K-12 Teacher's Appropriation of Digital Technologies and Innovative Instruction Across EU: A Scoping Review

Leonidas Chalkiadakis
Universitat Autònoma de Barcelona, Spain, *1574642@uab.cat*

Ingrid Noguera
Universitat Autònoma de Barcelona, Spain, *ingrid.noguera@uab.cat*

The K-12 education has lived an upsetting period where teachers have been forced to incorporate technologies intensively, bringing to light numerous issues and opportunities, whose assessment can result in educational renewal. This scoping review's objective is to examine the positive impact of the pandemic on digital technologies appropriation and innovative instruction across EU from K-12 teachers' point of view. Within a total of 77 articles, published between 2020 and 2022, research showed that K-12 teachers perceived the lockdown as an opportunity to increase their competences to teach through digital tools and apply novel instructional strategies. Additionally, they have progressed on digital appropriation for assessing and interacting with students and colleagues. K-12 teachers consider the pandemic as an opportunity for professional development in terms of establishment of new digital skills, despite the lack of necessary equipment and the psychological well-being creating challenges in distance education. In conclusion the Covid-19 pandemic enabled K-12 teachers to expand their professional skills to respond to the needs of future schooling.

Keywords: digital technologies, innovative instruction, European Union, K-12 teachers, perceptions

INTRODUCTION

The utilization of digital technologies is revolutionizing the pedagogical approach in K-12 education throughout the European Union. The incorporation of novel pedagogical approaches that utilize digital technologies holds promise in enhancing students' involvement, motivation, and academic achievements. Educators play an essential role in operating this transformation, and their perceptions towards the integration of digital technology in every aspect of education can exert a considerable influence on its efficacy. The European Union has been implementing measures to bolster this transition by formulating policies, projects and initiatives that strive to expedite the assimilation of digital technologies in primary and secondary education. Consequently, numerous schools throughout the European Union are implementing inventive pedagogical

approaches that utilize digital technologies to augment the educational experiences of students. Despite the progress made in the field of education technology, there are remain obstacles that require attention, including the issue of the digital divide, disparities in resource availability, and the necessity for teacher professional development opportunities. The effective integration of digital technologies in K-12 education necessitates a cooperative endeavour among policymakers, educators, and other invested parties to guarantee that all students can reap the advantages of these advancements.

Related Literature

Covid-19 pandemic effect on Education

The dawn of the new millennium found the educational systems attempting to undergo a comprehensive digital transformation to be able to meet the needs of the young generation and their digitalized future (United Nations, 2020). At the end of the second decade, a mild challenge put schools' digital readiness to the test. The Covid-19 pandemic, frequently described as a "game changer" in modern educational literature, forced all school procedures to be conducted remotely (Harris & Jones, 2020). During the first year of the pandemic, the average number of school closures in Europe was 17 weeks, according to UNESCO (2021).

This led to numerous changes in the teaching methods used during a school year at all educational levels. The implementation of these measures impacted the work lives of many teachers, altering work features such as job demands and job resources, as well as job-related well-being (Kniffin et al., 2021). The majority of European teachers had never really used digital technologies for distance learning application purposes in their lessons before (di Pietro et al., 2020). However, even if some of them had prior experience, the strategies that were commonly used in education during the pandemic era had nothing in common with the tenets and methods of distance learning, thus, it was, instead, called emergency remote teaching (ERT) (Hodges et al., 2020). The primary purpose of ERT is to provide a framework that in a short period of time will ensure immediate and reliable access to instructions and support for all involved (students, teachers and parents), and not to create a new integrated educational ecosystem.

Teachers' perception of ERT

Numerous studies demonstrate how organizing and planning lessons became more difficult for many teachers than it used to be, and it was clear that teachers needed to improve their digital competence (Goman et al., 2021; König et al., 2020; Müller et al., 2021). The necessity of and ability for adapting to the new system of remote learning immediately after the pandemic's breakout gave rise to a lot of debate, cause, and opportunity (Bawa'aneh, 2021). Bao (2020) identifies as the key obstacles to digital technologies appropriation to be the lack of expertise and appropriate resources to support teaching (audio and video recorded content), the limited amount of time available for training, and the inadequate support from educational technology staff.

On the other hand, the imperative use of digital technologies, due to the Covid-19 pandemic emergency conditions, has given the chance to set the stage for the introduction of digital teaching (Dhawan, 2020). As instructors, parents, and children shared similar experiences, the potential for collaboration, innovative solutions, a willingness to learn from others, and the adoption of new techniques grew exponentially. (Doucet et al., 2020; Sun et al., 2020). In terms of educational theories, the pandemic led to more flexible teaching methods and teaching delivery methods (Author, 2023). This interpretation of the emergency situation as an opportunity for development, and not exclusively as a setback, passes through the prism of the teachers' perceptions.

This abrupt and forced transition to distance learning, helped teachers gain favourable perspectives on the improvement of abilities, the technology utilization, the instruction consistency, and the improvement of time management skills (Author, 2022). In order to properly implement the essential technological integration and keep educational systems from being impacted by global issues, teachers' responsibilities increase (Karakaya et al., 2021).

The rising term "Recovering Education" as set by UNESCO (Giannini et al., 2021) and the preparation for a possible new emergency (Soete, 2021), reinforce the need for adaptability in education. According to the framework of Green et al. (2020), adaptability in education is the capacity of educational systems to adapt to quickly transforming circumstances while preserving stability, supporting equality, and extending substantive freedoms and, also, well-being. It is recommended that educators acquire proficiency in contemporary pedagogical techniques and methodologies, including digital instruction, to enhance students' cognitive capabilities and equip them with the necessary skills to navigate the complex landscape of tomorrow (Shana & Abulibdeh, 2023). The immediate recording and subsequent analysis of perceptions-issues, prevalent throughout the EU, can pave the way for redefining effective educational practices, the advantages of new technological trends, and the need for intervention in response to emergent challenges.

The COVID-19 pandemic, apart from causing a significant disruption to conventional methods of delivering education, it has also created novel prospects for education to evolve and adjust. Nonetheless, a dearth of research investigations exists regarding the beneficial influence of the pandemic on innovation in technology and digital proficiency among K-12 teachers in the European Union. Additionally, most present studies focus on the utilization of technology within the context of education, compared to novel pedagogical approaches that utilize digital technologies. The novelty of this study is its emphasis on the prospects that the COVID-19 pandemic presents for K-12 education across EU regarding digital proficiency and innovative pedagogical approaches.

Purpose and Research Questions

This review aims to present the published research related to EU K12 teachers' perceptions concerning the opportunities and the issues of the appropriation of digital technologies in school procedures. The European Union tries to implement a common policy on education in all member countries, aiming at reducing, as much as possible,

the gap in the quality of education provided to students and the working circumstances of teachers. An iconic example of this effort is the development of the European Framework for the Digital Competence of Educators (DigCompEdu) (Caena & Redecker, 2019). An emergency such as the abrupt closing of schools in the spring of 2020 and the options for dealing with the crisis in the months that followed created conditions worthy of investigation. In light of the aforementioned circumstances, the aim of this review, concerning the K-12 EU teachers' population, is to highlight perceptions regarding digital technologies appropriation across their professional context.

The following research questions serve as a guide for this review:

- Which are the specific topics recorded in teacher's perceptions?
- Which are the K12 teachers' perceptions of digital technologies appropriation and innovative teaching across EU countries?
- In which aspects did K-12 teachers make progress by appropriating digital technologies due to emergency conditions?
- What were the recorded challenges and opportunities for teaching professional development?

METHOD

Research Design and Overview of Procedure

In order to examine the breadth and depth of the literature on K–12 teachers' perceptions of digital technologies appropriation, this study employs a scoping review methodology. According to Arksey and O'Malley (2005), whose five steps methodology is carried out at the current review (Figure 1), a scoping review's objective is to examine the range of research that has been undertaken. Very recent objectives, whose full effect has not been revealed yet, cannot be addressed unless there is a preliminary searching and scoping activity to inform the conduct of a systematic review, which aims to summarize findings across studies (Kazi et al., 2021). This led to the choice of scoping review, since it has been less than 3 years since the pandemic changed the way school procedures were implemented.

	Steps
1	Identifying the research question
2	Identifying relevant studies
3	Selecting appropriate articles for the scoping review
4	Charting the data
5	Summarizing, analyzing and reporting the results

Figure 1
Arksey and O' Malley five steps scoping review methodology (Arksey & O'Malley, 2005)

Sampling and Relevance Criteria

Searching of the sampled articles was conducted in the indexes of Scopus, Web of Science and ERIC. After searching in those databases, a gap in the literature was found for some countries. In an effort to cover all EU countries we, then, searched in

Mendeley reference manager. These databases were chosen to guarantee the retrieval of all pertinent studies. Using subject terms and keyword searches in the title and abstract fields, we conducted the initial search in Scopus database. The search was focused on three basic concepts: Covid-19 pandemic, K-12 teachers, perceptions; plus, the name of each EU country. After each country's articles were reached at every database, the next country in alphabetical order was picked. Keywords included digital technologies, pandemic, Covid-19, Covid, teachers, educators, professors, perceptions, beliefs, attitudes, thoughts, impressions, opinions. Each concept's synonyms were separated by the Boolean operator OR, and the search terms for each of the three primary concepts were combined by the Boolean operator AND. Each database's search was modified yet were always looked through for publications written in English and published between 2020 and 2022.

The initial database search yielded 457 articles. 39 overlapping articles were found. The exclusion of 39 articles based on title and 252 articles based on abstract followed. 112 full text articles were assessed for eligibility with 77 of them to, finally, meet the criteria (Table 1) and be included in the analysis (16,8% of the initial record) (Figure 2).

Table 1
Inclusion criteria

|	
Pandemic Impact	The included studies examined the EU K-12 teachers' perceptions of the intensive use of digital technologies during the pandemic outbreak.
Publication dates, language and type	The included studies were published in a peer-reviewed journal from June 1, 2020, to May 31, 2022 (when most of the publications related to the pandemic appear) and were available in English. Literature reviews, secondary data analyses, book chapters, dissertations, and conference papers were excluded.
Countries	Each article had to present research on, at least, a member country of the European Union. Articles that referred to more than one European Union country were also included. In case the studies involved EU members and non-EU members in the same article, then the article was included, only if the data were presented separately for each country. Under these circumstances, only the data from EU countries were considered in the scoping review. This criterion was based on the fact that EU countries have a common central policy in matters of distance education, and similarities in the level of implementation and online learning tradition.
Education level	Surveys had to present perceptions of kindergarten to high school teachers. Similarly, when the survey sample also included pre-school or higher education teachers, only data from K-12 teachers were considered, if presented separately.
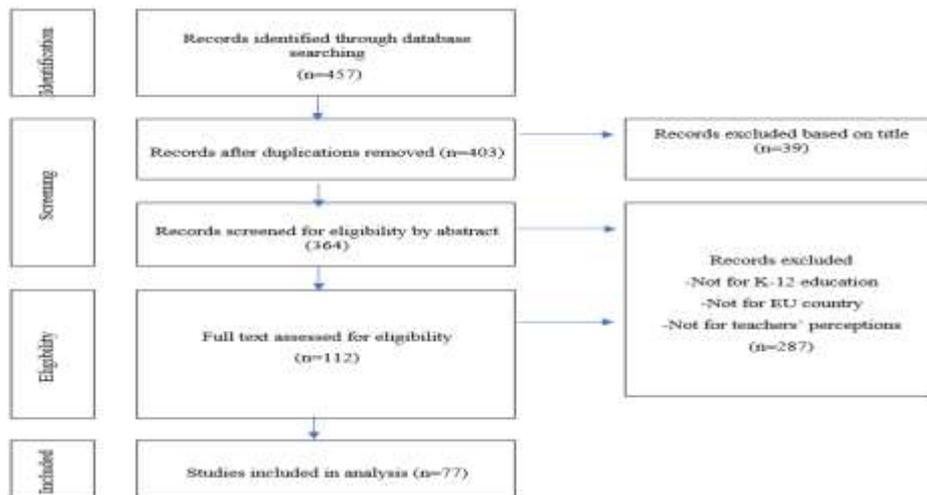
Figure 2
PRISMA flow diagram depicting records identified, included, and excluded at each stage, with reasons

Coding

The following criteria were used to log and code relevant articles in a chart:
1.   Geographic location (EU country)
2.   Year of publication
3.   Level of education (kindergarten, primary, middle, high and special school)
4.   Data type (quantitative, qualitative, mixed)
5.   Data collection method (survey, interview, observation, focus group)
6.   Teacher specialty (chemistry, craft, dance, foreign language, general, ICT, math, physical, music, science, special education)

The primary goal of the review was to gather teachers' perceptions research from across the European Union, therefore the country in which the article was referenced was the first criterion to be classified, all EU countries were represented, apart from Luxembourg. Each education level contained in the articles is recorded separately. On the other hand, in cases where the articles do not concern only one specialty, which is the most common, the option "various" is declared.

Analysis and summary of findings

For each of the six coded items, frequency analysis was generated. The purpose of this analysis is to demonstrate that the topics addressed by the research questions are consistently presented, regardless of country, educational level, specialty, or data collection method. A more in-depth inspection at the articles' contents followed, based on data analysis via descriptive statistics, aiming to answer the research questions, identifying the frequency and common themes or patterns in K-12 teachers' perceptions of digital technologies appropriation and innovative teaching across EU countries, the

distribution of the reported progress, as well as the common themes or patterns in the recorded challenges and opportunities for teaching professional development.

FINDINGS

Characteristics of included studies

Of the 28 countries, members of the EU, there were articles for 25 of them that addressed K-12 teachers' perceptions from a single country. On the other hand, 7 articles were presenting research on a group of countries (Table 2, click here to see this table). Totally, research from 27 out of 28 countries was included (Table 3).

Since the start of pandemic outbreak in Europe is very recent, relative to when this review is carried out, the articles' publication dates are listed in a very short range of years. There are 13 articles (16.9%) published in 2020, 57 (74%) were published in 2021, and 7 (9.1%) in 2022. The vast majority of articles were identified in "Scopus" database (N=58, 75.3%). "Mendeley" followed with 8 articles (10.4%), "Web of Science" with 6 articles (7.8%), and "ERIC" with 5 (6.5%).

Table 3
Articles per EU country (N1= articles referring to a single country, N2= articles referring to multiple countries)

	Countries	N^1	N^2
1.	Austria	4	0
2.	Belgium	1	0
3.	Bulgaria	1	1
4.	Croatia	0	1
5.	Republic of Cyprus	1	0
6.	Czech Republic	3	0
7.	Denmark	1	1
8.	Estonia	1	0
9.	Finland	5	0
10.	France	3	0
11.	Germany	5	1
12.	Greece	6	0
13.	Hungary	1	0
14.	Ireland	4	1
15.	Italy	9	1
16.	Latvia	1	0
17.	Lithuania	1	0
18.	Luxembourg	0	0
19.	Malta	2	0
20.	Netherlands	1	0
21.	Norway	0	1
22.	Poland	1	1
23.	Portugal	2	1
24.	Romania	1	0
25.	Slovakia	2	0
26.	Slovenia	1	0
27.	Spain	10	1
28.	Sweden	3	1

Almost half of the studies were quantitative, with the remaining ones being qualitative or mixed (Table 4). Medical advice for avoiding face-to-face contact has led many researchers to use online questionnaire surveys in order to record teachers' perceptions (Table 5).

Table 4
Research approach

Approach	Articles (N)	Percent (%)
Quantitative	37	48.0
Qualitative	20	26.0
Mixed	20	26.0
Total	77	100

Table 5
Data source

Data source	Articles (N)	Percent (%)
Survey	49	63.6
Survey and Interview	12	15.6
Interview	9	11.7
Focus group	5	6.5
Observation	2	2.6
Total	77	100

The articles, within K-12 education levels, were mostly relating to research of multiple education levels (Table 6). Only 23 out of 77 (29,9%) articles are presenting data from a certain level. Specifically, there are 2 studies for kindergarten, 7 for primary school, 2 for middle school, 11 for high school and 1 for special school. Similarly, the vast majority of articles (75%) did not refer to a specific teacher specialty. The remaining 25% is distributed as shown in Table 7.

Table 6
Education level

Education level	Articles (N)	Percent (%)
Kindergarten	16	20.8
Primary school	52	67.5
Middle school	55	71.4
High school	60	77.9
Special school	6	7.8

(Since some articles covered various education levels, the totals exceed 100%)

Table 7
Articles referring to specific specialties

Teachers' Specialty	Articles (N)
Chemistry	1
Craft	1
Dance	1
Foreign Language	2
Computer Science	1
Math	3
Physical Education	4
Music	1
Science	1
Special Education	4

Article topics

Teachers across EU have been affected by the intensive use of digital technologies, both in terms of everyday school life, and in thinking about the education methodology they applied before or after the pandemic outbreak. Across the studies presented in this review, there are specific topics recorded in teacher's perceptions (Table 8). Some of those topics were put under investigation by the researchers while others were pointed out by the respondents.

Table 8
Addressed topics in included articles

Topic	Articles		EU countries that was recorded	
	N	% out of 77	N	% out of 28
Interaction with students	50	64.9	22	78.6
Opportunities for development	48	62.3	22	78.6
Digital skills	46	59.7	25	89.3
Teaching practices	45	58.4	18	64.3
Technical/equipment difficulties	44	57.1	24	85.7
Workload/stress	41	53.2	22	78.6
Interaction with colleagues/administration	32	41.6	21	75.0
Attitudes influence teaching practices	31	40.3	18	64.3
Assessment	23	29.9	18	64.3
Unequal opportunities	23	29.9	15	53.6
Teachers' well-being	21	27.3	15	53.6
Age differences	18	23.4	12	42.9
Gender differences	15	19.5	8	28.6

K12 teachers' perceptions of digital technologies appropriation and innovative teaching across EU countries.

There were 50 articles (64.9%) that recorded perceptions on the imprint of the pandemic on interaction with students. Ranked as the most discussed subject, it is demonstrated that the majority of teachers in remote learning, during lockdown, concentrated on interactions with the child/family unit. Within the included articles, Panesi et al. (2021)

and Ferretti et al. (2021) stated that teachers use new teaching strategies and identify novel ways to engage with students as they adapt to the new social and political context brought about by the COVID-19 crisis. Schwantler & Tellioglu (2021) and Zecca (2021) discovered that teachers have witnessed how technology and computer devices offer new opportunities and ways of interacting that can be utilized to communicate with families and deepen relationships with students beyond emergency cases On the contrary, Brown et al.,(2022), Decarli et al., (2022), García-Samapedro et al. (2021) and Ramploud et al. (2021) mention that technology-based education eliminates the dynamic of teacher-student interaction, not allowing emotional engagement . Niemi & Kousa (2020) noted that teachers wanted students to participate more and believed that interactions were artificial and not real engagement.

The second most often mentioned topic in teachers' responses is their perspective of the pandemic as a chance to enhance educational conditions (N=48, 62,3%). In particular, Ávalos et al. (2021) and Seabra et al (2021) acknowledged that responders extracted a significant learning from this experience, viewing it as a chance to transform teaching and learning with potential effects on the post-pandemic future. Additionally, Kouhia et al. (2021) and Woltran et al (2021) observed that teachers considered the advantages and disadvantages of their practiced and internalized pedagogical actions and approaches and formed a new perspective on the requirements of their students, as digital technology provides more options, than the typical classroom setting, for individualized student guidance and feedback.

Another topic that is often discussed in the included articles is the impact of the pandemic on the applied teaching practices (N=45, 58,4%). Specifically, according to Mankki & Räihä (2022), teachers were asked to consider the applicability of their practices to distant learning from a variety of angles during the first weeks of online classes. However, the type and the application frequency of those practices, according to the 40,3% of the articles (N=31), were influenced by the teachers' attitudes and expectations. Börnert-Ringleb et al. (2021), Dincher & Wagner (2021), Drijvers et al (2021) and Kast et al (2021) discovered that teachers' self-efficacy beliefs and their confidence level with employing digital technology are positively corelated to emerging teaching approaches. In 23 articles (29,9%), inequality in socio-economic conditions is mentioned by teachers as a factor that also affected the teaching process to a greater extent during the pandemic period than before it. Börnert-Ringleb et al. (2021), García-Samapedro et al. (2021), Kast et al. (2021) and Seabra et al.(2021) noted that unequal opportunities heighten concerns that the educational gap between students widened during school closures.

Aspects in which K-12 teachers made progress by appropriating digital technologies due to emergency conditions.

Numerous articles (N=32, 41,6%) referred to the enhancement of the interaction between colleagues and the administration. Particularly, according to Herrmann et al. (2021) and Prieto-Ballester et al. (2021), the use of ICTs has shifted from mostly focusing on individual work to more collaborative work with coworkers. Faltýnková et al (2020) and Korhonen et al. (2021) stated that the value of sharing educational

materials and strategies enhanced, while Jurs & Kulberga (2021) Raišienė et al. (2021) claimed that, in addition to methodological support, administration offered psychological and emotional support.

Special reference was made to the effort to improve assessment processes (formative and summative), during the pandemic period in 23 articles (29,9%). According to Seabra et al (2021) and Tomczyk & Walker (2021), many teachers questioned the viability of assessing students' learning remotely, highlighting the issue of authenticity. Consequently, attempts were being undertaken to discover novel and more efficacious approaches. Also, Said Pace (2021) and García-Samapedro et al (2021) recorded that teachers mentioned, along with the lack of training, as main issue, the amount of time needed to provide every student feedback, referring to how e-assessment can act as a facilitator.

Recorded challenges and opportunities for teaching professional development.

More than half of the articles referred to technical difficulties and the lack of necessary equipment (N=44, 57,1%). More specifically, apart from Niemi & Kousa's research (2020), which found no technical difficulties, Carvalho et al (2020), Nikiforos et al. (2020), Petek (2021) and Willermark & Gellerstedt (2022) argued that technical issues caused frustration and together with the equipment shortage contributed to a lower-than-expected quality of distance learning. K-12 teachers noted in 41 studies (53,2%) that, during the pandemic period, stress levels increased significantly. Haskova et al. (2021), Jurs & Kulberga (2021), Mankki & Räihä (2022) and Rannastu-Avalos & Siiman (2020) concluded that the most common explanation for this was the significant increase in workload, due to the significant digital leap required during the pandemic. Likewise, 21 articles (27,2%) identified distance learning had a noticeable effect on the teachers' general psychological well-being, with Bianchi & Caso (2021), D'isanto & D'elia (2021), Hilger et al. (2021) and Lindorff et al. (2021) reporting the effect of the abrupt and forced use of technologies on the general psychological state of teachers. Less frequently, reported data were related to the differences in teachers' perceptions among age and gender groups. López-Fernández et al. (2021) agreed that perceptions had a significant difference between younger and older teachers, while Hatos et al. (2022) admitted significant difference between gender.

In contrast, within the context of opportunities for teaching professional development, digital skills were mentioned in the majority of the publications (N=46, 59,7%). Particularly, according to the findings of Albó et al (2020), during the pandemic teachers had more possibilities for professional development, considered online training to be more useful, and developed confidence in using a wide range of technologies for teaching and for interacting with parents and students. Teachers' perceptions on this topic focused on two main aspects. First, Kouhia et al (2021) and Tzimopoulos et al., (2021) admitted the establishment of new digital skills, resulting from novel instructional strategies and techniques applied due to the pandemic; and second, Cadamuro et al. (2021), Jimoyiannis et al. (2021) and Topalska (2021) alleged the necessity for teachers' digital skills improvement in the context of e-learning application. In addition, Beardsley et al (2021), Panesi et al. (2021) and Pirone (2021)

claimed that the majority of the teachers, being strongly motivated, made changes to their instructional strategies, which allowed them to gradually stabilize their practices.

DISCUSSION

During the last years, the entire educational system was tasked with responding to the conditions brought on by emergency situations, while being in a state of complete of surprise. Education researchers quickly began to question the new circumstance, which has been referred to as "a digital boost" (Stenliden et al., 2020) as it had the ability to enhance knowledge of digital competence.

Results of this study are in line with other research that has found a shift in teachers' perspectives regarding the use of digital technology in the classroom since they are more motivated and qualified (Ishak et al., 2022; Silva et al., 2022). Teachers' adaptive instructional actions appear to lead to enhanced student learning, motivation, and behaviour. Typically, when teachers respond to stimuli and alter their instruction, they do so through questioning, assessing, encouraging, demonstrating, managing, clarifying, providing feedback, challenging, or establishing connections (Parsons et al., 2018). All the above can be facilitated by the use of digital technologies. Teachers' attitudes influenced and were influenced by the applied teaching practices. As Patwardharr et al. (2020) state, educators have been obliged to rapidly swift their methods, content, forms, and pedagogic tools to digital communication contexts, due to emergency conditions, but, the record of ineffectiveness of those methods reveals the need for educators to redefine their teaching approach to each situation. In addition, Shareefa (2023) referring to the same issue, claims that to increase the likelihood of successfully implementing a differentiated instructional strategy, it is imperative that the educational system of the school provides teachers with adequate guidance and support.

This review, also, revealed, via teachers' perceptions, a wide range of starting points in digital education between and within EU countries. The efforts of the EU administration for a common educational policy, but also of the state-members for equal opportunities for their citizens, have not been successful and, as Berry et al. (2020) report, the Covid-19 pandemic has made the stark reality of the digital divide and glaring disparities visible. Moreover, teachers' emphasis on interaction highlights the necessity of frequent and meaningful communication between stakeholders in education. Effective interactions that foster relationships between teachers and their students are essential to students' academic success in traditional classroom environments (Quin, 2017).

Teachers collaboration and assessment procedures are aspects in which K-12 teachers made progress by appropriating digital technologies due to emergency conditions. According to Ferdig et al. (2020), this period demonstrated the value of teachers working together to create shared lesson plans and precise schedules for students' and families' convenience. This recorded improvement of the communication with their colleagues or administration can become the basis for an evaluation of interaction methods and tools that can be used in the future. Moreover, teachers specifically referred to the assessment implementation during the school closures, concluding that they made many attempts to keep it at the same level and frequency, compared to the

pre-pandemic period. This argument is consistent with the findings of Ferretti et al. (2021), who also claim that the need to continue all school procedures forced teachers to find new, more successful evaluation techniques.

Teachers' perceptions revealed several challenges and opportunities for teaching professional development. As Mäkelä et al. (2020) also asserted, this period acted as a magnifying glass to emphasize the factors that can help a teacher evolve or remain stable. Technical difficulties, lack of equipment, missing digital skills, and limited time in relation to the workload created confusion and affected teachers' stress levels. Deli et al. (2022), detecting the same issue, propose that remote schooling and face-to-face professional development sessions should be established, distance education in all its aspects should be introduced, and teaching approaches, strategies, and materials applicable to this process should be taught. Age and gender were also identified, to a lesser extent, as factors affecting teachers' professional development. According to Šabić et al (2022), there are differences in the use of technologies based on gender and age; consequently, there are also differences in the need to enhance teachers' efficacy and self-efficacy, based on their age/gender group. Self-efficacy, specifically, is associated with teachers' well-being, which is, also, recorded as a factor of DT appropriation. Duraku & Hoxha (2020) claimed that the deterioration of teachers' well-being, during the period of closed schools due to the pandemic, was combined with the aversion to the use of digital technologies in education.

It is very important that from the teachers' point of view, the specific crisis emerged as an opportunity for educational development, digital advancement and skills' update. Teachers have strengthened their digital proficiency and have been facilitating tasks in a more innovative way than usual (Bubb & Jones, 2020). The in-depth analysis of the opportunities mentioned by the teachers must become the basis and direction towards which the educational administration of each country will evolve its intervention strategies.

LIMITATIONS

One of the limitations of the research was the restriction to specific article databases and a reference manager which potentially limited the scope of the research and the number of articles that were included. Also, the short period from the start of the pandemic to the start of this review did not make it possible for running studies to be published or included in our reviewed databases. In addition, in a multilanguage European Union, the search for articles written exclusively in the English language excluded studies published in the language of the country in which they were conducted.

Additionally, focusing on a certain period of time, very close to the outbreak of a pandemic, discarded articles published later on were the short- and long-term effects are being studied. In fact, this is one of the possibilities for further research, to analyse what was the imprint of the Covid-19 pandemic for the future of K-12 education.

CONCLUSIONS

This review gathered perceptions of K-12 teachers from European Union countries about the digital technologies' appropriation and innovative instruction. The impact of

emergency circumstances during the last years was so significant that, in a short period of time, a large amount of research related to this issue was carried out, thus, through the present scoping review, specific K12 teachers' perceptions of digital technologies appropriation and innovative teaching, aspects in which K-12 teachers made progress by appropriating digital technologies, as well as challenges and opportunities for teaching professional development are highlighted.

Despite the documented issues, such as the lack of experience, skills and equipment, teachers' psychological pressure, as well as major digital inequalities within the population of stakeholders, educators developed professionally by changing or initiating a change in educational processes. They sought to acquire new knowledge to improve their level of interaction with their students, while at the same time benefiting from increased interaction with their colleagues.

The insights gained from this scoping review highlight the transformative potential of these approaches and emphasize the need for equitable access, pedagogical versatility, and sustainable integration of technology in classrooms. By leveraging the lessons learned during the pandemic, K-12 teachers in the EU can harness digital tools to enhance teaching and learning outcomes, fostering a more inclusive and engaging educational environment. As we navigate the post-pandemic era, it is crucial to continue supporting teachers with professional development and resources to effectively appropriate digital technologies and promote innovative instruction, ultimately preparing students for the demands of the 21st century.

The purpose of future research should be whether those perceptions and the changes brought by the intensive use of technologies were maintained over time. Also, in order to obtain a complete, detailed and deeper overview in a future review, perceptions of other participants involved in the educational reality must also be collected. Students, parents, administrators, and other education levels teachers could reveal new perspectives on education implemented during the pandemic outbreak, reject or confirm what teachers indicate. Additionally, as the pandemic was a worldwide occurrence, it would be intriguing to collect data from around the world to identify similarities and differences.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest: The authors report there are no competing interests to declare.

Research involving human rights: This study does not involve human subjects and was not funded by any agency.

REFERENCES

Albó, L., Beardsley, M., Martínez-Moreno, J., Santos, P., & Hernández-Leo, D. (2020). Emergency remote teaching: Capturing teacher experiences in spain with selfie. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *12315 LNCS*. https://doi.org/10.1007/978-3-030-57717-9_23

Arksey, H., & O'Malley, L. (2005). Scoping Studies: Towards a Methodological Framework. *International Journal of Social Research Methodology: Theory & Practice*, *8*, 19–32. https://doi.org/10.1080/1364557032000119616

Author, (2022) …

Author, (2023) …

Ávalos, B., Flores, M. A., & Araneda, S. (2021a). Battling to keep education going: Chilean and Portuguese teacher experiences in COVID-19 Times. *Teachers and Teaching: Theory and Practice*. https://doi.org/10.1080/13540602.2021.2012758

Ávalos, B., Flores, M. A., & Araneda, S. (2021b). Battling to keep education going: Chilean and Portuguese teacher experiences in COVID-19 Times. *Teachers and Teaching: Theory and Practice*. https://doi.org/10.1080/13540602.2021.2012758

Bao, W. (2020). COVID -19 and online teaching in higher education: A case study of Peking University. *Human Behavior and Emerging Technologies*, *2*(2). https://doi.org/10.1002/hbe2.191

Bawa'aneh, M. S. (2021). Distance learning during COVID-19 pandemic in UAE public schools: Student satisfaction, attitudes and challenges. *Contemporary Educational Technology*, *13*(3). https://doi.org/10.30935/cedtech/10872

Beardsley, M., Albó, L., Aragón, P., & Hernández-Leo, D. (2021a). Emergency education effects on teacher abilities and motivation to use digital technologies. *British Journal of Educational Technology*, *52*(4). https://doi.org/10.1111/bjet.13101

Beardsley, M., Albó, L., Aragón, P., & Hernández-Leo, D. (2021b). Emergency education effects on teacher abilities and motivation to use digital technologies. *British Journal of Educational Technology*, *52*(4). https://doi.org/10.1111/bjet.13101

Berry, B., Doucet, A., & Owens, B. (2020). *Teacher Leadership in the Aftermath of a Pandemic: The Now, The Dance, The Transformation by Education International - Issuu*. https://issuu.com/educationinternational/docs/2020_research_covid-19_nowdancetransformation

Bianchi, M., & Caso, D. (2021). Distance learning during covid-19 pandemic: Italian teachers' well-being and the role of age on ICT adoption. *Statistica Applicata*, *33*(2). https://doi.org/10.26398/IJAS.0033-010

Börnert-Ringleb, M., Casale, G., & Hillenbrand, C. (2021a). What predicts teachers' use of digital learning in Germany? Examining the obstacles and conditions of digital learning in special education. *European Journal of Special Needs Education*, *36*(1). https://doi.org/10.1080/08856257.2021.1872847

Börnert-Ringleb, M., Casale, G., & Hillenbrand, C. (2021b). What predicts teachers' use of digital learning in Germany? Examining the obstacles and conditions of digital learning in special education. *European Journal of Special Needs Education*, *36*(1). https://doi.org/10.1080/08856257.2021.1872847

Brown, M., Skerritt, C., Shevlin, P., McNamara, G., & O'Hara, J. (2022a). Deconstructing the challenges and opportunities for blended learning in the post emergency learning era. *Irish Educational Studies*, *41*(1). https://doi.org/10.1080/03323315.2021.2022526

Brown, M., Skerritt, C., Shevlin, P., McNamara, G., & O'Hara, J. (2022b). Deconstructing the challenges and opportunities for blended learning in the post emergency learning era. *Irish Educational Studies*, *41*(1). https://doi.org/10.1080/03323315.2021.2022526

Bubb, S., & Jones, M. A. (2020). Learning from the COVID-19 home-schooling experience: Listening to pupils, parents/carers and teachers. *Improving Schools*, *23*(3). https://doi.org/10.1177/1365480220958797

Cadamuro, A., Bisagno, E., Rubichi, S., Rossi, L., Cottafavi, D., Crapolicchio, E., & Vezzali, L. (2021). Distance learning and teaching as a consequence of the covid-19 pandemic: A survey of teachers and students of an italian high school taking into account technological issues, attitudes and beliefs toward distance learning, metacognitive skills. *Journal of E-Learning and Knowledge Society*, *17*(1). https://doi.org/10.20368/1971-8829/1135463

Caena, F., & Redecker, C. (2019). Aligning teacher competence frameworks to 21st century challenges: The case for the European Digital Competence Framework for Educators (Digcompedu). *European Journal of Education*, *54*(3). https://doi.org/10.1111/ejed.12345

Carvalho, J., Casado, I. S., & Delgado, S. C. (2020). Conditioning factors in the integration of technology in the teaching of portuguese nonnative language: A post-COVID 19 reflection for the current training of teachers. *International Journal of Learning, Teaching and Educational Research*, *19*(9). https://doi.org/10.26803/ijlter.19.9.11

Decarli, G., Surian, L., Vignoli, M., & Franchin*, L. (2022a). What Teachers Tell Us About the Impact of the COVID-19 Pandemic on Public Education in Italy. *European Journal of Educational Research*, *11*(2). https://doi.org/10.12973/eu-jer.11.2.1103

Decarli, G., Surian, L., Vignoli, M., & Franchin*, L. (2022b). What Teachers Tell Us About the Impact of the COVID-19 Pandemic on Public Education in Italy. *European Journal of Educational Research*, *11*(2). https://doi.org/10.12973/eu-jer.11.2.1103

Dhawan, S. (2020). Online Learning: A Panacea in the Time of COVID-19 Crisis. *Journal of Educational Technology Systems*, *49*(1). https://doi.org/10.1177/0047239520934018

di Pietro, G., Biagi, F., Costa, P., Karpiński, Z., & Mazza, J. (2020). The Likely Impact of COVID-19 on Education: Reflections based on the Existing Literature and Recent International Datasets. In *Publications Office of the European Union, Luxembourg: Vol. EUR 30275* (Issue JRC121071).

Dincher, M., & Wagner, V. (2021). Teaching in times of COVID-19: determinants of teachers' educational technology use. *Education Economics*. https://doi.org/10.1080/09645292.2021.1920000

D'isanto, T., & D'elia, F. (2021). Primary school physical education in outdoor during COVID-19 pandemic: The perceptions of teachers. *Journal of Human Sport and Exercise*, *16*(Proc3). https://doi.org/10.14198/jhse.2021.16.Proc3.67

Doucet, A., Netolicky, D., Timmers, K., & Tuscano, F. J. (2020). Thinking about Pedagogy in an Unfolding Pandemic. In *Work of Education International and UNESCO.* (Issue March).

Drijvers, P., Thurm, D., Vandervieren, E., Klinger, M., Moons, F., van der Ree, H., Mol, A., Barzel, B., & Doorman, M. (2021). Distance mathematics teaching in Flanders, Germany, and the Netherlands during COVID-19 lockdown. *Educational Studies in Mathematics*, *108*(1–2). https://doi.org/10.1007/s10649-021-10094-5

Faltýnková, L., Šimonová, I., & Kostolányová, K. (2020a). *Utilization of distance education during COVID_19 crisis*. 59–62. https://doi.org/10.1109/CiSt49399.2021.9357233

Faltýnková, L., Šimonová, I., & Kostolányová, K. (2020b). *Utilization of distance education during COVID_19 crisis*. 59–62. https://doi.org/10.1109/CiSt49399.2021.9357233

Ferdig, R. E., Baumgartner, E., Hartshorne, R., Kaplan, R. R., & Mouza, C. (2020). Teaching, Technology, and Teacher Education During the COVID-19 Pandemic: Stories from the Field Edited by AACE-Association for the Advancement of Computing in Education. In *… USA: Association for ….*

Ferretti, F., Santi, G. R. P., Zozzo, A. del, Garzetti, M., & Bolondi, G. (2021). Assessment practices and beliefs: Teachers' perspectives on assessment during long distance learning. *Education Sciences*, *11*(6). https://doi.org/10.3390/educsci11060264

García-Samapedro, M., Elsa, P.-S., & Lucía, R.-O. (2021a). Online Education during the COVID 19 lockdown and school closures in Spain. Teachers' perceptions. *Aloma: Revista de Psicologia, Ciències de l'educació i de l'esport Blanquerna*, *39*(2), 43–51. https://doi.org/10.51698/aloma.2021.39.2.43-51

García-Samapedro, M., Elsa, P.-S., & Lucía, R.-O. (2021b). Online Education during the COVID 19 lockdown and school closures in Spain. Teachers' perceptions. *Aloma: Revista de Psicologia, Ciències de l'educació i de l'esport Blanquerna*, *39*(2), 43–51. https://doi.org/10.51698/aloma.2021.39.2.43-51

Giannini, S., Jenkins, R., & Saavedra, J. (2021). Mission: Recovering Education 2021. In UNICEF, UNESCO, and World Bank.

Goman, J., Huusko, M., Isoaho, K., Lehikko, A., Metsämuuronen, J., Rumpu, N., Seppälä, H., & Venäläinen, S. (2021). *Impacts of the exceptional teaching arrangements on the realisation of equality and equity at different levels of education. –*

Part III of the evaluation project: Summary and recommendations of the national evaluation.

Green, C., Mynhier, L., Banfill, J., Edwards, P., Kim, J., & Desjardins, R. (2020). Preparing education for the crises of tomorrow: A framework for adaptability. International Review of Education, 66(5–6). https://doi.org/10.1007/s11159-020-09878-3

Harris, A., & Jones, M. (2020). COVID 19–school leadership in disruptive times. In *School Leadership and Management* (Vol. 40, Issue 4). https://doi.org/10.1080/13632434.2020.1811479

Haskova, A., Havettova, R., & Vogelova, Z. (2021). Learning to teach and learn (not only foreign languages) during the coronavirus pandemics. *XLinguae*, *14*(1). https://doi.org/10.18355/XL.2021.14.01.01

Hatos, A., Cosma, M.-L., & Clipa, O. (2022). Self-Assessed Digital Competences of Romanian Teachers During the COVID-19 Pandemic. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.810359

Herrmann, L., Nielsen, B. L., & Aguilar-Raab, C. (2021a). The Impact of COVID-19 on Interpersonal Aspects in Elementary School. *Frontiers in Education*, *6*. https://doi.org/10.3389/feduc.2021.635180

Herrmann, L., Nielsen, B. L., & Aguilar-Raab, C. (2021b). The Impact of COVID-19 on Interpersonal Aspects in Elementary School. *Frontiers in Education*, *6*. https://doi.org/10.3389/feduc.2021.635180

Hilger, K. J. E., Scheibe, S., Frenzel, A. C., & Keller, M. M. (2021). Exceptional Circumstances: Changes in Teachers' Work Characteristics and Well-Being During COVID-19 Lockdown. *School Psychology*, *36*(6). https://doi.org/10.1037/spq0000457

Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). The Difference Between Emergency Remote Teaching and Online Learning. *Educause*.

Jimoyiannis, A., Koukis, N., & Tsiotakis, P. (2021). Shifting to Emergency Remote Teaching Due to the COVID-19 Pandemic: An Investigation of Greek Teachers' Beliefs and Experiences. In A. Reis, J. Barroso, J. B. Lopes, T. Mikropoulos, & C.-W. Fan (Eds.), *Technology and Innovation in Learning, Teaching and Education* (pp. 320–329). Springer International Publishing.

Jurs, P., & Kulberga, I. (2021a). Pedagogical challenges in distance learning during COVID-19 conditions – Experience of Latvia. *World Journal on Educational Technology: Current Issues*, *13*(4). https://doi.org/10.18844/wjet.v13i4.6278

Ishak, N., Din, R., & Othman, N. (2022). Teachers' Perceptions and Challenges to the Use of Technology in Teaching and Learning during Covid-19 in Malaysia. *International Journal of Learning, Teaching and Educational Research*, 21(5). https://doi.org/10.26803/ijlter.21.5.15

Jurs, P., & Kulberga, I. (2021b). Pedagogical challenges in distance learning during COVID-19 conditions – Experience of Latvia. *World Journal on Educational Technology: Current Issues*, *13*(4). https://doi.org/10.18844/wjet.v13i4.6278

Karakaya, F., Adıgüzel, M., Üçüncü, G., Çimen, O., & Yilmaz, M. (2021). Teachers' views towards the effects of covid-19 pandemic in the education process in Turkey. *Participatory Educational Research*, *8*(2). https://doi.org/10.17275/per.21.27.8.2

Kast, J., Lindner, K. T., Gutschik, A., & Schwab, S. (2021a). Austrian teachers' attitudes and self-efficacy beliefs regarding at-risk students during home learning due to COVID-19. *European Journal of Special Needs Education*, *36*(1). https://doi.org/10.1080/08856257.2021.1872849

Kast, J., Lindner, K. T., Gutschik, A., & Schwab, S. (2021b). Austrian teachers' attitudes and self-efficacy beliefs regarding at-risk students during home learning due to COVID-19. *European Journal of Special Needs Education*, *36*(1). https://doi.org/10.1080/08856257.2021.1872849

Kazi, M. R., Chowdhury, N., Chowdhury, M., & Turin, T. C. (2021). Conducting comprehensive scoping reviews to systematically capture the landscape of a subject matter. *Population Medicine*, *3*(December). https://doi.org/10.18332/POPMED/143831

Kniffin, K. M., Narayanan, J., Anseel, F., Antonakis, J., Ashford, S. P., Bakker, A. B., Bamberger, P., Bapuji, H., Bhave, D. P., Choi, V. K., Creary, S. J., Demerouti, E., Flynn, F. J., Gelfand, M. J., Greer, L. L., Johns, G., Kesebir, S., Klein, P. G., Lee, S. Y., … Vugt, M. van. (2021). COVID-19 and the workplace: Implications, issues, and insights for future research and action. *American Psychologist*, *76*(1). https://doi.org/10.1037/amp0000716

König, J., Jäger-Biela, D. J., & Glutsch, N. (2020). Adapting to online teaching during COVID-19 school closure: teacher education and teacher competence effects among early career teachers in Germany. *European Journal of Teacher Education*, *43*(4), 608–622. https://doi.org/10.1080/02619768.2020.1809650

Korhonen, T., Juurola, L., Salo, L., & Airaksinen, J. (2021). Digitisation or digitalisation: Diverse practices of the distance education period in finland. *Center for Educational Policy Studies Journal*, *11*(Sp.Issue). https://doi.org/10.26529/cepsj.1125

Kouhia, A., Kangas, K., & Kokko, S. (2021). The effects of remote pandemic education on crafts pedagogy: Opportunities, challenges, and interaction. *Center for Educational Policy Studies Journal*, *11*(Special Issue). https://doi.org/10.26529/cepsj.1126

Lindorff, A. M., Chang, M.-L., Lindner, K.-T., Savolainen, H., & Schwab, S. (2021). Development of Teachers' Emotional Adjustment Performance Regarding Their Perception of Emotional Experience and Job Satisfaction During Regular School Operations, the First and the Second School Lockdown in Austria. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2021.702606

López-Fernández, I., Burgueño, R., & Gil-Espinosa, F. J. (2021). High school physical education teachers' perceptions of blended learning one year after the onset of the COVID-19 pandemic. *International Journal of Environmental Research and Public Health*, *18*(21). https://doi.org/10.3390/ijerph182111146

Mäkelä, T., Mehtälä, S., Clements, K., & Seppä, J. (2020). Schools Went Online Over One Weekend : Opportunities and Challenges for Online Education Related to the COVID-19 Crisis. *EdMedia + Innovate Learning 2020*.

Mankki, V., & Räihä, P. (2022a). Primary teachers' professional learning during a COVID-19 school lockdown. *Educational Research*, *64*(1). https://doi.org/10.1080/00131881.2021.2013127

Mankki, V., & Räihä, P. (2022b). Primary teachers' professional learning during a COVID-19 school lockdown. *Educational Research*, *64*(1). https://doi.org/10.1080/00131881.2021.2013127

Müller, A. M., Goh, C., Lim, L. Z., & Gao, X. (2021). COVID-19 Emergency eLearning and Beyond: Experiences and Perspectives of University Educators. *Education Sciences*, *11*(1). https://doi.org/10.3390/educsci11010019

Niemi, H. M., & Kousa, P. (2020). A Case Study of Students' and Teachers' Perceptions in a Finnish High School during the COVID Pandemic. *International Journal of Technology in Education and Science*, *4*(4). https://doi.org/10.46328/ijtes.v4i4.167

Nikiforos, S., Tzanavaris, S., & Kermanidis, K. L. (2020). Post-pandemic Pedagogy: Distance Education in Greece During COVID-19 Pandemic Through the Eyes of the Teachers. *European Journal of Engineering Research and Science*. https://doi.org/10.24018/ejers.2020.0.cie.2305

Panesi, S., Fante, C., & Ferlino, L. (2021). Online learning in kindergarten during Covid-19: Teachers' experience and perception in Italy. *Qwerty*, *16*(2). https://doi.org/10.30557/QW000044

Patwardharr, V., Rao, S., Thirugnanasambantham, C., & Prabhu, N. (2020). Community of inquiry (CoI) framework and course design as predictors of satisfaction in emergency remote teaching: Perspectives of hospitality management students. *Journal of E-Learning and Knowledge Society*, *16*(4). https://doi.org/10.20368/1971-8829/1135315

Petek, T. (2021). The opinion of slovene (mother tongue) teachers on distance learning in primary schools. *Center for Educational Policy Studies Journal*, *11*(Special Issue). https://doi.org/10.26529/cepsj.1139

Pirone, F. (2021). School closures in France in 2020: Inequalities and consequences for perceptions, practices and relationships towards and within schools. *European Journal of Education*, *56*(4). https://doi.org/10.1111/ejed.12479

Prieto-Ballester, J. M., Revuelta-Domínguez, F. I., & Pedrera-Rodríguez, M. I. (2021). Secondary school teachers self-perception of digital teaching competence in spain

following covid-19 confinement. *Education Sciences*, *11*(8). https://doi.org/10.3390/educsci11080407

Quin, D. (2017). Longitudinal and Contextual Associations Between Teacher–Student Relationships and Student Engagement: A Systematic Review. *Review of Educational Research*, *87*(2), 345–387. https://doi.org/10.3102/0034654316669434

Raišienė, A. G., Lučinskaitė-Sadovskienė, R., & Gardziulevičienė, L. (2021). Telework experience of pedagogues during the covid-19 pandemic: Strong learning seniors and relaxed leaders? *Education Sciences*, *11*(10). https://doi.org/10.3390/educsci11100631

Ramploud, A., Funghi, S., & Mellone, M. (2021). The time is out of joint. Teacher subjectivity during COVID-19. *Journal of Mathematics Teacher Education*. https://doi.org/10.1007/s10857-021-09506-3

Rannastu-Avalos, M., & Siiman, L. A. (2020). Challenges for distance learning and online collaboration in the time of covid-19: Interviews with science teachers. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *12324 LNCS*. https://doi.org/10.1007/978-3-030-58157-2_9

Said Pace, D. (2021a). Formative assessment in online teaching and learning during the first COVID-19 Malta lockdown -Educators' voices, types of practices and users Doreen Said Pace Ministry for Education. *Malta Journal of Education*, *2*, 142–166.

Said Pace, D. (2021b). Formative assessment in online teaching and learning during the first COVID-19 Malta lockdown -Educators' voices, types of practices and users Doreen Said Pace Ministry for Education. *Malta Journal of Education*, *2*, 142–166.

Schwantler, S., & Tellioglu, H. (2021). Impact of the COVID-19 Pandemic: Distance Learning at Schools: An Analysis of Problems through the Switch from Classroom Teaching to Distance Learning in Austria. *2021 the 6th International Conference on Distance Education and Learning*, 195–201. https://doi.org/10.1145/3474995.3475028

Seabra, F., Teixeira, A., Abelha, M., & Aires, L. (2021a). Emergency remote teaching and learning in portugal: Preschool to secondary school teachers' perceptions. *Education Sciences*, *11*(7). https://doi.org/10.3390/educsci11070349

Seabra, F., Teixeira, A., Abelha, M., & Aires, L. (2021b). Emergency remote teaching and learning in portugal: Preschool to secondary school teachers' perceptions. *Education Sciences*, *11*(7). https://doi.org/10.3390/educsci11070349

Silva, S., Fernandes, J., Peres, P., Lima, V., & Silva, C. (2022). Teachers' Perceptions of Remote Learning during the Pandemic: A Case Study. *Education Sciences*, 12(10). https://doi.org/10.3390/educsci12100698

Soete, L. (2021). Learning from the COVID-19 pandemic: How to better prepare for the next global crisis. UNU MERIT, Maastricht University. https://www.merit.unu.edu/learning-from-the-covid-19-pandemic-how-to-better-prepare-for-the-next-global-crisis/

Stenliden, L., Bylund, A., Landkvist, L., Lind, L., Lundberg, S., Stenmark, H., & Wilhelmsson, C. (2020). *Lärares digitala kompetens före, under och efter covid-19*. https://doi.org/10.31235/osf.io/bvca3

Sun, L., Tang, Y., & Zuo, W. (2020). Coronavirus pushes education online. In *Nature Materials* (Vol. 19, Issue 6). https://doi.org/10.1038/s41563-020-0678-8

Tomczyk, Ł., & Walker, C. (2021). The emergency (crisis) e-learning as a challenge for teachers in Poland. *Education and Information Technologies*, *26*(6). https://doi.org/10.1007/s10639-021-10539-7

Topalska, R. (2021). Education during a State of Emergency. *TEM Journal*, *10*(1). https://doi.org/10.18421/TEM101-50

Tzimopoulos, N., Provelengios, P., & Iosifidou, M. (2021). Emergency remote teaching in Greece during the first period of the 2020 Covid-19 pandemic. *Advances in Mobile Learning Educational Research*, *1*(1), 19–27. https://doi.org/10.25082/AMLER.2021.01.003

UNESCO. (2021, January 25). *UNESCO figures show Two thirds of an academic year lost on average worldwide due to Covid-19 closures*. https://en.unesco.org/news/unesco-figures-show-two-thirds-academic-year-lost-average-worldwide-due-covid-19-school

United Nations. (2020). Policy Brief: Education during COVID-19 and beyond. [Resumen de políticas: Educación durante COVID-19 y más allá]. *Policy Bried: Education during COVID-19 And*, *26*.

Willermark, S., & Gellerstedt, M. (2022). Facing Radical Digitalization: Capturing Teachers' Transition to Virtual Classrooms Through Ideal Type Experiences. *Journal of Educational Computing Research*. https://doi.org/10.1177/07356331211069424

Woltran, F., Chan, R., Lindner, K. T., & Schwab, S. (2021). Austrian Elementary School Teachers' Perception of Professional Challenges During Emergency Distance Teaching due to COVID-19. *Frontiers in Education*, *6*. https://doi.org/10.3389/feduc.2021.759541

Zecca, L. (2021). Distance Educational Links: a qualitative study on the perception of kindergarten teachers. *Journal of E-Learning and Knowledge Society*, *17*(3). https://doi.org/10.20368/1971-8829/1135563