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Learning lessons to build resilience in times of crisis – a STEM teachers' view

SCIENTIX OBSERVATORY REPORT - FEBRUARY 2022

European Schoolnet

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AUTHORS: Antoine Bilgin, Lidija Kralj, Giuseppe Mossuti, Patricia Wastiau & Agueda Gras-Velazquez

DESIGN: Rocio Benito Colliga

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Executive summary and recommendations

How well were teachers in general, and Science, Technology, Engineering and Mathematics (STEM) teachers especially, prepared for distance teaching when schools went into closure during the COVID-19 pandemic? What problems did they face and what strategies did they use to cope with these problems? Once they switched to distance teaching to what extent were teachers able to implement what they intended to do in the classroom?

The current survey aimed to explore what were the challenges and strategies of teachers during the pandemic. The survey was run in 25 languages from September 10th 2020 until January 15th 2021. There were 54,081 respondents in total from 49 countries who participated in the survey. Most participants were from Croatia, Greece, Italy, Portugal, Spain and Turkey.

Key findings

Teachers had to adapt their usual teaching practices after the outbreak. Most teachers (84%) report that they modified their original mix of pedagogical practices. Classes mostly lasted around 30 min and more communication with parents was necessary daily, especially in pre-primary and primary school education. More than half of the teachers went for a blended approach during distance teaching.

The use of educational technologies was largely part of the routine of most teachers. Therefore, teachers were mostly prepared for distance teaching in terms of knowing how to use some ICT tools for their teaching. However, only in Estonia was distance teaching a regular practice for more than half of the teachers. Training on distance teaching was even less often the case for teachers overall before the outbreak.

Student-centred practices were negatively impacted by the outbreak. Teachers employed fewer pedagogical practices after the outbreak compared to what they intended for their usual practice. The most negatively impacted were teaching with experiments, collaborative learning and peer teaching, followed by project-/problem-based learning, formative assessment, integrated teaching and inquiry-based education.

It was challenging for STEM teachers to continue their practical lessons during distance teaching. A quarter of STEM teachers had to simplify their practical lessons. Almost a quarter of STEM teachers left out practical lessons while almost a quarter of them continued practical work demonstrations synchronously or asynchronously at a distance. The uptake of online laboratories for practical work was very low (5%).

Teachers reported mostly external factors as problems they experienced during the pandemic. Teachers perceived their personal lack of digital competences as a problem that they experienced to a lesser extent than the lack of digital skills of students and their parents. Rather than their digital skills, teachers more often experienced difficulty in providing a personalised learning experience.

Teachers mostly employed some pedagogical solutions to simplify their usual classes and manage remote classes better. These were to ask their students questions frequently to check their comprehension (92%), setting students new and more realistic goals (89%), and segmenting presentations into short sequences to enhance student engagement (86%). On the other hand, only 37% of teachers provided personalised learning support to specific groups of students, through e.g., one-to-one online sessions with more vulnerable groups of students, 36% developed flipped classroom models and 32% organised peer-learning and studying groups.

Teachers probably went for digital tools that they were already familiar with. Teachers mostly used tools for teachers to create digital learning content (75%). Teachers may have used a variety of tools to create content like videos of themselves giving instructions or online documents and presentations, as well as online quizzes for practice and to check for students' knowledge. All-in-one solutions such as digital learning management systems were also highly used, although to a lesser extent (66%). The use of such solutions may have required more preparation before class. Augmented reality/virtual reality and artificial intelligence-based tools were among the least used educational technology solutions.

Although the situation was demanding, some things worked well for teachers during distance teaching. More than half of the STEM teachers agreed that this was an opportunity to update their digital skills (59%), a freedom to discover and experiment with new online education tools and resources (56%) and an opportunity for students to update their digital skills as well (55%).

Finally, what teachers did before the outbreak largely determined what they did after. Teachers who employed various teaching practices, who practised distance teaching, who were trained to do distance teaching and who used educational technologies before the pandemic, were also more likely to use a larger and more diverse set of teaching practices and solutions during distance teaching.

Recommendations for policy makers

1. **Offer professional development opportunities that combine distance teaching and pedagogical practices**

   The results suggest a drop in innovative pedagogical practices after the outbreak. Teachers also recommend that policy makers facilitate and promote professional development courses on the use of different educational technologies and on teaching strategies for remote classrooms. Organising professional development for teachers with a focus on practices such as peer teaching, flipped classroom, personalised learning or project-/problem-based approach in the context of distance teaching could have benefits for future situations of distance or hybrid education.

2. **Adopt distance teaching as a regular practice during and beyond the pandemic**

   Past research and the current survey suggest that not all teachers, students and parents have the same level of necessary digital skills. Schools can benefit a lot from keeping distance teaching as a regular practice, even if as occasional projects throughout the year. First, it can help to identify students who struggle with digital skills and to provide them with support. Second, it can be an opportunity for teachers to practise various student-centred activities using educational technology. Ultimately, regular distance teaching or e-school projects can help close the digital gap.

3. **Promote teacher collaboration to support upskilling and resilience**

   Professional learning communities and other activities that promote teacher collaboration can help them learn from the experiences of colleagues and could also support them in adapting to new conditions such as those brought about by the COVID-19 pandemic. For instance, teachers could join forces to organise co-teaching that can facilitate implementing activities that keep students active and collaborating with one another.

4. **Support students and parents in developing their digital skills**

   Although teachers had to quickly get to grips with distance teaching, the survey suggests that they felt that they had the development of their digital skills under control. They seemed to experience more as a problem the fact that students and their parents lacked the necessary infrastructure and digital skills. Parents and students could also benefit from training, resources and guidelines which will ultimately also improve their ability to benefit from the teachers' skills and help teachers with their practices.

5. **Explore lessons learned with parents and students**

   According to the teachers, parents' ability to support their children at home was important during distance teaching. Teachers also had to communicate more often with parents during the COVID-19 pandemic. Investigating how parents experienced the pandemic and the communication with the school can provide valuable insights on the role of parents during distance teaching and beyond the pandemic. Students, on the other hand, can report how they experienced diverse teaching practices during distance teaching and help identify obstacles to implementing collaborative, student-led activities in the digital environment.

6. **Encourage the use of online/virtual laboratories and educational technologies among STEM teachers**

   Only 5% of teachers reported organising practical work for students in online laboratories. As 25% of STEM teachers had to put aside practical work, it is clear that the great potential of online and virtual laboratories has been underused during distance teaching. Now that STEM teachers have experienced the shortcomings of on-

site practical work, teachers who have never used such platforms could now be more open to exploring what online laboratories have to offer. However, teachers need to be provided with time, resources and training to try to adopt this new practice.

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Introduction

Following the outbreak of the COVID-19 pandemic, education systems all over the world had to switch to distance teaching. As countries took their first actions to adapt to emergency distance teaching, educators also started reflecting on the situation. How ready were schools and teachers for distance teaching? What will be the implications of this event for the future of education?

International surveys rolled up their sleeves to investigate what kinds of actions each country took during school closure. Surveys like the UNESCO WHAT'S NEXT? Lessons on Education Recovery and OECD's special surveys on the state of school education (2021a, 2021b) inform us on national coping strategies and resources provided to students and teachers. However, there is a need for international data providing insights from the teachers' perspective. The current survey, titled Online Survey on teaching during the COVID-19 pandemic, aimed to explore what were the challenges and strategies of teachers during the pandemic. This survey is also unique as it focuses on teachers of Science, Technology, Engineering and Mathematics (STEM) subjects and their practices.

Over five sections, the report will provide an overview of the key findings of the survey. After explaining the methodology and sample, the first section will give a snapshot of teachers' pedagogical practices before and after the outbreak of the COVID-19 pandemic. The second section will summarise the main problems that teachers and more specifically STEM teachers have experienced. The third section will report the data on what kind of educational technology and pedagogy solutions teachers used in addressing challenges brought by distance teaching. The fourth section will go over what worked well according to the teachers, and what actions they would recommend to improve their experience.

Finally, the fifth section will explore what teacher characteristics had a positive impact on using more teaching practices and solutions after the

outbreak, based on the results of predictive statistical analyses.

The survey was organised under Scientix and in collaboration with European Schoolnet's Perspectives, Amgen Foundation and the STEM Alliance. The report is part of the Scientix Observatory series. Scientix, the community for science and mathematics education in Europe, initiated by the European Commission (Directorate General for Research and Innovation), set up the Scientix Observatory to help the development and dissemination of different science education projects and document good practices in various aspects of STEM education. The Observatory provides short synthesising articles, focused on one or several related themes or initiatives, or the state of play of different topics related to science education (http://www.scientix.eu/observatory).

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Questionnaire method

Aim

The Online Survey on teaching during the COVID-19 pandemic was designed to collect information from teachers in primary and secondary education (students aged 3-21) about:

1. The pedagogical practices they intended to use before the pandemic and the practices that they actually implemented in the weeks that followed the outbreak of COVID-19.
2. The problems they experienced and the forms of support they received from their schools during the COVID-19 pandemic.
3. The educational technologies and pedagogical solutions that they used to solve the problems they encountered during distance teaching.
4. What worked well for teachers and their recommendations to school leaders and policy makers to address the challenges brought about by the COVID-19 pandemic.
5. The teacher characteristics that were associated with the innovative teaching practices and solutions that they used.

Data collection

The questionnaire was run online exclusively. The survey was run in 25 languages from September 10th 2020 until January 15th 2021. The online survey platform SurveyMonkey was used to create the questionnaire. The dissemination channels of Scientix and European Schoolnet were used to disseminate the survey's launch. The networks of Scientix partners, members of the Ministries of Education STEM Representatives Working Group[1], the Scientix National Contact points and the Scientix Ambassadors were also encouraged to share the survey in their own channels.

1.The Ministries of Education Science, Technology, Engineering and Mathematics (STEM) representatives Working Group (MoE STEM WG) is a platform for discussion and exchange among Ministries of Education regarding their STEM education policies. Coordinated by European Schoolnet (EUN), the overall objective of this initiative is to help lay the foundations for medium- and long-term strategies and activities between Ministries of Education and EUN in the field of STEM education, and especially within the Scientix project, following an agenda that addresses the Ministries' priorities and main interests.

Sample

There were 54,081 respondents in total from 49 countries who participated in the survey. However, not all these respondents completed the survey; therefore the actual sample size for each analysis was indicated on each table and figure throughout the report. The majority of participants were from Croatia, Greece, Italy, Portugal, Spain and Turkey, each of which had more than a thousand respondents.

Participation in the Scientix survey was voluntary and no sampling constraints were applied. The survey was open to everyone willing to participate and no stratified sampling was applied. Although this helps with reaching many respondents easily, it also led to a bias in the distribution of the respondents' countries. The uneven sample sizes might be due to reasons such as the country's teacher population and outreach of the Ministry of Education, among others. The reader should therefore note that results cannot be generalised to Europe as a whole. The reader should also be careful not to draw conclusions concerning specific countries, because no randomisation was applied in sampling respondents.

To address this bias in the data analysis, countries with a sample size larger than a thousand were analysed separately. If the pattern of results was different from the overall sample and would affect the overall results when pooled, the results for these countries were reported separately in this report.

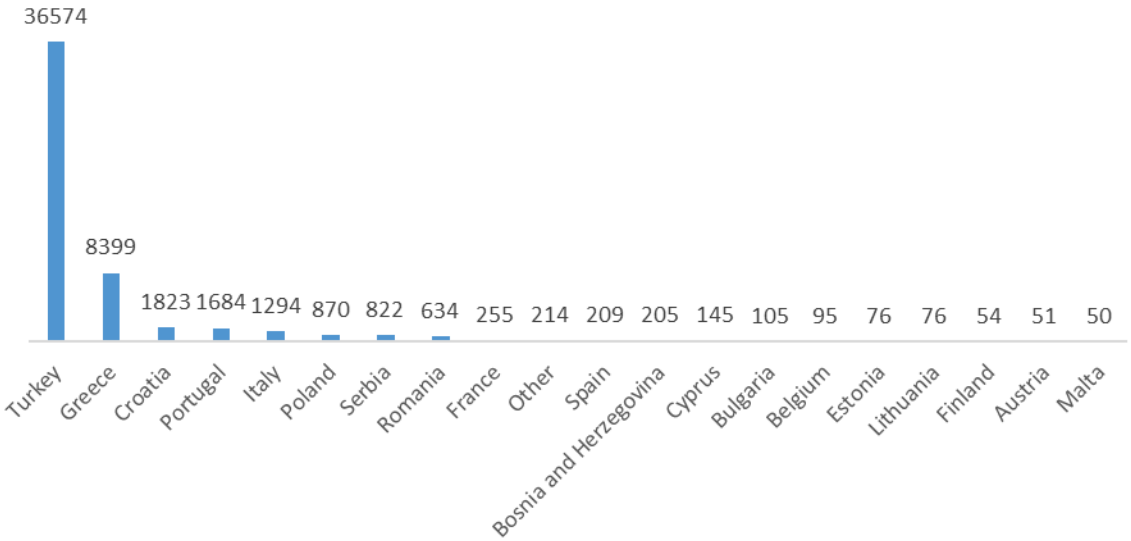


Figure 1. Respondents' countries. The figure shows only the countries that had more than 50 respondents and shows all the respondents who responded to at least one question in the survey.

The questionnaire

The final questionnaire consisted of 39 questions (27 multiple-choice, 3 checkbox questions, 6 rating scale matrices with a Likert rating scale and 3 open-ended questions). Among these 39 questions there were 15 specifically related to the class that the respondents taught. The respondents were given the option to answer this set of 15 questions once more for an additional subject that they taught. Thus, a respondent could answer up to 54 questions. The full list of questions is included in Appendix 2.

All Likert scales had 4 levels (e.g., 1: Strongly disagree, to 4: Strongly agree). Compared to a 5-level scale, this allows for a dichotomous grouping of respondents' answers (High vs Low; Agree vs Disagree).

The questionnaire asked respondents to rate the frequency of their use of 15 pedagogical practices. This enabled us to make a comparison between teachers' practices before and after the outbreak of the COVID-19 pandemic. This list of 15 practices was based on past Scientix Observatory surveys (e.g., Nistor et al., 2018). Except for traditional direct instruction and summative assessment, these practices can be defined as innovative. This is based on the meaning of innovation also proposed by Ferrari et. al. (2009), specifically, "the process leading to creative learning, the implementation of new methods, tools and contents which could benefit learners and their creative potential." All these practices put emphasis on student empowerment and student-centred teaching.

Profile of respondents

67% of respondents were female and 63% were lower (students typically aged 12-14) or upper (students typically aged 15-19) secondary school teachers.

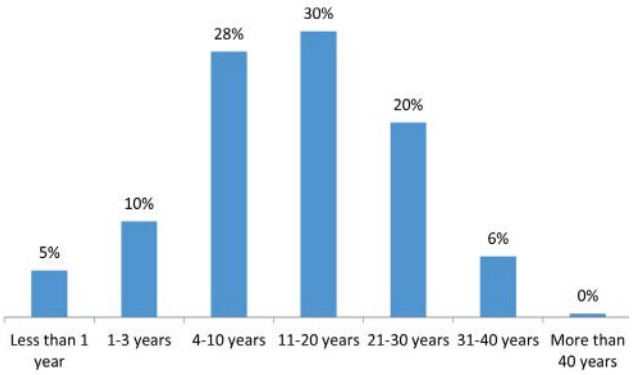


Figure 2. Teaching experience excluding the COVID-19 pandemic period (n = 54,081). Proportions were rounded up; 0.4% of teachers have more than 40 years of experience.

Regarding teaching experience, 11-20 years can be considered the mid-point, as 56% of teachers have 11 years of experience or more (Figure 2). The largest experience group is 11-20 years with 30%. A large proportion (65%) of respondents were aged 36 or over (Figure 3), a pattern that is consistent with the teacher profile in the EUN Academy and Teacher Academy course participant surveys, as well as past Scientix reports (e.g., Nistor et al., 2018).

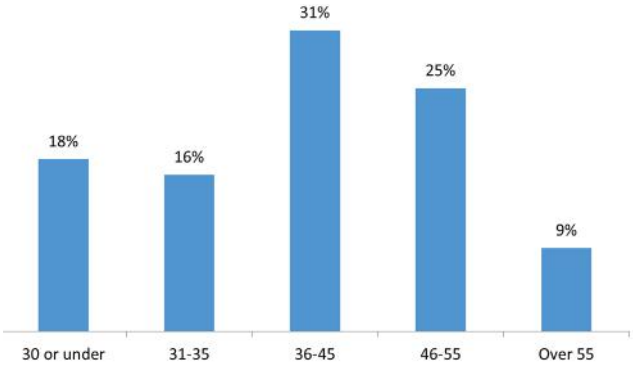


Figure 3. Age of respondents (n = 54,081)

A quarter of the overall sample are primarily teaching pre-primary or primary education subjects (Figure 4). The proportion of teachers teaching STEM subjects is similar (around 25%). Non-STEM subjects that can be considered as core are also well-represented in the sample, with reading/writing/literature at 10%, foreign languages at 10% and social studies (including history and philosophy) at 7%.

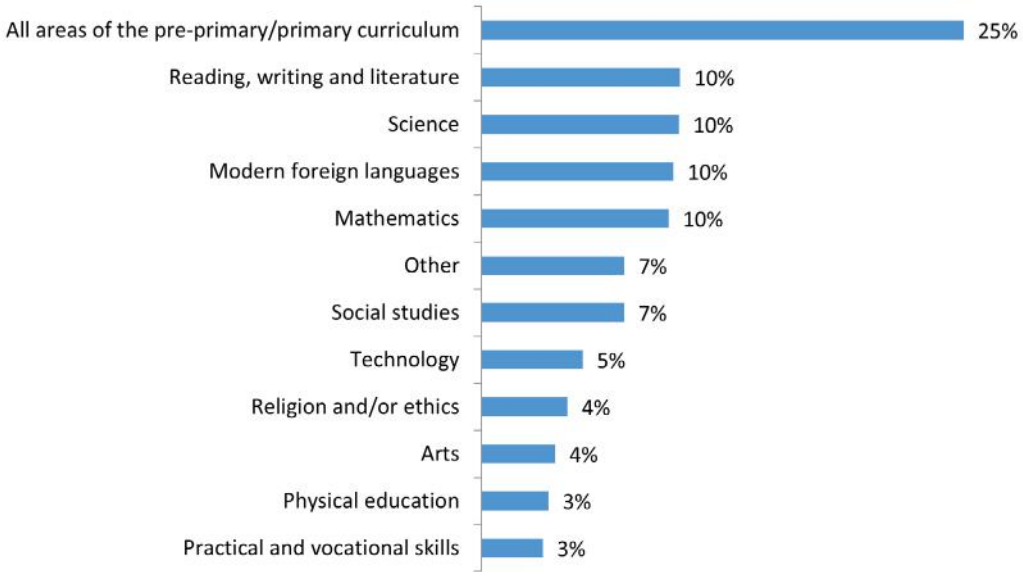


Figure 4. Main subject taught by the respondents (n = 50,953). Technology includes information technology, computer science, graphics design, electronics, keyboard skills and word processing.

Section 1: Pedagogical practices before and during the pandemic

Organisational changes during distance teaching

When something as sudden as the COVID-19 outbreak occurs, a quick strategy for teachers to adapt might be to try to recreate the usual teaching conditions in the online setting. However, teaching online means a completely different setting where there are fewer visual cues from students and less control over their IT infrastructure for the teacher to manage their students.

Most teachers (84%) reported that they had to modify their original mix of pedagogical approaches to some extent or a lot after the outbreak. 74% of teachers also said that their online teaching lasted shorter than the usual teaching hour. For 68% of teachers, their online teaching lasted around 30 min. Only 6% of teachers reported teaching lessons lasting 45 minutes or longer.

The results clearly show that parents were more involved after the outbreak: when asked if parents needed to increase their involvement in students' learning experience, 82% of teachers responded "Yes" overall. Furthermore, 81% of respondents overall reported that they had to increase their interaction with parents to some extent or a lot. Although these proportions were highest for teachers of pre-primary/primary education subjects (93% for both questions), the overall pattern was similar across all subjects.

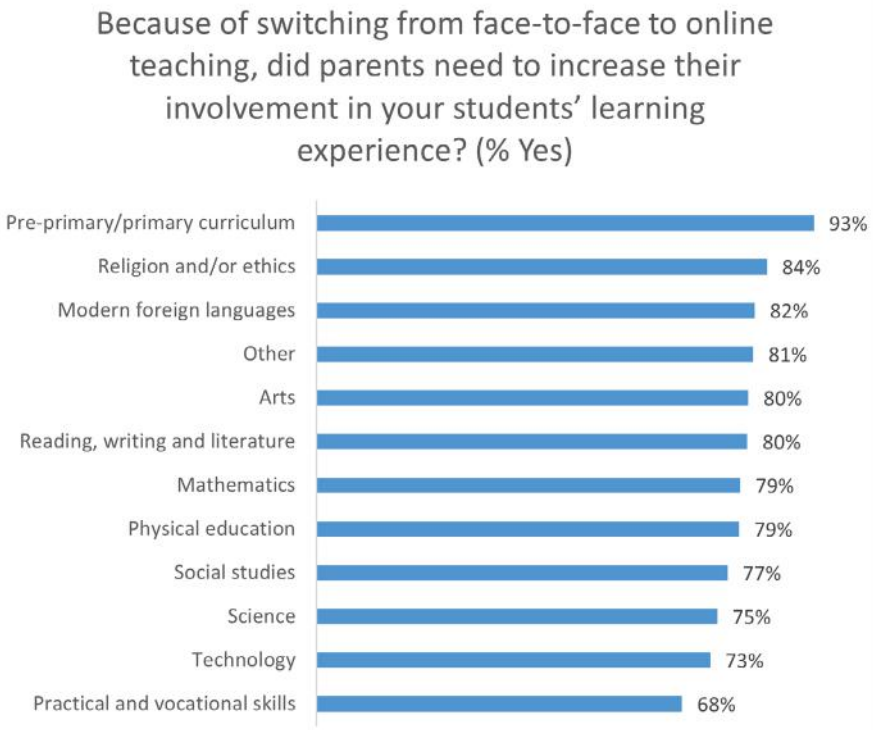


Figure 5. Proportion of respondents saying that parents had to increase their involvement in students' learning experience (n = 38,609), broken down by the subject that the teacher primarily taught during the pandemic.

Although teachers can at least relatively more easily adapt theoretical work and instruction to a distance teaching setting, adapting practical class work is a challenge by itself. The quantitative data suggests that practical work had to simplified or replaced by 25% of STEM[2] teachers (Figure 6). Comments by respondents suggest that they used many different methods, ranging from using materials they have at home, showing photos and videos of experiments, to using virtual labs or even shipping material to the students' homes so that they can carry out practical work at home. While 23% reported that no practical work could take place, another 23% reported that practical work was demonstrated by the teacher either synchronously or asynchronously. Only 5% reported that students conducted practical work using online laboratories.

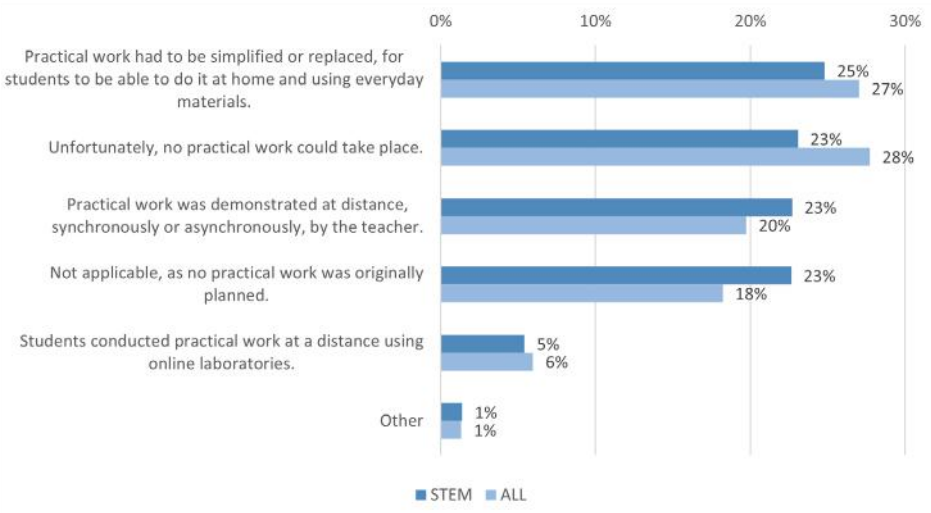


Figure 6. Teachers' approaches in carrying out practical work following the outbreak of the COVID-19 pandemic for teachers of STEM subjects (n = 5,128) and all teachers regardless of the subject they were teaching (n = 8,789).

2.Teachers who reported teaching primarily Science, Mathematics or Technology were analysed together.

Synchronous, asynchronous and blended approaches in teaching after the outbreak

Respondents were asked what their practice was in switching from face-to-face to online teaching (i.e., teaching at a distance, via information and communication technologies). Synchronous learning is online or distance learning, that is, based on real-time interactions between students and teachers. Asynchronous learning occurs through online platforms without real-time interactions. Both synchronous and asynchronous can be facilitated by instructors and can be student-centred (Murphy et al., 2011). More than half (57%) of the respondents (excluding Turkey) said they adopted a blended approach; that is, teaching happened in equal shares with and without real-time interaction with the students. Looking more specifically at the five countries with the largest proportion of respondents, this seems to be also the case for Portugal, Greece, and Croatia (Figure 7). On the other hand, more than half of teachers (53%) in Turkey and 41% in Italy reported going for a synchronous approach. Interestingly, 36% of teachers in Croatia reported going for an asynchronous approach, a larger proportion compared to the overall sample (19%).

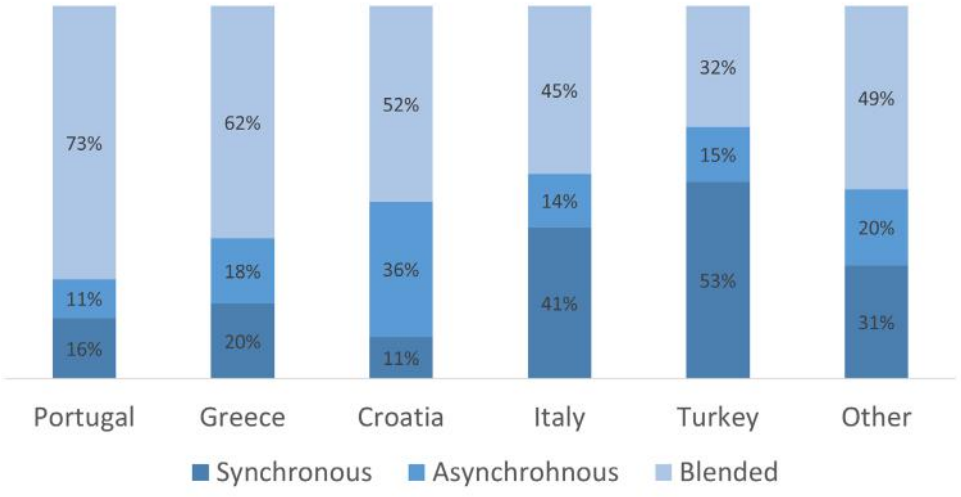


Figure 7. Teachers' practice of choice among three teaching modes: (1) synchronous, (2) asynchronous, (3) blended (n = 43,047). A blended approach seems to be preferred by a large proportion of teachers except in Turkey.

Teachers' preparedness for distance teaching

To understand how prepared teachers were to switch to distance teaching, respondents were asked whether they had received training on distance teaching, and whether distance teaching and the use of educational technologies were already part of their regular practice before the pandemic (Figure 8).

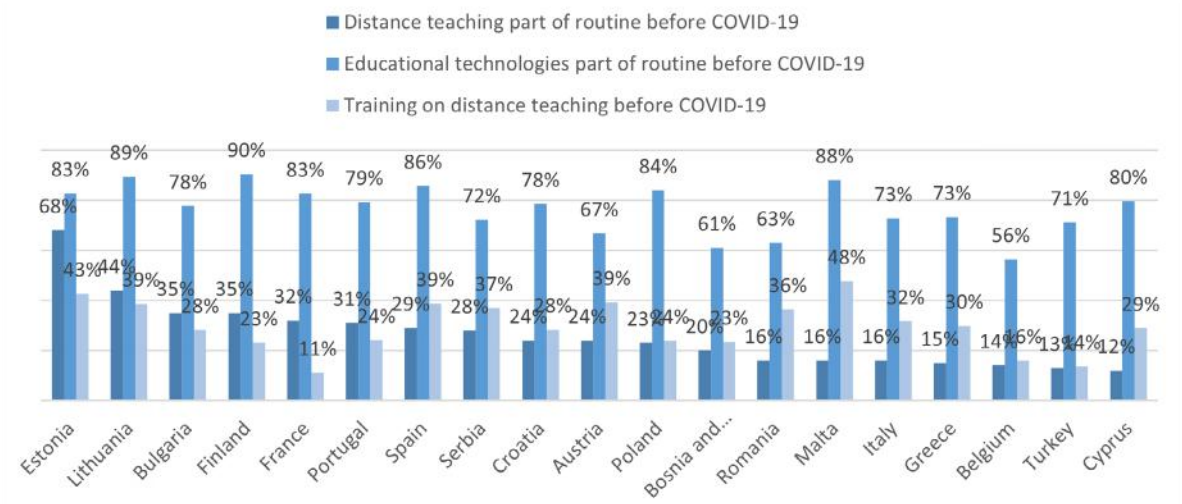


Figure 8. Respondents' preparedness for distance teaching, as measured by their experience with distance teaching and educational technologies and participation in training on distance teaching. The figure reports the countries that had 50 respondents or higher (n = 53,388), sorted by distance teaching practice from highest to lowest. Percentages represent respondents who replied "to some extent" or "a lot" for distance teaching and educational technologies, and "yes" to whether they participated in training on distance teaching before the pandemic.

A very high proportion of teachers in Estonia (68%) reported that distance teaching was part of their teaching practice before COVID-19 either to some extent or a lot. This is not surprising as Estonian schools are known to practise distance teaching regularly, as reported by Estonian policy makers in discussions on education during COVID-19 (Engelhardt, 2021). Estonia is followed by Lithuania, Bulgaria, Finland and France although at lower rates. Interestingly, the practice of using educational technologies before the pandemic does not seem to relate strongly to distance teaching (e.g. high rates of educational technology but low rates of distance teaching in Poland, Malta, Italy, Greece, Turkey and Cyprus). However, training on distance teaching is also relatively high in Estonia (43%) and Lithuania (39%).

If we look at teachers' responses by the subject they teach, the results do not reveal any large differences between different subjects. The exception is teachers of Technology subjects (which includes information technology, computer studies, construction/surveying, electronics, graphics and design, keyboard skills, word processing, workshop technology

and design technology) who can be considered more prepared than other teachers. Among all technology teachers, 24% reported that distance teaching and 87% reported that using educational technologies was part of their regular practice to some extent or a lot before the pandemic. 30% had also participated in training on distance teaching prior to the outbreak.

Overall, the use of educational technologies is largely part of teachers' routine in most countries; therefore, it can be said that teachers were already prepared to take up the challenge of distance teaching in terms of integrating the use of digital tools that they were already familiar with. In contrast, distance teaching was a new practice for most teachers except for a few countries, and even for those countries there was not a large offer or uptake of professional development opportunities for distance teaching.

Pedagogical practices before and after the COVID-19 outbreak

The survey aimed to explore to what extent teachers were able to continue implementing their usual teaching practices within the constraints of emergency distance teaching. The survey asked teachers what their intention had been to use 15 pedagogical practices before the COVID-19 pandemic outbreak and about their actual use after the outbreak.

There is overall a decreasing trend in teaching practices after the outbreak (Figure 9), except for flipped classroom and traditional direct instruction. Traditional direct instruction remained high as it might have been a way to do distance teaching with minimal preparation at the beginning of school closure. Teachers might have had opportunities to apply the flipped classroom method due to the reduced amount of teaching hours during distance learning and students preparing more for their classes on their own.

Figure 9 also indicates which teaching practices changed significantly, based on pairwise comparisons made with t-tests[3]. The analysis revealed that the practices the most negatively impacted were teaching with experiments, collaborative learning, and peer teaching, followed by project-/problem-based learning, formative assessment, integrated teaching, inquiry-based education. Interestingly, summative assessment has also decreased a lot in terms of percentage points. On the other hand, the low effect size suggests that there is high variability in teachers' responses.

3. Due to the large sample size, Cohen's d effect size calculations were used as a measure of significant differences. The asterisks depict small, moderate and large effect sizes. The effect size measure considers the variability in the responses of the whole sample, therefore being a reliable indicator of the difference between the ratings before and after the outbreak.

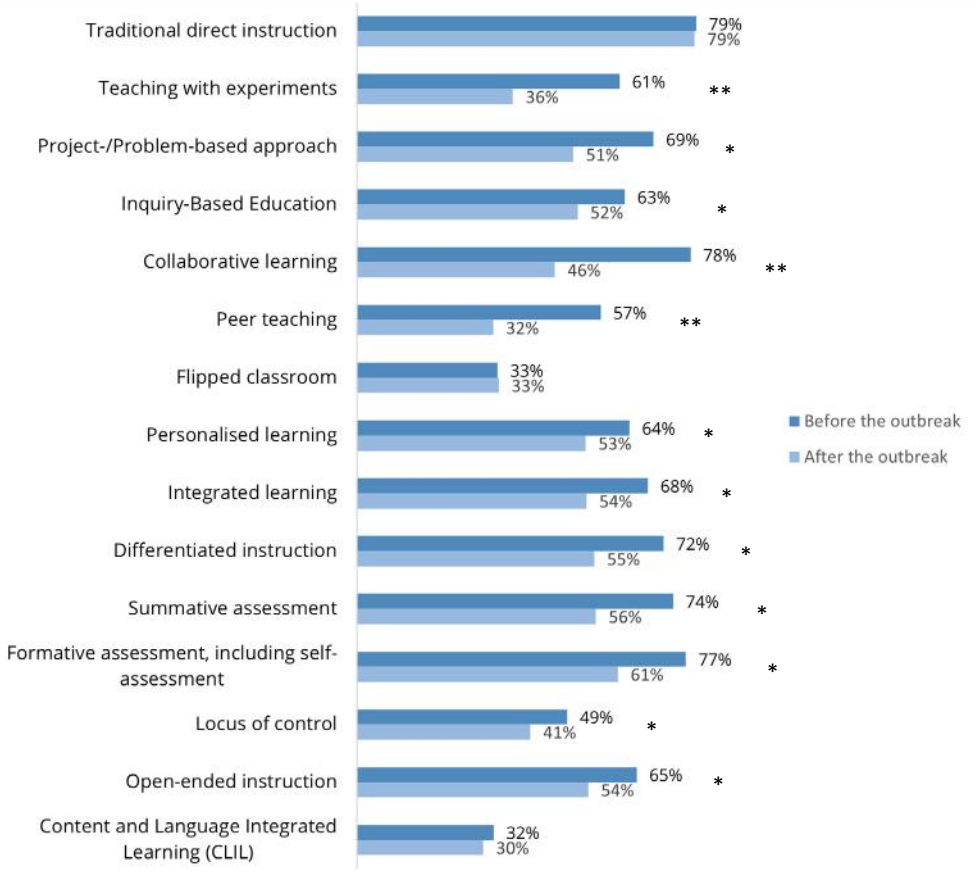
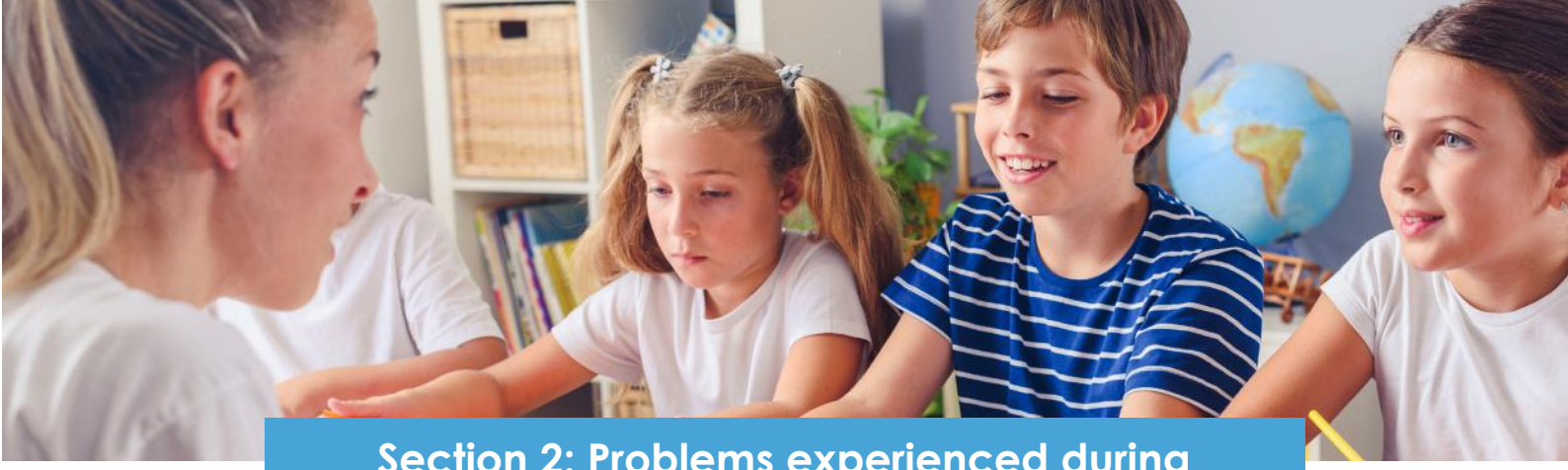


Figure 9. Teaching practices before and after the COVID-19 outbreak (n = 38,609). Percentages show the proportion of respondents who implemented these practices "to some extent" or "a lot". Teachers' average ratings before and after the outbreak were also analysed with paired samples t-test. Due to the large sample size, Cohen's d effect size calculations were used as a measure of significant differences. The asterisks depict significant effect sizes: small (*), moderate (**) and large (***).



Section 2: Problems experienced during distance teaching and the support received

Problems experienced

Teachers' readiness to adapt to distance teaching is important for a quick adaptation to the new context. Regardless of how ready they are, many external factors are also important in the smooth transition to distance teaching. The survey therefore investigated the most and least common problems that teachers experienced. Respondents were asked to what extent they experience a list of 19 problems (Table 1).

Table 1: Problems most experienced by teachers. Percentages show the total of respondents who selected "to some extent" or "a lot"). Highest ranking problems are highlighted in dark/light brown and lowest ranking problems highlighted in dark/light green. Items refer to teachers

To what extent did you experience the following problems in switching from face-to-face to online teaching?						
	Croatia	**Greece**	**Italy**	**Portugal**	**Turkey**	**All other**
Students' lack of a suitable Internet connection.	75%	83%	76%	77%	84%	72%
Students' lack of suitable IT equipment (hardware and/or software) to carry out assignments, e.g. PC, laptop, tablet, appropriate software, etc.	71%	82%	69%	77%	83%	74%
Parents' lack of digital competences.	76%	77%	70%	77%	77%	65%
Students' difficulty in managing the prescribed learning activities.	71%	67%	60%	73%	78%	64%
Students' lack of digital competences.	74%	70%	60%	72%	67%	67%
Lack of educational solutions for learners with special needs.	70%	66%	56%	71%	73%	67%
Difficulty of providing a personalised learning experience.	67%	69%	54%	68%	76%	66%
Low accessibility of resources for learners with special needs.	71%	63%	54%	70%	73%	67%

To what extent did you experience the following problems in switching from face-to-face to online teaching?						
	Croatia	**Greece**	**Italy**	**Portugal**	**Turkey**	**All other**
Lack of a suitable pedagogical approach to evaluate and assess students from distance.	74%	61%	61%	63%	76%	60%
Difficulty of engaging and maintaining students' attention during online classes.	74%	59%	50%	58%	76%	62%
Lack of suitable software to effectively teach the subject matter, e.g. online and virtual labs, language-learning applications, AR/VR-based tools for knowledge acquisition, online resources, etc.	55%	65%	50%	60%	74%	65%
Lack of suitable IT equipment (hardware and/or software) to assess students' homework satisfactorily, e.g. PC, tablet, laptop, appropriate software, etc.	48%	59%	43%	56%	77%	57%
Lack of suitable IT equipment (hardware and/or software) to communicate with the students satisfactorily, e.g. PC, tablet, laptop, videoconferencing software, etc.	47%	56%	42%	58%	76%	56%
Difficulty of adapting my usual pedagogical approach to distance learning.	52%	56%	47%	51%	70%	50%
Lack of purpose-built educational tools which grant students' and teachers' personal data protection.	48%	62%	35%	60%	64%	57%
Difficulty in accessing public national and/or local platforms with learning resources recommended by public authorities.	47%	53%	33%	46%	68%	53%
Lack of access to curriculum-relevant online teaching resources.	56%	36%	29%	46%	49%	51%
Personal lack of a suitable Internet connection.	34%	37%	29%	38%	34%	36%
Personal lack of digital competences.	37%	25%	26%	32%	31%	32%

Student-related issues appear on the top of the list of problems most experienced and this pattern of results is consistent across the large-sample countries Croatia, Greece, Italy, Portugal, Turkey, and the rest of the sample. Interestingly and contrary to what one might have expected, teachers perceived their personal lack of digital competences as a problem that they experienced the least. Regarding internal (teacher-specific) challenges, rather than their digital skills, teachers more often experienced difficulty of providing a personalised learning experience. It should be noted that all the problems listed were experienced at least to some extent by at least a quarter of respondents.

Parents' lack of digital competences was also a problem experienced frequently. This could be due to many teachers in the sample teaching in primary education, where students might have needed more technical support from their parents. When looking at teachers of STEM subjects specifically,[3] the results are similar: students' lack of suitable Internet connection (62%), students' lack of suitable IT equipment (61%), students' difficulty in managing the prescribed learning activities (56%) and parents' lack of digital competences (56%) were the most frequently experienced problems ("to some extent" or "a lot"). Problems that are more likely to impact STEM subjects were also noted by around half of the teachers: lack of suitable software to teach the subject matter (e.g., online, and virtual labs) and lack of IT equipment. Only 30% of STEM teachers reported experiencing lack of access to curriculum-relevant online teaching resources.

School support

52% of teachers reported that their school was technologically ready to switch to distance learning to some extent or a lot. Similarly, 50% of teachers reported that their school provided them and their students with IT support.

According to the respondents, schools mostly supported them (62%) by providing clear instruction on how to use the available IT tools and infrastructure (Figure 10). The least occurring form of support was student-/parent-oriented training courses on how to use the available IT tools and infrastructure (16%), although parents' and students' lack of IT skills was a frequently occurring problem according to the teachers, as mentioned in the previous section (see Table 1). Some forms of support that can be considered more advanced occurred for fewer teachers: 44% said they received teacher-oriented training courses on how to use the available IT tools and infrastructure (30% for Turkey and Greece) and 28% said they received training on distance learning (as low as 7% for Greece and 17% for Croatia). Facilitating peer learning could be helpful for teachers to collaborate and autonomously learn from one another to adapt quickly to new practices such as distance teaching (Goddard et al., 2007; OECD, 2020). However, this potential seems to be underused as only 32% were supported by schools through access to teacher communities and 37% through creation of specific online group pages.

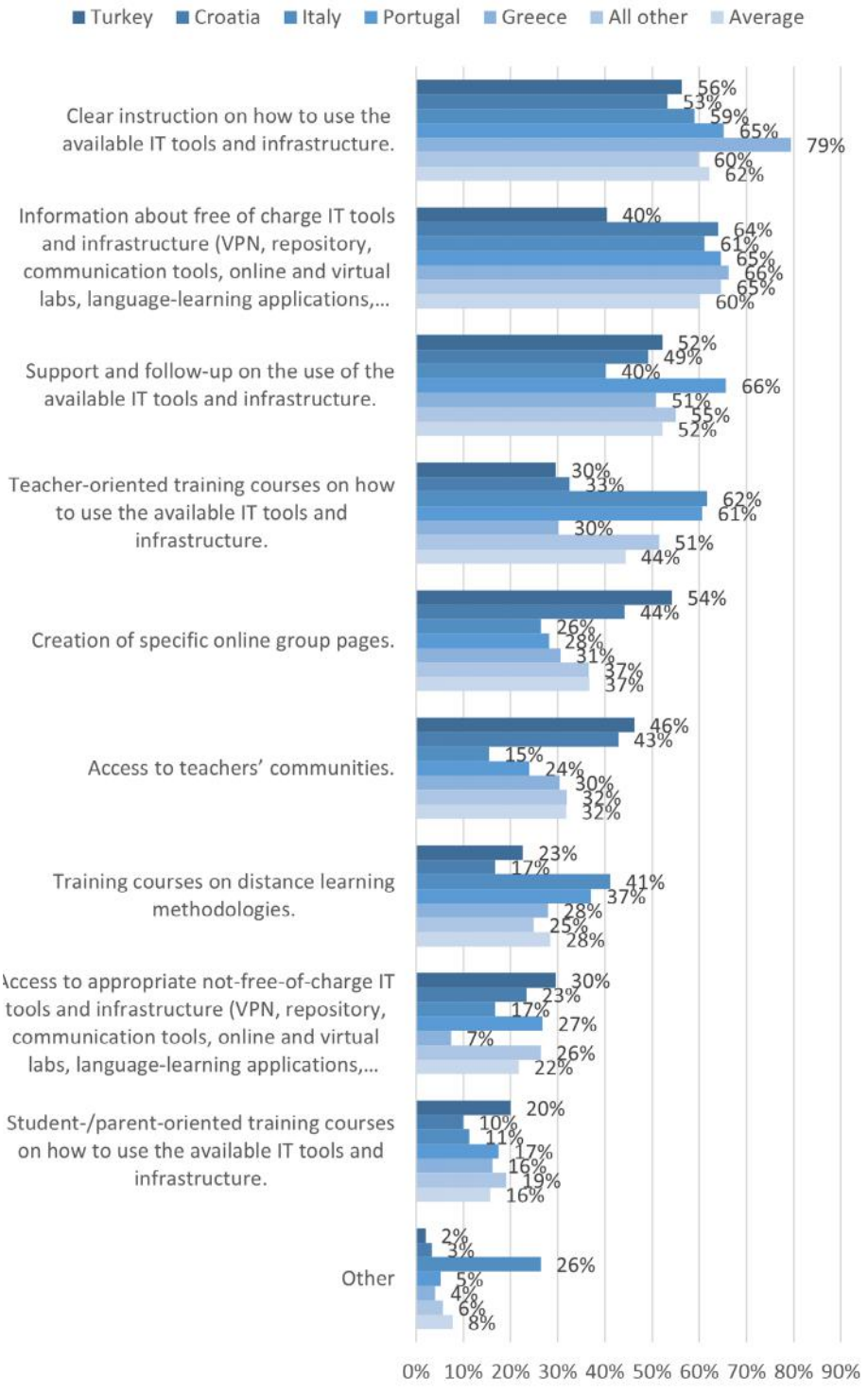


Figure 10. Support that the school provided to teachers and their students according to the respondents (total n = 18,779). Multiple selections were possible.

Section 3: Solutions employed by teachers to overcome problems

Pedagogical solutions

The emergency distance teaching conditions required teachers to employ logistical, technical and pedagogical solutions. Therefore, the survey aimed to understand the most frequently used solutions by asking to what extent they performed a list of activities to adapt their usual practice to distance teaching.

Respondents were asked to rate how frequently they used a list of 13 pedagogical solutions (Figure 11). A large proportion of respondents (92%, "to some extent" or "a lot") said that they asked their students questions frequently to check their comprehension. This was followed by setting new and more realistic goals for students (89%) and segmenting presentations into short sequences to enhance student engagement (86%). These suggest that teachers were aware of the challenge of keeping students active in an online environment and were taking steps to monitor their students' engagement. Many teachers also increased their collaboration with other teachers to provide students with a more coherent learning experience (73%).

Although 67% of respondents reported granting students more autonomy, the proportions drop when it comes to more specific actions of keeping students active, except for designing assignments using shareable online documents to foster student collaboration (62%). Only 46% of teacher fostered student collaboration by using discussion boards, 36% developed flipped classroom models and 32% organised peer-learning and studying groups. Finally, personalising the learning experience might have been a challenge in emergency distance teaching as only 37% of teachers provided personalised learning support to specific groups of students, through e.g., one-to-one online sessions with more vulnerable groups of students.

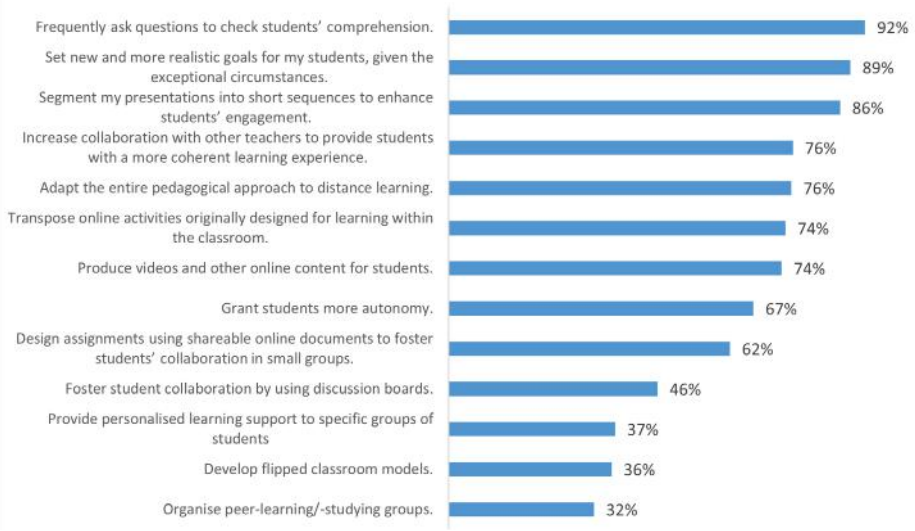


Figure 11. Pedagogical solutions used by the respondents to adapt their class to distance teaching (n = 35,119). Percentages represent the proportion of teachers who employed these solutions either "to some extent" or "a lot".

Educational technology solutions

Teachers were also asked to rate their frequency of using a list of 13 categories of educational technology solutions to adapt their work to distance teaching conditions. Teachers mostly used tools for teachers to create digital learning content (75% "to some extent" or "a lot"). This suggests that teachers probably went for digital tools that they were already familiar with. Teachers might have used a variety of tools to create content like videos of themselves giving instructions or online documents and presentations, as well as online quizzes for practice and to check for students' knowledge. Some STEM-related tools mentioned are Bee-bot**,** Matific, Mathigon, MathAids, GeoGebra, Tinkercad, Scratch (as well as national platforms, e.g., Nikola Tesla Portal in Croatia). Collaboration platforms that support live video communication were also in high use (72%), probably because they also allowed for synchronous class activities and direct instruction via online conferencing. Some of the tools mentioned in the comments are Zoom, Microsoft Teams, Webex, Google Classroom, and even Discord, Microsoft Yammer, Skype and WhatsApp. All-in-one solutions such as digital learning management systems were also highly used, although to a lesser extent (66%). The use of such solutions might have required more preparation before class. Some tools mentioned in the comments are Moodle, ClassDojo, Edmodo, Schoology, BigBlueButton, as well as national platforms (e.g. Stuudium, eKool in Estonia; Scoala Intuitext or Digitaliada in Romania). More than half of the teachers reported using external repositories of distance learning (59%) and online communities (58%). Artificial intelligence-

based tools and augmented/virtual reality-based solutions were the least used solutions on the list (16% and 20%, respectively). Assistive educational technology for special needs education was also not frequently used (21%), suggesting that teachers either were not ready for or did not have large access to technological solutions that would support the inclusion of students with special needs. Finally, not many teachers employed online and virtual laboratories (25%). Go-Lab was frequently mentioned among the comments, as well as national platforms (e.g. e-labatorij in Croatia, PhET Colorado in Croatia and Turkey). This trend is consistent across the large-sample countries. Furthermore, consistent with the results presented in the previous sections concerning practical work (see Figure 6), only 23% of STEM subject teachers made frequent use of these solutions, although these would have facilitated practical work during distance teaching.

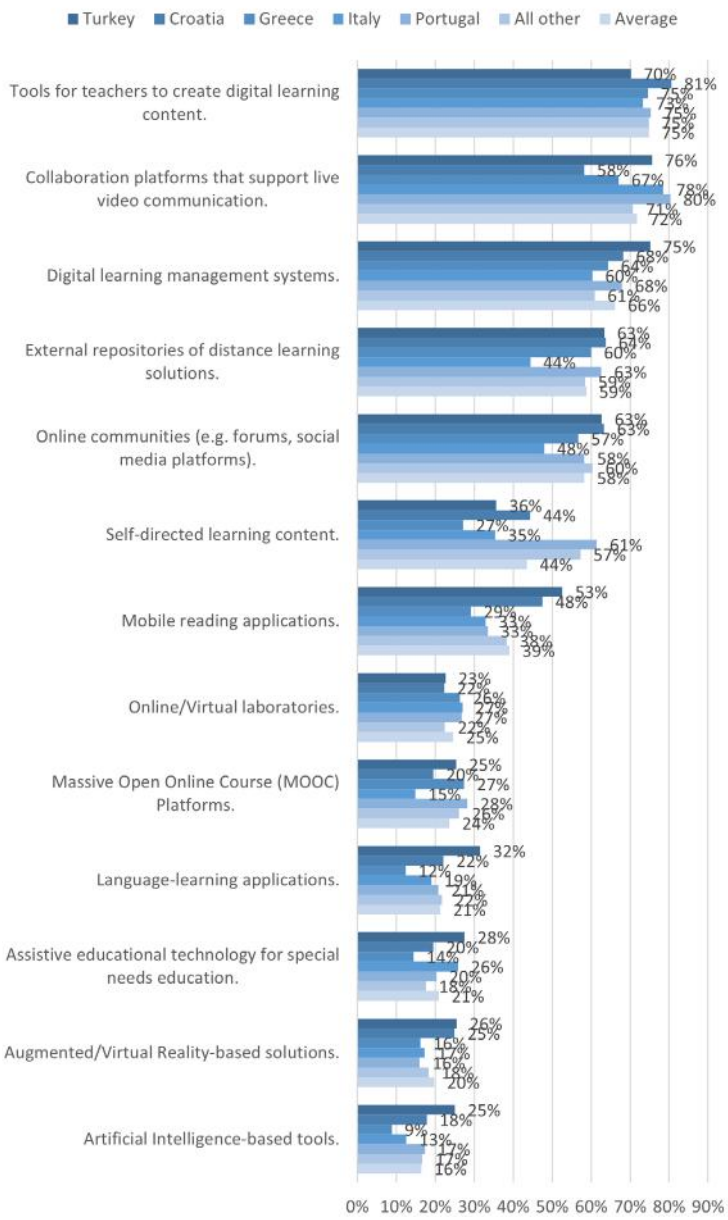
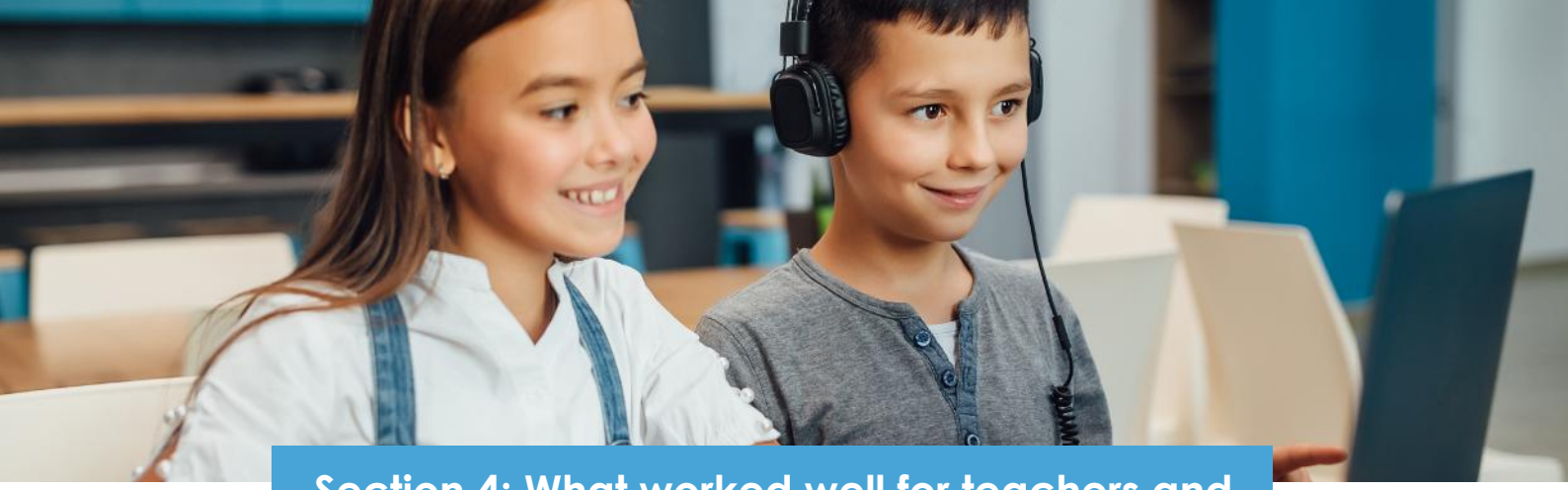


Figure 12. Educational technology solutions used by the respondents to adapt their class to distance teaching (total n = 35,119). Percentages represent the proportion of teachers who employed these solutions either "to some extent" or "a lot".



Section 4: What worked well for teachers and what they suggested as solutions

What worked well according to the teachers? And what could be done to improve their experience? Respondents were asked not only about the problems they experienced, but also about their positive experiences, about what worked rather well during distance teaching (Figure 13). Respondents selected up to 5 options from a list of 12 items. More than half of the STEM teachers agreed that this was an opportunity to update their digital skills (59%), a freedom to discover and experiment with new online education tools and resources (56%) and an opportunity for students to update their digital skills as well (55%).

Interestingly, 40% of teachers did recognise that this period offered them flexibility in organising lessons. This is not a low proportion considering the constraints brought about by the limitations of distance teaching. On the other hand, only 29% of STEM teachers said it worked well to have the freedom to discover and experiment with different pedagogical approaches. Taken together, the period after the outbreak was most of all seen as an opportunity to focus on digital skills and the use of digital educational tools and resources and less about educational skills.

Teachers might have increased their interaction with parents, students and colleagues in this period to better organise distance teaching. However, only 14% saw the improved relationship with parents and students as something that worked well. When it comes to improved relationships with school administrators and colleagues, the proportion drops to 8%. It is not possible to say whether this means that relations did not work well or that relations with parents, students and colleagues were as good as before.

To understand what teachers would suggest as solutions to the problems experienced during the pandemic, respondents were asked to rate 13 solutions (Figure 14). As there were no large differences between teachers from different subjects and between teachers of STEM or other subjects, the whole dataset was pooled. Results

reveal that teachers were highly in favour of all the solutions listed, but two things stood out. First, teachers rated highly the solutions that were related to their students, that is, facilitating student access to suitable devices and better Internet. This is in line with the digital gap experienced during the pandemic, where not all students had suitable infrastructure to keep up with distance learning. Second, teachers were also in favour of solutions that are related to resources specific to distance teaching, such as providing lists of websites with useful resources, providing video clips/lesson plans of good practice, and providing good-quality resources and tools from educational technology companies. The only exception was educational TV programmes, which were at the bottom of the list.

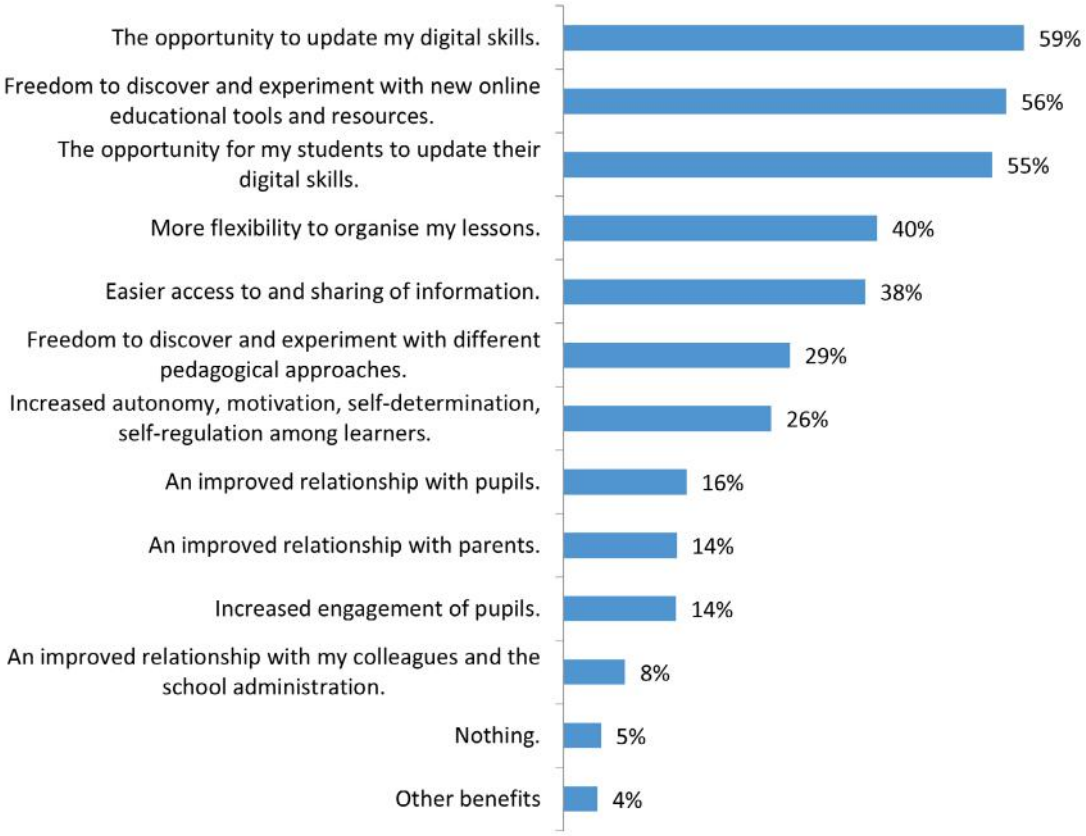


Figure 13. Things that worked well during the online teaching activities imposed by the COVID-19 pandemic outbreak according to STEM teachers (n = 4,865). Respondents were asked to select up to 5 options.

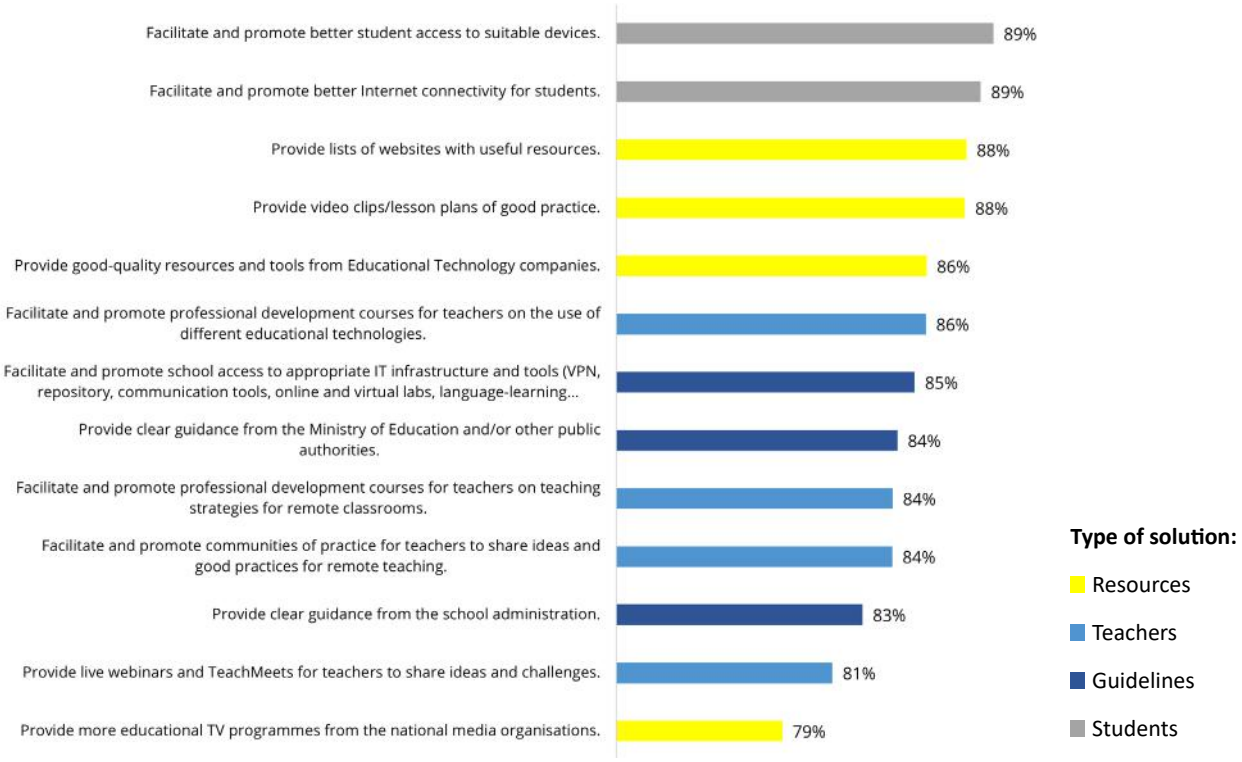


Figure 14. Respondents' suggestions of solutions to improve the quality of distance teaching and learning based on their experience during the COVID-19 pandemic (n = 33,181). The proportions represent respondents who said they would suggest the solution either "to some extent" or "a lot".

Section 5: Predictors of pedagogical practices and solutions

The data reported so far is descriptive except for comparing teachers' practices before and after the outbreak. The survey also aimed to investigate the teachers' characteristics that had an impact on their practices and actions after the outbreak. More specifically, we wanted to know what teacher characteristics were related to more and diverse use of innovative teaching practices, and more and diverse use of pedagogical and educational technology solutions to address problems encountered during distance teaching. Based on a second-level analysis of TALIS 2018 data (Schizzerotto, Bazoli & Burlacu, 2020), we expected that being trained for distance teaching and use of technology would be positively related to innovative practices and the use of more diverse solutions after the outbreak.

To address this question, we conducted three separate multiple regression analyses on respondents' teaching practices, pedagogical solutions and educational technology solutions. This analysis helps to test the relation between the main dependent (e.g., teaching practices) and explanatory factors (e.g., whether the teacher had had training on distance teaching before the outbreak), while controlling for the influence of other explanatory or control variables (e.g., country, age, years of experience). The method is detailed in the section below. Those who are interested in reading about the results can skip this section.

Method

To obtain more standardised measures, we constructed three variables based on the sum of item ratings (Figure 15). Among the 15 teaching practice items, "traditional direct instruction" and "summative assessment" were excluded as they were not considered "student-centred" approaches. The item rating options were recoded to take the following values: "not at all" = 0; "very little" = 1; "to some extent" = 2; "a lot" = 3. These values were added up for the remaining 13 items

to obtain a single score of innovative teaching for each respondent. Therefore, a higher score meant that the teacher was more likely both to use a wider range of practices and to use them more often. As teachers were asked to rate their use of these practices before and after the outbreak (Questions 19 and 25 in the questionnaire), the innovative practices index score was calculated for both before and after.

All 13 pedagogical solution items (in Question 33) and all 13 educational technology solution items (in Question 34) were recoded and summed in the same way to obtain a pedagogical solutions and ICT (i.e., educational technology) solutions index.

Both categorical and continuous variables were used as explanatory variables. We recoded categorical variables to turn them into dichotomous variables or reduce the number of categories. The question whether distance teaching was part of teachers' routine before COVID-19 (Question 6) was converted from a 4-level Likert scale into a dichotomous "high/low" grouping ("a lot/to some extent" vs "very little/not at all"). The same was done for whether educational technologies were part of teachers' routine before COVID-19 (Question 7). For years of experience (Question 4) and subjects taught (Question 13), recoding was done as follows: (1) years of experience were regrouped as "three years or less", "4 – 10 years", "11 – 20 years", "21 years or more"; (2) subjects taught were regrouped as "language/literature", "STEM", "Social sciences", "Primary/pre-primary", "art" and "Other".

Categorical variables were entered as dummy variables into the regression models. This allowed investigating whether there are significant differences between teachers from different categories, by taking one group as a reference to compare with others (e.g., STEM vs other subjects, synchronous vs blended or asynchronous teaching). Respondents who did not answer all the questions used in these analyses were excluded.

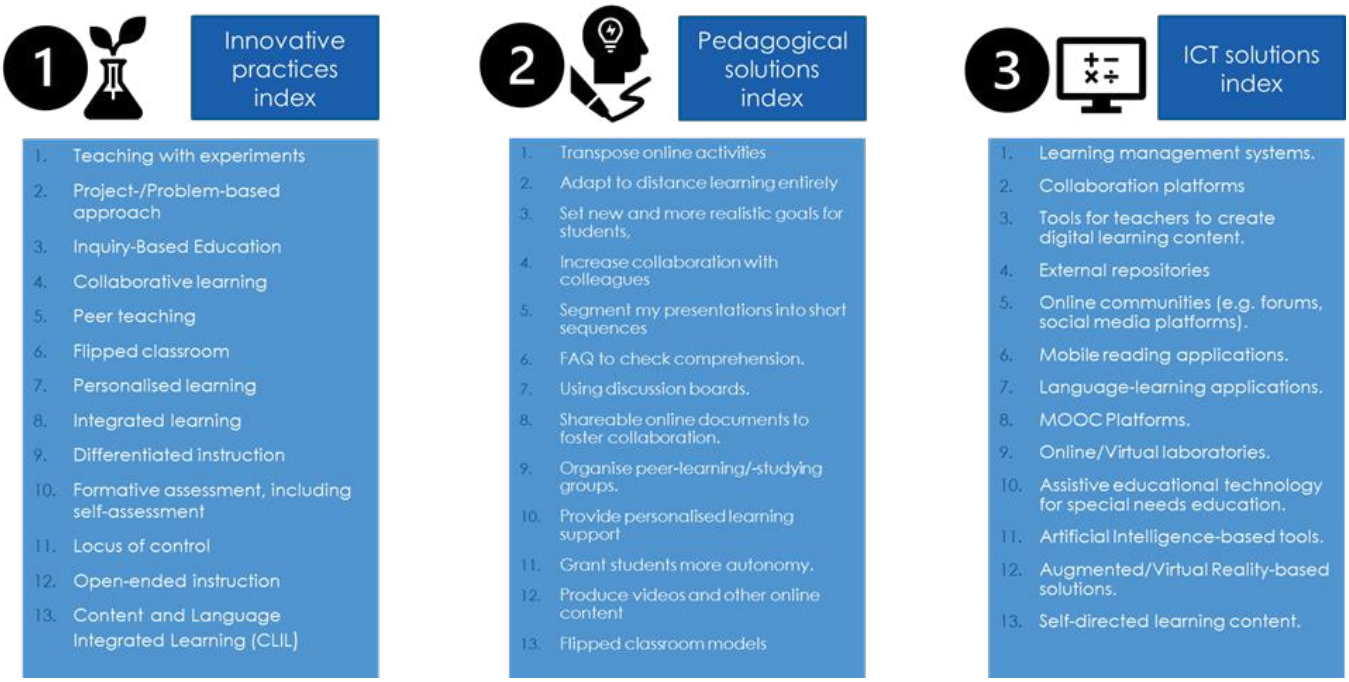


Figure 15. The three constructed variables used for the predictive analyses.

Results

The results reveal several teacher characteristics that had positive or negative relationship with innovative practices and pedagogical and ICT solutions (Table 2). There were some differences based on age and gender: female teachers were slightly less likely to use innovative practices and ICT solutions, but also slightly more likely to use more pedagogical solutions. While teachers with 10 or more years of experience were slightly more likely to use innovative practices, they were also slightly less likely to use ICT solutions. Teachers with 21 or more years of experience were specifically more likely to use more pedagogical solutions during distance teaching.

The results clearly suggest that some teachers were more prepared for distance teaching because of their prior experiences. Not surprisingly, there was a very strong positive relation between innovative practices of teachers before and after the outbreak. Teachers were also more likely to use more innovative practices, pedagogical solutions and ICT solutions if distance teaching was already part of their pre-COVID routine and if they had participated in training on distance teaching. Similarly, teachers who used educational technologies regularly before the outbreak were also more likely to use pedagogical solutions and ICT solutions after the outbreak, but not more likely to implement innovative practices.

Regarding subjects taught, STEM subject teachers seemed overall less likely to use innovative practices after the outbreak but more likely to

use educational technology solutions (except for language/literature teachers who were slightly more likely than STEM teachers to use these solutions). Regarding pedagogical solutions, STEM teachers did not seem to differ from others except for doing slightly better than pre-primary/primary subject teachers. Language/literature teachers were also slightly more likely to use pedagogical solutions compared to STEM teachers during distance teaching.

Finally, asynchronous teaching was negatively associated with innovative practices and more strongly with pedagogical and ICT solutions. This could be due to solutions also requiring direct interaction between teachers and students. Blended learning seemed to be associated with more innovative practices compared to synchronous learning, suggesting that the flexibility of blended teaching allowed for a slightly more diverse set of practices.

Table 2 Factors associated with the use of innovative practices, pedagogical solutions and educational technology (ICT) solutions after the COVID-19 outbreak. The plus symbol (+) indicates a positive relationship and the minus symbol (-) indicates a negative relationship between the factor (rows) and the explained variable (columns). The number of symbols indicates the size of the effect: +/- = small effect; ++/-- = moderate effect; +++. The table is based on the beta coefficients from the multiple regression models. The table of coefficients can be found in Appendix 1.

	Innovative practices index	Pedagogical solutions index	ICT solutions index
Female	-	+	-
Teaching experience +21 years (vs 1-3 years)	+	++	-
Teaching experience 10-20 years (vs 1-3 years)	+		-
10-4 years (vs 1-3 years)	+		
Distance teaching part of routine before COVID	++	++	++
Use of ed. tech. part of routine before COVID		++	++
Training on distance teaching before COVID	++	++	++
Language/literature (vs STEM)	++	+	+
Social sciences (vs STEM)	+		--
Art (vs STEM)	++		--
Pre-primary/primary (vs STEM)	+	-	--
Other (vs STEM)	+		--
Blended (vs synchronous)	+		
Asynchronous (vs synchronous)	-	--	--
Innovative practices before COVID	+++	+++	+++

Conclusions

The current survey investigated teachers' perspective and practices during distance teaching after the COVID-19 pandemic outbreak, and how their practices were impacted by it. Teachers faced the big challenge of urgently switching to distance teaching. The survey clearly shows that, at least in the first year of the pandemic, being prepared was important. Teachers who practised distance teaching, who were trained to do distance teaching and who used educational technologies before the pandemic, were also more likely to use a larger and more diverse set of teaching practices and solutions during distance teaching after the outbreak.

The pandemic did not have a transforming effect on teachers' teaching practices in the first year. Overall, more innovative, student-centred teaching practices seem to have decreased in diversity and frequency during distance teaching. It remains to be seen if teachers have been diversifying their practices in the second year of the pandemic. The transformation might have happened in the second year of the pandemic, and more likely regarding the use of educational technologies.

Teachers in STEM subjects had the particular challenge of adapting their practical lessons to distance teaching. At least half of the STEM teachers reported lack of suitable software to teach the subject matter (e.g., online and virtual labs) and lack of IT equipment. Nearly a quarter of STEM teachers reported not being able to carry out practical work and nearly another quarter reported having to demonstrate the practical work themselves. Another quarter of STEM teachers had to simplify the practical work they originally planned.

Teacher demographics were to some extent influential in their use of pedagogical practices and educational technology (i.e., ICT) solutions. Female teachers were slightly less likely to use ICT solutions during distance teaching. However, this could be a matter of confidence in their skills

rather than their skill level, as seen in international surveys (e.g., ICILS, 2018). Teachers with more experience were more likely to implement more pedagogical practices and use more pedagogical solutions, which might be due to experience and confidence in their skills. On the other hand, teachers with more than 20 years of experience were less likely to use educational technology solutions during distance teaching. Schools can try to target teachers' existing habits to encourage them to adapt new practices (e.g., Kotter & Schlesinger, 1979).

Teachers' suggestions for improvement mostly related to improving students' digital skills and digital infrastructure. This is understandable because teachers had less control over the tools that their students had access to at home and less control over whether they had the skills to use them effectively. This concern of teachers is also echoed in the Dutch survey conducted in secondary education (Smeets, 2021a), where teachers suggested that there was a digital divide between students from low- and high-income families and that students needed more digital skills in general (regarding the digital divide and income, see also Fraillon et al. 2020). Respondents in the current survey also suggested that parents needed to be trained in digital skills which would enable them to support their children further (Carretero et al., 2021).

A positive impact of the pandemic could be that teachers and students had the opportunity, even if under pressure, to develop their digital skills. Enhancing their own and their students' digital skills and experimenting with new tools and resources were things that worked best according to the teachers participating in the survey. Another positive impact of the outbreak might be the increased involvement of parents. Parents were much more involved in their children's daily education and more in contact with teachers. This might also be thanks to countries encouraging more interaction between teachers and families, either nationally or at the discretion of the local school administration (OECD, 2021a). The Dutch survey conducted by Kennisnet indicates that the support of parents was especially beneficial for primary school students (Smeets, 2021b). These collaborations might persist after the first years of the outbreak and beyond, promoting more dialogue and collaboration between parents and other education stakeholders.

Many teachers were already familiar with using different educational technology tools and solutions which helped them rise to the challenge of distance teaching. However, many teachers also suggested that they should be provided with good-quality resources and tools. It is likely that

teachers made the decision to pick tools and resources based on their preferences. If schools provide teachers with school-wide platforms, this can prevent confusion for students having to use several digital platforms depending on the class (Engelhardt, 2021), facilitate the exchange of resources and experience between teachers and provide a safe digital environment to teachers and students.

National surveys suggest that regardless of schools' support, teachers have been adapting better to the use of educational technologies in distance teaching since the first year of the pandemic. This is illustrated by INDIRE's surveys conducted in spring 2020 and later in 2021. Compared to the first survey, many more teachers reported using all-in-one solutions (INDIRE, 2021). More international surveys are needed to understand how teachers' practices have changed since the outbreak. The results of the current survey offer valuable insights about teachers' pedagogical practices and coping strategies during distance teaching after the outbreak, as well as what worked well and what could be improved from their perspective. It is important to understand better what teachers experienced in this extraordinary situation so as to draw lessons from it. More surveys such as this one will be needed to understand the evolution of teachers' practices from the start to the end of the pandemic. This understanding can help policy makers predict better the future of education after the pandemic as well as plan their actions better by taking teachers' perspective into account more accurately, not just for future waves of the current pandemic, but for any challenge that can impact on education systems globally.

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Appendix 1 – Beta coefficients from the multiple regression models

	Innovative practices index (Q25)[a]	Pedagogical solutions index (Q33)[a]	ICT solutions index (Q34)[a]
Gender (Q3)			
Female	-0.092***	0.089***	-0.091***
Male (reference)	0	0	0
Teaching experience (Q4)			
21 years or more	0.074***	0.122***	-0.094***
11-20 years	0.028*	0.06	-0.036*
4-10 years	-0.024*	0.002	-0.015
3 years or less (ref.)	0	0	0
Distance teaching part of routine before COVID (Q6)			
A lot/to some extent	0.17***	0.174***	0.246***
Very little/not at all (ref.)	0	0	0
Use of ed. tech part of routine before COVID (Q7)			
A lot/to some extent	-0.001	0.124***	0.158***
Very little/not at all (ref.)	0	0	0
Training on distance teaching before COVID (Q8)			
Yes	0.114***	0.148***	0.276***
No (ref.)	0	0	0
Subject (Q13)			
Language/literature	0.114***	0.066***	0.038**
Social sciences	0.089***	-0.008	-0.148***
Art	0.12***	-0.043	-0.209***
Pre-primary/primary	0.022*	-0.091***	-0.155***
Other	0.071***	-0.023	-0.119***
STEM (ref.)	0	0	0
Teaching mode (Q21)			
Blended	0.019*	0.017	0.036***
Asynchronous	-0.088***	-0.226***	-0.163***
Synchronous (ref.)	0	0	0
Innovative practices before COVID (Q19)	0.650***	0.497***	0.431***
Sample size (total)	38576	35054	35054

[a]The three indexes were converted to standardised (Z) scores. Therefore, the value of the beta coefficients enables us to judge the size of the effect: values below 0.1 are considered small, 0.1 to 0.4 moderate, and above 0.4 large. Significance levels: * $p < .05$; ** $p < .01$; *** $p < .001$.

Country was also included as a variable in the model to control for its effect.

Appendix 2 – Survey questions

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Teachers practices and use of educational technologies during the COVID-19 pandemic

1. Objective of the study

The present questionnaire is addressed to teachers in primary and secondary education (students aged 3 to 21). It aims to collect information on the educational technologies you used in the weeks that followed the outbreak of the COVID-19 pandemic, the problems you encountered, the solution you adopted, and the recommendations you may wish to share.

Sharing your experience is crucial to identifying common problems and good practices. For this reason, please answer this short questionnaire and provide feedback for one of the classes you taught during the 2019-2020 school year. By class, we mean the specific group of students who attend a specific lesson.

If, during the reference period – i.e. the 2019-2020 school year – you taught more than one class, at the end of the survey you will have the option of providing information about one additional class, by revisiting just a few class-specific questions of the survey.

Participating in this survey should require no more than 25 minutes.

This survey has received funding from the European Union's H2020 research and innovation programme – project Scientix 4 (Grant Agreement N. 101000063), coordinated by European Schoolnet (EUN), the STEM Alliance and the Amgen Foundation, through the Amgen Teach project. The content of the document is the sole responsibility of the organizer and it does not represent the opinion of the European Commission (EC), Amgen Foundation or the STEM Alliance partners, and the EC, Amgen Foundation or the STEM Alliance partners are not responsible for any use that might be made of information contained.

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Teachers practices and use of educational technologies during the COVID-19 pandemic

2. Respondent's background information

* 1. Please indicate the country in which you taught during the 2019-2020 school year:

* 2. Please indicate your age by selecting one of the following age groups:

- 30 or under
- 31-35
- 36-45
- 46-55
- Over 55

* 3. Are you:

- Male
- Female

* 4. Excluding the 2020-2021 school year, how long have you been teaching (at any school)?

- Less than 1 year
- 1-3 years
- 4-10 years
- 11-20 years
- 21-30 years
- 31-40 years
- More than 40 years

* 5. At what level of education did you teach during the 2019-2020 school year?

- [ ] Early years education
- [ ] Primary education
- [ ] Lower secondary education
- [ ] Upper secondary education
- [ ] Vocational education

* 6. To what extent was distance teaching part of your teaching routine before the outbreak of the COVID-19 pandemic?

- Not at all
- Very little
- To some extent
- A lot

* 7. To what extent did you use educational technologies (i.e. Personal Computers, laptops, mobile phones, video conferencing systems, software, online educational resources, etc.) in your classes before the outbreak of the COVID-19 pandemic?

- Not at all
- Very little
- To some extent
- A lot

* 8. Did you follow any training course related to distance learning in the 12 months that preceded the outbreak of the COVID-19 pandemic in the country where you were teaching?

- Yes
- No

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3. Respondent's background information

* 9. Please indicate how long before the outbreak of the COVID-19 pandemic you followed the last course on distance learning.

- ○ Right before the outbreak of the COVID-19 pandemic
- ○ One month before the outbreak of the COVID-19 pandemic
- ○ Two months before the outbreak of the COVID-19 pandemic
- ○ Three months or more before the outbreak of the COVID-19 pandemic

* 10. Please indicate who provided the last course on distance learning you followed before the outbreak of the COVID-19 pandemic.

- ○ The Ministry of Education
- ○ The regional/local authority
- ○ The school
- ○ Other (please specify)

* 11. Please indicate in which format the last training course on distance learning you followed was conducted.

- ○ Online
- ○ Face-to-face
- ○ Blended (i.e. partly online, partly face-to-face)

* 12. Please indicate how many hours of training related to distance learning you followed in total in the 12 months that preceded the outbreak of the COVID-19 pandemic?

- ○ 2 or less
- ○ 3 to 4
- ○ 5 to 6
- ○ 7 to 9
- ○ 10 or more

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4. Class-specific information

Please always refer to the same class when answering class-related questions.

* 13. What was the subject taught?

Please note that the exact name of your subject may not appear in the list below. If it does not, please mark the category you think best fits the subject.

- All areas of the pre-primary/primary curriculum
- Reading, writing and literature
  Includes reading and writing (and literature) in the mother tongue, reading and writing (and literature) in the language of instruction, reading and writing in the tongue of the country (region) as a second language (for non-natives), language studies, public speaking, literature.
- Mathematics
  Includes mathematics, mathematics with statistics, geometry, algebra, etc.
- Science
  Includes science, physics, physical science, chemistry, biology, human biology, environmental science, agriculture/horticulture/forestry.
- Social studies
  Includes social studies, community studies, contemporary studies, economics, environmental studies, geography, history, humanities, legal studies, studies of own country, social sciences, ethical thinking, philosophy.
- Modern foreign languages
  Includes languages different from the language of instruction.
- Other (please specify)
- Technology
  Includes orientation in technology, including information technology, computer studies, construction/surveying, electronics, graphics and design, keyboard skills, word processing, workshop technology / design technology.
- Arts
  Includes arts, music, visual arts, practical art, drama, performance music, photography, drawing, creative handicraft, creative needlework.
- Physical education
  Includes physical education, gymnastics, dance, health.
- Religion and/or ethics
  Includes religion, history of religions, religious culture, ethics.
- Practical and vocational skills
  Includes vocational skills (preparation for a specific occupation), domestic science, accountancy, business studies, career education, clothing and textiles, driving, home economics, polytechnical courses, secretarial studies, tourism and hospitality, handicraft.

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5. Class-specific information

Please always refer to the same class when answering class-related questions.

* 14. Could you please specify what STEM subject you taught in the class you are providing information about?

Please tick the option that best suits your class.

- ○ Mathematics
- ○ Statistics
- ○ Geometry
- ○ Algebra
- ○ Science
- ○ Physics
- ○ Physical science
- ○ Chemistry
- ○ Biology
- ○ Human biology
- ○ Other (please specify)
- ○ Environmental science
- ○ Agriculture/Horticulture/Forestry
- ○ Technology
- ○ Information technology/Computer studies
- ○ Construction/surveying
- ○ Electronics
- ○ Graphics and design
- ○ Keyboard skills
- ○ Word processing
- ○ Design technology

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6. Class-specific information

Please always refer to the same class when answering class-related questions.

* 15. How old were the students?

- ◯ 3 – 5
- ◯ 6 – 9
- ◯ 10 – 12
- ◯ 13 – 15
- ◯ 16 – 19
- ◯ 20 and over

* 16. How many students were there in the class?

- ◯ 1-5
- ◯ 6-10
- ◯ 11-15
- ◯ 16-20
- ◯ 21-25
- ◯ >25

* 17. How many teaching hours per week did you teach this class for?

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5 or more

* 18. How long is one teaching hour in the school where you taught the class you are providing information about?

- ◯ 60 minutes
- ◯ 55 minutes
- ◯ 50 minutes
- ◯ 45 minutes
- ◯ 40 minutes
- ◯ Other (please specify)

* 19. Please describe your normal pedagogical practice (i.e. pre-COVID-19 pandemic outbreak) by selecting to what extent you intended to use each of the approaches presented here below before school closure.

	Not at all	Very little	To some extent	A lot
Traditional direct instruction (lessons are focused on the delivery of content by the teacher and the acquisition of content knowledge by the students).				
Teaching with experiments (experiments are used in the classroom to explain the subject matter, e.g. students work in groups on carefully designed guided inquiry questions. Through the collection of observations, they try to answer the research question or solve a problem).				
Project-/Problem-based approach (students are engaged in learning through investigation of real-world challenges and problems).				
Inquiry-Based Education (students design and conduct their own investigations).				
Collaborative learning (students are involved in joint intellectual efforts with their peers or with their teachers and peers).				
Peer teaching (students are provided with opportunities to teach other students).				
Flipped classroom (students gain their first exposure to new material outside of class, and then use classroom time to discuss, challenge and apply ideas or knowledge).				
Personalised learning (teaching and learning are tailored to meet students' individual interests and aspirations as well as their learning needs).				
Integrated learning (learning brings together content and skills from more than one subject area).				
Differentiated instruction (classroom activities are designed to address a range of learning styles, abilities and readiness).				
Summative assessment (student learning is evaluated at the end of an instructional unit and compared with a benchmark or standard).				
Formative assessment, including self-assessment (student learning is constantly monitored, and ongoing feedback is provided; students are provided with opportunities to reflect on their own learning).				
Locus of control (meaningful opportunities are provided for students to choose elements of programme content, the medium in which they wish to work, and/or to go deeper into a chosen issue).				
Open-ended instruction (lessons are structured so that multiple/complex answers are possible: students are not simply steered toward one "right" answer).				
Content and Language Integrated Learning (CLIL) (lessons are taught through an additional language, i.e. both the subject and the language are taught at the same time).				

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7. Problems caused by the outbreak of the COVID-19 pandemic

Please always refer to the same class when answering class-related questions.

* 20. For how long did your class shift to (emergency) distance teaching due to the outbreak of the COVID-19 pandemic?

- ◯ Not at all
- ◯ 1 month or less
- ◯ 2 months
- ◯ 3 months
- ◯ 4 months
- ◯ 5 months or more

* 21. Which of the following was your practice in switching from face-to-face to online teaching (i.e. teaching at a distance via Information and Communication Technologies)?

- ◯ Synchronous teaching, i.e. teaching mostly happened through real-time interaction with the students
- ◯ Asynchronous teaching, i.e. teaching mostly happened without real-time interaction with the students
- ◯ Blended approach, i.e. teaching happened in equal shares with and without real-time interaction with the students

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8. Problems caused by the outbreak of the COVID-19 pandemic

Please always refer to the same class when answering class-related questions.

* 22. Overall, was one hour of online teaching shorter than the usual teaching hour?

- ○ Yes
- ○ No

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9. Problems caused by the outbreak of the COVID-19 pandemic

Please always refer to the same class when answering class related questions

* 23. How long would a teaching hour last while teaching online the class you are providing information about?

- 55 minutes
- 50 minutes
- 45 minutes
- 40 minutes
- 35 minutes
- 30 minutes
- Other (please specify)

24. Due to the outbreak of the COVID-19 pandemic, to what extent were you forced to modify the original mix of pedagogical approaches you usually employ for this class?

- Not at all
- Very little
- To some extent
- A lot

* 25. Please describe your pedagogical practice during the COVID-19 pandemic outbreak by selecting to what extent you used each of the approaches presented here below.

	Not at all	Very little	To some extent	A lot
Traditional direct instruction (lessons are focused on the delivery of content by the teacher and the acquisition of content knowledge by the students).				
Teaching with experiments (experiments are used in the classroom to explain the subject matter, e.g. students work in groups on carefully designed guided inquiry questions. Through the collection of observations, they try to answer the research question or solve a problem).				
Project-/Problem-based approach (students are engaged in learning through the investigation of real-world challenges and problems).				
Inquiry-Based Education (students design and conduct their own investigations).				
Collaborative learning (students are involved in joint intellectual efforts with their peers or with their teachers and peers).				
Peer teaching (students are provided with opportunities to teach other students).				
Flipped classroom (students gain the first exposure to new material outside of class, and then use classroom time to discuss, challenge and apply ideas or knowledge).				
Personalised learning (teaching and learning are tailored to meet students' individual interests and aspirations as well as their learning needs).				
Integrated learning (learning brings together content and skills from more than one subject area).				
Differentiated instruction (classroom activities are designed to address a range of learning styles, abilities and readiness).				
Summative assessment (student learning is evaluated at the end of an instructional unit and compared with a benchmark or standard).				
Formative assessment, including self-assessment (student learning is constantly monitored, and ongoing feedback is provided; students are provided with opportunities to reflect on their own learning).				
Locus of control (meaningful opportunities are provided for students to choose elements of programme content, the medium in which they wish to work, and/or to go deeper into a chosen issue).				
Open-ended instruction (lessons are structured so that multiple/complex answers are possible: students are not simply steered toward one "right" answer).				
Content and Language Integrated Learning (CLIL) (lessons are taught through an additional language, i.e. both the subject and the language are taught at the same time).				

* 26. To what extent did you experience the following problems in switching from face-to-face to online teaching?

	Not at all	Very little	To some extent	A lot
Lack of suitable IT equipment (hardware and/or software) to communicate with the students satisfactorily, e.g. PC, Tablet, laptop, videoconferencing software, etc.	○	○	○	○
Lack of suitable IT equipment (hardware and/or software) to assess students' homework satisfactorily, e.g. PC, Tablet, laptop, appropriate software, etc.	○	○	○	○
Lack of suitable software to effectively teach the subject matter, e.g. online and virtual labs, language-learning applications, AR/VR-based tools for knowledge acquisition, online resources, etc.	○	○	○	○
Difficulty in accessing public national and/or local platforms with learning resources recommended by public authorities.	○	○	○	○
Students' lack of suitable IT equipment (hardware and/or software) to carry out assignments, e.g. PC, laptop, tablet, appropriate software, etc.	○	○	○	○
Students' lack of a suitable Internet connection.	○	○	○	○
Personal lack of a suitable Internet connection.	○	○	○	○
Lack of purpose-built educational tools which grant students' and teachers' personal data protection.	○	○	○	○
Personal lack of digital competences.	○	○	○	○
Students' lack of digital competences.	○	○	○	○
Parents' lack of digital competences.	○	○	○	○
Difficulty of adapting my usual pedagogical approach to distance learning.	○	○	○	○
Difficulty of engaging and maintaining students' attention during online classes.	○	○	○	○
Students' difficulty in managing the prescribed learning activities.	○	○	○	○
Lack of a suitable pedagogical approach to evaluate and assess students from distance.	○	○	○	○
Lack of access to curriculum-relevant online teaching resources.	○	○	○	○
Lack of educational solutions for learners with special needs.	○	○	○	○
Low accessibility of resources for learners with special needs.	○	○	○	○
Difficulty of providing a personalised learning experience.	○	○	○	○

* 27. Because of switching from face-to-face to online teaching, did you need to increase your interaction with parents?

- ○ Not at all
- ○ Very little
- ○ To some extent
- ○ A lot

* 28. Because of switching from face-to-face to online teaching, did parents need to increase their involvement in your students' learning experience?

- Yes
- No

* 29. To what extent did parents increase their involvement in your students' learning experience due to the new distance learning setting?

- Not at all
- Very little
- To some extent
- A lot

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10. School's readiness for online teaching

* 30. At the outbreak of the COVID-19 pandemic, to what extent was the school technologically ready to switch to online teaching?

- ◯ Not at all
- ◯ Very little
- ◯ To some extent
- ◯ Totally

* 31. Did the school provide you and/or your students with IT support?

- ◯ Yes
- ◯ No

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11. School readiness to online teaching

* 32. Which of the following solutions did the school provide you and/or your students with? Please select all those that apply

- [ ] Information about free of charge IT tools and infrastructure (VPN, repository, communication tools, online and virtual labs, language-learning applications, AR/VR based tools for knowledge acquisition, etc.)
- [ ] Access to appropriate not-free-of-charge IT tools and infrastructure (VPN, repository, communication tools, online and virtual labs, language-learning applications, AR/VR based tools for knowledge acquisition, etc.)
- [ ] Clear instruction on how to use the available IT tools and infrastructure.
- [ ] Support and follow-up on the use of the available IT tools and infrastructure.
- [ ] Teacher-oriented training courses on how to use the available IT tools and infrastructure.
- [ ] Student/parent-oriented training courses on how to use the available IT tools and infrastructure.
- [ ] Training courses on distance learning methodologies.
- [ ] Access to teachers' communities.
- [ ] Creation of specific online group pages.
- [ ] Other (please specify)

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12. Solutions adopted to ensure educational continuity

Please always refer to the same class when answering class-related questions.

* 33. To what extent did you use each of the following pedagogical solutions to adapt your class to online teaching?

	Not at all	Very little	To some extent	A lot
Transpose online activities originally designed for learning within the classroom.	○	○	○	○
Adapt the entire pedagogical approach to distance learning.	○	○	○	○
Set new and more realistic goals for my students, given the exceptional circumstances.	○	○	○	○
Increase collaboration with other teachers to provide students with a more coherent learning experience.	○	○	○	○
Segment my presentations into short sequences to enhance students' engagement.	○	○	○	○
Frequently ask questions to check students' comprehension.	○	○	○	○
Foster student collaboration by using discussion boards.	○	○	○	○
Design assignments using shareable online documents to foster students' collaboration in small groups.	○	○	○	○
Organise peer-learning/-studying groups.	○	○	○	○
Provide personalised learning support to specific groups of students, i.e. organise one-to-one online sessions with more vulnerable groups of students.	○	○	○	○
Grant students more autonomy.	○	○	○	○
Produce videos and other online content for students.	○	○	○	○
Develop flipped classroom models.	○	○	○	○

* 34. To what extent did you use each of the following educational technology solutions to adapt your class to online teaching?

	Not at all	Very little	To some extent	A lot
Digital learning management systems.				
Collaboration platforms that support live video communication.				
Tools for teachers to create digital learning content.				
External repositories of distance learning solutions.				
Online communities (e.g. forums, social media platforms).				
Mobile reading applications.				
Language-learning applications.				
Massive Open Online Course (MOOC) Platforms.				
Online/Virtual laboratories.				
Assistive educational technology for special needs education.				
Artificial Intelligence-based tools.				
Augmented/Virtual Reality-based solutions.				
Self-directed learning content.				

* 35. Following the outbreak of the COVID-19 pandemic, how did you carry on/replace the practical work originally planned?

- Not applicable, as no practical work was originally planned.
- Students conducted practical work at a distance using online laboratories.
- Practical work had to be simplified or replaced, for students to be able to do it at home and using everyday materials.
- Practical work was demonstrated at distance, synchronously or asynchronously, by the teacher.
- Unfortunately, no practical work could take place.
- Other (please specify)

36. Please mention all the online laboratories or dedicated STEM-related repositories that you used in order to adapt your class and adjust the practical work to distance teaching.

37. Please mention all the technological tools (e.g. Teams, Zoom, WhatsApp, BigBlueButton, ClassDojo, EkStep, Google Classroom, Moodle, Schoology, Skooler, Go-Lab, Gmail, etc.) that you used to adapt your class to online teaching.

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13. Suggestions for a better distance teaching and learning experience

* 38. In your experience, what worked well during the online teaching activities imposed by the COVID-19 pandemic outbreak? Please select up to five options.

- [ ] More flexibility to organise my lessons.
- [ ] Increased engagement of pupils.
- [ ] Increased autonomy, motivation, self-determination, self-regulation among learners.
- [ ] Freedom to discover and experiment with new online educational tools and resources.
- [ ] Freedom to discover and experiment with different pedagogical approaches.
- [ ] Easier access to and sharing of information.
- [ ] The opportunity to update my digital skills.
- [ ] The opportunity for my students to update their digital skills.
- [ ] An improved relationship with pupils.
- [ ] An improved relationship with parents.
- [ ] An improved relationship with my colleagues and the school administration.
- [ ] Other benefits (not mentioned above).
- [ ] Nothing.

* 39. Based on your experience during the COVID-19 pandemic outbreak, to what extent would you suggest the following solutions to improve the quality of distance teaching and learning?

	Not at all	Very little	To some extent	A lot	Do not know
Facilitate and promote professional development courses for teachers on teaching strategies for remote classrooms.	○	○	○	○	○
Facilitate and promote professional development courses for teachers on the use of different educational technologies.	○	○	○	○	○
Facilitate and promote better student access to suitable devices.	○	○	○	○	○
Facilitate and promote better Internet connectivity for students.	○	○	○	○	○
Facilitate and promote school access to appropriate IT infrastructure and tools (VPN, repository, communication tools, online and virtual labs, language-learning applications, AR/VR based tools for knowledge acquisition, etc.)	○	○	○	○	○
Provide clear guidance from the Ministry of Education and/or other public authorities.	○	○	○	○	○
Provide clear guidance from the school administration.	○	○	○	○	○
Provide lists of websites with useful resources.	○	○	○	○	○
Provide video clips/lesson plans of good practice.	○	○	○	○	○
Provide Live Webinars and TeachMeets for teachers to share ideas and challenges.	○	○	○	○	○
Provide more educational TV programmes from the national media organisations.	○	○	○	○	○
Provide good-quality resources and tools from Education Technology companies.	○	○	○	○	○
Facilitate and promote communities of practice for teachers to share ideas and good practices for remote teaching.	○	○	○	○	○

* 40. Would you like to provide information about one more class you taught during the 2019-2020 school year, when the COVID-19 crisis broke out?

- ○ Yes
- ○ No
- ○ Not applicable

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14. Information about one additional class

Please always refer to the same class when answering class-related questions .

* 41. What was the subject taught?

Please note that the exact name of your subject may not appear in the list below. If it does not, please mark the category you think best fits the subject.

- All areas of the pre-primary/primary curriculum
- Reading, writing and literature
  Includes reading and writing (and literature) in the mother tongue, reading and writing (and literature) in the language of instruction, reading and writing in the tongue of the country (region) as a second language (for non-natives), language studies, public speaking, literature.
- Mathematics
  Includes mathematics, mathematics with statistics, geometry, algebra, etc.
- Science
  Includes science, physics, physical science, chemistry, biology, human biology, environmental science, agriculture/horticulture/forestry.
- Social studies
  Includes social studies, community studies, contemporary studies, economics, environmental studies, geography, history, humanities, legal studies, studies of own country, social sciences, ethical thinking, philosophy.
- Modern foreign languages
  Includes languages different from the language of instruction.
- Other (please specify)
- Technology
  Includes orientation in technology, including information technology, computer studies, construction/surveying, electronics, graphics and design, keyboard skills, word processing, workshop technology / design technology.
- Arts
  Includes arts, music, visual arts, practical art, drama, performance music, photography, drawing, creative handicraft, creative needlework.
- Physical education
  Includes physical education, gymnastics, dance, health.
- Religion and/or ethics
  Includes religion, history of religions, religious culture, ethics.
- Practical and vocational skills
  Includes vocational skills (preparation for a specific occupation), domestic science, accountancy, business studies, career education, clothing and textiles, driving, home economics, polytechnical courses, secretarial studies, tourism and hospitality, handicraft.

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15. Information about one additional class

Please always refer to the same class when answering class-related questions.

* 42. Could you please specify what STEM subject you taught in the class you are providing information about?

Please tick the option that best suits your class.

- ◯ Mathematics
- ◯ Statistics
- ◯ Geometry
- ◯ Algebra
- ◯ Science
- ◯ Physics
- ◯ Physical science
- ◯ Chemistry
- ◯ Biology
- ◯ Human biology
- ◯ Environmental science
- ◯ Agriculture/Horticulture/Forestry
- ◯ Technology
- ◯ Information technology/Computer studies
- ◯ Construction/surveying
- ◯ Electronics
- ◯ Graphics and design
- ◯ Keyboard skills
- ◯ Word processing
- ◯ Design technology
- ◯ Other (please specify)

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16. Information about one additional class

Please always refer to the same class when answering class-related questions.

* 43. How old were the students?

- 3 – 5
- 6 – 9
- 10 – 12
- 13 – 15
- 16 – 19

* 44. How many students were there in the class?

- 1-5
- 6-10
- 11-15
- 16-20
- 21-25
- >25

* 45. How many teaching hours per week did you teach this class for?

- 1
- 2
- 3
- 4
- 5 or more

* 46. For how long did your class shift to (emergency) distance teaching due to the outbreak of the COVID-19 pandemic?

- Not at all
- 1 month or less
- 2 months
- 3 months
- 4 months
- 5 months or more

* 47. Which of the following was your practice in switching from face-to-face to online teaching (i.e. teaching at distance via Information and Communication Technologies)?

- Synchronous teaching, i.e. teaching mostly happened through real-time interaction with the students
- Asynchronous teaching, i.e. teaching mostly happened without real-time interaction with the students
- Blended approach, i.e. teaching happened in equal shares with and without real-time interaction with the students

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17. Information about one additional class

Please always refer to the same class when answering class-related questions.

* 48. Overall, was one hour of online teaching shorter than the usual teaching hour?

- Yes
- No

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18. Information about one additional class

Please always refer to the same class when answering class-related questions.

* 49. How long would a teaching hour last while teaching online the class you are providing information about?

- ○ 55 minutes
- ○ 50 minutes
- ○ 45 minutes
- ○ 40 minutes
- ○ 35 minutes
- ○ 30 minutes
- ○ Other (please specify)

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19. Information about one additional class

Please always refer to the same class when answering class-related questions.

* 50. Due to the outbreak of the COVID-19 pandemic, to what extent were you forced to modify the original mix of pedagogical approaches you usually employ for this class?

- ◯ Not at all
- ◯ Very little
- ◯ To some extent
- ◯ A lot

* 51. To what extent did you use each of the following pedagogical solutions to adapt your class to online teaching?

	Not at all	Very little	To some extent	A lot
Transpose online activities originally designed for learning within the classroom.	◯	◯	◯	◯
Adapt the entire pedagogical approach to distance learning.	◯	◯	◯	◯
Set new and more realistic goals for my students, given the exceptional circumstances.	◯	◯	◯	◯
Increase collaboration with other teachers to provide students with a more coherent learning experience.	◯	◯	◯	◯
Segment my presentations into short sequences to enhance students' engagement.	◯	◯	◯	◯
Frequently ask questions to check students' comprehension.	◯	◯	◯	◯
Foster student collaboration by using discussion boards.	◯	◯	◯	◯
Design assignments using shareable online documents to foster students' collaboration in small groups.	◯	◯	◯	◯
Organise peer-learning/-studying groups.	◯	◯	◯	◯
Provide personalised learning support to specific groups of students i.e. organise one-to-one online sessions with more vulnerable groups of students.	◯	◯	◯	◯
Grant students more autonomy.	◯	◯	◯	◯
Produce videos and other online content for students.	◯	◯	◯	◯
Develop flipped classroom models.	◯	◯	◯	◯

* 52. To what extent did you use each of the following educational technology solutions to adapt your class to online teaching extent?

	Not at all	Very little	To some extent	A lot
Digital learning management systems.				
Collaboration platforms that support live video communication.				
Tools for teachers to create digital learning content.				
External repositories of distance learning solutions.				
Online communities (e.g. forums, social media platforms).				
Mobile reading applications.				
Language-learning applications.				
Massive Open Online Course (MOOC) Platforms.				
Online/Virtual laboratories.				
Assistive educational technology for special needs education.				
Artificial Intelligence-based tools.				
Augmented/Virtual Reality based solutions.				
Self-directed learning content.				

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20. Information about one additional class

Please always refer to the same class when answering class-related questions.

* 53. Following the outbreak of the COVID-19 pandemic, how did you carry on/replace the practical work originally planned?

- ( ) Not applicable, as no practical work was originally planned.
- ( ) Students conducted practical work at a distance using online laboratories.
- ( ) Practical work had to be simplified or replaced, for students to be able to do it at home and using everyday materials.
- ( ) Practical work was demonstrated at a distance, synchronously or asynchronously, by the teacher.
- ( ) Unfortunately, no practical work could take place.
- ( ) Other (please specify)

54. Please mention all the online laboratories or dedicated STEM related repositories that you used in order to adapt your class and adjust the practical work to distance teaching.

55. Please mention all the technological tools (e.g. Teams, Zoom, WhatsApp, BigBlueButton, ClassDojo, EkStep, Google Classroom, Moodle, Schoology, Skooler, Go-Lab, Gmail, etc.) that you used to adapt your class to online teaching.

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