more comprehensive adoption of the new teaching practices beyond what was considered as intervention time.

When considering specific subgroups of interest, the findings of this pilot were particularly encouraging for secondary students. These subgroups mostly belonged to populations that could be defined as disadvantaged either in terms of cultural resources (e.g. low socio-economic background) or from a cognitive point of view (e.g. poor understanding of the concepts of creativity and critical thinking), and many interventions were designed with some of these subgroups as targets. The success of some interventions in closing the existing gaps between these subgroups and the general population in terms of outcomes of interest constitutes a highly relevant and evidence-based result for targeted education policies.

The results were also positive in terms of the development of instruments. In most cases, all the items included in the questionnaire were retained, and configural invariance was observed across teams. This suggest that the instruments could effectively measure the concepts for which they were built (e.g. the different indices of interest). In some cases, the results held only at secondary level, but this could be expected, as the complexity of some indices may not be fully grasped at primary level. The ability of the instruments to measure meaningful changes in the outcomes of interest across countries could not be thoroughly tested due to the variation in the fieldwork conditions across the different teams. However, since they actually measured some significant changes in all countries across the different outcomes, evidence would suggest that they are capable of doing so. Yet, further research in this direction would be recommendable.

Finally, the pilot showed that most costs due to survey management and data collection could be internalised when staff with previous experience in action research are available. If not, some teams resorted to external consultants (often sourced through contacts with academia), which also ensured a good quality of the outputs while maintaining costs at a relatively manageable level. The majority of the teams that managed to adhere the most to the research protocol, use the instruments as intended and promptly communicate crucial details concerning the data collection to the OECD were those where experienced researchers were given the lead for the management of survey operations. As the current context of action research in education mostly relies on limited available resources, the findings of this pilot acquire significant relevance from a policy-making perspective.

Notes

1) For STEM scores, the correlation between simple weighted scores and IRT scores was 0.93 for primary students and 0.84 for secondary students. For VAM scores, these correlations were 0.77 and 0.69, respectively.

2) The correct order of the vignettes was defined as follows: the vignette with the highest level of creativity had to be ranked above or at the same level of the vignette with the average level of creativity; the vignette with the average level of creativity had to be ranked above or at the same level of the vignette with the lowest level of creativity; the vignette with the highest level of creativity had to be evaluated as "Fairly creative" or "Very creative"; and the vignette with the lowest level of creativity had to be evaluated as "Not very creative" or "Not creative at all". The same procedure was applied to the vignettes on critical thinking.

3) The weights consist of the probability of being part of the intervention group given each student's values for a set of explanatory variables.

4) In Table 7.3., the 121 models can be obtained by summing the 59 models for the row "Discipline of teacher: STEM (vs. VAM)" and the 62 models for "Discipline of teacher: VAM (vs. Other)". The 27 models of the row "Discipline of teacher: STEM (vs. Other)" should not be considered for the total, as they are already included in the 59.

5) Teacher's teaching hours with the class per week; performance of the class relative to the country as reported by the teacher; whether the teacher felt prepared for fostering students' creativity and critical thinking; whether the teacher believed that creativity and critical thinking could be taught in schools; the teacher's seniority; the teacher's level of education; the subject matter; the average socio-economic status of the students' household as seen by the teacher; the share of females in the classroom; the immigrant background of students; the class climate; the time between pre- and post- data collections; the duration of the intervention with students; the EPoC, STEM and VAM scores; the proportion of students only learning what they are interested in; and change in use of teaching practices related to creativity and critical thinking as perceived by the students.

6) Classes with a challenging engagement climate were identified as those where the teacher agreed or strongly agreed with at least one of the following items: "When the lesson begins, I have to wait quite a long time for students to quiet down" or "It is difficult to keep the group concentrated for more than a few minutes". Classes were also included in this group if the teacher disagreed or strongly disagreed with at least one of the following items: "Students in this class take care to create a pleasant learning atmosphere" or "Students in this class are generally active and eager to participate in class activities and discussion".

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Chapter 8

Country team notes

This chapter presents a synthesis of the approaches and outcomes of the country teams that participated in the OECD-CERI project. For each of the thirteen local school settings, it summarises the pedagogical interventions that were implemented and provides a selection of key findings about the attitudes and practices observed amongst teachers, school principals and students, based on qualitative and quantitative evidence. Finally, to help contextualise the results, infographics display the main characteristics of the students and teachers that participated in the project compared to either national populations or other project teams.

Brazilian Team

Work in Brazil took place during the entire duration of the development project. The intervention with students spanned two school years, between May 2016 and December 2017. While the team participated in both rounds of the project, given the difference in school calendar between the northern and southern hemispheres, there was no quantitative data collection in the second round. Qualitative observation in the field was continued the second school year too.

The OECD-CERI project was implemented in the city of Chapecó (state of Santa Catarina, located in the South Region of the country). Indeed, as both the state and the city governments greatly value the development of so-called 21st century skills, the project got strong support from local policy makers. The fieldwork was led by the Ayrton Senna Institute, a non-profit educational organisation that promotes the cognitive and socio-emotional development of children and young people by designing and implementing innovative educational solutions through evidence-based pedagogical practices and public policies. The project was a partnership between the Ayrton Senna Institute and the Santa Catarina State Department of Education, the Chapecó Municipality Department of Education and the Industry Federation of Santa Catarina.

The students in Brazil belonged to many different age groups, including a few high school students (grouped with secondary students in the analysis due to their small sample size). The project was undertaken in both primary and secondary schools, and covered science, maths, visual arts and music. All schools were public and administered by either the municipality or the state Department of Education, with the exception of one private school run by the Santa Catarina State's Industry Federation. The post-data collection for several instruments was severely affected by the impact of the LaMia Flight 2933 air crash, which caused 71 deaths including the local Chapecoense football team. This accident mobilized the entire city and made the post-data collection impossible in most schools.

Compared to the other teams taking part in the study, Brazilian classes reported one of the lowest shares of students with an immigrant background (2%), and one of the lowest proportions of classes with a positive class climate (36%). The time span between pre- and post-measurements in Brazil was relatively long (32 weeks), but not particularly intensive (9 hours of class intervention).

In Brazil, the project had a strong focus on teachers' professional development. It consisted of an induction training session and several follow-up sessions. A network of local advisers acted as facilitators between participating schools and spurred a professional learning community amongst teachers. The goal of this community was to encourage collaboration between teachers on designing new activities and reflecting on their teaching practices. In addition, teachers could share ideas, materials and advice on an online platform. In fact, this online platform became the main digital community of practice, with exchanges facilitated by the local co ordinators. They aimed at generating a cultural change within and across the schools involved in the project.

After the initial professional development, facilitators in Brazil imagined their own student self-assessment rubrics based on the OECD framework. Teachers then used them to adapt lesson plans and develop new pedagogical activities that were meant to develop students' creativity and critical thinking. Those pedagogical activities were visible to other participating teachers (and to the co-ordinators), who could comment on them and give feedback to their designers.

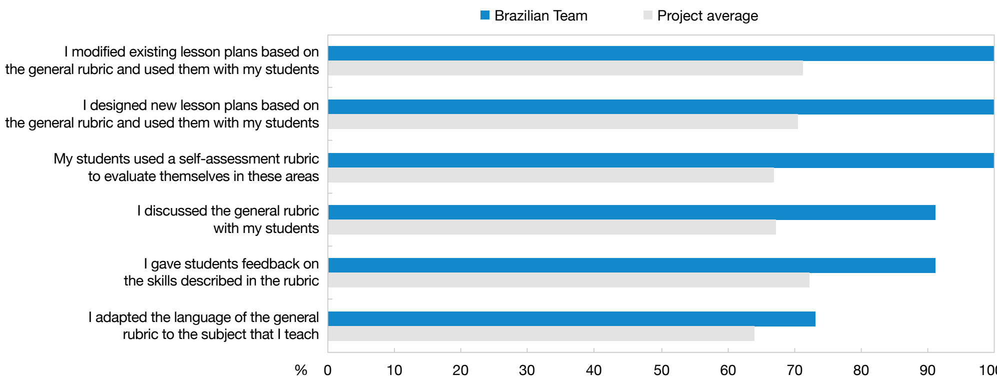
What teachers and school principals said

- High acceptance of the project materials amongst teachers.
- Increased collaboration with peers on creativity and critical thinking.
- Teachers changed their teaching practices.
- School principals strongly welcomed the project.

Teachers' views and practices around creativity and critical thinking changed during the project. At the end of the second year of intervention, 90% of the intervention teachers reported that they had used the project rubrics in multiple ways over the past six months, notably to design or review some of their lessons and to discuss ideas with their students (Figure 8.1). Teachers found the OECD rubrics – as redesigned by Brazilian co ordinators – easy to use and considered that their curricula gave them enough space to put them into practice (90%). However, some of them reported that they had too many students (40%) or not enough training (36%) to implement the pedagogical strategies implied by the rubrics. Nonetheless, they considered them as relevant to their teaching (80%).

The vast majority of intervention teachers reported they collaborated with peers in relation to the project over its duration. This collaboration mostly took the form of discussions with colleagues about students' creativity and critical thinking (91%) and participating in working groups to refine or develop lessons plans aligned with the rubrics (91%). All teachers highlighted a change in their pedagogies and in the way they prepared their lessons, in the way they designed assessment tasks and assessed student work. All of them also stated that their understanding of what developing students' creativity and critical thinking entailed had evolved, as had their consistency in trying to foster these skills in students. They all perceived changes in students' motivation and engagement, in their enjoyment of class activities, in their autonomy as learners, and in the overall class climate. Finally, they all considered their participation in the project as a (very) positive experience.

Figure 8.1. Teachers largely adopted the project rubrics, Brazilian Team
Percentage of intervention teachers who reported any use of the project rubrics



Notes: Bars represent percentages of teachers who used the project rubrics over the last six months of the project.

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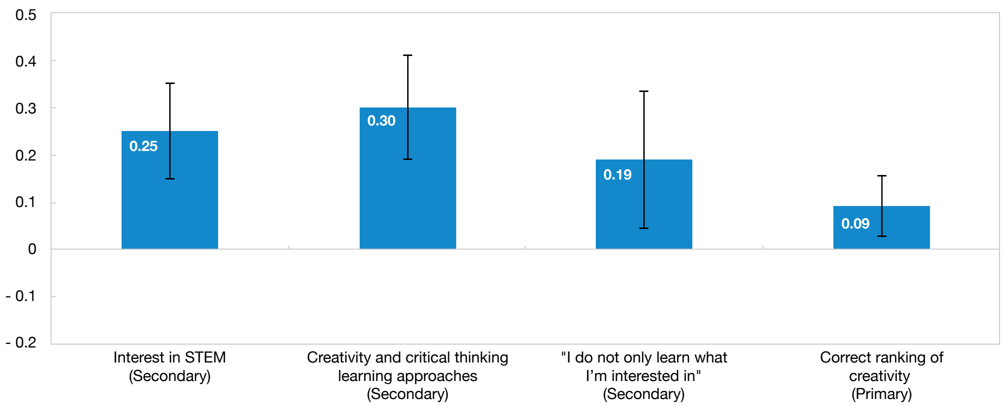
Before the beginning of the intervention, school principals reported several challenges associated with previous education projects in which their school had embarked, including, for instance, the lack of time given to regular school activities and the inadequacy of the funding. Furthermore, only a few of them considered that such projects had had a strong positive impact on the students' motivation and engagement. At the end of this project, however, all the principals of the intervention schools said that the intervention had led to positive changes in students' motivation and broadened their learning opportunities. Only one-third of them perceived challenges due to time constraints, and less than 15% felt a lack of interest and support from local education authorities, which highlights the success of the partnership established amongst the different institutions. By the end of the project, most of them were sure that their teachers would continue using the lesson plans and the rubrics in the following school year.

What students experienced

- Greater interest in science and mathematics.
- Greater uses of learning approaches nurturing creativity and critical thinking.
- Better understanding of creativity.
- Socio-economically advantaged students benefited more from the project.

Students noticed some of the changes in pedagogies that teachers reported (Figure 8.2). Compared to their peers in control classes, students in the intervention classes had an increased interest in mathematics and science, and in the prevalence of learning approaches related to creativity and critical thinking (e.g. solving problems with several possible solutions, challenging ideas and assumptions, making connections with other school subjects). Furthermore, students in the intervention group reported greater levels of curiosity (i.e. stronger willingness to learn things that they were not initially interested in). Data collection difficulties related to the above-mentioned circumstances complicated the capture of statistically significant changes amongst primary students. Nonetheless, estimates show that their understanding of what creativity means and how it is expressed improved during the project.

Figure 8.2. Effects of the intervention on students' outcomes, Brazilian Team



Notes: STEM: science, technology, engineering and mathematics. Bars represent coefficient estimates and black lines represent confidence intervals. All effects are statistically significant at the 80% level of confidence. Control and intervention groups were compared after a propensity score matching.

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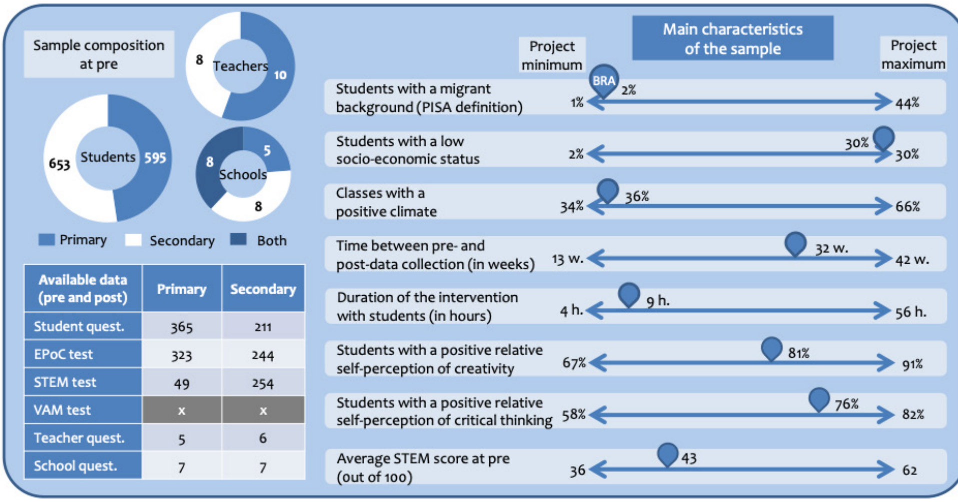
At both primary and secondary levels, children from advantaged socio-economic households seemed to be more receptive to the pedagogical intervention. Older students in the intervention group progressed more than their younger peers in terms of self-perceived creativity and critical thinking, while their younger peers showed greater progress in their scores in the Evaluation of Creative Potential (EPoC) creativity tests. Paradoxically, shorter, less-intensive interventions were associated with better results amongst students, especially in terms of disposition and attitudes towards creativity and critical thinking. Finally, students whose teachers taught mathematics or science seemed to experience more positive changes than those whose teachers taught visual arts, music or other subjects.

The multiplicity of contexts and pedagogical interventions led to the evaluation of direct and indirect effects of many predictors on many teachers' and students' outcomes. Sample sizes did not always allow us to capture, amongst students, the sizeable changes observed in teachers' attitudes and practices. In some cases, the initial monitoring captured paradoxical results. However, the monitoring design of the project has proven to be efficient and successful in numerous ways. A short pedagogical intervention on teachers fostered some changes in their teaching and had effects on some dimensions of students' creativity and critical thinking. The circumstances, size and main beneficiaries of the effects would have to be measured in a validation study.

Who was involved in the project



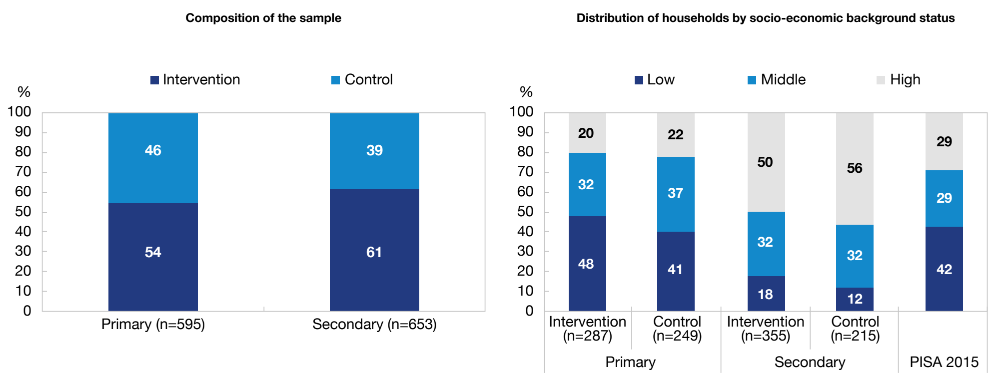
Note: EPoC: Evaluation of Creative Potential; STEM: science, technology, engineering and mathematics; VAM: visual arts and music.

Compared to the other teams, the Brazilian students were more likely to come from a low socio-economic background (30%, versus a project minimum of 2%) and less likely to have an immigrant background (2%, versus a project minimum of 1% and a maximum of 44%). In Brazil, classes had a tougher class climate than average and included students with weaker academic achievement. The average achievement score in maths and science at the beginning of the project was 43 (versus a project minimum of 36 and a maximum of 62), and 36% of classes had a positive climate (versus a project minimum of 34% and a maximum of 66%). At the beginning of the project, 81% of students evaluated themselves as fairly or very creative (compared with a project minimum of 67% and a maximum of 91%). As for critical thinking, 76% felt they were strong, putting the Brazilian group at the higher end of the project (with a project minimum of 58% and a maximum of 82%). Finally, the interventions with students carried out by the local team had an average length (32 weeks, versus a project minimum of 13 and a maximum of 42) and a shorter duration in class (5 hours on average, versus a project minimum of 4 and a maximum of 56).

Overall, the Brazilian student population taking part in the project included 595 primary students and 653 secondary students, for a total of 1 248 students. Due to sample selection issues faced by the local team, the sample sizes of the control and intervention groups were imbalanced, particularly for secondary students. In fact, while the control group represented 46% of the students in primary education, it only amounted to 39% of the secondary students (Figure 8.3, left panel).

The control and intervention groups presented some differences in terms of gender and cultural background, and were sometimes far from what would be expected from a representative national sample (taking Programme for International Student Assessment (PISA) 2015 as a reference; see p.230 in Chapter 7 for further discussion of PISA reference values). Girls were under-represented in both primary and secondary education, particularly in the intervention groups. Control and intervention groups at both educational levels were well matched regarding students' cultural background (Figure 8.3, right panel). While primary students had a profile close to that of PISA 2015, students with higher socio-economic status were over-represented in secondary education, especially in the control group. Finally, students in control classes belonged to a handful of schools, while their peers in intervention came from many different schools, with various socio-economic backgrounds.

Figure 8.3. Students participating in the project, Brazilian Team



Note: PISA 2015 references are taken as representative of the entire country population of 15-year-old students.

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In Brazil, the project involved 40 teachers. Eighteen responded to the teacher questionnaire at baseline (before the intervention), evenly distributed in primary and secondary schools. At each level, six of them took part in the intervention development, the rest were control teachers. The large majority (83%) reported at least six years of teaching experience, but only 33% held a bachelor's degree or higher, with the remaining 67% having just a teaching certificate. At the school level, nine principals expressed their views on previous and current innovation projects through the baseline questionnaire.

Overall completion rates of students were satisfactory: 62% of the 1 248 students completed at least one instrument at both pre and post. Looking at each instrument separately, the attrition is the following: amongst the students who completed the corresponding instrument at baseline, 51% completed the post-questionnaire, 31% completed the STEM achievement post-test and 90% completed the EPoC creativity post-test. The statistical analysis that was then conducted to ensure the comparability between the control and intervention groups caused minor losses of data only.

Completion rates of teachers and school principals were satisfactory. Out of the 40 teachers who took part in the project, almost half (18) completed the baseline questionnaire, and a quarter (11) filled in the questionnaire at the end of the intervention. The latter group allowed providing key information on the changes reported by Brazilian teachers in their feelings, practices and assessments around creativity and critical thinking. Finally, out of the nine principals who completed the school questionnaires at baseline, eight also completed the school questionnaire at the end of the intervention.

Other effects of the project

The work developed and implemented by Ayrton Senna Institute in Brazil will fuel a broader initiative of the Institute. This initiative includes: 1) a systematic review of the international and national literature; 2) a plan to develop, systematise and distribute an innovative formative assessment methodology and instruments to develop, monitor and evaluate the so-called 21st century skills, including higher order skills such as creativity and critical thinking and social and emotional skills. In 2019, the Institute plans to make a Digital Guide for Creativity and Critical Thinking publicly available. It will address questions such as: what is creativity and critical thinking, why are these competences important for education and for life, how can they be developed and assessed?

Dutch Team

Fieldwork in the Netherlands took place from December 2015 to July 2016. The team undertook one round of data collection.

The Dutch Ministry of Education funded the work, which was led by a research company. There were three distinct groups: primary students in a mathematics intervention, secondary students in a mathematics intervention and secondary students engaged in a visual arts intervention. Each of them had a dedicated researcher, didactic expert, digital platform and training sessions. In the Netherlands, the distinction between public and private schools does not stem from differences in funding, but to the possible religious or ideological character of the school (which is only possible in the private context). In the sample, the mix between public and private schools was balanced.

The Dutch team reported a light intervention (4 hours of pedagogical sessions) and a short time span between pre- and post-measurements (19 weeks). At the beginning of the study, the Dutch students involved in the project had one of the highest achievement scores in maths and science of the international network. An above average proportion of them came from a lower socio-economic background.

Teacher professional development in the Dutch context was comprised of one induction session at the beginning of the project and one follow-up session halfway through the intervention. External didactic experts in mathematics or visual arts and researchers provided further individual support to the teachers. The teachers also took part in interviews and focus groups to get advice and feedback on their teaching practices, and shared materials and collaborated with peers through an online platform.

A network of local advisers acted as facilitators between participating schools. They spurred a professional learning community to encourage collaboration between teachers to design new activities and reflect on their practices, with the help of the online platform to share materials, ideas and advice.

In the intervention classes, the pedagogical work revolved around a three-round incremental approach: 1) teachers first familiarised themselves with the OECD rubrics to seamlessly integrate them into existing lessons and activities; 2) they then produced new pedagogical activities that focused on creativity and critical thinking around a common (comparable) theme; 3) finally, they freely developed new forms of pedagogical work.

What teachers and school principals said

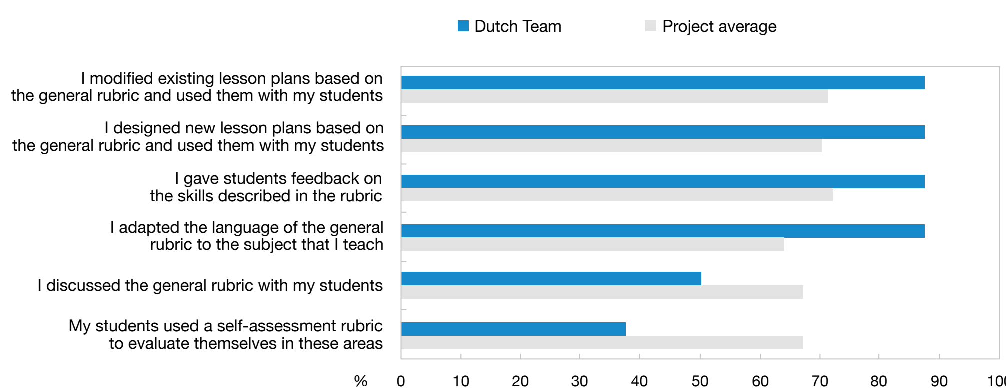
- Good degree of adoption of the project materials.
- Increased collaboration with peers on creativity and critical thinking.
- Teachers changed their pedagogies.
- Positive changes in students' academic motivation and engagement.

Teachers' views and practices around creativity and critical thinking changed during the project. At the end of the intervention, 87% of intervention teachers reported that they had used the project rubrics over the previous six months in multiple ways, notably to design or review some of their lessons, but also to discuss creativity or critical thinking with their students (Figure 8.4). However, some of them encountered obstacles in using the rubrics, either because the project was too short to use them in a meaningful way (43%) or because the curriculum they had to teach did not leave much room to implement the rubrics (43%), or they would have needed much more training to do so (57%). A minority thought that they had too many students to implement the pedagogical strategies implied by the rubrics (29%), which they all found relevant to their teaching.

Large shares of intervention teachers reported collaboration with peers with respect to the project over the previous six months, such as discussion with colleagues about students' creativity and critical thinking (88%) or participation in working groups to refine or develop lesson plans aligned to the rubrics (50%). All of them signalled changes in pedagogy, be it the way they prepare their lessons, design assessment tasks or assess student work. They all said that their understanding of what it entailed to develop students' creativity and critical thinking had evolved over the duration of the project, as had the consistency with which they tried to foster those skills amongst students. Most of them perceived changes in students' motivation and engagement (88%), enjoyment of class activities (75%), autonomy as learners (63%), and in the overall class climate (63%). They all evaluated their participation in the project as a (very) positive experience.

Figure 8.4. Teachers largely adopted the project rubrics, Dutch Team

Percentage of intervention teachers who reported any use of the project rubrics



Note: Bars represent percentages of teachers who used the project rubrics over the last six months of the project.

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At the beginning of the project, several school principals already considered that past innovation projects had had a strong positive impact on student academic performance (50%), on motivation and engagement in their school (70%), and on teacher professional development (90%), despite the lack of adequate funding and time, given regular school activities. At the end of the project, all seven intervention school principals reported that the project expanded leaning opportunities for students, many being sure that their teachers will most likely continue to use the project materials in the following years, and thus expecting a sustainability of the work.

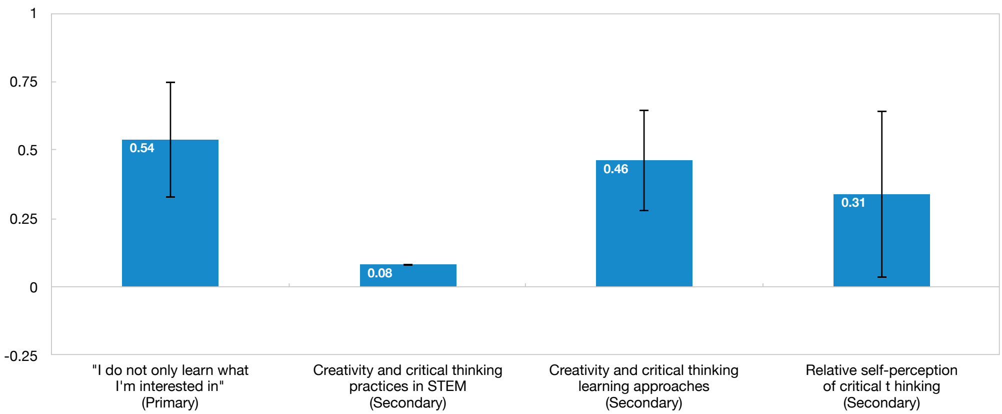
What students experienced

- Improved performances in the achievement and creativity tests.
- More emphasis on creativity and critical thinking in mathematics.
- Increased interest in creativity and critical thinking.
- No impact of socio-economic status or gender.

Some of the results reported by teachers were aligned with what students experienced (Figure 8.5). The first important point is that students perceived the changes in pedagogy that the teachers reported. A statistically significant increase in the perceived use of practices related to creativity and critical thinking in mathematics (the focus of the intervention) was found in secondary education. In fact, the pedagogical intervention appears to have been particularly successful for secondary students, who showed increased interest and engagement on several dimensions. Compared to their counterparts in the control classes, they made more progress in the science, technology, engineering and mathematics (STEM) test; the arts and creativity tests; and improved their understanding and self-perceived creativity and critical thinking.

The positive impacts seen in secondary schools could not be observed in the primary schools. Nonetheless, primary students had a statistically significant increase in their levels of curiosity (greater willingness to learn what they were not initially interested in). Further analyses carried out by the local team highlighted that, by the end of the project, primary students in the intervention group reported to be working in groups more frequently than their peers in the control group.

Figure 8.5. Effects of the intervention on students' outcomes, Dutch Team



Notes: STEM: science, technology, engineering and mathematics. Bars represent coefficient estimates and black lines represent confidence intervals. All effects are statistically significant at the 80% level of confidence. Control and intervention groups were compared after a propensity score matching.

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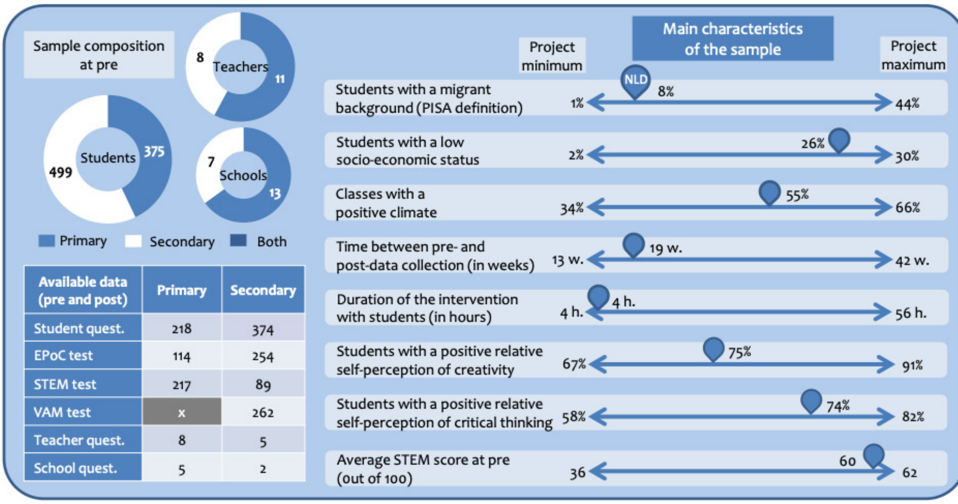
In addition, it appears that students who had a better understanding of critical thinking at the beginning of the project obtained better results. Socio-economic status, immigrant background and gender did not seem to play any decisive role. In secondary schools, the intervention in mathematics led to more progress than in visual arts in terms of test scores.

The local co ordinators carried out complementary analyses focused on their students' practices and attitudes in class. They found significant differences between students in intervention classes and their counterparts in control groups: more group work (an expected outcome) and less imaginative proposals (an unexpected outcome). Furthermore, students' progress differed depending on teachers' didactics. For instance, children whose teachers tended to give week-long, project-based assignments ended up making more connections between different subjects; those whose teachers used everyday life examples to show why the content they taught was useful were required to use their imagination more often.

The multiplicity of contexts and pedagogical interventions led to the evaluation of direct and indirect effects of many predictors on many teachers' and students' outcomes. Sample sizes did not always allow us to capture, amongst students, the sizeable changes observed in teachers' attitudes and practices. In some cases, the initial monitoring captured paradoxical results. However, the monitoring design of the project has proven to be efficient and successful in numerous ways. A short pedagogical intervention on teachers fostered some changes in their teaching and had effects on some dimensions of students' creativity and critical thinking. The circumstances, size and main beneficiaries of the effects would have to be measured in a validation study.

Who was involved in the project



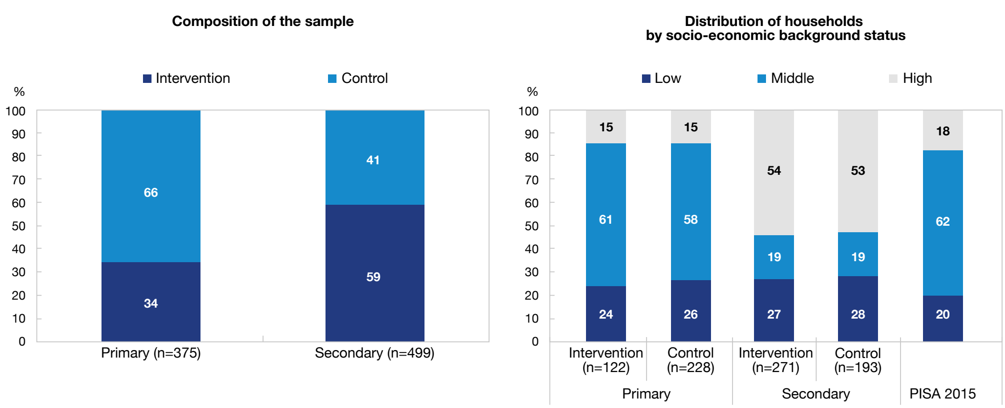
Notes: EPoC: Evaluation of Creative Potential; STEM: science, technology, engineering and mathematics; VAM: visual arts and music.

Compared to the other teams, the Dutch students were more frequently from a lower socio-economic background (26%, versus a project minimum of 2% and a maximum of 30%), less often from an immigrant background (8%, versus a project minimum of 1% and a maximum of 44%). The average achievement score in maths and science at the beginning of the project was amongst the highest (60, versus a project minimum of 36 and a maximum of 62), and the share of classes with a positive climate was close to the average (55%, versus a project minimum of 34% and a maximum of 66%). In terms of students' relative self-perception of their creativity and critical thinking, the share of students evaluating themselves as fairly or very creative was average (75%, versus a project minimum of 67% and a maximum of 91%), while the one concerning critical thinking was at the higher end (74%, versus a project minimum of 58% and a maximum of 82%). Finally, the duration between pre- and post-measurements was shorter than average (19 weeks, versus a project minimum of 13 and a maximum of 42) and so was the duration of the pedagogical interventions (average of 4 hours for each class, versus a project average of 15 per class).

Overall, the Dutch classes included 375 primary students and 499 secondary students, amounting to 874 students. The sample sizes of control and intervention groups were imbalanced, particularly for primary students, where two-thirds of the students belonged to the control classes (Figure 8.6, left panel). This imbalance was mostly due to changes in the project timeline, which induced some schools to switch from the intervention to the control group, as the updated timeline for the intervention no longer fit their schedule.

Student control and intervention groups presented some differences in terms of gender and socio-cultural background, and were sometimes far from what would be expected from a representative national sample (taking PISA 2015 as a reference; see p.230 in Chapter 7 for further discussion of PISA reference values). In both primary and secondary education, girls were slightly over-represented. Control and intervention groups aligned in terms of students' socio-cultural background (Figure 8.6, right panel). However, compared to a representative sample, the primary education classes had a profile close to that of PISA 2015, while the secondary education classes had a strong over-representation of students with a higher socio-cultural background.

Figure 8.6. Students participating in the project, Dutch Team



Note: PISA 2015 references are taken as representative of the entire country population of 15-year-old students.

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In the Netherlands, the project involved 37 teachers, 19 of whom responded to the questionnaires, evenly distributed between primary and secondary schools. Approximately half took part in the intervention in primary schools, but nearly all of them did so in secondary schools. The majority (72%) reported at least six years of experience as a teacher, and more than 90% hold a bachelor's degree or higher. At the school level, 15 principals expressed their views on previous and current innovation projects through a baseline questionnaire.

Completion rates of students were satisfactory, as 73% of the 874 students completed at least one instrument at both pre and post in primary and secondary schools. Looking at each instrument separately, the attrition was low: amongst the students who completed the corresponding instrument at baseline (before the intervention), 69% completed the post-background questionnaire, 62% completed the STEM post-test, 75% completed the VAM (visual arts and music) post-test and 56% completed the EPoC post-test. The data collection was successful, and the subsequent statistical treatment implemented to ensure comparability only caused minor losses of data.

Completion rates of teachers and school principals were high as well. Out of the 37 teachers who took part in the project, half completed the baseline questionnaire and around a third followed through to the post-questionnaire. This sample allows providing key information on the changes reported by Dutch teachers in their feelings, practices and assessments around creativity and critical thinking. Finally, out of the 15 school questionnaires completed at baseline, 7 were followed up with a post-questionnaire.

French (CRI) Team

The French (Centre for Interdisciplinary Research, CRI) team participated in both rounds of the project, with the first round administering an intervention in science and the second in the social sciences. The intervention took place only in primary education and was mostly carried out in public schools, with the exception of one private school. Data collection lasted from November 2015 until June 2017. It is worth pointing out that both the intervention and control classes had already been working on creativity and critical thinking skills. However, only the intervention teachers were given access to the OECD rubrics and resources. The intervention with students ran in the second semester for several months, with at least one occurrence per week. Les Savanturiers, a French programme of the CRI aimed at promoting teaching and learning through scientific research, acted as the channel for the intervention. The French team thus used research-based learning as its signature pedagogy (a derivative of Project Based Learning). See Chapter 3 for a more detailed discussion of the different signature pedagogies.

The French (CRI) network had the least positive class climate across the international network taking part in the project. Nonetheless, students reported a very good understanding of creativity and critical thinking at baseline, and the highest average achievement score in science and mathematics. This points to a globally favourable environment to teach and learn creativity and critical thinking in everyday class, and mirrors the context of the other French team that participated in the project.

Teacher professional development in the French (CRI) Team was centred on an induction training session, as teachers in the school network were already familiar with the adopted innovative teaching approach. One school nevertheless organised a follow-up meeting during the course of the project implementation. In addition, teachers received feedback from classroom observations.

In class, only a few teachers used the OECD rubrics, from which they derived a pedagogical activity to nurture creativity and critical thinking. The signature pedagogy used in the network was considered as already aligned with the goals of the project.

What teachers and school principals said

- Substantial changes in teachers' pedagogy, teaching and assessment.
- Limited adoption of the project materials.
- Improvements in students' academic motivation, engagement and enjoyment.
- School principals support positive effects amongst teachers and students.

Teachers' views and practices around creativity and critical thinking changed during the project. Although only few teachers actually used the OECD rubrics, virtually all who took part in the professional development plans declared having modified the way they prepared lessons, designed assessment tasks and assessed student work. Over the duration of the project, they tried to foster students' creativity and critical thinking with more consistency as they gradually understood what those skills entail.

After the intervention, most teachers considered that trying to foster creativity and critical thinking had positive effects on students' understanding, motivation, engagement and autonomy as learners. They all evaluated their participation in the project as a (very) positive experience.

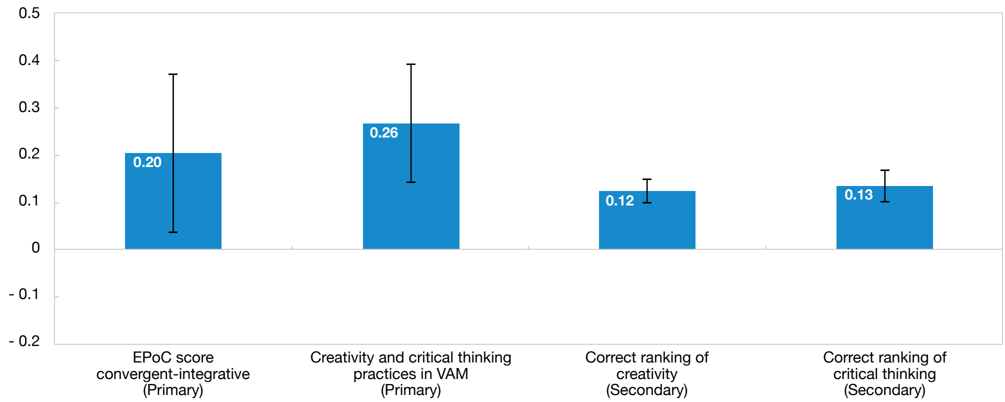
At baseline, school principals in the French (CRI) Team mostly reckoned that past innovation projects in their establishments had had strong positive impacts on student academic performance, motivation and engagement and on teacher professional development. However, they acknowledged challenges in their implementation regarding the lack of adequate funding, of time, given other regular school activities and of alignment with usual curricular and testing requirements. School leaders were equally satisfied with the OECD-CERI project. The majority of principals said that the intervention provided access to valuable tools and materials, expanded students' learning opportunities, and improved their academic motivation and engagement. Some of them planned to use the project's rubrics and lesson plans with other classes the following year.

What students experienced

- More interest in science and mathematics.
- Positive effect on parental engagement.
- Better results amongst girls and students from advantaged households.
- Greater effects after longer intervention.

Amongst students, the pedagogical intervention brought about some statistically significant positive results (Figure 8.7), some of them in line with what teachers expressed. Trying to nurture creativity and critical thinking in everyday teaching raised students' interest in science and mathematics, for instance. The intervention did not seem to have any positive or negative effect on students' performance in the achievement test. Compared to their counterparts in the control groups, students in the intervention group reported higher levels of parental engagement: more and more, they discussed music, literature and movies with their parents, or talked about school in general – possibly as an effect of the explicit intentional focus on creativity and critical thinking.

Figure 8.7. Effects of the intervention on students' outcomes, French (CRI) Team



Notes: EPoC: Evaluation of Creative Potential; VAM: visual arts and music. Bars represent coefficient estimates and black lines represent confidence intervals. All effects are statistically significant at the 80% level of confidence. Control and intervention groups were compared after a propensity score matching.

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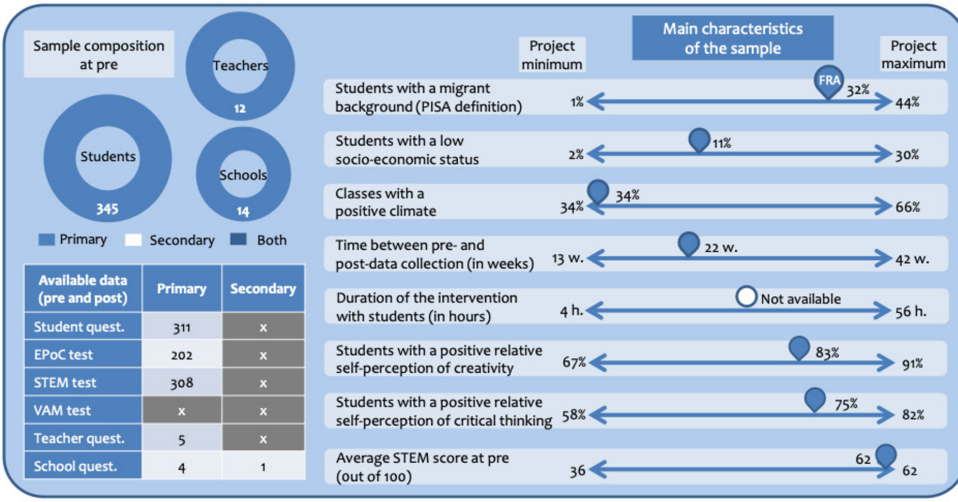
Girls and children from socio-culturally advantaged households are those who seem to have improved the most their understanding of what creativity and critical thinking mean, and how those skills translate into daily behaviours. Furthermore, as nearly everywhere, a longer gap between pre- and post-measurements produced greater effects, with students showing more disposition to creativity and critical thinking, and more curiosity towards topics they were initially not interested in.

The multiplicity of contexts and pedagogical interventions led to the evaluation of direct and indirect effects of many predictors on many teachers' and students' outcomes. Sample sizes did not always allow us to capture, amongst students, the sizeable changes observed in teachers' attitudes and practices. In some cases, the initial monitoring captured paradoxical results. However, the monitoring design of the project has proven to be efficient and successful in numerous ways. A short pedagogical intervention on teachers fostered some changes in their teaching and had effects on some dimensions of students' creativity and critical thinking. The circumstances, size and main beneficiaries of the effects would have to be measured in a validation study

Who was involved in the project



Available data (pre and post)	Primary	Secondary
Student quest.	311	x
EPoC test	202	x
STEM test	308	x
VAM test	x	x
Teacher quest.	5	x
School quest.	4	1

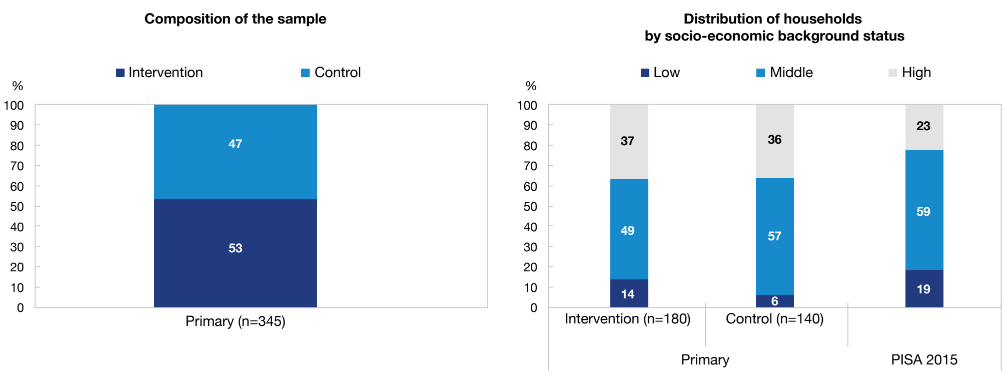
Notes: EPoC: Evaluation of Creative Potential; STEM: science, technology, engineering and mathematics; VAM: visual arts and music.

Compared to the other teams, the French (CRI) students showed a lower prevalence of students with a lower socio-economic status (11%, versus a project minimum of 2% and a maximum of 30%), and a presence of students with an immigrant background which was amongst the highest of all teams (32%, versus a project minimum of 1% and a maximum of 44%). The average achievement score in maths and science at the beginning of the project was the highest across all teams (62, versus a project minimum of 36), even if the share of classes with a positive climate was the lowest (34%, versus a project maximum of 66%). In terms of students' relative self-perception of their creativity and critical thinking, the share of students evaluating themselves as fairly or very creative was at the higher end of the observed values (83%, versus a project minimum of 67% and a maximum of 91%). The same was observed for critical thinking (75%, versus a project minimum of 58% and a maximum of 82%). Finally, the interventions with students carried out by the local team had an average project length (22 weeks, versus a project minimum of 13 and a maximum of 42), while data on the duration of the intervention were not available.

Overall, the Savanturiers classes of the French (CRI) Team included 345 students in primary education. The sample sizes of control and intervention classes were well balanced, with the share of controls being 47% (Figure 8.8, left panel).

Student control and intervention groups presented minor differences in terms of gender and socio-cultural background of the students' households, but were sometimes far from what a national representative sample would look like (taking PISA 2015 as a reference; see p.230 in Chapter 7 for further discussion of PISA reference values). Girls were under-represented in both groups, as their share was almost 5 percentage points lower than the PISA 2015 value (50%). Control and intervention classes counted the same shares of students with a high socio-cultural background, shares that are way above the representative profile described by PISA 2015. The picture is the opposite for students with a low socio-cultural background, who are under-represented compared to the national population, especially in control classes (Figure 8.8, right panel).

Figure 8.8. Students participating in the project, French (CRI) Team



Note: PISA 2015 references are taken as representative of the entire country population of 15-year-old students.

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The project involved 15 teachers, 12 of whom responded to the teacher questionnaires at baseline (before the intervention). Approximately half took part in the intervention. The large majority (90%) reported at least six years of teaching experience and hold a bachelor's degree or higher. At the school level, ten principals expressed their views on previous and current innovation projects through a baseline questionnaire.

Completion rates of students were satisfactory: 338 of the 345 students completed at least one instrument at both pre and post, which corresponds to an overall completion rate of 98%. Looking at each instrument separately, the attrition was low: amongst the students who completed the corresponding instrument at baseline, 96% completed the post-questionnaire, 95% completed the STEM post-test and 99% completed the EPoC creativity post-test. The data collection was successful, and the subsequent statistical treatment implemented to ensure comparability only caused minor losses of data.

Completion rates of teachers and school principals were high as well. Out of the 15 teachers who took part in the project, 80% completed the baseline questionnaire, and all of them except one followed through to the post-questionnaire. This provided key information on the changes reported by French teachers in their feelings, practices and assessments around creativity and critical thinking.

French (Lamap) Team

The French La Main à la Pâte (Lamap) Team only undertook the first round of pedagogical intervention and data collection, with data collection between December 2015 and January 2016. The pedagogical intervention was carried out in primary schools of the cities of Nancy, Troyes and Nogent sur Oise, in public schools exclusively. The foundation Lamap co-ordinated the local work, while the Laboratoire Adaptations Travail Individu (LATI, Paris Descartes University) collected the creativity data. All teachers participating in the project for the French (Lamap) team were focusing on science, and critical thinking was the focus of the intervention for this team. The intervention used Project Based Learning, the typical signature science pedagogy used by Lamap, with a strong emphasis on hands-on activities. See Chapter 3 for more detailed discussion on signature pedagogies.

The French schools involved by Lamap in the project had the most positive class climates across the international network. Moreover, students reported a good understanding of creativity and critical thinking at baseline (before the intervention), as well as a high average achievement score in science and mathematics. It denotes a good educational environment, a priori favourable to teaching and learning creativity and critical thinking in everyday class, and mirrors the context of the other French team that participated in the project.

Teacher professional development consisted of one induction training session. Teachers in the school network were already familiar with the Project Based Learning approach promoted by Lamap. While the control group implemented the usual approach, the OECD rubrics and example materials were presented to the intervention group, who was asked to be more intentional in its development of creativity and critical thinking. Nonetheless, follow-up sessions with teachers could be held remotely upon request, through mails or phone calls.

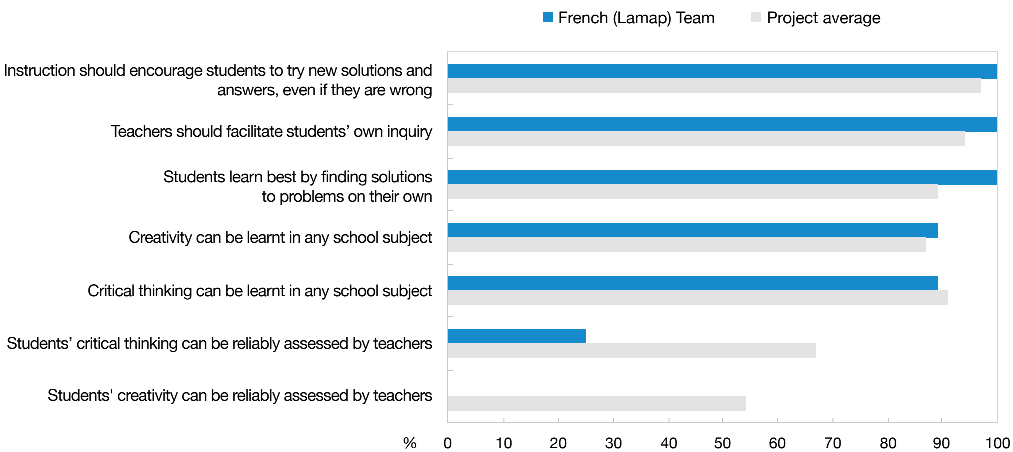
What teachers and school principals said

- Positive attitudes towards teaching creativity and critical thinking.
- Good understanding of those skills.
- Current instruction and assessment practices not aligned with the project's approach.

At the beginning of the project, teachers in the French (Lamap) team reported a very calm and active class climate, with students taking care to create a pleasant learning atmosphere and generally eager to participate in class discussions. The teachers had largely positive beliefs and attitudes towards creativity and critical thinking (Figure 8.9). Virtually all respondents agreed that teachers should facilitate students' own inquiry, that instruction should encourage them to try new solutions and to express new ideas. Most of them did not think that instruction was mainly about transmitting accepted knowledge to students.

Figure 8.9. Teachers' enthusiastic beliefs around teaching and learning creativity and critical thinking, less around assessing them, French (Lamap) Team at baseline

Percentage of teachers who believed that…



Note: Bars represent percentages of teachers who (strongly) agreed with each statement, before the project.

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Teachers understood what creativity and critical thinking entail. Indeed, anchoring vignettes with scaled scenarios seemed to show that they mostly managed to correctly rank and identify creative and critical thinking attitudes. They acknowledged the challenges involved in teaching and assessing those skills, and were aware of their lack of training. At the beginning of the project, only a few of them felt prepared to foster students' creativity (13%) and critical thinking (25%), collaborative learning approaches (14%), Project Based Learning (50%), and individualised learning approaches (89%).

At baseline, teachers believed that creativity and critical thinking were malleable and transferable skills that they could effectively teach and assess, with no stringent constraint regarding the curricula they teach. They did feel constrained by the workloads they face. However, they expressed shared scepticism in their capacity to assess those skills reliably.

Before the project, only a few French (Lamap) teachers declared frequent use of innovative instruction practices (asking students to work in small groups to come up with a joint solution to a task, to explain the reasoning behind an answer, etc.), ranking consistently behind their colleagues from the other international teams participating in the project. Equally low is the share of teachers who actually assessed their students in those dimensions: virtually none of them gave credit for wrong answers with original thinking or asked students to self- or peer-assess performance.

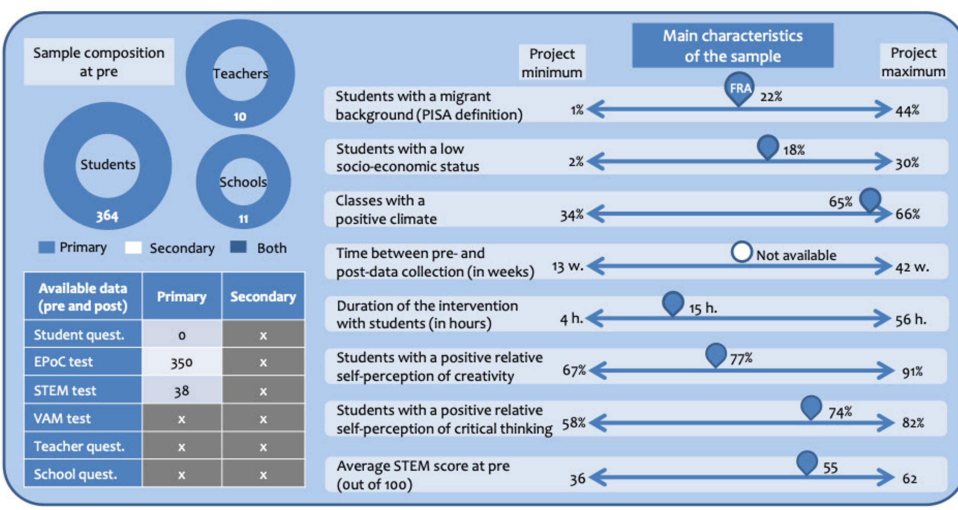
The lack of post-data collection prevented concluding how those encouraging dispositions around creativity and critical thinking evolved following their subsequent teaching. Nevertheless, students' perceptions, feelings, abilities and attitudes towards those skills provided some relevant information.

What students experienced

Students in the French (Lamap) team took both the science, technology, engineering and mathematics (STEM) and Evaluation of Creative Potential (EPoC) creativity tests. The low sample sizes due to the pilot nature of the project combined with high attrition rates led to few statistically significant results. Nonetheless, the amount of information was sufficient to detect positive (but not statistically significant) effects of the pedagogical intervention on students' creativity. Indeed, compared to their counterparts in the control groups, intervention students experienced an increase in their EPoC scores, both in terms of convergent-integrative and divergent-exploratory tasks.

However, the monitoring design of the project has proven to be difficult to implement in this context, even though the instruments worked well when they were answered. Whether a short pedagogical intervention on teachers can foster some changes in their teaching and had effects on some dimensions of students' creativity and critical thinking remains to be shown. The circumstances, size and main beneficiaries of the effects would have to be measured in a validation study.

Who was involved in the project



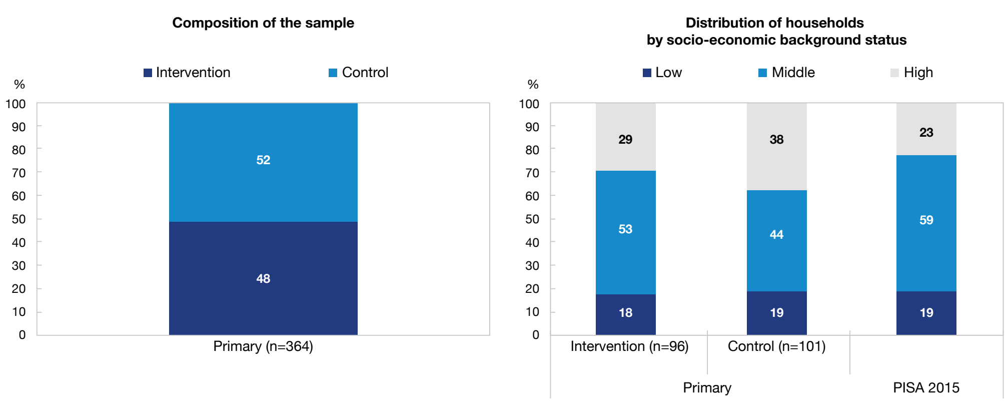
Notes: EPoC: Evaluation of Creative Potential; STEM: science, technology, engineering and mathematics; VAM: visual arts and music.

Compared to the other teams, students in the French (Lamap) team showed an average prevalence of students with a lower socio-cultural status (18%, versus a project minimum of 2% and a maximum of 30%) and an average presence of students with an immigrant background (22%, versus a project minimum of 1% and a maximum of 44%). The average achievement score in maths and science at the beginning of the project was amongst the highest across all teams (55, versus a project minimum of 36 and a maximum of 62), just like the share of classes with a positive climate (65%, versus a project minimum of 34% and a maximum of 66%). In terms of students' self-perceived level of creativity and critical thinking, the share of students evaluating themselves as fairly or very creative was average (77%, versus a project minimum of 67% and a maximum of 91%), while the one concerning critical thinking was at the higher end of the observed values (74%, versus a project minimum of 58% and a maximum of 82%). Finally, the interventions with students carried out by the local team were at the lower end of the observed values in terms of duration of the interventions (15 hours, versus a project minimum of 4 and a maximum of 56).

Overall, 364 primary students were included in the Lamap network involved in the project. The sample sizes of the control and intervention groups were balanced, with control students representing 48% of all students in the project (Figure 8.10, left panel).

Student intervention and control groups presented a few differences in terms of gender and socio-cultural background of the students' households, and were sometimes far from what would be expected from a national representative sample (taking PISA 2015 as a reference; see p.230 in Chapter 7 for further discussion of PISA reference values). Girls were under-represented amongst intervention students, with a share almost 10 percentage points lower than the PISA 2015 value (50%). Control and intervention classes counted equal shares of students with a low socio-cultural background, in line with the national representative samples of PISA 2015. However, students with high socio-cultural background were over-represented compared to the national population, especially in control groups (Figure 8.10, right panel).

Figure 8.10. Students participating in the project, French (Lamap) Team



Note: PISA 2015 references are taken as representative of the entire country population of 15-year-old students.

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The project involved 16 teachers, 10 of whom responded to the teacher questionnaires at baseline. Eight out of ten reported at least ten years of experience as a teacher, and seven hold a bachelor's degree or higher.

Response rates of students were poor, especially when trying to match information from several sources. Looking at each instrument separately, amongst the students who completed the corresponding instrument at baseline, 97% completed the EPoC creativity post-test, but only 19% completed the STEM post-test, and none completed the student post-questionnaire. The subsequent data treatment only caused minor losses of information.

Out of the 16 teachers who took part in the project, 10 completed the baseline questionnaire, and none followed through to the post one.

Hungarian Team

Work in Hungary took place during the entire duration of the development project. Pedagogical work was conducted over two school years between February 2016 and June 2017. The team undertook two rounds of data collection. Apart from three private schools, schools involved in the project were public. In Hungary, the local co-ordinators focused on a school population of disadvantaged students, many of them young Romani. The team already carried out work with a network of schools and teachers and added the project materials and ideas to its previous practice. It worked in both primary and secondary education and focused on mathematics and science education.

In this study, Hungary reported one of the lowest shares of students with an immigrant background (2%), and a high proportion of classes with a positive class climate (60%). The time span between pre- and post-measurements in Hungary was relatively short (17 weeks), and relatively light for students (8 hours of intervention in class), although they continued working with the new pedagogical activities during the whole school year, 90 minutes a week. The difference between rounds was remarkable: the second year of the project, the intervention with students lasted considerably longer (51 hours of intervention in class), and 34 weeks passed between pre- and post-measurements.

Teacher professional development in the Hungarian Team comprised one intensive induction training followed up by regular meeting sessions throughout the intervention. Professional development workshops, monitoring sessions and continuous mentoring was provided.

During the first round, the team used the Creative Partnerships method (see Chapter 3 for more information on the signature pedagogies). During the second round, two kinds of pedagogies were used in the "intervention" schools: Creative Partnerships and the Step by Step approach. The Creative Partnerships approach involves continuous teacher professional development based on collaboration with an artist or a creative professional with the class teacher. The artist helps the teachers change their teaching in different subjects to make it more creative and engaging for students. The Step by Step approach focuses on structured co operation and teamwork. All intervention teachers had sessions about the OECD rubrics and the Hungarian project team closely supported teachers participating in the Creative Partnerships programme.

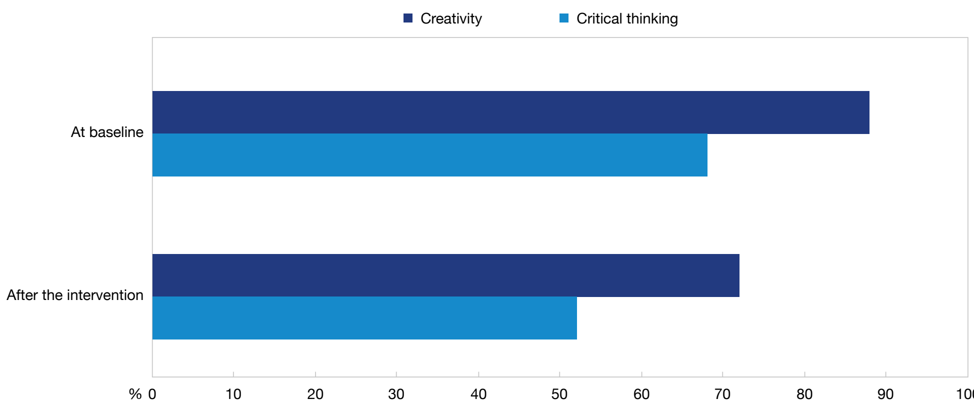
What teachers and school principals said

- High acceptance of the project materials.
- Substantial changes in pedagogical practices around creativity and critical thinking.
- Increased awareness.
- Positive changes in students' academic motivation and engagement.

Teachers' views and practices around creativity and critical thinking changed during the project. Compared to their colleagues in the control groups, teachers who were part of the pedagogical intervention reported a decreasing sense of preparedness to foster students' creativity and critical thinking (Figure 8.11), probably due to an increased awareness of the changes in teaching and learning that fostering creativity and critical thinking involves. Teachers better understood the challenges and felt less prepared than they initially thought. They reckoned that more class time should be devoted to promoting creativity skills, even at the expense of some content knowledge acquisition.

Figure 8.11. Teachers' sense of preparedness decreased as their awareness increased, Hungarian Team

Percentage of intervention teachers who feel prepared for fostering students' creativity and critical thinking



Note: The percentages correspond to the sum of the response categories "Well prepared" and "Very well prepared".

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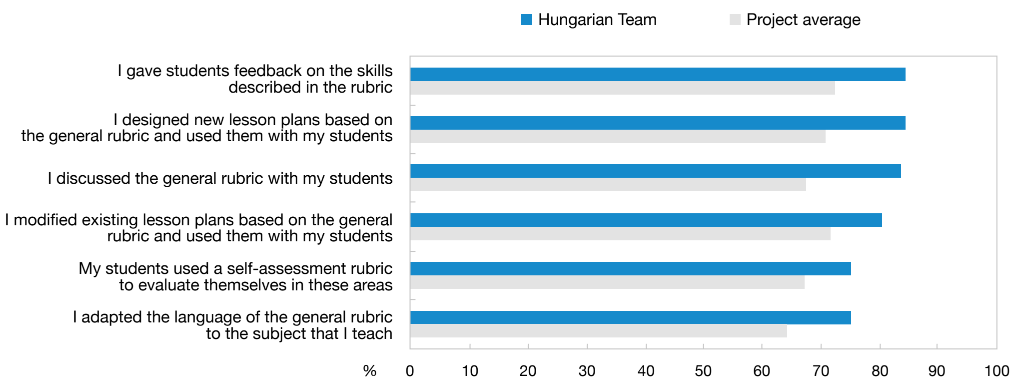
Over the course of the intervention, teachers gave students more credit for being creative than they used to despite inaccurate responses or weak performance. At the end of the second year of the intervention, 80% of intervention teachers reported having used the project rubrics over the previous six months in multiple ways, notably to design or review some of their lessons, but also to discuss the ideas with their students (Figure 8.12). The same proportion of teachers evaluated all aspects of their participation in the project as a positive experience.

Figure 8.12. Teachers largely adopted the project rubrics, Hungarian Team
Percentage of intervention teachers who reported any use of the project rubrics



Note: Bars represent percentages of teachers who used the project rubrics over the last six months of the project.

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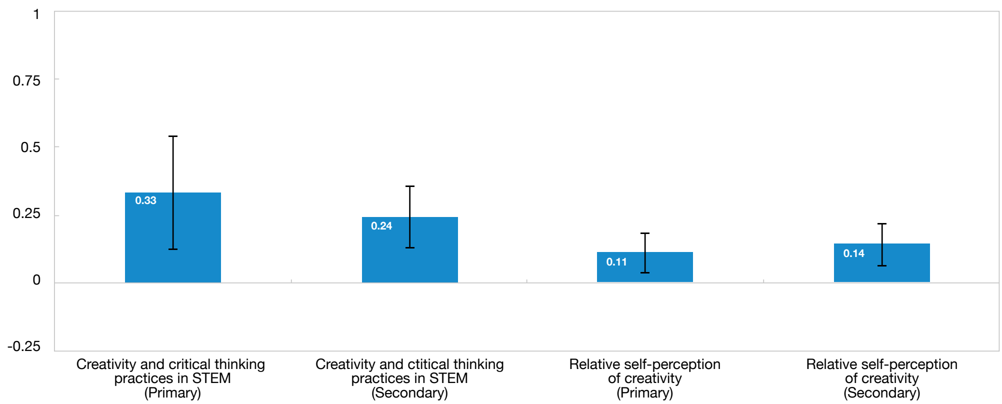
At the beginning of the project, only a third of the school principals considered that past innovation projects had had a strong positive impact on student motivation and engagement in their school, and half of them considered that it had had a strong positive impact on teacher professional development. At the end of the project, nine out of the ten intervention school principals declared that the project had led to positive changes in students' academic motivation and engagement, with a majority anticipating that their teachers would continue to use the project materials in the following years, thus expecting a sustainability of the effects on teachers' practice.

What students experienced

- Higher self-perception of creativity.
- More emphasis on creativity and critical thinking in science, technology, engineering and mathematics (STEM) courses.
- Stronger positive effects amongst girls and students from high socio-economic status background.
- Better results after long and intensive intervention.

Some of the results reported by teachers were aligned with what students experienced (Figure 8.13). The first important point is that students perceived the changes in pedagogy that teachers reported. A statistically significant perception of the use of practices related to creativity and critical thinking in science and mathematics (the focus of the intervention in Hungary) was found in both primary and secondary education. Students' self-perceived creativity increased over the project. An improved feeling of belonging was also captured amongst secondary students in the intervention classes, while their primary peers reported greater levels of curiosity (stronger willingness to learn what they were not initially interested in).

Figure 8.13. Effects of the intervention on students' outcomes, Hungarian Team



Note: STEM: science, technology, engineering and mathematics. Bars represent coefficient estimates and black lines represent confidence intervals. All effects are statistically significant at the 80% level of confidence. Control and intervention groups were compared after a propensity score matching

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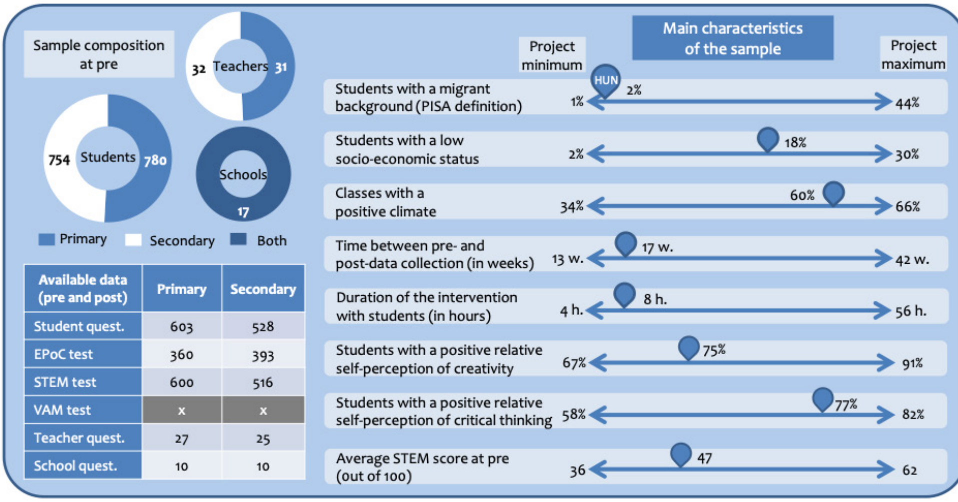
Within the intervention group, the positive effects were stronger for girls, the younger students in the class and for students from a relatively higher socio-economic background. In every way, a longer time frame between pre- and post-measurements seemed to have played an important and positive role: students benefited more from longer and intensive interventions.

The multiplicity of contexts and pedagogical interventions led to the evaluation of direct and indirect effects of many predictors on many teachers' and students' outcomes. Sample sizes did not always allow us to capture, amongst students, the sizeable changes observed in teachers' attitudes and practices. In some cases, the initial monitoring captured paradoxical results. However, the monitoring design of the project has proven to be efficient and successful in numerous ways. A short pedagogical intervention on teachers fostered some changes in their teaching and had effects on some dimensions of students' creativity and critical thinking. The circumstances, size and main beneficiaries of the effects would have to be measured in a validation study.

Who was involved in the project



Available data (pre and post)	Primary	Secondary
Student quest.	603	528
EPoC test	360	393
STEM test	600	516
VAM test	x	x
Teacher quest.	27	25
School quest.	10	10

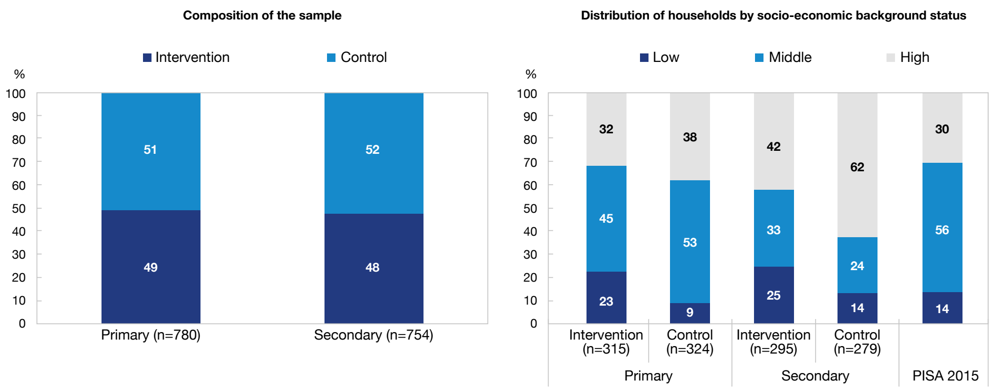
Notes: EPoC: Evaluation of Creative Potential; STEM: science, technology, engineering and mathematics; VAM: visual arts and music.

Compared to the other teams, Hungarian students in the project showed an average prevalence of students with a lower socio-economic status (18%, versus a project span of 2 30%) and one of the lowest presences of students with an immigrant background (2%, versus a project minimum of 1% and a maximum of 44%). The average achievement score in maths and science at the beginning of the project was close to the average (47, versus a project minimum of 36 and a maximum of 62). The share of classes with a positive climate was amongst the highest (60%, versus a project minimum of 34% and a maximum of 66%). Hungarian students in the project evaluated their creativity and critical thinking slightly below the project average (75% as fairly or very creative, with a project range between 67% and 91%). Their self-evaluation of critical thinking was amongst the highest (77%, versus a project minimum of 58% and a maximum of 82%). Finally, the interventions with students were at the lower end of the declared values both in terms of the project's length (17 weeks, versus a project minimum of 13 and a maximum of 42) and the duration of the interventions (8 hours on average, versus a project minimum of 4 and a maximum of 56).

Overall, the Hungarian classes included 780 primary students and 754 secondary students, for a total of 1 534 students. The control and intervention groups were well balanced, with the share of controls being 51% at primary level and 52% at secondary level (Figure 8.14, left panel).

Student groups had a good gender balance at both primary and secondary levels, and showed only a minor under-representation of girls compared to what would be expected from a representative sample (taking PISA 2015 as a reference; see p.230 in Chapter 7 for further discussion of PISA reference values). However, the groups presented significant differences regarding the cultural background of the students' households (Figure 8.14, right panel). Both primary and secondary students showed substantially greater amounts of students with a low cultural background in the intervention compared to the control group. Furthermore, the primary students' profile better mirrored that of PISA 2015 than did the secondary students' profile, suggesting that, on that front, primary students in the project were closer to a standard class in Hungary than secondary students.

Figure 8.14. Students participating in the project, Hungarian Team



Note: PISA 2015 references are taken as representative of the entire country population of 15-year-old students.

StatLink https://doi.org/10.1787/888934003858

In Hungary, the project involved 93 teachers , of which 63 responded to questionnaires at baseline (before the intervention), evenly distributed between primary and secondary schools. Approximately half of them took part in the pedagogical intervention at both primary and secondary levels. A large majority (95%) reported at least six years of experience as a teacher, and more than 85% hold a bachelor's degree or higher. At the school level, 15 principals in the first school year and 13 in the second expressed their views on previous and current innovation projects through a baseline questionnaire.

Completion rates of students were satisfactory, as 85% of the 1 534 students completed at least one instrument at both pre and post in primary and secondary schools. Looking at each instrument separately, the attrition was low: amongst the students who completed the corresponding instrument at baseline, 89% completed the post-questionnaire, 87% completed the STEM post-test and 62% completed the EPoC post-test. The data collection was successful, and the subsequent statistical treatment implemented to ensure comparability only caused minor losses of data.

Completion rates of teachers and school principals were high as well. Out of the 93 teachers who took part in the project, more than two-thirds completed the baseline questionnaire, and around half followed through to the post one. This sample allows providing key information on the changes reported by Hungarian teachers in their feelings, practices and assessments around creativity and critical thinking. Finally, out of the 28 school questionnaires completed at baseline, 10 followed up with a post-questionnaire.

Indian Team

Work in India took place during the entire duration of the project, with pedagogical work being conducted over two school years between November 2015 and October 2016. However, data collection only took part in the first round and for a subset of the measures. Participating schools were located in Delhi and Bangalore, with a mix of state government, government aided and private schools. The schools were mostly public, with the exception of two private ones. The Learning Links Foundation led and co-ordinated the local work, with government approval.

Indians started the project with the lowest self-perceived levels of creativity and critical thinking, and the lowest average achievement score in science and mathematics. The duration between pre- and post-measurements was 42 weeks, the longest period across country teams.

Teacher professional development in the Indian Team consisted of an extensive training programme with induction and follow-up sessions all along the intervention. To encourage reflection on their instruction practices, teachers got interviewed and received feedback from classroom observations. They were also mentored by experts from the National Council of Educational Research and Training.

Teacher professional development empowered teachers to understand the importance of creativity and critical thinking in a formal school setting. In class, the training oriented them towards strategies that develop those skills through pedagogical activities, which they adopted and redesigned. Teachers picked examples from a bank of pedagogies and assessment exercises, providing a proof of concept that these skills could be cultivated in schools.

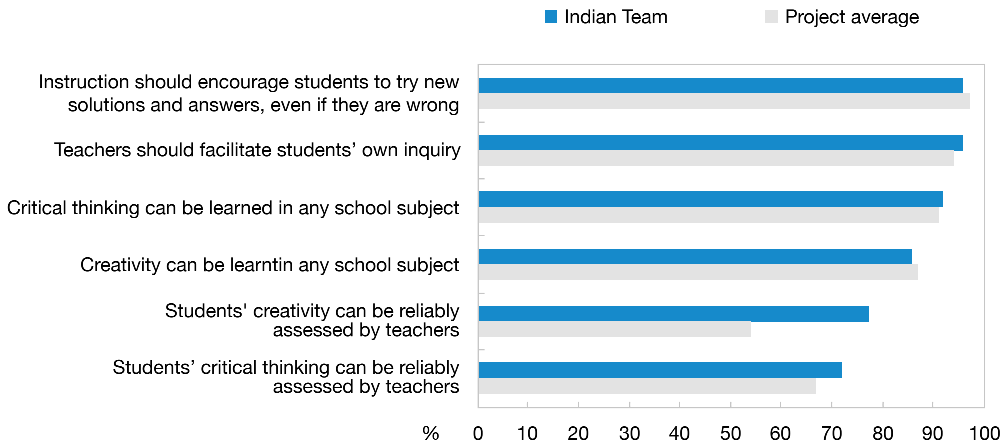
What teachers and school principals said

- Enthusiastic beliefs towards teaching and assessing creativity and critical thinking.
- Sense of preparedness.
- Alignment with existing instruction practices.

At the beginning of the project, teachers involved in the Indian field work virtually all agreed that teachers should facilitate students' own inquiry, that instruction should encourage students to try new solutions and to express new ideas (Figure 8.15). Two-thirds of them did not think that instruction was mainly about transmitting accepted knowledge to students.

Figure 8.15. Teachers' enthusiastic beliefs around creativity and critical thinking, Indian Team at baseline

Percentage of teachers who believed that…



Note: Bars represent percentages of teachers who (strongly) agreed with each statement, before the project.

StatLink https://doi.org/10.1787/888934003877

Teachers felt prepared for fostering students' creativity (90%) and critical thinking (90%), collaborative learning approaches (89%), Project Based Learning (89%), and individualised learning approaches (78%). Yet, they faced some difficulties in properly identifying creative (20%) and critical thinking behaviours (54%). There was thus an initial gap between self-efficacy (or social desirability) and actual understanding of the underlying concepts and practices.

At baseline (before the intervention), teachers believed that creativity and critical thinking were malleable and transferable skills that they could effectively teach and assess, with no stringent constraint regarding the curricula they teach or the workloads they face.

Before the project, they already declared frequent use of instruction practices fostering creativity and critical thinking (asking students to argue for a specific point of view that may be different from their own, to explain the reasoning behind an answer, etc.). However, only a few of them actually assessed their students in those dimensions: they usually did not give credit for wrong answers with original thinking, and did not ask students to self- or peer-assess performance.

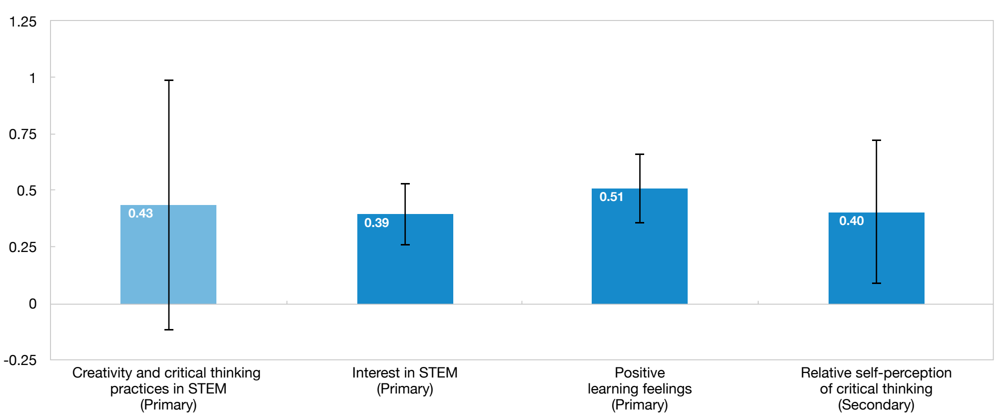
Alas, too few teachers and school principals responded to the pre- and post- questionnaires to have a good record of how teachers' views and practices around creativity and critical thinking during the project.

What students experienced

- Increased interest in science and mathematics.
- Better feelings about learning.
- Improved self-perception of critical thinking skills.
- Better results amongst boys and socio-economically advantaged students.

The pedagogical intervention seems to have led to positive changes amongst students (Figure 8.16). Throughout the project implementation, teacher development plans spiked students' interest in science and mathematics, at least in primary schools. By comparison to their counterparts in control groups, students taught by intervention teachers expressed improved feelings about learning: they felt included in the class and thought they were doing a good job at school. Additionally, students' self-perceived critical thinking increased over the course of the project. However, data collection difficulties prevented capturing all the changes triggered by the pedagogical intervention, especially in secondary schools, where no student questionnaires were answered.

Figure 8.16. Effects of the intervention on students' outcomes, Indian Team



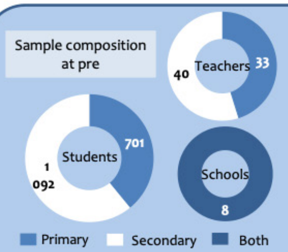
Notes: STEM: science, technology, engineering and mathematics. Bars represent coefficient estimates, with a darker tone indicating statistically significant effects at the 80% level of confidence. Black lines represent confidence intervals. Control and intervention groups were compared after a propensity score matching.

StatLink https://doi.org/10.1787/888934003896

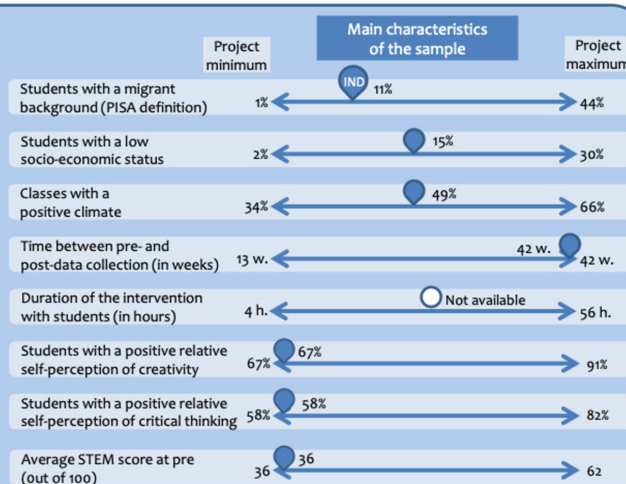
It seems that the positive effects were, on average, stronger for boys, older students in the class and students from an upper socio-economic background.

The multiplicity of contexts and pedagogical interventions led to the evaluation of direct and indirect effects of many predictors on many teachers' and students' outcomes. Sample sizes did not always allow us to capture, amongst students, the sizeable changes observed in teachers' attitudes and practices. In some cases, the initial monitoring captured paradoxical results. However, the monitoring design of the project has proven to be efficient and successful in numerous ways. A short pedagogical intervention on teachers fostered some changes in their teaching and had effects on some dimensions of students' creativity and critical thinking. The circumstances, size and main beneficiaries of the effects would have to be measured in a validation study.

Who was involved in the project



Available data (pre and post)	Primary	Secondary
Student quest.	241	65
EPoC test	x	x
STEM test	264	61
VAM test	x	x
Teacher quest.	9	10
School quest.	x	x



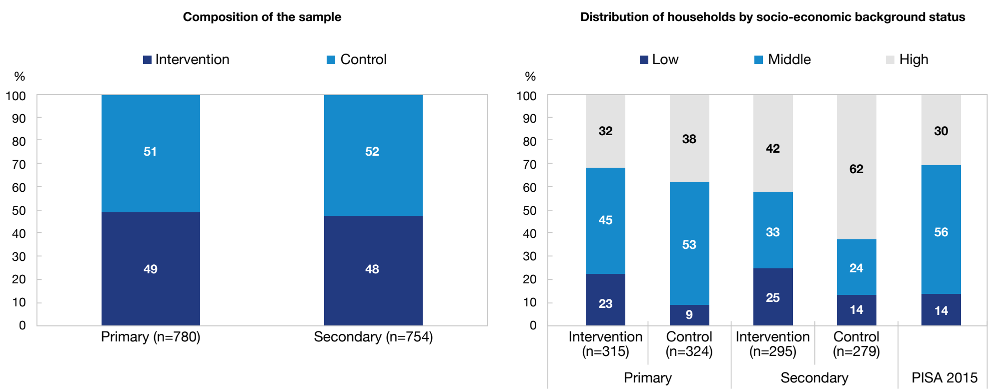
Notes: EPoC: Evaluation of Creative Potential; STEM: science, technology, engineering and mathematics; VAM: visual arts and music.

Compared to the other teams, the Indian classes showed an average prevalence of students with a lower socio-economic status (15%, versus a project range of 2-30%) and a low presence of students with an immigrant background (11%, versus a project minimum of 1% and a maximum of 44%). The average achievement score in maths and science at the beginning of the project was the lowest observed (36, versus a project maximum of 62), just like the share of students evaluating themselves as fairly or very creative (67%, versus a project maximum of 91%) and the one concerning critical thinking (58%, versus a project maximum of 82%). Nonetheless, the share of classes with a positive climate was close to the network average (49%, versus a project minimum of 34% and a maximum of 66%). Finally, when eventually available, the time between pre- and post-measurements was the longest across the international network (42 weeks, versus a project minimum of 13). Data on the duration of the pedagogical interventions with students were not available.

The Indian students participating in the project included 701 primary students and 1 092 secondary students, amounting to 1 793 students. Due to sample selection and operational issues faced by the local team, the sample sizes of control and intervention groups were strongly imbalanced, with students in the control groups representing only about a third of the total sample (34% at primary level and 38% at secondary level) (Figure 8.17, left panel).

Student intervention and control groups presented important differences in terms of the gender and cultural background of the students' households. In both primary and secondary education, girls represented more than half of the sample. Control and intervention classes looked relatively similar in terms of students' cultural background (Figure 8.17, right panel) even if at primary level the control group seemed to be composed of children from wealthier households.

Figure 8.17. Students participating in the project, Indian Team



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In India, the project involved 114 teachers[1], of which 73 responded to questionnaires at baseline, evenly distributed between primary and secondary schools. Approximately half took part in the pedagogical intervention at both primary and secondary levels. The large majority (92%) reported at least six years of experience as a teacher, and more than 90% hold a bachelor's degree or higher. At the school level, eight principals expressed their views on previous and current innovation projects through a baseline questionnaire.

Initial large sample sizes compensated for low completion rates of students, as only 28% of the 1 793 students completed at least one instrument at both pre and post. Looking at each instrument separately, the attrition was significant: amongst the students who completed the corresponding instrument at baseline, 31% completed the post-questionnaire and 22% completed the STEM achievement post-test. Due to imbalances in the completion rates amongst groups, the multivariate analysis could only be carried out for primary education students. Subsequent statistical treatment implemented to ensure comparability only caused minor losses of data.

Completion rates of both pre- and post- teacher and school principal questionnaires were also low. Out of the 114 teachers who took part in the project, 73 completed the baseline questionnaire, but only 19 also completed the post-questionnaire, all belonging to the control groups. This prevented extracting any information on the changes in the participating Indian teachers' feelings, practices or assessments on creativity and critical thinking. Finally, out of the eight school questionnaires received at baseline, none followed up with a post-questionnaire. This highlighted the vulnerability of quasi-experimental designs requiring multiple answers to yield good results – an issue that would have to be dealt within the frame of a validation study.

Russian Team

Work in the Russian Federation took place during the entire duration of the project, with pedagogical work in primary and secondary education spreading over two school years between summer 2016 and spring 2017. The team undertook both rounds of data collection.

The National Research University Higher School of Economics, with the approval of the Ministry of Education, co-ordinated the local work. Only public schools were included in the network of participating schools.

The Russian school network had the highest shares of classes with a positive climate, and a low proportion of students from disadvantaged socio-economic backgrounds. At the beginning of the project, the participating Russian students had amongst the highest achievement scores in maths and science across the international network, and reported relatively good levels of self-perceived critical thinking and creativity.

Teacher professional development in the Russian Federation consisted of an extensive training programme comprised of one induction session and several follow-up sessions held at regular intervals over the course of the intervention. Teachers received feedback based on classroom observations of their practices to improve the innovative pedagogical activities that were initially designed by external experts. They later collaborated with their peers to redesign those pedagogical activities collectively, within schools.

In class, trained teachers tried to design a new learning environment, with a shift from the usual teacher-centred courses to activities where students worked in groups, mostly independently, i.e. not consulting the teacher. The pedagogical redesign did not implement any particular signature pedagogy, but rather tried to adapt existing practices. From the OECD examples of pedagogical activities that they had collectively revisited, teachers especially planned "integrated lessons", working on pedagogical redesign with no shift of the curriculum. With the help of pedagogical experts, they further developed and tested activities to infuse creativity and critical thinking amongst students.

What teachers and school principals said

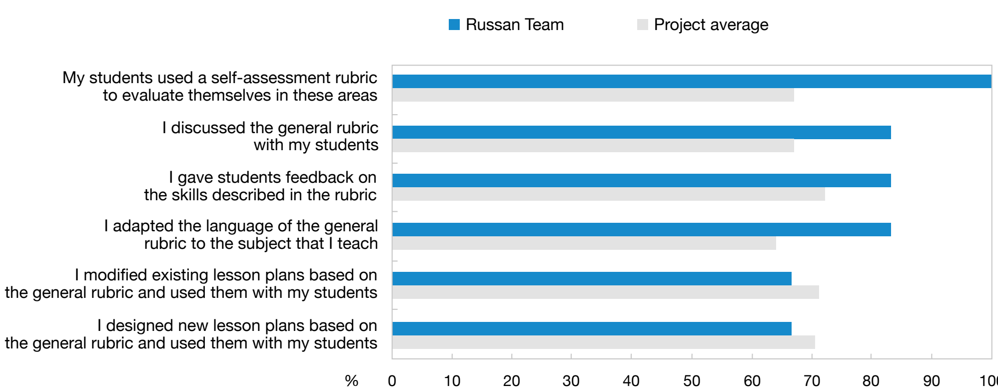
- High adoption of the project materials.
- Increased collaboration with peers on creativity and critical thinking.
- Change in their pedagogies.
- Positive changes perceived in students' academic motivation and engagement.

Teachers' views and practices around creativity and critical thinking changed during the project. At the end of the second year of intervention, two-thirds of intervention teachers reported that they used the project rubrics in multiple ways, notably to design or review some of their lessons, but also to discuss creativity and critical thinking with their students (Figure 8.18). Very few of them found it difficult to use the rubrics. They all considered that their curriculum left enough room to implement the rubrics' ideas and the project's approach. Some of them reckoned that the project was too short to use the rubrics in a consistent way (17%) or that they did not receive enough training to that effect (33%). However, none of them thought that they had too many students to implement the pedagogical strategies suggested by the rubric, which they all found relevant to their teaching.

The vast majority of intervention teachers reported collaboration with peers in relation to the project over the previous six months, such as discussing students' creativity and critical thinking with colleagues (100%) or participating in working groups to refine or develop lessons plans aligned with the rubrics (83%). All of them reported that they changed their pedagogy, in the way they prepare their lessons, design assessment tasks or assess student work. They all felt that their understanding of what it entails to develop students' creativity and critical thinking has evolved, as well as the consistency with which they try to foster those skills amongst students. Almost all of them (+ 95%) perceived changes in students' motivation and engagement, enjoyment of class activities, autonomy as learners, and on the overall class climate. They all evaluate their participation in the project as a (very) positive experience.

Figure 8.18. Teachers largely adopted the project rubrics, Russian Team

Percentage of intervention teachers who reported any use of the project rubrics



Note: Bars represent percentages of teachers who used the project rubrics over the last six months of the project.

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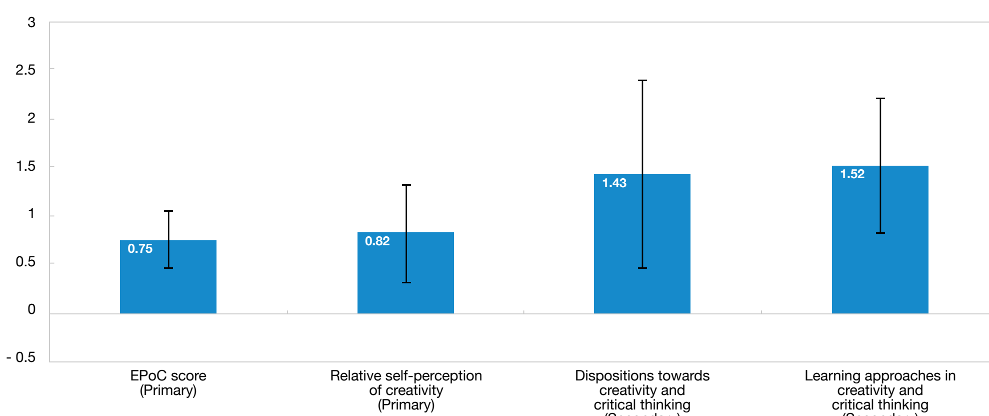
What students experienced

- Improved understanding of and self-perceived levels of creativity and critical thinking.
- More emphasis on creativity and critical thinking in science and maths courses.
- Innovative disposition inside and outside schools.
- Better results for children who did initially not perceive themselves as creative or critical thinkers.

Some of the results reported by teachers were aligned with what students experienced (Figure 8.19). The first important point is that students perceived the changes in pedagogy that teachers reported. In secondary schools, for instance, students in the intervention classes perceived a statistically significant increase in the practices related to creativity and critical thinking in science and mathematics (the focus of the intervention), and reported a stronger interest for them. Those same students also enhanced their dispositions related to creativity and critical thinking, for example with a greater curiosity for topics that did not interest them initially. Students had to consider more frequently different perspectives on a problem, try to understand why people have certain ideas, and were more often asked to challenge assumptions or to make connections with other school subjects.

Additionally, the intervention seems to have improved students' comprehension and self-perceived levels of creativity and critical thinking. Compared to their peers in the control classes, the primary students in the intervention group experienced an increase in their science and maths and in their creativity test scores, especially in divergent-explanatory tasks in the latter case.

Figure 8.19. Effects of the intervention on students' outcomes, Russian Team



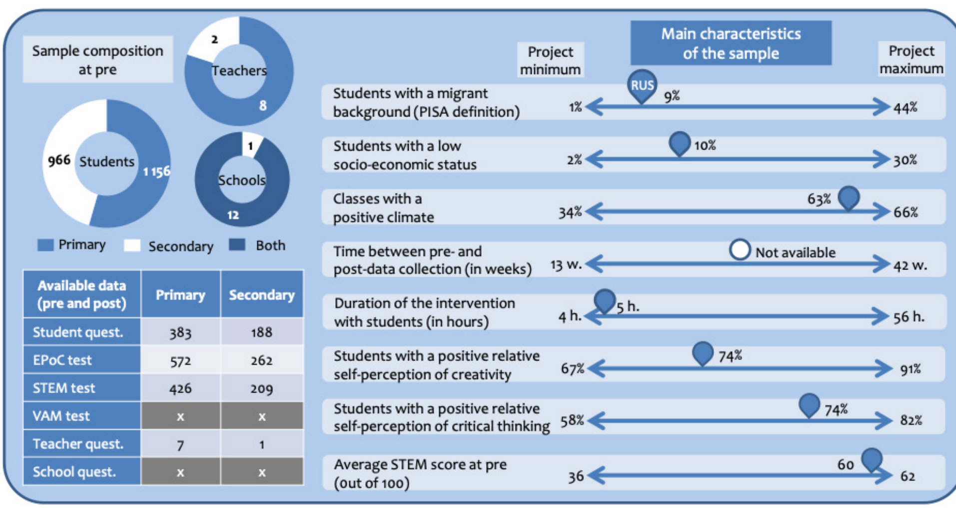
Notes: EPoC: Evaluation of Creative Potential. Bars represent coefficient estimates and black lines represent confidence intervals. All effects are statistically significant at the 80% level of confidence. Control and intervention groups were compared after a propensity score matching.

StatLink https://doi.org/10.1787/888934003953

In addition, girls and students from middle or upper socio-cultural backgrounds seem to have benefited the most from the redesigned pedagogies. Finally, mathematics or science teachers and, to a lesser extent, music and arts teachers, seemed to have had a greater effect on students than their colleagues who took an interdisciplinary approach (or teach other subjects).

The multiplicity of contexts and pedagogical interventions led to the evaluation of direct and indirect effects of many predictors on many teachers' and students' outcomes. Sample sizes did not always allow us to capture, amongst students, the sizeable changes observed in teachers' attitudes and practices. In some cases, the initial monitoring captured paradoxical results. However, the monitoring design of the project has proven to be efficient and successful in numerous ways. A short pedagogical intervention on teachers fostered some changes in their teaching and had effects on some dimensions of students' creativity and critical thinking. The circumstances, size and main beneficiaries of the effects would have to be measured in a validation study.

Who was involved in the project



Available data (pre and post)	Primary	Secondary
Student quest.	383	188
EPoC test	572	262
STEM test	426	209
VAM test	x	x
Teacher quest.	7	1
School quest.	x	x

Notes: EPoC: Evaluation of Creative Potential; STEM: science, technology, engineering and mathematics; VAM: visual arts and music.

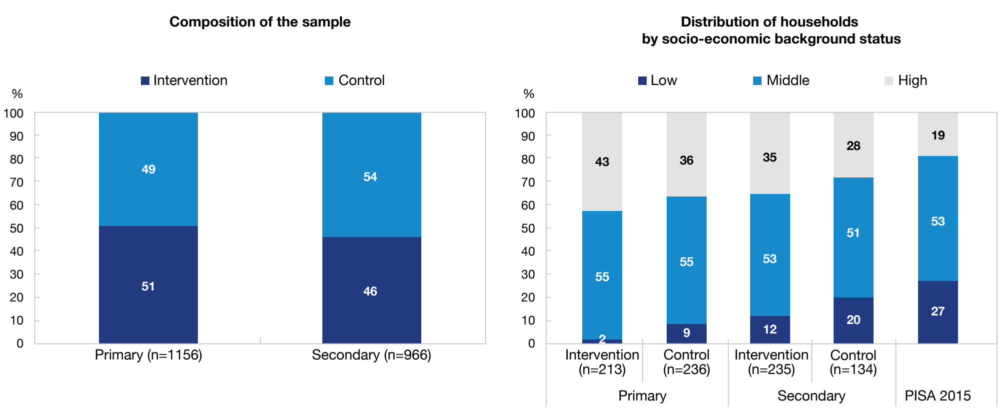
Compared to the other teams, the Russian sample was at the low end in terms of prevalence of students with a lower socio-economic status (10%, versus a project span between 2% and 30%) and of presence of students with an immigrant background (9%, versus a range of 1-44%). The average achievement score in maths and science at the beginning of the project was amongst the highest (60, versus a project minimum of 36 and a maximum of 62), just like the share of classes with a positive climate (63%, versus a project minimum of 34% and a maximum of 66%). In terms of students' self-perceived creativity and critical thinking levels, the share of students evaluating themselves as fairly or very creative was average (74%, versus a project minimum of 67% and a maximum of 91%), and above average for critical thinking (74%, versus a project minimum of 58%

and a maximum of 82%). Finally, the interventions with students carried out by the local team were amongst the shortest in terms of duration of the activities with students (5 hours on average, versus a project minimum of 4 and a maximum of 56), while data on the length between the pre- and post-data collection was not recorded.

Overall, the Russian students in the project included 1 156 primary students and 966 secondary students, for a total of 2 122 students. The sample sizes of the control and intervention groups were balanced, with the share of control students at about 49% at primary level and 54% at secondary level (Figure 8.20, left panel).

The control and intervention groups presented some differences in terms of gender and socio-cultural background, and were sometimes far from what would be expected from a national representative sample (taking PISA 2015 as a reference; see p.230 in Chapter 7 for further discussion of PISA reference values). Overall, girls were over-represented, and this was particularly true in the intervention group in secondary education, where their share was almost 8 percentage points greater than the PISA 2015 value. Furthermore, classes counted substantially more students with a high socio-cultural background than the representative shares described by PISA 2015, especially in the intervention group (Figure 8.20, right panel). Conversely, students from modest socio-cultural households were under-represented, notably in primary schools.

Figure 8.20. Students participating in the project, Russian Team



Note: PISA 2015 references are taken as representative of the entire country population of 15-year-old students.

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In the Russian Federation, the project involved 91 teachers1, 10 of whom responded to the teacher questionnaires at baseline (before the intervention), mainly in primary education. Approximately half of them took part in the intervention at both primary and secondary levels. All of them reported at least ten years of experience as a teacher, and nine out of ten hold a teaching certificate or higher.

Completion rates of students were satisfactory given the large sample sizes: 50% of the 2 122 students completed at least one instrument at both pre and post in primary and secondary schools. Looking at each instrument separately, attrition varied: amongst the students who completed the corresponding instrument at baseline, 66% completed the post-questionnaire, 37% completed the STEM post-test and 64% completed the EPoC creativity post-test. The subsequent statistical treatment implemented to ensure comparability only caused minor losses of data.

Attrition rates amongst teachers and school principals were low. Out of the ten teachers who completed the baseline questionnaire, eight followed through the post one. This provided key information on the changes reported by Russian teachers in their feelings, practices and assessments around creativity and critical thinking, in addition to the local co-ordinator's report.

Slovak Team

Work in the Slovak Republic took place over one school year, between November 2015 and June 2016. The team undertook the first round of implementation and data collection. The intervention covered a balanced assortment of public and private schools, composed of state schools, grammar schools aided by the church and private schools. The Ministry of Education funded the project, which was led by a local research university. Out of 12 schools, 6 were "training" schools that co operate regularly with the Constantine the Philosopher University and where university students can do their teacher training.

Slovak students started the project with average self-perceived levels of creativity and critical thinking and average performances in the science, technology, engineering and mathematics (STEM) achievement test. Slovak schools reported one of the most positive class climates, and an extremely low share of students with an immigrant background.

Teacher professional development first consisted of a one-day induction session with workshops to introduce the projects to teachers and foster reflection on their teaching practices. Then, upon request, teachers could benefit from school visits or remote contacts to follow-up on their professional development plans.

In class, teachers extensively used the project's rubric, from which they designed their own pedagogical activities, prepared lesson plans and developed materials. The pedagogical intervention did not revolve around a specific signature pedagogy (see Chapter 3 for more details), but focused on the incremental change of existing practices.

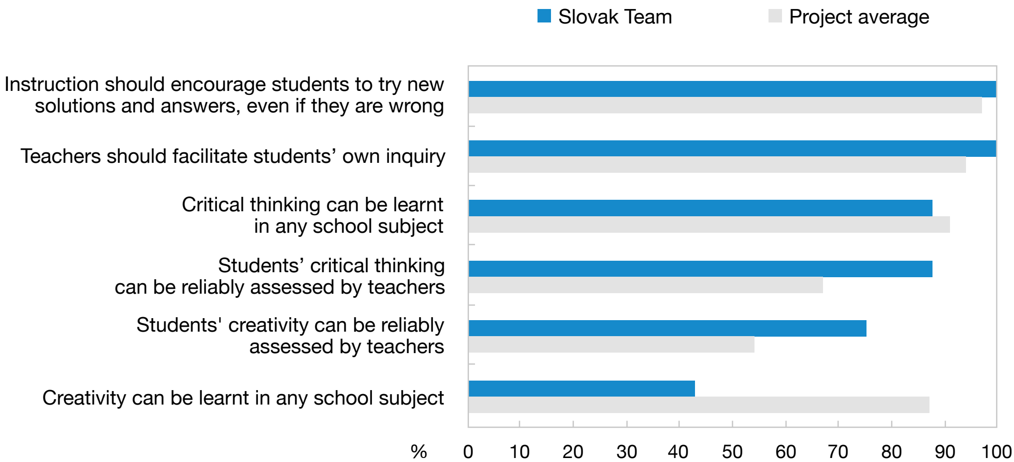
What teachers and school principals said

- Positive beliefs and attitudes towards teaching and assessing creativity and critical thinking.
- Sense of preparedness.
- Alignment with existing instruction practices.
- School principals highly welcomed the project.

At the beginning of the project, teachers in the Slovak Republic had largely positive beliefs and attitudes towards the teaching of creativity and critical thinking (Figure 8.21). Virtually all respondents agreed that teachers should facilitate students' own inquiry, that instruction should encourage them to try new solutions and to express new ideas. Three-quarters of them did not think that instruction was mainly about transmitting accepted knowledge to students.

Figure 8.21. Teachers' enthusiastic beliefs around creativity and critical thinking, Slovak Team at baseline

Percentage of teachers who believed that…



Note: Bars represent percentages of teachers who (strongly) agreed with each statement, before the project.

StatLink https://doi.org/10.1787/888934003991

Teachers felt prepared for fostering students' creativity (100%) and critical thinking (75%), collaborative learning approaches (88%), and individualised learning approaches (100%). Anchoring vignettes with scaled scenarios seemed to confirm this sense of preparedness and understanding, as most Slovak teachers managed to correctly rank and identify creative and critical thinking attitudes.

At baseline (before the intervention), teachers believed that creativity and critical thinking were malleable and transferable skills that they could effectively teach and assess, with no stringent constraint regarding the curricula they teach or the workloads they face.

At the beginning of the project, they already declared frequent use of instructional practices fostering creativity and critical thinking (asking students to argue for another's point of view, to explain the reasoning behind an answer, etc.). However, only a few of them actually assessed their students in those dimensions: they usually did not give credit for wrong answers with original thinking, and did not ask students to self- or peer-assess performance.

Both before and after the project, Slovak school principals regarded past and present innovation projects as effective means to improve student academic performance, motivation and engagement and to foster teacher professional development. When evaluating the OECD-CERI project in particular, they noted similar benefits: the project provided access to valuable materials and development opportunities; it led to collaboration between teachers in unusual and positive ways;

and expanded learning opportunities for students. In the intervention schools, principals declared that teachers would most likely use the project's rubrics and lesson plans with other classes the following year, and saw no stringent challenges in project implementation.

Because of a lack of respondents amongst teachers and school principals, most information on the evolution of pedagogical practices around creativity and critical thinking comes from the student reports.

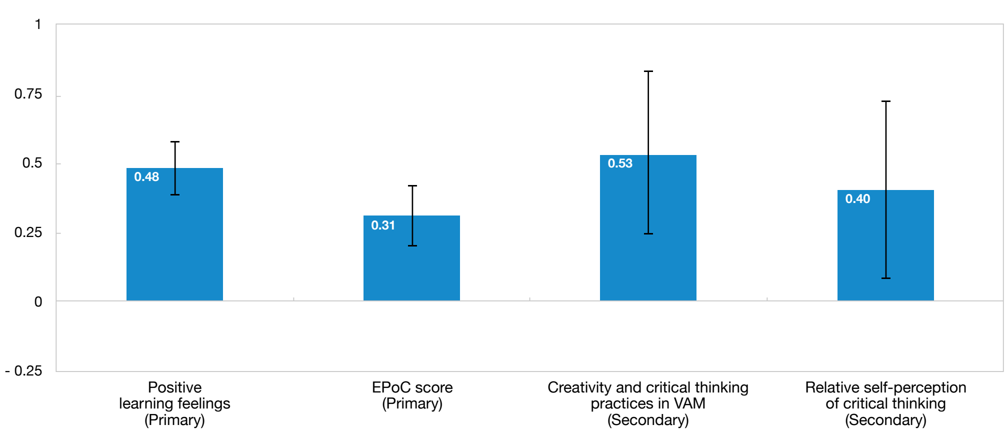
What students experienced

- Improved performances in science and maths, visual arts and music, and Evaluation of Creative Potential (EPoC) creativity test scores.
- More emphasis on creativity and critical thinking in arts courses.
- Better feelings about learning.
- Higher self-perceived levels of creativity and critical thinking.

Some information about what students experienced over time could be estimated (Figure 8.22). The first important point is that students perceived changes in teachers' pedagogy, notably in visual arts and music at the secondary level. The pedagogical intervention led to improved performances in the science and mathematics (STEM), visual arts and music (VAM), and EPoC creativity tests, both in primary and secondary education. Compared to their counterparts in control groups, intervention students expressed better feelings about learning, and their self-perceived level of creativity and critical thinking significantly increased over the course of the project.

On average, girls and younger students in the class witnessed better results, as well as those who benefited from a longer time frame between pre- and post-measurements.

Figure 8.22. Effects of the intervention on students' outcomes, Slovak Team

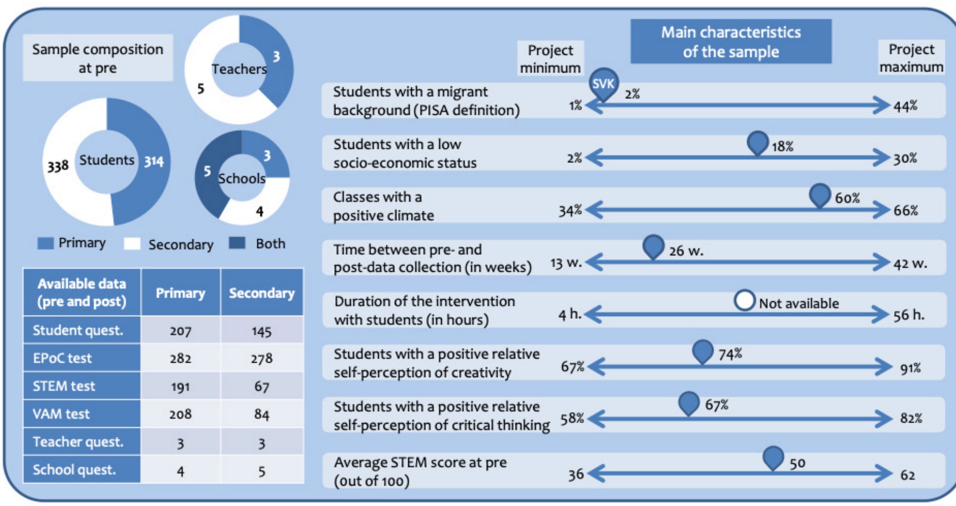


Notes: EPoC: Evaluation of Creative Potential. Bars represent coefficient estimates and black lines represent confidence intervals. All effects are statistically significant at the 80% level of confidence. Control and intervention groups were compared after a propensity score matching.

StatLink https://doi.org/10.1787/888934004010

The multiplicity of contexts and pedagogical interventions led to the evaluation of direct and indirect effects of many predictors on many teachers' and students' outcomes. Sample sizes did not always allow us to capture, amongst students, the sizeable changes observed in teachers' attitudes and practices. In some cases, the initial monitoring captured paradoxical results. However, the monitoring design of the project has proven to be efficient and successful in numerous ways. A short pedagogical intervention on teachers fostered some changes in their teaching and had effects on some dimensions of students' creativity and critical thinking. The circumstances, size and main beneficiaries of the effects would have to be measured in a validation study.

Who was involved in the project



Available data (pre and post)	Primary	Secondary
Student quest.	207	145
EPoC test	282	278
STEM test	191	67
VAM test	208	84
Teacher quest.	3	3
School quest.	4	5

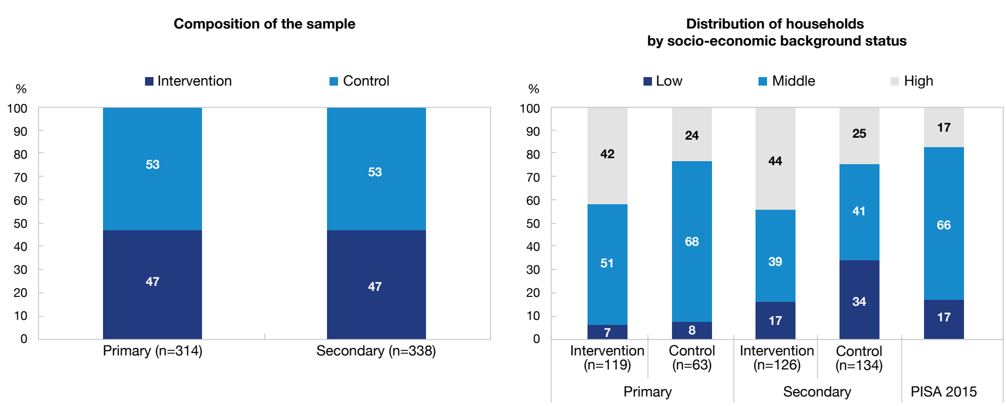
Note: EPoC: Evaluation of Creative Potential; STEM: science, technology, engineering and mathematics; VAM: visual arts and music.

Compared to the other teams, the Slovak classes showed an average prevalence of students with a lower socio-cultural status (18%, versus a project minimum of 2% and a maximum of 30%) and one of the lowest presences of students with an immigrant background (2%, versus a project minimum of 1% and a maximum of 44%). The average achievement score in maths and science at the beginning of the project was slightly above average (50, versus a project minimum of 36 and a maximum of 62), and the share of classes with a positive climate was amongst the highest (60%, versus a project minimum of 34% and a maximum of 66%). In terms of students' self-perceived level of creativity and critical thinking, the share of students evaluating themselves as fairly or very creative was below average (74%, versus a project minimum of 67% and a maximum of 91%), just like the one concerning critical thinking (67%, versus a project minimum of 58% and a maximum of 82%). Finally, the duration between the pre- and post-measurements was slightly less than average (26 weeks, versus a project minimum of 13 and a maximum of 42), while data on the duration of the pedagogical interventions with students were not available.

Overall, the Slovak students in the project included 314 primary students and 338 secondary students, amounting to 652 students. The sample sizes of control and intervention groups were balanced, with the share of control students amounting to 53% at both primary and secondary levels (Figure 8.23, left panel).

The control and intervention groups presented some differences in terms of gender and cultural background, and were sometimes far from what a national representative sample would look like (taking PISA 2015 as a reference; see p.230 in Chapter 7 for further discussion of PISA reference values). Girls were notably over-represented in the intervention group of secondary classes, as well as in both groups of primary classes. Both primary and secondary classes counted substantially more students from a high socio-cultural background than the shares described by PISA 2015, especially in the intervention groups (Figure 8.23, right panel). Students from households with a low cultural background were equally less represented in the intervention groups, particularly in secondary education.

Figure 8.23. Students participating in the project, Slovak Team



Note: PISA 2015 references are taken as representative of the entire country population of 15-year-old students.

StatLink https://doi.org/10.1787/888934004029

In the Slovak Republic, the project involved 38 teachers, 8 of whom responded to the teacher questionnaires at baseline, all in the control group. The large majority (83%) reported at least six years of experience as a teacher, and they all hold a master's degree or higher. At the school level, ten principals expressed their views on previous and current innovation projects through a baseline questionnaire.

Completion rates for students' instruments were satisfactory, as 88% of the 652 students completed at least one instrument at both pre and post in primary and secondary schools. Looking at each instrument separately, the attrition was low: amongst the students who completed the corresponding instrument at baseline, 63% completed the post-questionnaire, 54% completed the STEM post-test, 59% completed the VAM (visual arts and music) post-test and 90% completed the EPoC creativity post-test. The data collection was successful, and the subsequent statistical treatment implemented to ensure comparability only caused minor losses of data.

Out of the 38 teachers who took part in the project, only 8 completed the baseline questionnaire, and 6 followed through to the post one. Moreover, those respondents all belonged to control groups and did not take part in the pedagogical intervention. Finally, out of the ten school questionnaires completed at baseline, six were followed up with a post-questionnaire.

Spanish (Madrid) Team

Pedagogical work in Spain took place between October 2016 and June 2017. The team only took part in the second round of the project and data collection. The field work took place in the Madrid Region, and was co-ordinated by the local government. The local team developed a virtual learning community for the teachers.

The Spanish (Madrid) schools involved in the project did not start the project with the most positive class climate across the international network, although students were active and eager to participate. However, at baseline students reported a good understanding of creativity and critical thinking, as well as an average achievement score in science and mathematics.

Teacher professional development consisted of an extensive training programme of one induction session and four follow-up meetings. Throughout the training sessions, assignments and collective reflection workshops fostered teachers' experimentation of new practices in the classroom.

A network of local advisers acted as facilitators between participating schools. They spurred a professional learning community to encourage collaboration between teachers to design new activities and reflect on their practices, with the help of an online platform to share materials, ideas and advice.

In class, professional development plans empowered teachers to use the project's rubrics, adapt them to their curriculum and derive pedagogical activities that nurture creativity and critical thinking amongst students. The pedagogical intervention did not revolve around a specific signature pedagogy (see Chapter 3 for more information on the signature pedagogies).

Several challenges prevented a sound quantitative analysis of the collected data, so that the main findings are qualitative.

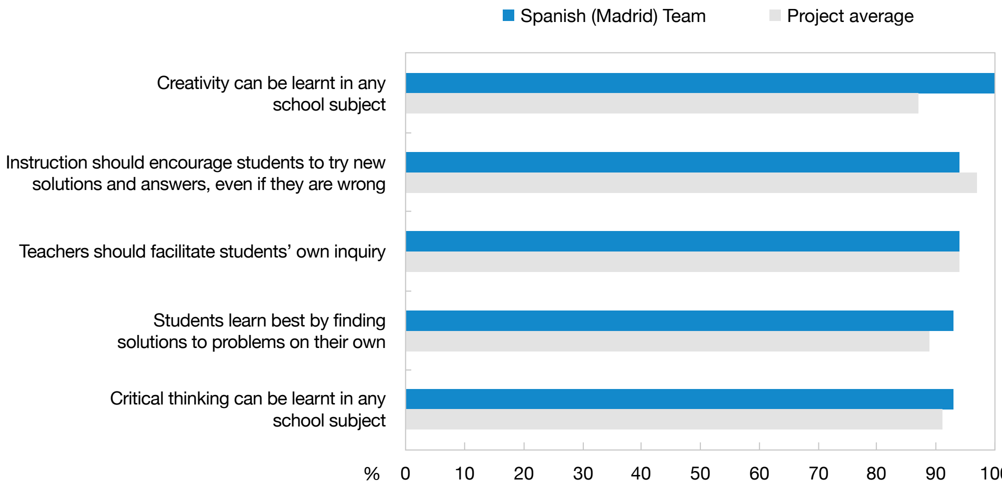
What teachers and school principals said

- Positive beliefs and attitudes towards teaching and assessing creativity and critical thinking.
- Good understanding of creativity and critical thinking skills.
- Alignment of existing instruction practices with those promoted by the project.
- Assessment practices lag behind.

At the beginning of the project, teachers in the Spanish (Madrid) team reported a moderately peaceful but active class climate, with students taking care to create a pleasant learning atmosphere and generally eager to participate in class discussion. The teachers had largely positive beliefs and attitudes towards creativity and critical thinking (Figure 8.24). Virtually all respondents agreed that teachers should facilitate student's own inquiry, and that instruction should encourage them to try new solutions or to express new ideas. Most of them did not think that instruction was mainly about transmitting accepted knowledge to students.

Figure 8.24. Teachers' enthusiastic beliefs around creativity and critical thinking, Spanish (Madrid) Team at baseline

Percentage of teachers who believed that…



Note: Bars represent percentages of teachers who (strongly) agreed with each statement, before the project.

StatLink https://doi.org/10.1787/888934004048

Despite a limited sense of preparedness to foster students' creativity (53%) and critical thinking (53%), for a collaborative learning approach (60%), Project Based Learning (53%), and individualised learning approaches (74%), teachers showed a good understanding of those skills. Anchoring vignettes with scaled scenarios showed that most managed to correctly identify (and rank) creative and critical thinking attitudes.

At baseline, teachers believed that creativity and critical thinking were malleable and transferable skills that they could effectively teach and assess, with no stringent constraint regarding the curricula they teach (27%), but rather regarding the workloads they face (60%).

Before the project, they already declared frequent use of innovative instruction practices (asking students to work in small groups to come up with a joint solution to a task, to explain the reasoning behind an answer, etc.). However, only a few of them actually assessed their students in those dimensions: they usually did not give credit for wrong answers with original thinking and did not ask students to self- or peer-assess performance.

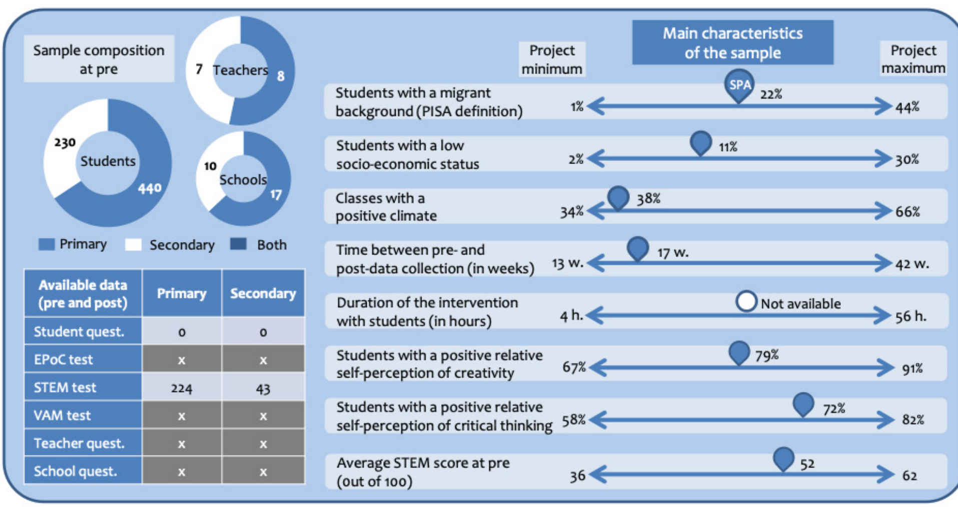
At the institution level, the eight school principals said that past innovation projects had a strong and positive impact on student academic performance, motivation and engagement and on teacher professional development. However, they mostly recognise challenges in the lack of adequate funding, support from local education authorities, and time, given regular school activities. Above all, they point out a poor fit between curricular and assessment requirements.

The lack of answers to teacher post-questionnaires prevented an assessment of the evolution of those encouraging dispositions and attitudes on creativity and critical thinking. Nonetheless, one of the main conclusions drawn by the local team in its project report suggests that the results of the project were strongly appreciated by participants. In their words, "the teachers who attended the professional development events set up for this project, who followed all the suggested steps and who used the rubrics as a conclusion to the whole process, have valued very positively the whole experience and the results that it had amongst the students".

What students experienced

No useable data were collected on this topic.

Who was involved in the project

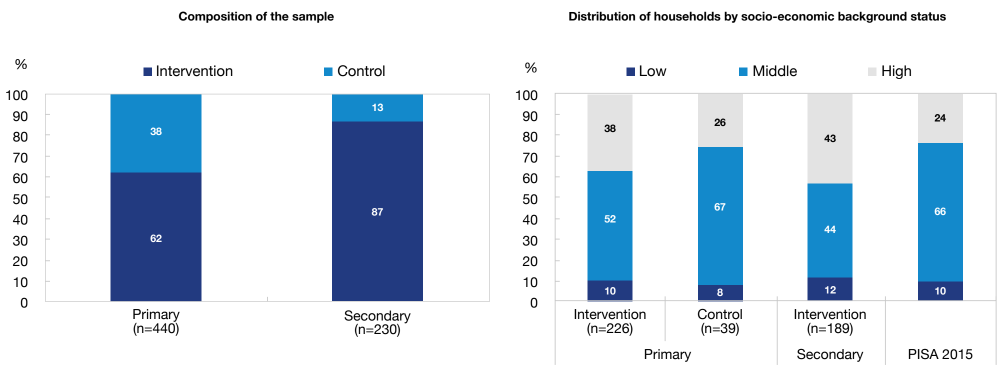


Notes: EPoC: Evaluation of Creative Potential; STEM: science, technology, engineering and mathematics; VAM: visual arts and music.

Compared to the other teams, the Spanish (Madrid) students had a lower prevalence of students with a lower socio-economic status (11%, versus a project minimum of 2% and a maximum of 30%) and an average presence of students with an immigrant background (22%, versus a project minimum of 1% and a maximum of 44%). The average achievement score in maths and science at the beginning of the project was higher than average (52, versus a project minimum of 36 and a maximum of 62), but the share of classes with a positive climate was amongst the lowest (38%, versus a project minimum of 34% and a maximum of 66%). In terms of students' self-perceived level of creativity and critical thinking, the share of students evaluating themselves as fairly or very creative was average (79%, versus a project minimum of 67% and a maximum of 91%), while that concerning critical thinking was on the higher end (72%, versus a project minimum of 58% and a maximum of 82%).

Overall, students in the Spanish (Madrid) classes included 440 primary students and 230 secondary students, amounting to 670 students. Due to sample selection and operational issues faced by the local team, the sample sizes of controls and interventions were heavily imbalanced, particularly for secondary students. In fact, the share of control students in primary education was 38% and only 13% in secondary education (Figure 8.25, left panel).

Figure 8.25. Students participating in the project, Spanish (Madrid) Team



Note: PISA 2015 references are taken as representative of the entire country population of 15-year-old students.

StatLink https://doi.org/10.1787/888934004067

The control and intervention groups did not differ much in terms of gender or socio-cultural background, and they were sometimes close to what would be expected from a national representative sample (taking PISA 2015 as a reference; see p.230 in Chapter 7 for further discussion of PISA reference values). Minor exceptions concerned girls, who were slightly over-represented in primary schools; and students with a high socio-cultural background, over-represented at both primary and secondary levels, especially in the intervention groups (Figure 8.25, right panel).

The project involved 31 teachers, 15 of whom responded to the teacher questionnaires at baseline. All of them reported at least ten years of experience as a teacher. At the school level, eight principals expressed their views on previous and current innovation projects through a baseline questionnaire.

It was not possible to carry out any meaningful multivariate analysis on the Spanish sample. One instrument had pre- and post-measures, but errors in the data made analysis impossible.

Out of the 31 teachers who took part in the project, half completed the baseline questionnaire, and none of them completed the post-questionnaire. Similarly, out of the eight school questionnaires completed at baseline by the principals, none had a matching post-questionnaire.

Thai Team

The work in Thailand was carried out over two rounds of the project and data collection by the joint collaboration between the Office of Basic Education Commission (OBEC), Ministry of Education and the Equitable Education Fund (EEF)[2], across two Thai school years. Data collection took place between November 2015 and May 2017. Most classes were in public schools (with a small share in private schools). All participating schools volunteered to take part in the OECD-CERI project. Allocation to the intervention or control groups followed a stratified random sampling, at both primary and secondary education level: stratification depended on the schools' overseeing institution (either the Office of the Basic Education Commission or another institution), on their average national standardised test score (either high or low), and on the size of schools (small, medium, and large). National policy makers expressed deep interest in randomising control and intervention schools, so as to have better robustness of the findings, even if preliminary before validation. Following the results of this pilot, Thai policy makers implemented policy reforms continuing or aligned with this initiative to foster creativity and critical thinking – and, more generally, improve teaching and learning.

Thailand reported the lowest share of students with an immigrant background (1%), and one of the highest prevalence of students living in socio-economically disadvantaged households. The time frame in Thailand between pre- and post-data collections was the shortest (13 weeks), and pedagogical interventions with students were also amongst the shortest (9 hours of class intervention).

Teacher professional development in the Thai Team consisted of an extensive training programme with a two-day induction training, followed by monthly follow-up sessions throughout the intervention. A network of local advisers provided teachers with individual reviews of their professional development plans by visiting schools, observing classrooms and reporting feedback to advise them on ways to improve their teaching practices. Teachers could also collaborate and exchange with peers on an online platform. A specificity in the Thai case is that in the second year of the project implementation, trained teachers from the first round (the first school year) turned into trainers the second year: they gave induction sessions and tutoring assistance to their peer teachers involved in the second round of the field work.

In Thailand, schools and teachers were not supported by pedagogical re-designers taking a particular pedagogical approach to fostering creativity and critical thinking. It embraced several incremental strategies around teachers' views and practices, so they gradually assimilated the OECD project's rubrics, approach and lesson plans.

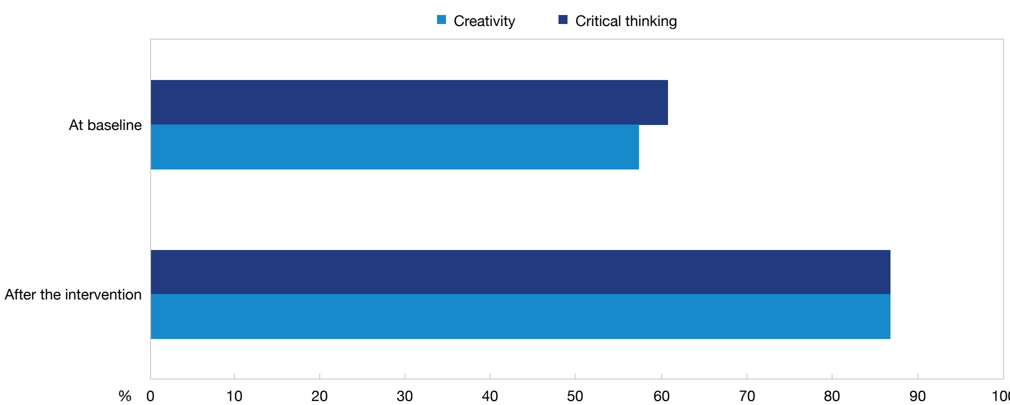
What teachers and school principals said

- Teachers feel more prepared to teach and assess creativity and critical thinking.
- Substantial changes in pedagogical practices around those skills.
- High acceptance of the project materials.
- Positive changes in students' academic motivation and engagement.

Teachers' views and practices around creativity and critical thinking changed during the project. Compared to their colleagues in the control groups, teachers who were part of the pedagogical intervention reported an increasing sense of preparedness to foster students' creativity and critical thinking (Figure 8.26). On the other hand, fewer teachers reckoned that critical thinking could be reliably taught and assessed in schools.

Figure 8.26. Teachers' sense of preparedness increased, Thai Team

Percentage of intervention teachers who feel prepared for fostering students' creativity and critical thinking



Note: The percentages correspond to the sum of the response categories "Well prepared" and "Very well prepared".

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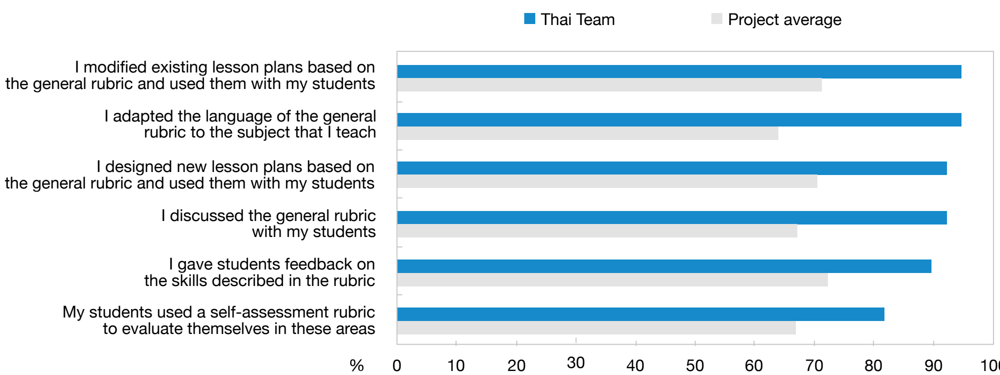
Over the course of the field work, teachers intensified their pedagogical practices around creativity and critical thinking. Thai teachers asked students more often to argue for a point of view that may not be their own, or to work in small groups to come up with a joint solution to a problem. Local co-ordinators reported this as quite different from the average Thai approach to teaching.

Intervention teachers massively adopted and used the project rubrics in their courses, notably to design or review some of their lessons, but also to discuss creativity and critical thinking with their students (Figure 8.27). However, they felt that their training and the project length were too short to use the rubrics in a more effective way. Finally, almost all of them reported changes in their pedagogies over the project's duration, and that trying to foster and assess students' creativity and critical thinking had a positive effect on student's motivation, understanding, autonomy and overall class climate.

Figure 8.27. Teachers largely adopted the project rubrics, Thai Team

Percentage of intervention teachers who reported any use of the project rubrics



Note: Bars represent percentages of teachers who used the project rubrics over the last six months of the project.

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In intervention schools, principals provided very enthusiastic feedback. They all reported a strong positive impact on student motivation and engagement, and that their participation led to collaboration levels between teachers that were both unusual and positive. A fair share claimed that teachers would most likely continue to use the OECD rubrics and lesson plans the following year with other classes.

What students experienced

- Improved academic achievement in primary education.
- Better results for girls and socio-economically advantaged students.
- Enhanced parental engagement in their children's education.
- Stronger effects for students whose teachers showed more self-efficacy on teaching creativity and critical thinking.

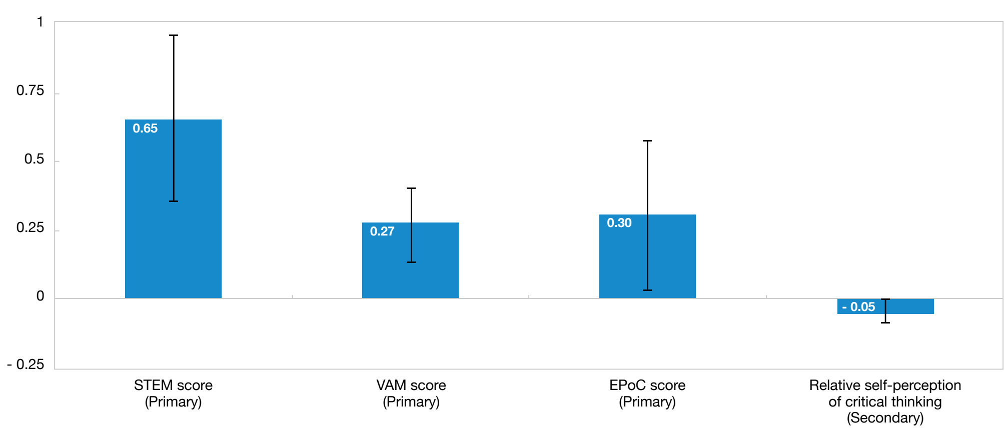
The pedagogical intervention was also associated with statistically significant positive results for students (Figure 8.28), some of them aligned with what teachers reported. Positive effects were observed in primary schools: teachers' pedagogical interventions led to improved student performance in both maths-science and music-visual arts achievements tests, and in the Evaluation of Creative Potential (EPoC) creativity test, especially in divergent-exploratory tasks. Furthermore, the intervention was associated with greater parental engagement: children in the intervention talked to their parents more about books, films, music or school in general.

It was more difficult to capture significant changes in students' practices, interests and disposition at the secondary education level. Students reported lower levels of self-perceived creativity and critical thinking skills after the implementation of the project. To put this in perspective, they were taught by teachers who themselves encountered increasing difficulty in the understanding of creativity and critical thinking.

Analysing student's profiles provided some additional details concerning the subgroups that benefited the most from the intervention. Girls seem to have benefited more from the intervention than boys, in nearly all domains observed. Students from a higher socio-economic background, but also from a lower socio-economic background in the case of secondary students, were more receptive to the innovative pedagogies and practices, showing more interest in courses, and making more progress in the achievement and creativity tests.

Neither the length between pre- and post-measurements nor the intensity of the pedagogical interventions seemed to have played a decisive role on students' outcomes related to creativity and critical thinking.

Figure 8.28. Effects of the intervention on students' outcomes, Thai Team

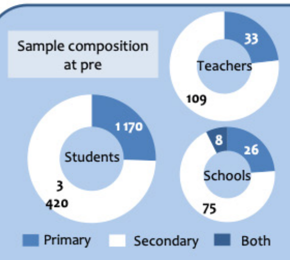


Notes: STEM: science, technology, engineering and mathematics; VAM: visual arts and music; EPoC: Evaluation of Creative Potential. Bars represent coefficient estimates and black lines represent confidence intervals. All effects are statistically significant at the 80% level of confidence. Control and intervention groups were compared after a propensity score matching.

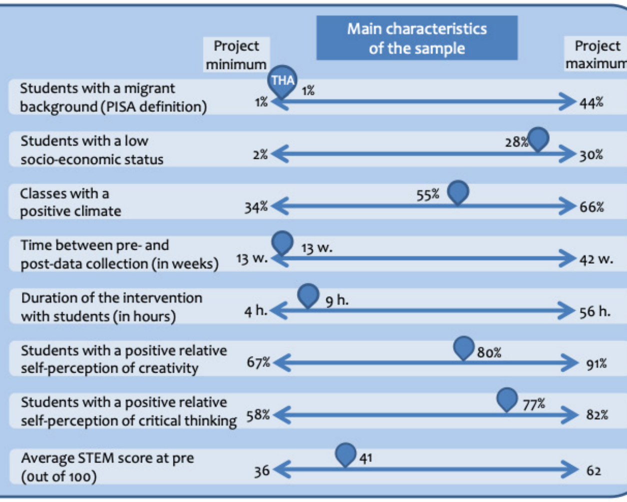
StatLink https://doi.org/10.1787/888934004124

The multiplicity of contexts and pedagogical interventions led to the evaluation of direct and indirect effects of many predictors on many teachers' and students' outcomes. Sample sizes did not always allow us to capture, amongst students, the sizeable changes observed in teachers' attitudes and practices. In some cases, the initial monitoring captured paradoxical results. However, the monitoring design of the project has proven to be efficient and successful in numerous ways. A short pedagogical intervention on teachers fostered some changes in their teaching and had effects on some dimensions of students' creativity and critical thinking. The circumstances, size and main beneficiaries of the effects would have to be measured in a validation study.

Who was involved in the project



Available data (pre and post)	Primary	Secondary
Student quest.	902	2 828
EPoC test	998	2 112
STEM test	218	2 658
VAM test	451	x
Teacher quest.	26	100
School quest.	34	68



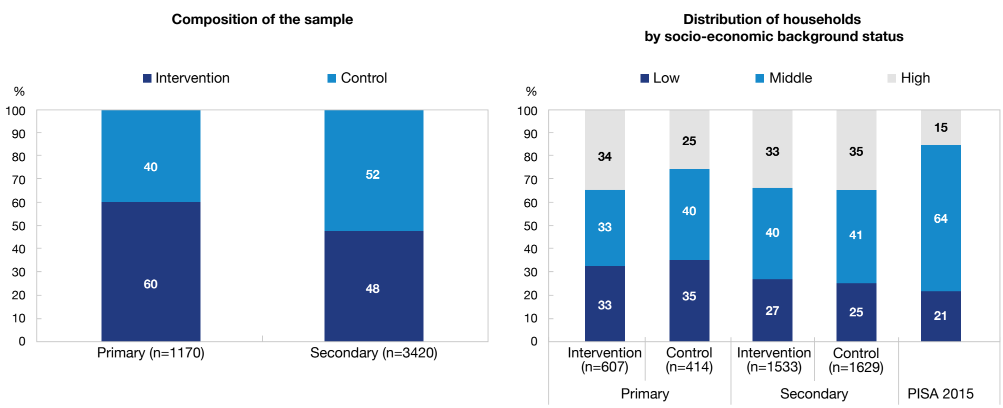
Notes: EPoC: Evaluation of Creative Potential; STEM: science, technology, engineering and mathematics; VAM: visual arts and music.

Compared to the other country teams, the Thai students included the highest prevalence of students from a lower socio-economic status (28%, versus a minimum of 2% and a maximum of 30%) and the lowest presence of students with an immigrant background (1%, versus a project maximum of 44%). The average achievement score in maths and science at the beginning of the project was lower than average (41, versus a project minimum of 36 and a maximum of 62), while the share of classes with a positive climate was slightly above average (55%, versus a project minimum of 34% and a maximum of 66%). In terms of students' self-perceived creativity and critical thinking, the share of students evaluating themselves as fairly or very creative was close to the average (80%, versus a project minimum of 67% and a maximum of 91%), while the one concerning critical thinking was at the higher end (77%, versus a project minimum of 58% and a maximum of 82%). Finally, the constraint to carry out the project for one of the two terms making up the Thai school year implied that the time between pre- and post-measurements were the shortest amongst the network of participating teams (13 weeks, versus a project maximum of 42) and included relatively short pedagogical interventions (9 hours on average, versus a project minimum of 4 and a maximum of 56).

The Thai students involved in the project included 1 170 primary students and 3 420 secondary students, for a total of 4 590 students. In spite of the randomisation, the sample sizes of the control and intervention groups were imbalanced, particularly for primary students. In fact, while the share of students in the control group in secondary education was 52%, it was only 40% at the primary level (Figure 8.29, left panel).

The control and intervention groups presented only minor differences in terms of gender and socio-cultural background. They were sometimes far from what would be expected from a national representative sample (taking PISA 2015 as a reference; see p.230 in Chapter 7 for further discussion of PISA reference values). Girls outnumbered boys by a few percentage points at both primary and secondary levels, and this was especially true in the control group. In addition, the groups included more students with low and high socio-cultural backgrounds than the representative samples of PISA 2015, even though the control and intervention groups both had comparable levels (Figure 8.29, right panel).

Figure 8.29. Students participating in the project, Thai Team



Note: PISA 2015 references are taken as representative of the entire country population of 15-year-old students.

StatLink https://doi.org/10.1787/888934004143

In Thailand, the project involved 159 teachers1, 144 of whom responded to questionnaires at baseline, (before the intervention) mostly in secondary schools. Approximately half of them took part in the intervention development at both primary and secondary levels. A large majority of respondents (75%) reported at least six years of experience as a teacher, and practically all of them hold a bachelor's degree or higher. At the school level, 23 principals in the first school year and 96 in the second expressed their views on previous and current innovation projects through a baseline questionnaire.

Completion rates of students were satisfactory, as 95% of the 4 349 students completed at least one instrument at both pre and post in primary and secondary schools. Looking at each instrument separately, the attrition was low: amongst the students who completed the corresponding instrument at baseline, 86% completed the post-questionnaire, 82% completed the maths and science achievement post-test, 59% completed the visual arts and music post-test, and 85% completed the EPoC creativity post-test. The data collection was successful, and the subsequent statistical treatment implemented to ensure comparability only caused minor losses of data.

Completion rates of teachers and school principals were high as well. Out of the 159 teachers who took part in the project, 90% completed the baseline questionnaire and around 80% followed through to the post one. This provided key information on the changes reported by Thai teachers in their feelings, practices and assessments around creativity and critical thinking. Finally, out of the 119 school questionnaires completed at baseline, 81 had a matching post-questionnaire.

UK (Welsh) Team

Work in Wales took place between October 2016 and July 2017. The Welsh Team undertook the second round of pedagogical redesign and data collection as part of the Lead Creative Schools national scheme, a partnership programme between the Welsh government and the Arts Council of Wales. The project only involved public schools. The intervention was based on the Creative Partnerships approach (see Chapter 3 for more information on the signature pedagogies), with teacher professional development delivered by the Wales programme team in partnership with Creativity, Culture and Education, and the use of the "Creative Habits of Mind" rubric (see Chapter 2) by teachers rather than the OECD rubric. The intervention with students consisted of interdisciplinary creative projects developed in collaboration with artists with a literacy or numeracy focus. It lasted 6-12 weeks over the spring.

In this study, the Welsh Team started the project with the largest share of students living in relatively disadvantaged households. Additionally, they had a relatively weak average achievement score in maths and science at baseline (before the intervention). On the other hand, Welsh students showed relatively high self-perception of creativity and critical thinking, and benefited from the most time-intensive intervention, with 56 hours of creative teaching in class.

Teacher professional development in Wales first consisted of an intensive two-day induction training in creative teaching methods and in learning to address low attainment in literacy or numeracy. The training also involved creative practitioners, such as artists, who directly intervened in classrooms to promote reflection on teaching practices and experimentation of innovative approaches. Throughout the intervention, a network of creative agents acted as facilitators (trained for four days beforehand) and provided further individual support to teachers and artists in the elaboration of their pedagogical activities.

What teachers and school principals said

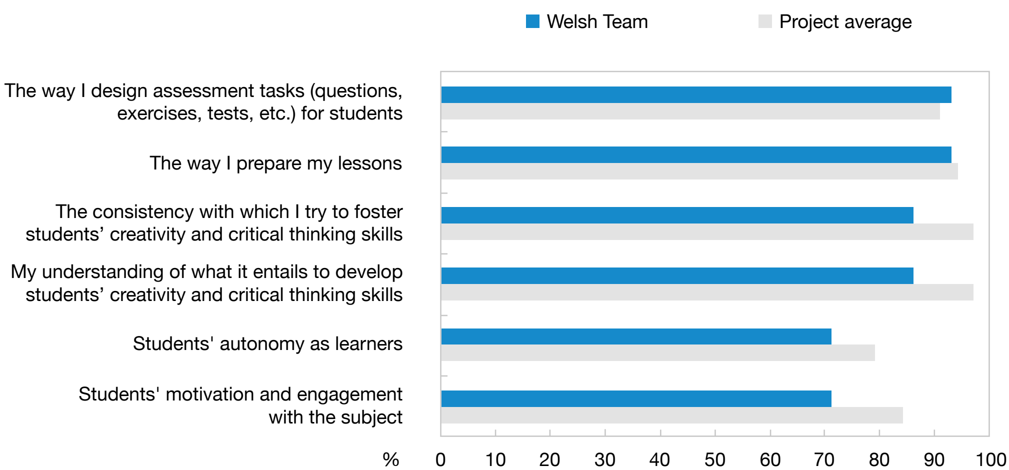
- Substantial changes in teachers' pedagogies, teaching and assessment.
- Limited adoption of project materials by teachers.
- Improvements in students' academic motivation, engagement and enjoyment.
- School principals supported the positive effects observed amongst teachers and students.

Teachers' views and practices around creativity and critical thinking changed during the project. Although teachers did not use the OECD rubrics, they used a rubric that is aligned with it in more or less the ways intended by the project. Amongst those who took part in the professional development plans, the majority declared they modified the way they prepare lessons and design assessment tasks. Over the duration of the project, they tried to foster students' creativity and critical thinking with more consistency as their understanding of those skills increased (Figure 8.30).

Around two-thirds of the intervention teachers felt that the project had positive effects on students' motivation, engagement and understanding of the subject; on their enjoyment of class activities; and on their autonomy as learners. After the project, virtually all respondents evaluated their participation in the intervention as a (very) positive experience.

Figure 8.30. Teachers' pedagogical approaches changed and students' attention increased, UK (Welsh) Team

Percentage of intervention teachers who reported positive changes over the project in…



Note: Bars represent percentage of intervention teachers who reported positive changes throughout the project in those dimensions.

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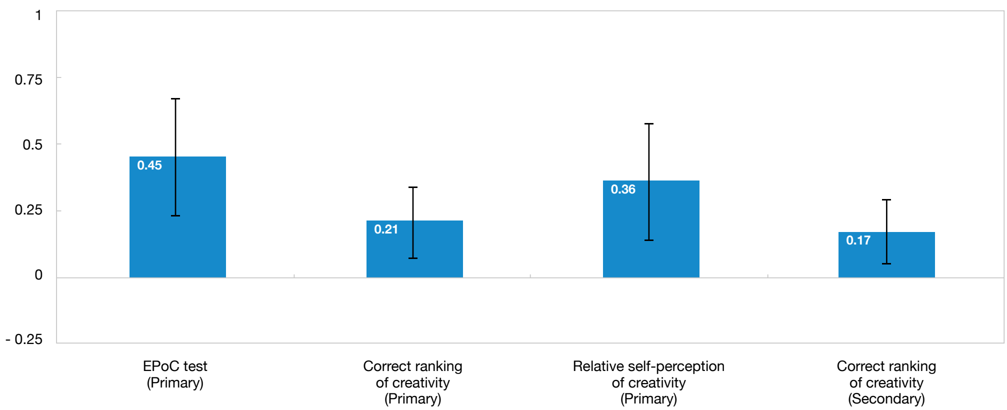
What students experienced

- Positive impact on creativity test.
- Increased ability to identify creativity.
- Augmented self-perception of creativity.
- Girls and socio-economically advantaged students achieved better results.

Some of the results reported by teachers align with what the students experienced (Figure 8.31). Trying to nurture creativity and critical thinking in everyday teaching raised students' performance in the Evaluation of Creative Potential (EPoC) creativity test, especially in divergent-exploratory tasks. Compared to their peers in control classes, students whose teachers took part in the pedagogical intervention saw an increase in their ability to correctly rank and identify creative behaviours, as well as a rise in their self-perceived creativity.

Figure 8.31. Effects of the intervention on students' outcomes, UK (Welsh) Team



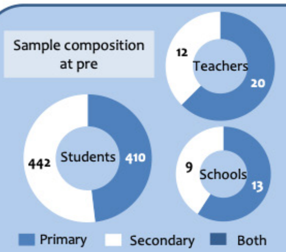
Notes: EPoC: Evaluation of Creative Potential. Bars represent coefficient estimates and black lines represent confidence intervals. All effects are statistically significant at the 80% level of confidence. Control and intervention groups were compared after a propensity score matching.

StatLink https://doi.org/10.1787/888934004181

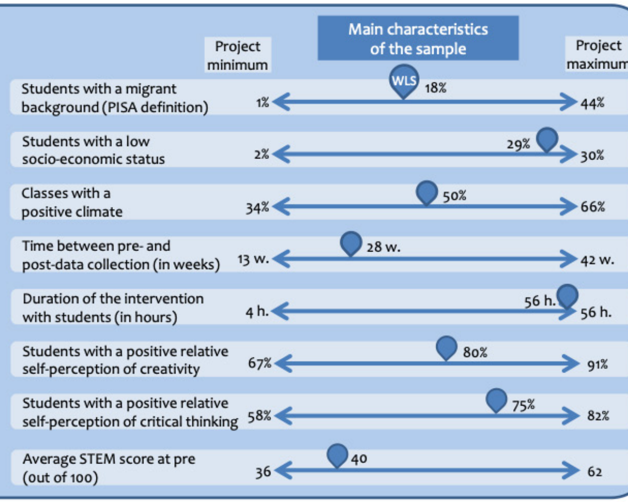
In the Welsh Team, girls and students from socio-economically advantaged households seem to have better understood what creativity and critical thinking mean. They showed more curiosity towards topics they were not initially interested in, and engaged with their parents more often in discussions on arts, movies, music or school in general. Furthermore, nearly everywhere a longer gap between pre- and post-measurements, combined with frequent pedagogical intervention in class hours, produced greater effects, with students reporting more disposition towards creativity and critical thinking.

The multiplicity of contexts and pedagogical interventions led to the evaluation of direct and indirect effects of many predictors on many teachers' and students' outcomes. Sample sizes did not always allow us to capture, amongst students, the sizeable changes observed in teachers' attitudes and practices. In some cases, the initial monitoring captured paradoxical results. However, the monitoring design of the project has proven to be efficient and successful in numerous ways. A short pedagogical intervention on teachers fostered some changes in their teaching and had effects on some dimensions of students' creativity and critical thinking. The circumstances, size and main beneficiaries of the effects would have to be measured in a validation study.

Who was involved in the project



Available data (pre and post)	Primary	Secondary
Student quest.	296	300
EPoC test	352	376
STEM test	322	298
VAM test	x	x
Teacher quest.	14	10
School quest.	9	6



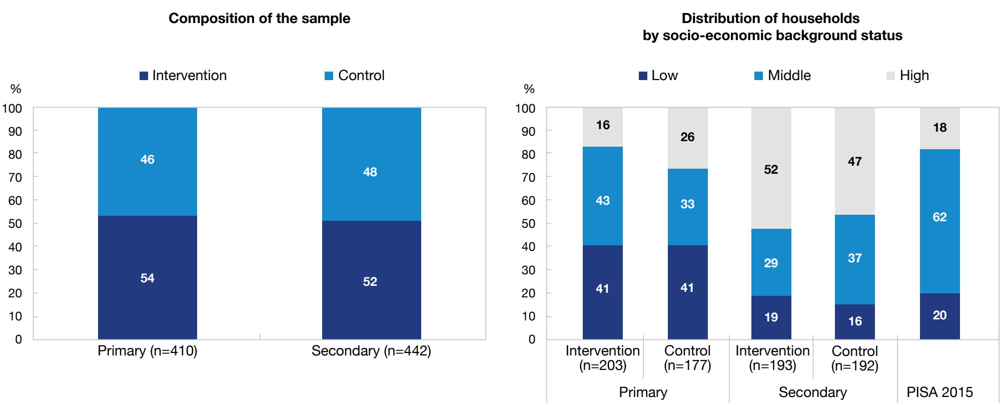
Notes: EPoC: Evaluation of Creative Potential; STEM: science, technology, engineering and mathematics; VAM: visual arts and music.

Compared to the other teams, Welsh students showed one of the highest prevalence of lower socio-economic status (29%, versus a project minimum of 2% and a maximum of 30%) and an average presence of students with an immigrant background (18%, versus a project minimum of 1% and a maximum of 44%). The average achievement score in maths and science at the beginning of the project was lower than average (40, versus a project minimum of 36 and a maximum of 62). The share of classes with a positive climate was close to the average (50%, versus a project minimum of 34% and a maximum of 66%). Welsh students in the project evaluated their creativity as close to the project average (80% as fairly or very creative, versus a project range between 67% and 91%). Their self-evaluation of critical thinking was at the higher end of the project range (75%, versus a project minimum of 58% and a maximum of 82%). Finally, the interventions with students were close to average in terms of the annual project's length (28 weeks, versus a project minimum of 13 and a maximum of 42) and the longest in terms of duration of the pedagogical activities with students (56 hours on average, versus a project minimum of 4).

Overall, the Welsh classes included 410 primary students and 442 secondary students, for a total of 852 students. The control and intervention groups were balanced, with 46% of students in the control group in primary education, and 48% in secondary education (Figure 8.32, left panel).

Students' groups presented some differences in terms of gender and cultural background, and were sometimes far from what would be expected from a representative national sample (taking the PISA 2015 as a reference; see p.230 in Chapter 7 for further discussion of PISA reference values). Both groups were gender-balanced at the secondary level, but in primary schools girls were over-represented in the control classes, and slightly under-represented in the intervention classes. Primary classes counted substantially more students with a low cultural background than the shares described in PISA 2015, while secondary classes showed an opposite picture; that is, a strong over-representation of students with a high cultural background (especially in the intervention classes) (Figure 8.32, right panel).

Figure 8.32. Students participating in the project, UK (Welsh) Team



Note: PISA 2015 references are taken as representative of the entire country population of 15-year-old students.

StatLink https://doi.org/10.1787/888934004200

In Wales, the project involved 55 teachers[1], of whom 32 completed questionnaires at baseline, evenly distributed in primary and secondary schools and between intervention and control groups. They were mostly female (72%) and fairly experienced (38% of them reported more than ten years of experience). Less than 10% reported fewer than two years of experience. Approximately half took part in the intervention development at both primary and secondary levels. The large majority (84%) holds a bachelor's degree or higher. At the school level, 22 principals expressed their views on previous and current innovation projects through a baseline questionnaire.

Completion rates of students were satisfactory, as more than 90% of the 852 students completed at least one instrument at both pre and post in primary and secondary schools. Looking at each instrument separately, the attrition was low: amongst the students who completed the corresponding instrument at baseline, 75% completed the post-questionnaire, 82% completed the STEM post-test and 89% completed the EPoC post-test. The data collection was successful, and the subsequent statistical treatment implemented to ensure comparability only caused minor losses of data.

Completion rates of teachers and school principals were high as well. Out of the 55 teachers who took part in the project, 32 completed the baseline questionnaire and 24 answered the post one. This sample allows providing key information on the changes reported by Welsh teachers in their feelings, practices and assessments around creativity and critical thinking. Finally, out of the 22 school questionnaires completed at baseline, 15 had completed a post-questionnaire.

US (Montessori) Team

Work in the US (Montessori) Team took place during the entire duration of the project. Project related pedagogical work was conducted over the 2015-16 school year in primary and secondary education. The team undertook one round of data collection in spring 2016, but several challenges with collecting parental and school consent prevented any sound quantitative analysis. The project took place in two Montessori public schools districts: Milwaukee Public Schools District (Wisconsin) and Lexington School District (a smaller, rural district in South Carolina). The National Center co-ordinated the project for Montessori in the public sector.

Schools in the US (Montessori) Team appeared to have the most favourable learning environment: teachers reported a very positive class climate, and students showed the highest levels of self-perceived creativity and critical thinking. Classes were composed of very few students from lower socio-cultural or immigrant backgrounds.

The team did not provide any professional development or formulate any specific intervention and did not use the OECD rubrics, assuming that the Montessori pedagogy would naturally develop students' creativity and critical thinking (see Chapter 3 for a more detailed discussion of the Montessori pedagogy). In class as well, teachers followed the Montessori pedagogy, which states that nurturing creativity and critical thinking requires a holistic approach to all interactions between students, teachers and content.

No control group could be formed in either of the two rounds. Neither pre- nor post-questionnaires were administered to teachers, schools or primary students.

While the team contributed to the project discussions, its departure from the project research protocol makes the data below merely informative about Montessori contexts in the US public sector.

What teachers and school principals said

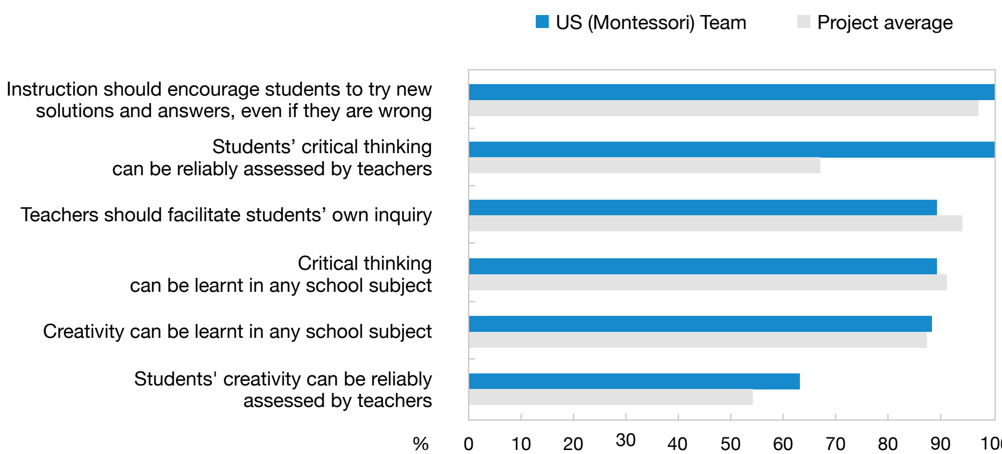
- Enthusiastic beliefs towards teaching and assessing creativity and critical thinking.
- Sense of preparedness.
- Alignment with existing instruction practices.
- Assessment practices lag behind.

At the beginning of the project, teachers in the US (Montessori) Team reported a peaceful and positive class climate, in line with what was observed elsewhere. They had largely positive beliefs and attitudes towards creativity and critical thinking (Figure 8.33). Virtually all respondents agreed that teachers should facilitate students' own inquiry, and that instruction should encourage them to try new solutions or to express new ideas. Most of them did not think that instruction was mainly about transmitting accepted knowledge to students.

Teachers felt prepared for fostering students' creativity (67%) and critical thinking (89%), collaborative learning approach (89%), Project Based Learning (78%), and individualised learning approaches (67%). Anchoring vignettes with scaled scenarios seemed to confirm that sense of preparedness and understanding, as most US Montessori teachers managed to correctly identify (and rank) creative and critical thinking attitudes.

Figure 8.33. Teachers' enthusiastic beliefs around creativity and critical thinking, US (Montessori) Team at baseline

Percentage of teachers who believed that…



Note: Bars represent percentages of teachers who (strongly) agreed with each statement, before the project.

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At baseline (prior to the intervention), teachers believed that creativity and critical thinking were malleable and transferable skills that they could effectively teach and assess, with no stringent constraint regarding the curricula they teach or the workloads they face.

Before the project, they already declared frequent use of instruction practices related to the project approaches (asking students to work in small groups to come up with a joint solution to a task, to explain the reasoning behind an answer, etc.). However, only a few of them actually assessed their students in those dimensions: they usually did not give credit for wrong answers with original thinking, and did not ask students to self- or peer-assess performance.

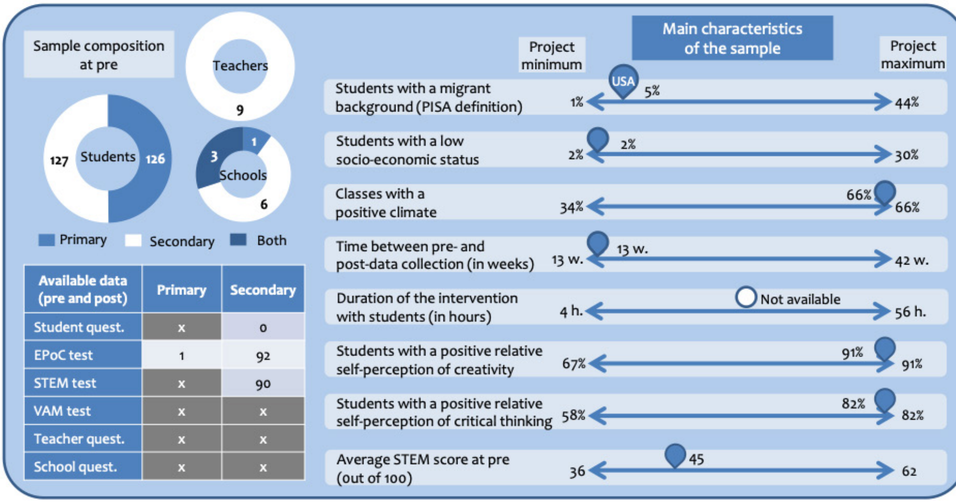
At the institution level, the three school principals said that past innovation projects had a strong and positive impact on student academic performance, motivation and engagement and on teacher professional development. They mostly recognise challenges in the lack of adequate funding, support from local education authorities and time, given regular school activities.

The lack of post-data prevents an analysis of how teachers' beliefs, attitudes and practices evolved during the duration of the project.

What students experienced

No data were collected.

Who was involved in the project



Available data (pre and post)	Primary	Secondary
Student quest.	x	0
EPoC test	1	92
STEM test	x	90
VAM test	x	x
Teacher quest.	x	x
School quest.	x	x

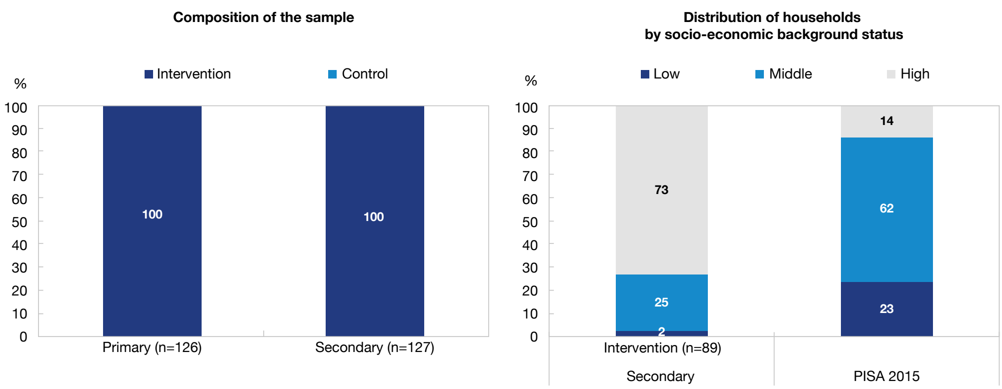
Notes: EPoC: Evaluation of Creative Potential; STEM: science, technology, engineering and mathematics; VAM: visual arts and music.

Compared to the other teams, the sample for the US (Montessori) Team had the lowest prevalence of students with a lower socio-economic status (2%, versus a project maximum of 30%) and one of the lowest presences of students with an immigrant background (5%, versus a project minimum of 1% and a maximum of 44%). The average achievement score in maths and science at the beginning of the project was lower than average (45, versus a project minimum of 36 and a maximum of 62), but the share of classes with a positive climate was the highest amongst the teams (66%, versus a project minimum of 34%). In terms of students' relative self-perception of their creativity and critical thinking, the share of students evaluating themselves as fairly or very creative was the highest (91%, versus a project minimum of 67%), as was the one concerning critical thinking (82%, versus a project minimum of 58%). Finally, the pre- and post-data collection with students was the shortest across the international network (13 weeks, versus a project maximum of 42).

Overall, US (Montessori) students in the project included 126 primary students and 127 secondary students, amounting to 253 students. No control student took part in the pilot (Figure 8.34, left panel).

At the secondary level, Montessori classes differed substantially from what a national representative sample would look like (taking PISA 2015 as a reference; see p.230 in Chapter 7 for further discussion of PISA reference values), both in terms of gender and of socio-cultural background of the students (Figure 8.34, right panel). Girls were over-represented and, more importantly, students from a low socio-cultural background were under-represented by about 20 percentage points compared to PISA 2015, while those with a high background were over-represented by almost 60 percentage points.

Figure 8.34. Students participating in the project, US (Montessori) Team



Note: PISA 2015 references are taken as representative of the entire country population of 15-year-old students.

StatLink https://doi.org/10.1787/888934004238

In the US (Montessori) Team, the project involved 64 intervention teachers, 9 of whom responded to questionnaires at baseline. The majority (66%) reported at least ten years of experience as a teacher, and they all hold a bachelor's degree or higher. At the school level, three principals expressed their views on previous and current innovation projects through a baseline questionnaire.

Only 37% of the 93 students completed at least one instrument at both pre and post in primary and secondary schools. Looking at each instrument separately, the attrition was as follows: amongst the students who completed the corresponding instrument at baseline, 53% completed the STEM post-test and 38% completed the EPoC post-test. Due to the local data collection constraints and choices, it was not possible to carry out any meaningful multivariate analysis in order to assess the effect of the Montessori pedagogy on the outcomes of interest to the project.

Out of the 64 teachers who took part in the project, 9 completed the baseline questionnaire, and none followed through with the post one. Finally, none of the three school questionnaires completed at baseline had a matching post-questionnaire.

US (Vista) Team

Work in the United States (Vista Unified School District) took place during the whole duration of the project, with pedagogical work being conducted over two school years between November 2015 and June 2017. The US (Vista) team undertook two rounds of data collection in both primary and secondary education, and in science, technology, engineering and mathematics (STEM) and arts subjects.

The Vista Unified School District undertook and funded the intervention through the Blueprint for Education Excellence and Innovation. The Vista Unified School District is one of northern San Diego County's (California) largest public educational agencies, with 29 schools plus 5 additional schools operating as independent charter schools authorised by Vista Unified. Overall, Vista Unified serves nearly 25 000 students from preschool to 12th grade, and approximately 20 000 students enrolled in adult education each year. The social context in which Vista Unified operates is quite complex, with 58% of its students qualifying for free lunch, 24% English learners and 10% homeless.

The US (Vista) Team had the largest shares of students from an immigrant background and lower socio-economic status across the project's international network, and their students scored the lowest in the baseline achievement tests in science and mathematics.

Teacher professional development in the US (Vista) Team consisted of an extensive training programme with one induction session at the beginning of the project coupled with several follow-up sessions held at regular intervals throughout the intervention. Frequent meetings and workshops allowed teachers within schools to collaborate on the design of the pedagogical activities and to reflect collectively on their teaching practices. To further foster collaboration with peers, teachers used an online platform to share ideas and materials around the project.

In class, teachers used and revised the OECD lesson plans and rubrics with the help of facilitators who gathered pedagogical work from various sites and synthesised them into cohesive "continuums" (preferred terminology to rubrics). The pedagogical intervention revolved around several strategies put in place to develop students' creativity and critical thinking. Those contributed to a broader local interest in the implementation of personalised learning, with a strong focus on students' learning agency.

What students experienced

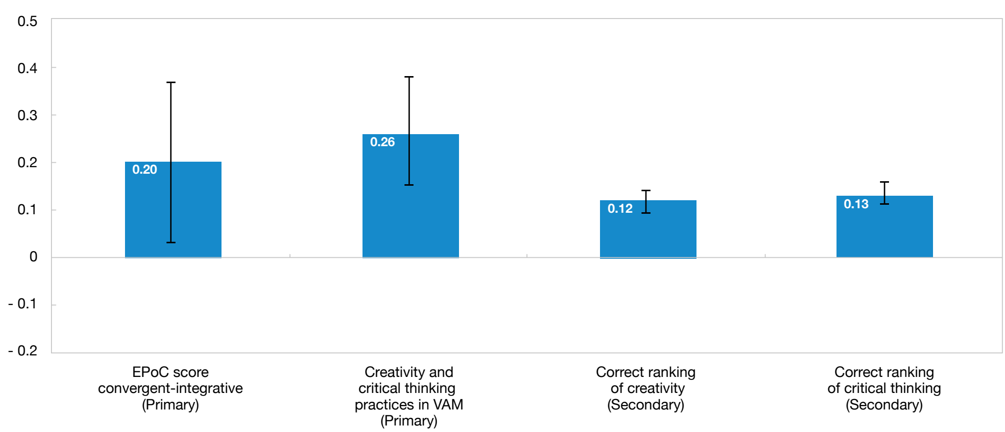
- Improved performances in science, technology, engineering and mathematics (STEM) and Evaluation of Creative Potential (EPoC) tests.
- More emphasis on creativity and critical thinking in visual arts and music courses.
- Higher self-perceived creativity and critical thinking.
- Better results amongst girls and students from an upper socio-economic background.

Because of a lack of recorded data on teachers' views, only students' reports provided information on whether teachers' practices around creativity and critical thinking changed during the project.

The first important point is that students perceived the changes in pedagogy that teachers from other teams reported, notably in visual arts and music at the primary level. The pedagogical intervention has led to improved performances in the mathematics, science and creativity tests for those students, especially in convergent-integrative tasks (Figure 8.35). Compared to their counterparts in control groups, students taught by intervention teachers improved their ability to correctly rank different levels of creativity and critical thinking, showing an increased comprehension of what those skills mean and articulate.

On average, girls and students from socio-economically advantaged households experienced better results, as well as students who had a longer time frame between pre- and post-measurements.

Figure 8.35. Effects of the intervention on students' outcomes, US (Vista) Team

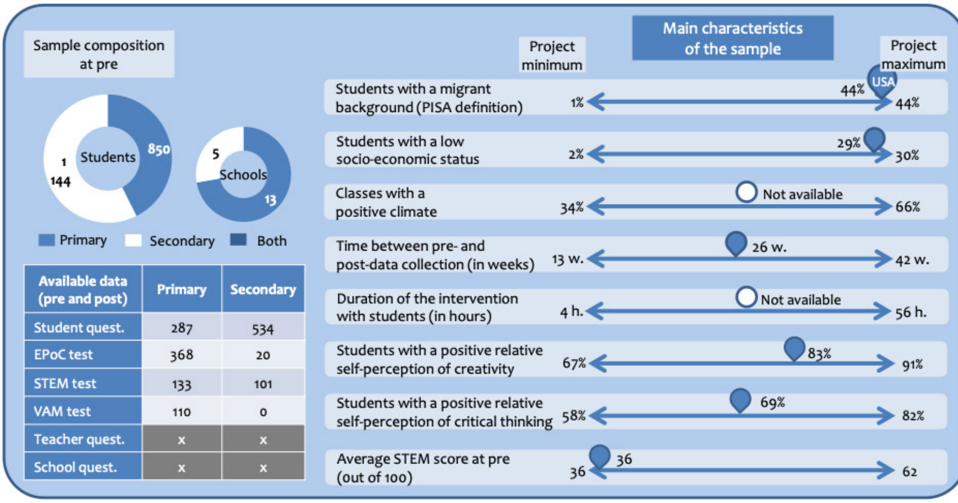


Notes: EPoC: Evaluation of Creative Potential; VAM: visual arts and music. Bars represent coefficient estimates and black lines represent confidence intervals. All effects are statistically significant at the 80% level of confidence. Control and intervention groups were compared after a propensity score matching.

StatLink https://doi.org/10.1787/888934004257

The multiplicity of contexts and pedagogical interventions led to the evaluation of direct and indirect effects of many predictors on many teachers' and students' outcomes. Sample sizes did not always allow us to capture, amongst students, the sizeable changes observed in teachers' attitudes and practices. In some cases, the initial monitoring captured paradoxical results. However, the monitoring design of the project has proven to be efficient and successful in numerous ways. A short pedagogical intervention on teachers fostered some changes in their teaching and had effects on some dimensions of students' creativity and critical thinking. The circumstances, size and main beneficiaries of the effects would have to be measured in a validation study.

Who was involved in the project



Available data (pre and post)	Primary	Secondary
Student quest.	287	534
EPoC test	368	20
STEM test	133	101
VAM test	110	0
Teacher quest.	x	x
School quest.	x	x

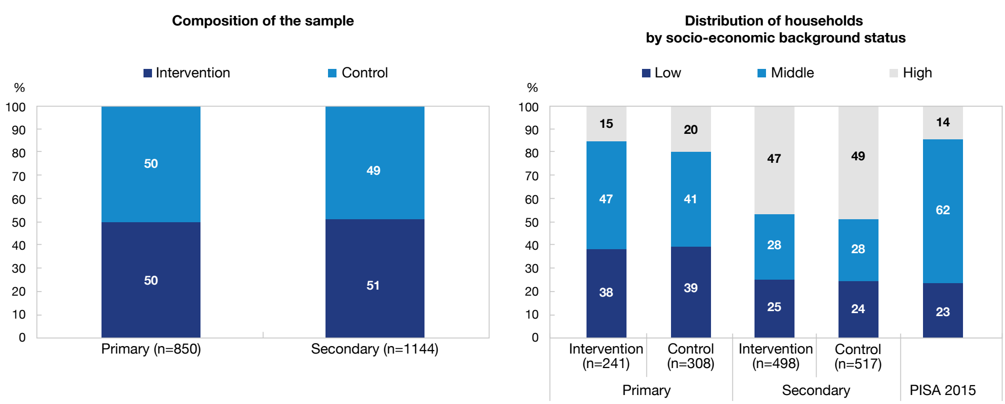
Notes: EPoC: Evaluation of Creative Potential; STEM: science, technology, engineering and mathematics; VAM: visual arts and music.

Compared to the other teams, the Vista Team showed the second highest prevalence of students with a lower socio-economic background (29%, versus a project minimum of 2% and a maximum of 30%) and the highest presence of students with an immigrant background (44%, versus a project minimum of 1%). The average achievement score in maths and science at the beginning of the project was the lowest across the international network (36, versus a project maximum of 62), but no data could be computed on the share of classes with a positive climate. In terms of students' self-perceived creativity and critical thinking, an above average share of students evaluated themselves as fairly or very creative (83%, versus a project minimum of 67% and a maximum of 91%), and an average share for critical thinking (69%, versus a project minimum of 58% and a maximum of 82%). Finally, the time between the pre- and post-data collection was average (26 weeks, versus a project minimum of 13 and a maximum of 42), while data on the duration of the pedagogical interventions with students were not available.

Overall, students in the project in Vista included 850 primary students and 1 144 secondary students, for a total of 1 994 students. Sample sizes of control and intervention groups were well balanced, with the share of control students being 50% in primary education and 49% in secondary education (Figure 8.36, left panel).

The control and intervention groups presented only minor differences in terms of gender and cultural background of the students' households, but were sometimes far from what would be expected from a national representative sample (taking PISA 2015 as a reference; see p.182 in Chapter 7 for further discussion of PISA reference values). In both educational levels and groups, the share of girls was slightly below 50%. Control and intervention groups were balanced in terms of socio-cultural backgrounds (Figure 8.36, right panel), although students with low (primary) and high (secondary) socio-cultural backgrounds were over-represented.

Figure 8.36. Students participating in the project, US (Vista) Team



Note: PISA 2015 references are taken as representative of the entire country population of 15-year-old students.

StatLink https://doi.org/10.1787/888934004276

In Vista, the project involved 65 teachers[1]. At the school level, four principals expressed their views on previous and current innovation projects through a baseline questionnaire.

Completion rates of students were acceptable: 58% of the 1 994 students completed at least one instrument at both pre and post in primary and secondary schools. Looking at each instrument separately, the attrition was unequal: amongst the students who completed the corresponding instrument at baseline (pre-intervention), 51% completed the post-questionnaire, 23% completed the maths and science post-test, 23% completed the visual arts and music post-test, and 41% completed the EPoC creativity post-test. Subsequent statistical treatment implemented to ensure comparability across groups only caused minor losses of data, but data unavailability hindered a comprehensive multivariate analysis of some domains of intervention, especially in secondary schools.

Out of the 65 teachers who took part in the project, none completed any of the questionnaires, so that direct information on Vista teachers' feelings, practices and assessments around creativity and critical thinking is missing. The four school principals' questionnaires completed at baseline were not followed up by a post-questionnaire.

Notes

1) In the Hungarian (9), Indian (54), Russian (1), Thai (15) and US Vista (11) Teams, a few teachers (90) participated in both rounds of the intervention and data collection over two school years. The total number of participant teachers reported in the statistical tables is 818, as this reflects the number of classes involved in the project. However, the actual number of individual teachers involved in the project was 728, of which 90 participated twice in their respective teams (Hungary, Thailand, and US Vista). Panel questionnaire data for these 90 teachers are treated as independent throughout the report after analysis failed to reveal significant differences in their response patterns between the two school years.

2) OBEC and EEF have received technical and operational supports by Sripatum University at Chonburi (SPUC) and Research Institute for Policy Evaluation and Design (RIPED) University of the Thai Chamber of Commerce.

Technical Annex

Instruments (questionnaires and tests)

The OECD Secretariat developed five different instruments: three pre- and post-questionnaires (for students, teachers and school principals) and two achievement tests for students in maths and science, and in visual arts and music. A sixth tool was also used in order to assess students' creativity, the domain-specific EPoC (Evaluation of Potential Creativity) test developed by Lubart, Besançon and Barbot (University of Paris-Descartes, France).

Questionnaires

Student questionnaires were administered to all students in both intervention and control groups. The length and complexity varied for students in primary and secondary education. In primary education, the questionnaire preceding the intervention included 75 items (background information, feelings, attitudes, activities, anchoring vignettes) while the questionnaire at the end of the intervention had 53 items (many background questions were not repeated). In secondary education, the pre-intervention questionnaire included 85 items (following the same outline), while the post-intervention had 58.

The pre-intervention questionnaire for teachers included 105 items: information about teachers' target class, their teaching practices, their views on the role and assessment of creativity and critical thinking, vignettes, and background information. As for students, the post-intervention questionnaire was shorter (87 items). However, the post-intervention questionnaire for intervention teachers also included an additional set of 37 items aiming to capture their feelings and perceived impact of the intervention. Teacher questionnaires were administered to all teachers in both the intervention and control groups.

School questionnaires were administered before and after the intervention, answered mostly by school principals, but sometimes by local project co ordinators. The pre-intervention questionnaire included 39 items on the school's characteristics and resources, and on previous participation in innovation projects. The post-questionnaire included 19 items giving feedback about the school's participation in the project.

Achievement tests in Science, Technology, Engineering and Mathematics (STEM)

The achievement tests in science and mathematics were built by the OECD Secretariat with released items taken from two large-scale surveys: Trends in International Mathematics and Science Study (TIMSS) for primary students and the Programme for International Student Assessment (PISA) for secondary students. The tests contained open- and closed-ended items on science and mathematics, some embedded questions on students' interest in these two subjects, and some questions about teacher practices in their science and mathematics classes.

For each educational level, two equivalent booklets, booklets A and B, were developed and alternatively administered to students, making it therefore possible to conduct a pre-post comparison. In primary education, booklet A consisted of 45 items, and booklet B of 46 items. In secondary education, there were 48 items in booklet A, and 50 items in booklet B. All booklets provided a balanced mix of items that addressed both content (e.g. geometric shapes, data display, earth science, etc.) and cognitive domains in mathematics and science (e.g. knowing, applying, reasoning), and also contained a few items investigating students' attitudes and practices. Specific guidelines were provided to local project co-ordinators concerning the administration of the STEM tests in class.

Achievement tests in Visual Arts and Music (VAM)

The achievement tests in visual arts and music were fully developed by the OECD Secretariat. The tests contained closed-ended items on visual arts and music and were based on the listening to music tunes and observation of pictures of painting and sculpture. In music, the students were tested on their vocabulary, observation (hearing and seeing), understanding of intended expressive effects, as well as theoretical knowledge about the field. Given the multicultural context, the test focused on listening-hearing and seeing-watching rather than on culture about the arts. As with the STEM test, some embedded items assessed students' interests in these two subjects, and captured information about teaching practices in their visual arts and music classes.

In primary education, the booklets were 78 item long, while in secondary education they included 119 items. Two different and equivalent booklets (A and B) were developed for both primary and secondary students, in order to allow pre-post comparisons with different equivalent tests.

Specific guidelines were provided to local project co-ordinators concerning the administration of the VAM tests in class. Most music questions required students to answer the test while listening to short music tunes (sampled from different cultural areas). Teachers were asked to give a brief explanation on the upcoming task before administering the test. Similarly, part of the visual arts questions required students to examine some pieces of art (paintings, drawings, sculptures).

None of the tasks in the VAM tests required students to know or be familiar with the music or the artwork used in the tests. Students were asked about their level of familiarity about the listened music (which, as wished, proved to be irrelevant to the accuracy of the answers).

Item selection in the VAM tests

The pilot phase of the project spanned over two complete school years for both the northern and the southern hemispheres. Between the first and the second year, the OECD-CERI team carried out several validation tests to make sure that the instruments were working well.

Firstly, items that presented success rates which were too low (typically, below 40% for dichotomous questions) were dropped from one round to the other. Secondly, items whose response patterns suggested they were subject to misunderstandings or translation issues were also removed from the instruments. Variance discrepancies across countries were investigated in order to identify these cases. Finally, IRT diagnostics (such as differential item functioning) flagged additional items that were removed from the final analysis of the tests (that were thus left with items that worked as expected).

EPoC Creativity test

The EPoC creativity tests (Évaluation du potentiel créatif) were developed by Lubart, Besançon and Barbot to measure the creative potential in children and adolescents in different domains of creative thinking and production: artistic-graphic, verbal-literary, social problem solving, scientific, mathematics and music composition. The test requires individuals to produce work (e.g. drawings, stories, maths answers, compositions, etc.) that is then assessed in a standardized way – either by human raters or computers. In each assessment domain, there are two types of tasks: divergent-exploratory thinking and convergent-integrative thinking (creative synthesis). The final creative potential measure includes both aspects of creativity, although both can be examined independently. For each domain, two equivalent booklets were developed, booklet A and B, making it possible to conduct a better pre-post comparison.

Construction of STEM and VAM scores

Several methods exist to construct scores and indices, and range from simple techniques, such as sums and (weighted) averages, to more complex ones, such as the Item Response Theory (IRT) models. This section provides details about how the achievement test scores were built and explains why country-specific weighted averages were selected over other possible methods.

Sums and weighted scores

"Raw scores" were first considered: they consist of a simple ratio between the sum of right answers provided by each student and the total number of questions. However, these scores do not discriminate across items, and assign to each of them the same importance. A second type of scores were built: weighted scores. These scores weighted each answer based on the successful response rate registered in the international survey from which they were sourced (or from the data of this project in the case of VAM tests that were specifically created for this project).

For instance, TIMMS 2011 reports a 90% international rate of correct answers for the item "which force causes a boat to move?". As it was a relatively easy question across all countries, a weight of 0.10 was assigned to this question. Giving a correct answer to it would not affect much the final STEM score.

However, great differences existed across countries in how they performed in single items. As the results of the pilot were analysed on a country-by-country basis, country-specific weights were used in order to account for these differences. This implies that, for a given question, weights were calculated country by country (and could thus differ across countries).

For instance, in Thailand 79% of students got the right answer to the "which force causes a boat to move?" item, as compared to 94% in the Netherlands. Therefore, it was assumed that this item was harder for Thai than for Dutch students, and a bigger weight was assigned to this item for Thailand (0.21) than for the Netherlands (0.06) when building the country-specific weighted scores.

Given that Brazil, France and India did not participate in TIMMS 2011 (primary education), and that India did not participate in PISA 2012 (secondary education), the international average weights were used for computing the scores in these countries. The same procedure was applied when a country did not have data for a specific question in either of the studies.

Further modifications in the computation of STEM scores were made to adjust for minor issues that emerged from the administration of the tests for two country teams (Thailand and India).

Booklet equivalence

Booklet equivalence was achieved through instrument design, their initial piloting, and minor adjustments at post after their administration, correcting for the slight imbalances that emerged between domains and subdomains.

To account for these differences, the ratio between weighted points and number of questions was compared between booklet A and booklet B. To ensure comparability, students' scores were adjusted whenever a subtopic's ratio (e.g. open questions in science) was higher in booklet A than in booklet B (meaning that the average question was more difficult in A than in B) or vice versa.

For example, let us consider the two batteries of open questions in mathematics in a given country: one in booklet A and one in booklet B. The battery in booklet A contained five items, for a total weight of 2.20 (i.e. the average item received a weight of 0.44). On the other hand, the battery in booklet B contained seven items, for a total weight of 2.52 (i.e. the average item received a weight of 0.36). In this example, the battery of questions in booklet A was, on average, more difficult than its counterpart in booklet B. Therefore, for each student, the score obtained in booklet A was adjusted by a coefficient of relative difficulty. If the resulting score was higher than the total of booklet B, then it was set to this same amount.

Formally, in the example, when booklet A is harder than booklet B, then the booklet adjustment for booklet A reads:

This approach was preferred to standardisation as the latter would have affected the extreme values of the interval of the scores, thus making interpretation more difficult. Admittedly, as a result, some details were lost for the students who had high scores in the more difficult booklet.

$$\textit{Final score A} = \operatorname{Min}\left(\textit{Initial score A} \times \frac{\sum \textit{weights A} \times \sum \textit{items B}}{\sum \textit{weights B} \times \sum \textit{items A}}, \sum \textit{weights A}\right)$$

$$\textit{Final score A} = \operatorname{Min}\left(\textit{Initial score A} \times \frac{2.20 \times 7}{2.52 \times 5}, 2.20\right)$$

$$\textit{Final score A} = \operatorname{Min}(\textit{Initial score A} \times 1.22, 2.20)$$

IRT scores

Another method to compute test scores relies on IRT models, which model the response of each participant of a given ability to each item in the test. These models also include parameters concerning items' difficulty, discriminatory power and guessing.

The difficulty parameter (b) describes the difficulty of the item. The greater the parameter, the greater the probability that the respondent will not answer it correctly. The discrimination parameter (a) describes the discriminatory power of the item, i.e. the capacity of the item to differentiate well respondents with a high ability and a low ability.

The guessing parameter (c) describes the probability of correctly answering to the item due to simple guessing (i.e. 1/k, where k is the number of possible answers to the item).

In such a three-parameter model, the probability of a correct response to a dichotomous item i for a respondent of ability is:

$$p_i(\theta) = c_i + \frac{1 - c_i}{1 + e^{-a_i(\theta - b_i)}}$$

In the context of this pilot, one, two and three parameters models were adapted to the data separately by educational level. However, sample sizes did not allow for their convergence when more than one parameter was used. With samples that are much bigger than those of this pilot, PISA implemented two-parameters IRT models since 2015 only.

For the STEM and VAM tests, one-parameter models were used to build scores that pooled altogether the information provided by all countries (cross-country score) or that were computed on a country-by-country basis (country-specific score).

Students' engagement

As both the STEM and the VAM tests administered in this project represented low-stake assessments for students, countermeasures were taken in order to mitigate the consequences of the possibly low engagement of some respondents. Specifically, all scores were computed by considering (and by excluding) a 30% threshold in terms of amount of missing answers provided by a student. In other words, this implied that, when the threshold was considered, students were assigned a valid score only if they had answered at least 70% of the items.

The choice of 30% for the threshold was empirically based on several practical considerations, such as the amount of records that would have been dropped or the possible range of available thresholds for all the different groups and subgroups of items (e.g. for batteries of six items, any threshold above 33% would have implied accepting also students with only three valid answers, which was not deemed acceptable). Across all students who completed both their pre- and post-tests, applying this threshold implied dropping 12% of the records for the STEM test at primary level and 9% of the records at secondary level. For the VAM test, this implied dropping 30% of the records at primary level and 13% of the records at secondary level (with the former suggesting that the workload required to primary students by the VAM test may have been excessive). While these data losses were expected, they were deemed to be reasonable for obtaining more reliable scores, both at the individual and at the country team level.

Additionally, only students who completed both the pre- and the post-student questionnaire, achievement or creativity tests, were considered in the analysis concerning that instrument. Those who did not were still assigned a score when possible, but were excluded from all analysis dealing with pre-post comparisons.

Table 1. Correlation table between the different STEM scores

At baseline, before the intervention

	Raw score	International weighted score	**Country-specific weighted score**	Country-specific weighted score (no threshold)	IRT cross-country score	IRT cross-country score (no threshold)	IRT country-specific score
Raw score	1.00						
International weighted score	0.98	1.00					
Country-specific weighted score	**0.96**	**0.98**	**1.00**				
Country-specific weighted score (no threshold)	0.96	0.97	**1.00**	1.00			
IRT cross-country score	0.87	0.85	**0.84**	0.84	1.00		
IRT cross-country score (no threshold)	0.88	0.86	**0.85**	0.84	0.97	1.00	
IRT country-specific score	0.84	0.82	**0.82**	0.81	0.90	0.87	1.00

Score selection

While IRT scores are more appropriate for computing final scores in a test, they are also more complex and, more importantly, harder to interpret (as they do not maintain the same range of values of the original test). In this pilot project, the correlation between IRT scores and the simpler ones was very high (always above 0.80).

For example, Table 1 presents the correlations observed between the different types of STEM scores based on the answers given during the pre-test. Correlations are always high, meaning that IRT models produce results that are similar to simpler methods. As a consequence, the simpler country-specific weighted score was chosen as the final method for computing STEM and VAM scores.

EPoC scores

The scoring of the EPoC creativity tests was carried out or co-ordinated by a dedicated external research team that evaluated the performances of students in each subdomain (e.g. convergent-integrative tasks in verbal literary) on a 7-point scale.

Not all students took the same EPoC test: countries focused on different domains, depending on the domain of their pedagogical intervention, and sometimes students only took part of the test (which is composed of four tasks in each domain). Given the variation of scores across domains, all scores were standardized in order to assign each student a unique EPoC score in a common range for all domains. The following rules were followed in order to assign the scores to the students:

- If the discipline of the students' teacher was mathematics, then only the EPoC score in mathematics was taken into account to compute their EPoC score (even if the students also took additional EPoC tests in other domains).
- If the discipline was either science or biology, then only the science EPoC score contributed to their EPoC score.
- If the discipline was either visual arts or arts and music, then only the artistic-graphic EPoC score contributed to their EPoC score.
- If the discipline was either physics or technology, then both their science and mathematics EPoC scores contributed to their EPoC score (if both were available, otherwise only the available one did).
- Finally, in all the other cases the EPoC score was built based on all available scores (mathematics, science, artistic-graphic, social problem solving, and verbal literary).

Construction of background indices

Various socio-economic indices were computed out of a large range of variables. They described the social, economic, and cultural background of students, and relied mostly – but not always – on the student, teacher, and school background questionnaires. In some countries, administrative data complemented self-reported information.

Age

In a few instances, the answers to the questionnaire were contrasted with and complemented with other available data: school files, administrative records, and other sources of information. Despite these efforts, 5 000 students still did not have a valid value for their age (mostly in India, the Russian Federation, Spain and the United States). In that case, their age was estimated as the age a child should typically have given their grade in their country.

Index of household's cultural environment

In line with the PISA item about the cultural possessions available at home, a country-specific index describing the household's cultural environment was built based on the number of books in the students' home. This index was country-specific because of the heterogeneity of book possession across countries (i.e. having 50 books at home does not indicate the same thing in different regions of the world). In order to build consistent thresholds, PISA data on the distribution of cultural possessions were used as a benchmark, as they are nationally representative. For all countries, the lowest and highest levels of possession were the same (e.g. 0-10 books and more than 200 books).

Index of Parental education

The index of parental education was based on the highest parental educational attainment (i.e. ISCED level, not schooling years). Similarly to what was done for the index of household's cultural environment, PISA (and Eurostat) data were used as nationally representative benchmarks for grouping students into the three following categories:

- Low level was equal or below lower-secondary education (primary education in Brazil and Thailand).
- Middle level ranged from the low-level boundary to post-secondary non-tertiary education.
- High level was equal or above bachelor's or short-cycle tertiary education.

This index only concerned secondary students, as the questions on parental education were not included in the student questionnaire for primary education.

Index of Immigration Status

The PISA definition of students with an immigrant background includes those students whose parents were both born abroad (i.e. regardless of the student's country of birth). In this pilot, the share of students with an immigrant background varied significantly across teams and for some of them showed a very low presence of students with an immigrant background, at least according to the PISA definition. However, when using the information about the country of birth of the students and of each of the parents separately, the data highlight several different student profiles, which differ even more when considering the information provided by the variable describing the main language spoken at home by the students.

Table 2. Index of immigration for teams with many students with an immigrant background

At baseline, before the intervention

Born in the country / Language spoken at home	Student no; parents no	Student yes; both parents no	Student no; one parent yes	Student yes; one parent no	Student no; both parents yes	Student yes; both parents yes
Foreign language	Strong	Strong	Strong	Strong	Moderate	Moderate
Secondary language of the country	Strong	Strong	Moderate	Moderate	Moderate	Moderate
Main language of the country	Moderate	Moderate	Moderate	Moderate	Non-immigrant	Non-immigrant

Note: the teams included in this group were: France (CRI), France (Lamap), India, US (Vista) and UK (Wales).

Table 3. Index of immigration for teams with few students with an immigrant background

At baseline, before the intervention

Language spoken at home \ Born in the country	Student no; parents no	Student yes; both parents no	Student no; one parent yes	Student yes; one parent no	Student no; both parents yes	Student yes; both parents yes
Foreign language	Strong	Strong	Strong	Strong	Strong	Strong
Secondary language of the country	Strong	Strong	Strong	Strong	Moderate	Moderate
Main language of the country	Strong	Strong	Moderate	Moderate	Non-immigrant	Non-immigrant

Note: the teams included in this group were: Brazil, Hungary, the Netherlands, the Russian Federation, the Slovak Republic, Thailand, and US (Montessori).

In order to have meaningful results for all teams, a new index describing the immigrant background of the students was built by using all the information provided by the variables about the country of birth of the students and their parents, and the language spoken at home by the students. The characteristics of this new index are illustrated in Table 2 and Table 3. Specifically, it can be seen that countries were divided into two groups based on the share of students that presented at least some aspects of an immigrant background.

Index of socio-economic and cultural status (SCS)

The index of socio-economic and cultural status (SCS) pools together the information provided by the index of household's cultural environment and the index of household education. In the sample, the majority of primary school students were assigned a neutral status, while around 20% were ascribed to the negative and positive groups. In secondary education, 85% of the students ended up in the neutral group, 10% in the highest one and only 5% in the lowest one.

Two additional versions of this index were computed, drawing on the teacher and school principal questionnaires. While they did not show any variation within classes (or schools), they remained a valuable source of information to contextualise results and findings.

Construction of indices related to creativity and critical thinking

Both the questionnaires and the achievement tests included several items capturing the respondents' feelings, practices and attitudes towards creativity and critical thinking.

Most of the indices pooling together the information contained in the different batteries of items were built through principal factor analysis (Table 4). When this was not possible (notably for incomplete records, low data availability or the violation of some assumptions in the answers distributions), other simpler summative methods were used (Table 5).

Statistical checks (such as Cronbach's Alpha and the amount of variance explained by the first factor – the one that was extracted from the analysis) were carried out to ensure the reliability of the indices, and it was assured that configural invariance was respected among all teams and levels. As Table 4 shows, some indices seemed to be working well only for secondary education students, suggesting thus a cognitive effort that was possibly too high for primary education students.

Table 4. Indices built through principal factor analysis

Index	Sample items	Scale	Pooled Cronbach's Alpha (in brackets, the number of items contributing to the index)	
			Primary	Secondary
CCT-related practices in science	In science lessons, we are asked to think about what we should do first to solve a science problem In science lessons, we are asked to explain why certain things are impossible	1 (never) to 4 (in all lessons)	0.732 (6)	0.756 (6)
CCT-related practices in mathematics	In maths lessons, we work on problems that have several right solutions In maths lessons, we work on problems for which there are several ways of getting the right answer	1 (never) to 4 (in all lessons)	0.699 (6)	0.696 (6)
CCT-related practices in visual arts	In visual arts lessons, I have to use my knowledge of other school subjects for my music work In visual arts lessons, we discuss styles of art that I did not know before	1 (never) to 4 (in all lessons)	0.632 (6)	0.733 (6)
CCT-related practices in music	In music lessons, we listen to or play kinds of music that I did not know before In music lessons, we compose some music	1 (never) to 4 (in all lessons)	0.683 (5)	0.752 (6)
Interest in science	I would like to learn to design scientific experiments I would like to understand why scientists sometimes disagree	1 (not at all) to 4 (very much)	0.570 (4)	0.722 (4)

Index	Sample items	Scale	Pooled Cronbach's Alpha (in brackets, the number of items contributing to the index)	
Interest in mathematics	I would like to learn to think like a mathematician	1 (not at all) to 4 (very much)	0.678 (4)	0.701 (4)
	I would like to understand better why people say maths is everywhere			
Interest in visual arts	I would like to learn enough to make artwork for my pleasure after school	1 (strongly disagree) to 4 (strongly agree)	0.576 (3)	0.847 (4)
	I would like to understand how visual arts convey certain feelings			
Interest in music	I would like to know enough about music to play with friends after school	1 (strongly disagree) to 4 (strongly agree)	0.636 (3)	0.796 (4)
	I would like to understand how music conveys certain feelings			
Positive learning feelings	I feel I am doing a good job in this course	1 (never) to 4 (often)	0.576 (4)	0.757 (6)
	I feel co-operative in this course	1 (not at all) to 4 (very much)		
Negative learning feelings	I feel stressed in this course	1 (not at all) to 4 (very much)	n.a.	0.759 (4)
	I feel confused in this course			
CCT dispositions[1]	I like to compare different perspectives on problems in my free time outside school	1 (not at all) to 4 (very much)	0.750 (6)	0.805 (6)
	Out of school, I try to understand why people have certain ideas			
CCT learning approach	In this course, I have to explore different points of view on a problem or topic	1 (strongly disagree) to 4 (strongly agree)	n.a.	0.722 (6)
	In this course, I have to assess strengths and weaknesses of ideas or works			
Parents engagement	My parents/caretaker discuss books, films or music with me	1 (never) to 4 (often)	n.a.	0.676 (4)
	My parents/caretaker ask me how well I am doing at school			
Class climate[2]	When the lesson begins, I have to wait quite a long time for students to quiet down[3]	1 (strongly disagree) to 4 (strongly agree)	0.673 (4)	0.718 (4)
	Students in this class are generally active and eager to participate in class activities and discussion			

Notes: For each subscale, three to six items were selected after conducting an exploratory factor analysis.
1. The CCT Dispositions index also exists in two subscales: Creativity dispositions and Critical thinking dispositions.
2. The Class climate index it the only one that builds on teacher-reported items.
3. For consistency, the scaling of this item has been reversed.

Table 5. Summative indices

Index	Sample items	Scale	Composition method (in brackets, the number of items contributing to the index)	
			Primary	Secondary
Self-efficacy in visual arts	In my visual arts classes, I can do even the hardest work if I try When it comes to visual arts, I make plans and follow through with them	1 (not at all) to 4 (very much)	Simple std. average (2)	Simple std. average (2)
Self-efficacy in music	In my music classes, I understand even the most difficult things When it comes to music, I persevere until the task is finished	1 (not at all) to 4 (very much so)	Simple std. average (2)	Simple std. average (2)
Negative learning feelings	I feel worried in this course I feel bored in this course	1 (never) to 4 (often)	Dichotomous variable[1] (2)	Principal Factor Analysis (4)
Cultural activities	In the last weeks, outside school, I drew, painted or produced some art craft for fun In the last weeks, outside school, I read a full book for my own enjoyment	1 (never) to 4 (4 times or more)	Dichotomous variable[2] (4)	Dichotomous variable[2] (4)
Parents engagement	In the last weeks, my parents/caretaker discuss books, films or music with me In the last weeks, my parents/caretaker ask me how well I am doing at school	1 (never) to 4 (4 times or more)	Dichotomous variable[2] (4)	Principal Factor Analysis (4)
School belonging	I feel like I belong at school I often feel bored in school	1 (strongly disagree) to 4 (strongly agree)	n.a.	Simple std. average (2)
School climate with regards to creativity and critical thinking	School is a place that helps me to be creative School is a place that helps me to consider different points of view	1 (strongly disagree) to 4 (strongly agree)	n.a.	Simple std. average (2)

Notes:
1. Methodology described in the paper «Investigating Optimal Learning Moments in U.S. and Finnish Science Classes» by Schneider and colleagues in 2016.
2. In these instances, the function determining the value of the dichotomous variable indicated when the students reported at least one of the items making up the index.

Propensity score matching

In terms of socio-demographic variables, local teams were asked to select schools, teachers and students from a variety of possible backgrounds when possible, and to ensure that control and intervention groups would be broadly comparable in terms of teacher quality and student characteristics. In spite of the teams' efforts, substantial differences between control and intervention groups could be observed through the data collection. In order to reduce their impact on the findings to a minimum, propensity score matching was carried out. This technique realigns the baselines of the two samples by attributing different weights to the students in the control group. A specific set of weights was computed for each of the survey instruments. The weights for the questionnaire were computed in order to adjust potential imbalances in gender, socio-economic status and age. The weights for the tests, additionally, also adjusted potential imbalances in the baseline of their main variable of interest (namely the EPoC, STEM and VAM scores).

For each student, the matching derived a propensity score that reflected their probability to be included in the intervention group. Student-specific weights were then derived and assigned to every individual in the control group (those for students in the intervention group were set at 1 by construction) based on how similar they were to the students in the intervention group to whom they were being matched. Kernel matching was used for carrying out the matching in practice (i.e. control students that were closer to the intervention student of interest were given bigger weights). Once the weights included in the analysis, the differences between the two groups were significantly reduced. In all except one of the models considered for this pilot, the residual differences between groups were not significant. As a consequence, all changes occurring between the two groups and between the beginning and the end of the intervention could be entirely imputed to the intervention, rather than potentially due to pre-existing differences between the two groups.

Table 6. Propensity score matching

Share of students retained (and numbers of students dropped) after the propensity score matching

	Questionnaires	EPoC creativity tests	STEM achievement tests	VAM achievement tests
Brazilian Team	98% (9)	96% (25)	75% (76)	..
Dutch team	96% (22)	87% (48)	99% (4)	95% (13)
French (CRI) Team	99% (3)	100% (0)	98% (6)	..
French (Lamap) Team	..	95% (16)	84% (6)	..
Hungarian Team	95% (54)	83% (131)	94% (68)	..
Indian Team	66% (103)	..	46% (177)	..
Russian Team	96% (21)	89% (91)	99% (4)	..
Slovak Team	93% (26)	79% (115)	98% (6)	76% (77)
Spanish Team	..	..	82% (48)	..
Thai Team	95% (178)	88% (383)	97% (84)	60% (260)
UK (Welsh) Team	96% (22)	77% (167)	91% (56)	..
US (Montessori) Team	..	x	x	..
US (Vista) Team	97% (24)	86% (54)	54% (107)	44% (142)
Total	**95% (462)**	**86% (1 123)**	**90% (732)**	**67% (492)**

In this pilot, the propensity score matching was performed by country and educational level, and the list of variables included for the matching varied depending on the tool that was being analysed (questionnaires, STEM, VAM or EPoC tests). More specifically, in all four cases the list of matching variables included gender, age, squared age and the index of socio-economic status. Additionally, for each of the three tests, the list also included the respective student score at pre.

A common support option was also used when carrying out the matching, and implied dropping selected intervention student whose propensity score was higher than the maximum, or less than the minimum, propensity score for conv trol students (Table 6).

Impact evaluation

This section provides insights on the methodology used to assess the effects of the intervention in Chapter 6 and Chapter 7.

Teachers

The analysis of changes in teachers' attitudes and practices entirely relied on data from the teacher pre- and post-questionnaires. They consisted of batteries of questions on their beliefs towards creativity and critical thinking, their instruction and assessment practices, their sense of preparedness, etc. – plus some general background information.

The project used a purposive sampling design, recruiting participant teams, schools and teachers mainly based on a shared interest in the project agenda. Thus, samples were not meant to be representative of their education systems.

The number of individual teachers involved in the project was 728, of which 90 participated in two rounds of the intervention over two different school years in their respective teams. The number of participant teachers reported in the statistical tables was 818 as this better reflected the number of classes involved in the project. Panel questionnaire data for these 90 teachers were treated as independent after analysis had failed to reveal significant differences in their response patterns between the two school years.

Participation and response rates were unequal across countries. In most teams, the small size of the teacher sample who filled in their questionnaires both before and after the intervention prevented robust difference-in-difference analyses. Once split for comparing the outcomes of teachers in control and intervention groups, the low number of responses did not afford enough statistical power to parse out genuine effects from random variation. Therefore, it was decided to focus the analysis of change due to the intervention exclusively on the Hungarian and Thai panel subsamples. These two subsamples were selected as they were the only samples to:

- include at least 30 teachers completing both pre- and post-questionnaires;
- have a good balance of respondents between intervention and control groups (each within the 45-55% range);
- represent more than 50% of the total number of participating teachers in their teams;
- represent over 80% of the number of teachers having completed pre-questionnaires in their teams.

In the remaining countries, analytical work on educators was restricted to either baseline reports, post-intervention questionnaires, or school principals' questionnaires; hence, they could not support any causal inference about the impact of the intervention.

For the Hungarian and Thai teams, linear regressions with clustered estimation of the variance (first level: school) permitted pre-post comparisons under the form of difference-in-differences estimates. The dependent variable was the pre-post difference of the outcomes of interest (e.g. practices, beliefs, self-efficacy), and the only explanatory variable was the exposure to the intervention (vs. control).

By construction, the estimate indicated the effect of belonging to the intervention group, and its significance served as a robust test of means.

For the remaining teams, post-intervention questionnaires allowed drawing some valuable findings on how teachers interacted with the project's rubrics and lesson plans, what they took away from the pedagogical intervention, and whether they assimilated innovative practices in their everyday teaching.

Students

Similarly to what was done for teachers, the main explanatory variable of interest for students was their participation in the intervention (as opposed to being in a control class). This dummy variable was present in all models. By construction, its estimated coefficient showed whether being taught by teachers who took part in the pedagogical development plans had a positive effect or not on the different outcomes of interest.

Data availability varied across domains, teams and educational levels. Similarly, the information retrieved from teachers' and principals' questionnaires were not available for all students. Therefore, the explanatory variables included in the models slightly differed from one setting to the other, but no analysis was conducted if the students' background information was not available.

More specifically, all models included age, gender, and socio-economic status. Furthermore, the time gap between pre- and post-measurements and the duration of the intervention with students (i.e. the number of minutes spent in pedagogical activities developed for this project) were also included when available. The domain in which the intervention was conducted was included in the models only when relevant (i.e. only when at least of few classes took the intervention in some domains). Finally, and similarly to what was done for the propensity score matching, the models always included as a covariate the value of the outcome interest in the pre-measurement (e.g. the VAM score at the beginning of the project).

Each model consisted of a linear regression with clustered estimation of the variance (first level: school) in order to account for intragroup correlation, and a separate model was run for each outcome, country and educational level. In all settings, the weights derived from the propensity score matching were included to ensure comparability between control and intervention groups.

As described in Chapter 7, the multivariate analysis included two stages:

- regression of the outcomes of interest on all available covariates;
- regression of the outcomes of interest on all available covariates and on interaction parameters (one at a time) combining the variable indicating the group of the students and the covariates of interest.

This analytical strategy allowed investigating both the effects on students of the intervention as a whole, and to focus on its effects on specific subgroups of students in order to explore whether the intervention had differential effects for some of them (e.g. did the intervention work better for girls rather than for boys?). Nevertheless, this approach implied the estimation of hundreds of models. In order to present them in a clear and accessible way, the tables in Chapter 7 present the number of significantly positive or negative results for the different outcomes of interest. By doing so, rather than focusing on the single country- and level-specific results, which are just tentative at this pilot stage, readers are driven to consider more generally the patterns emerging from the data in terms of effects of the intervention.

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OECD PUBLISHING, 2, rue André-Pascal, 75775 PARIS CEDEX 16
ISBN 978-92-64-94313-1 – 2019

Educational Research and Innovation

Fostering Students’ Creativity and Critical Thinking

WHAT IT MEANS IN SCHOOL

Creativity and critical thinking are key skills for complex, globalised and increasingly digitalised economies and societies. While teachers and education policy makers consider creativity and critical thinking as important learning goals, it is still unclear to many what it means to develop these skills in a school setting. To make it more visible and tangible to practitioners, the OECD worked with networks of schools and teachers in 11 countries to develop and trial a set of pedagogical resources that exemplify what it means to teach, learn and make progress in creativity and critical thinking in primary and secondary education. Through a portfolio of rubrics and examples of lesson plans, teachers in the field gave feedback, implemented the proposed teaching strategies and documented their work. Instruments to monitor the effectiveness of the intervention in a validation study were also developed and tested, supplementing the insights on the effects of the intervention in the field provided by the team co-ordinators.

What are the key elements of creativity and critical thinking? What pedagogical strategies and approaches can teachers adopt to foster them? How can school leaders support teachers’ professional learning? To what extent did teachers participating in the project change their teaching methods? How can we know whether it works and for whom? These are some of the questions addressed in this book, which reports on the outputs and lessons of this international project

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ISBN 978-92-64-94313-1

OECD*publishing*
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Co-funded by the European Union

9789264943131