European Journal of Education Studies
ISSN: 2501 - 1111
ISSN-L: 2501 - 1111
Available on-line at: www.oapub.org/edu

DOI: 10.46827/ejes.v102.4651 Volume 10 | Issue 2 | 2023

EMERGENCY REMOTE TEACHING IN K-12 EDUCATION DURING THE COVID-19 PANDEMIC: SYSTEMATIC REVIEW OF TECHNOLOGY USE, PROBLEMS AND FUTURE PRACTICES

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Abstract:
The period of health crisis we are going through due to Covid-19 pandemic has obvious effects on the educational field. The course was temporarily transferred from the physical space of the school classroom to the digital environment. This new condition has led to the emergence of a new form of distance education, which is globally defined as "Emergency Remote Teaching" (ERT). The purpose of this article is a systematic review of the literature in order to investigate issues related to technology used, challenges arisen, as well as future practices proposed during the first two years of the coronavirus pandemic (school years 2019-20, 2020-21) in K-12 education. The search was carried out with predefined criteria at both scientific databases and a list of scientific journals about distance education. The PRISMA protocol was implemented. 46 studies were included in the review. In conclusion, a variety of technological means was used, as well as synchronous and asynchronous applications. The main pedagogical functions of the latter were course conduct, open communication and production-distribution of educational material. Problems and future practices were classified into three categories related to technology (Category 1), pedagogical process (Category 2) and health-psychology issues (Category 3). The first two have the dominant role.

Keywords: emergency remote teaching, Covid-19, k-12 education, systematic review

1. Introduction

Coronavirus is a recent condition that has radically changed our daily life. From December 2019, when first appeared, to March 2020, when upgraded to the pandemic by

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the World Health Organization (WHO, 2020), until today, it continues to be of great concern to the global community.

The field of education could not remain unaffected by the new reality formed due to the health crisis. In the name of public health, governments around the world have decided to suspend the face-to-face operation of educational institutions. The time period of this decision and its duration fluctuated due to current national health data (Bozkurt et al., 2020; Hodges, Moore, Lockee, Trust & Bond, 2020).

The above political decision has led to the lesson transfer from its natural space, the school classroom, to the house environment. The physical distance created between teachers and their students was attempted to be covered with the aid of digital technology, which was used for synchronous and asynchronous communication during the pandemic (Hodges, Moore, Lockee, Bond & Jewett, 2021; Hodges et al., 2020; Sofos, 2021; UNESCO, 2021a).

All members of an educational community (teachers, students, school administrators, parents), directly or indirectly, involved in the educational process were suddenly called upon to cope with this critical and urgent situation without having time for preparation. Time and psychological pressure combined with issues like unequal access to technological equipment and inadequacy of digital skills, led a significant number of people to speak about a low-quality distance learning. However, a closer look at its basic features (limited time for educational planning, compulsory and urgent implementation, temporary choice) suggests that this is a form of distance education different from the conventional one. The correct term used globally to describe it is "Emergency Remote Teaching" (ERT) (Bozkurt et al., 2020; Crompton, Burke, Jordan & Wilson, 2021; Crompton & Burke, 2020; Ferri, Grifoni & Guzzo, 2020; Hodges et al., 2020; Sofos, 2021; Toquero, 2021).

2. Literature Review

Distance education is a complex concept with various definitions. Their common point is the spatial and often temporal distance during lesson delivery and the structure of teaching material (Papadimitriou, 2021; Sofos, Kostas & Paraschou, 2015).

A subcategory of distance education is that provided at school by public and private institutions. Its audience is either students of primary and secondary formal education or adults who, for various reasons, failed to complete their school education (Giasiranis & Sofos, 2021; Papadimitriou, 2021). Prior to Covid-19 pandemic, it was widely used by countries such as United States, Canada, China and Australia. On the contrary, in Greece it seems that it was not an alternative choice, except in a few cases, mainly for various European programs (Kelenidou, Antoniou, & Papadakis, 2017; Miminou & Spanaka, 2016). The main quality indicators that guarantee its effective implementation in an educational context are the following (Bozkurt et al., 2020; Hodges et al., 2020; Papadimitriou, 2021; Schlesselman, 2020):

- Sufficient time for careful educational planning and production of appropriate pedagogical material based on students' interests and needs;
- Two-way communication between instructor-trainees, substantial feedback on the educational project and active involvement of students in the educational process
- Emphasis on in-depth understanding rather than on surface curriculum coverage (quality is superior to quantity);
- Equal and safe access to educational material.

On the other hand, ERT is a form of distance education that is compulsorily applied to critical situations, such as health crises, war, or natural disasters (Crompton et al., 2021). Such a case is the period of school closure due to the Covid-19 pandemic.

In their effort to discover the features of ERT that differentiate it from conventional distance learning, Xie and Rice (2021) identified five key areas related to the definition, purpose, educational design, course delivery, and technology (use and access). According to an alternative approach (Hodges et al., 2021), the distinctive features of ERT are derived partly from the acronym itself as follows:

- Sense of urgency (Emergency);
- Learning process away from the physical space of the classroom (Remote);
- Application for a finite period of time (Temporary).

The selection of ERT during the pandemic was inevitable, with the primary aim being the maintenance of access to the educational process and not curriculum coverage (Giasiranis & Sofos, 2021; Ferri et al., 2020). However, a series of problems emerged. For example, teachers and students had to rush in order to find solutions for various issues, such as lack of digital skills and insufficiency of necessary technological equipment. At the same time, parents received a huge amount of technical information, when they were suddenly assigned the role of home teacher without any prior preparation (Bozkurt et al., 2020; Hodges et al., 2020; Ferri et al., 2020; Sofos, 2021).

The challenges arose fall into three general subcategories as follows (Ferri et al., 2020):

1) technological: internet quality, the sufficiency of technological equipment;
2) pedagogical: level of digital readiness, educational planning and teaching, evaluation and feedback of students' work;
3) social: communication channels between members of the educational community.

Various practices have been implemented worldwide in order to tackle the above problems as effectively as possible. Some of these were playful learning, pedagogical use of television or radio and sending of printed material at home (Ferri et al., 2020). At the same time, both digital learning platforms and various online educational resources from digital repositories were utilized (World Bank, 2020).

In order to best manage such emergencies in the future, a number of strategies are proposed in the literature (Bozkurt et al., 2020; Ferri et al., 2020; Hodges et al., 2020; UNESCO, 2021a, b). Some of them are the following:

- Upgrading of technological infrastructure, internet quality and teachers' digital platforms;

- Equal access to the necessary technological equipment;
- Combination of different technological means (TV, radio, PC);
- Enhancement of digital skills through training;
- Creating online communities for mutual support and exchange of ideas.

2.1 The paradigm of Greece

Since March 2020, when Covid-19 was officially declared as a pandemic by the World Health Organization, educational institutions in Greece have suspended their operation. The Greek Ministry of Education proceeded to the compulsory implementation of distance education in the name of public health. The main goal was for students not to lose contact with the educational process (Giasiranis & Sofos, 2021).

In K-12 education the training platforms during ERT were common. For synchronous distance education, Webex platform was chosen, while for asynchronous learning teachers could decide between e-class and e-me. Additionally, in primary education, educational television was utilized. Daily videotaped repetitive lessons within the school classroom were created, which had the form of a lecture but lacked the physical presence of students. At the same time, other alternative tools available to teachers were the digital repository of open educational resources "Fotodentro", e-mail and social media (Bozkurt et al., 2020; Giasiranis & Sofos, 2021; Liarakou, Kostas, Gavrilakis, Megalou & Panos, 2021; Papadimitriou, 2021).

The majority of problems that the educational community had to face referred to issues of technological and technical nature, such as low internet quality and difficult-to-use e-learning platforms. However, there were also issues related to communication, personal data protection, educational planning and levels of participation in distance learning (Giasiranis & Sofos, 2021; Liakopoulou & Stavropoulou, 2021).

3. Material and Methods

3.1 Aim and research questions

The purpose of this article is a systematic literature review in order to explore issues related to technology used, problems and challenges that emerged, as well as future practices proposed during the Covid-19 period focusing on the first two years ERT implementation in K-12 education (school years 2019-20, 2020-21).

Research questions were formulated taking into account previous systematic reviews conducted for ERT during Covid-19 or earlier. Thus, for the needs of current research, an attempt was made to answer the following questions (Bond, 2020; Crompton et al., 2021):

1) What were the research identity and methodology of studies included in the review (countries, publication year, research period, educational level, sample, research tools)?
2) What kind of technological tools and applications were selected and what was their pedagogical role?

3) What problems emerged and how could they be categorized?
4) What suggestions were made about the effective management of ERT in the future?

3.2 Study process

The method applied was a systematic literature review for the period July-August 2021 (last access 31/8/2021). The search was initially performed automatically in the databases Web of Science (WoS), Scopus and ERIC, using a specific algorithm (Table 1). The Boolean algebraic model was used. Keywords were selected from three groups related to the type of training (ERT), the condition (Covid-19) and the field (K-12 education).

Table 1: Search algorithm

Group 1	"emergency remote education" OR "emergency remote teaching" OR "ERT" OR "ERE" OR "distance education" OR "distance learning" OR "online education" OR "online learning" OR "e-learning" OR "homeschooling" AND
Group 2	"coronavirus" OR "coronavirus" OR "covid-19" OR "covid19" OR "pandemic" AND
Group 3	"K-12" OR "K12" OR "kindergarden" OR "primary school" OR "elementary school"

In the second phase, a manual search was conducted in scientific journals related to distance education (Table 2).

Table 2: List of journals about distance education which used for manual searching

1	Open Education
2	American Journal of Distance Education
3	Open Learning: The Journal of Open, Distance and e-Learning
4	International Journal of Distance Education Technologies
5	Journal of Online Learning Research
6	International Journal on E-Learning
7	International Journal of Online Pedagogy and Course Design
8	International Journal of Web-Based Learning and Teaching Technologies
9	European Journal of Open, Distance and E-Learning
10	Electronic Journal of e-Learning
11	MERLOT Journal of Online Learning and Teaching
12	The International Review of Research in Open and Distributed Learning
13	International Journal of E-Learning & Distance Education
14	Current Issues in Emerging eLearning (CIEE)
15	Asian Journal of Education and E-learning
16	Themes in e-Learning
17	Online Learning Journal
18	European Journal of Open Education and E-learning Studies
19	E-Learning and Digital Media
20	International Journal of Instructional Technology and Distance Learning
21	Online Journal of Distance Learning Administration

The review process followed the steps described by PRISMA protocol (Moher, Liberati, Tetzlaff, Altman & Prisma Group, 2009). For the inclusion or exclusion of a scientific article, a series of predefined criteria were set (Table 3). The final number of studies included in the sample was 46. The process from the initial search to the final selection is presented in detail in a flow chart (Figure 1).

Table 3: Inclusion criteria of scientific articles

Criterion	**Description**
Language	English
Publication date	March 2020 to August 2021
Type of study	Scientific article (peer-reviewed)
Methodology	Empirical study
Access	Full text
Education level	K-12 (only primary education or together with secondary)
Sample	In-service teachers, students or parents (>1)
Content	Technology use (means and applications) in formal education settings during Covid-19 (ERT) and challenges emerged

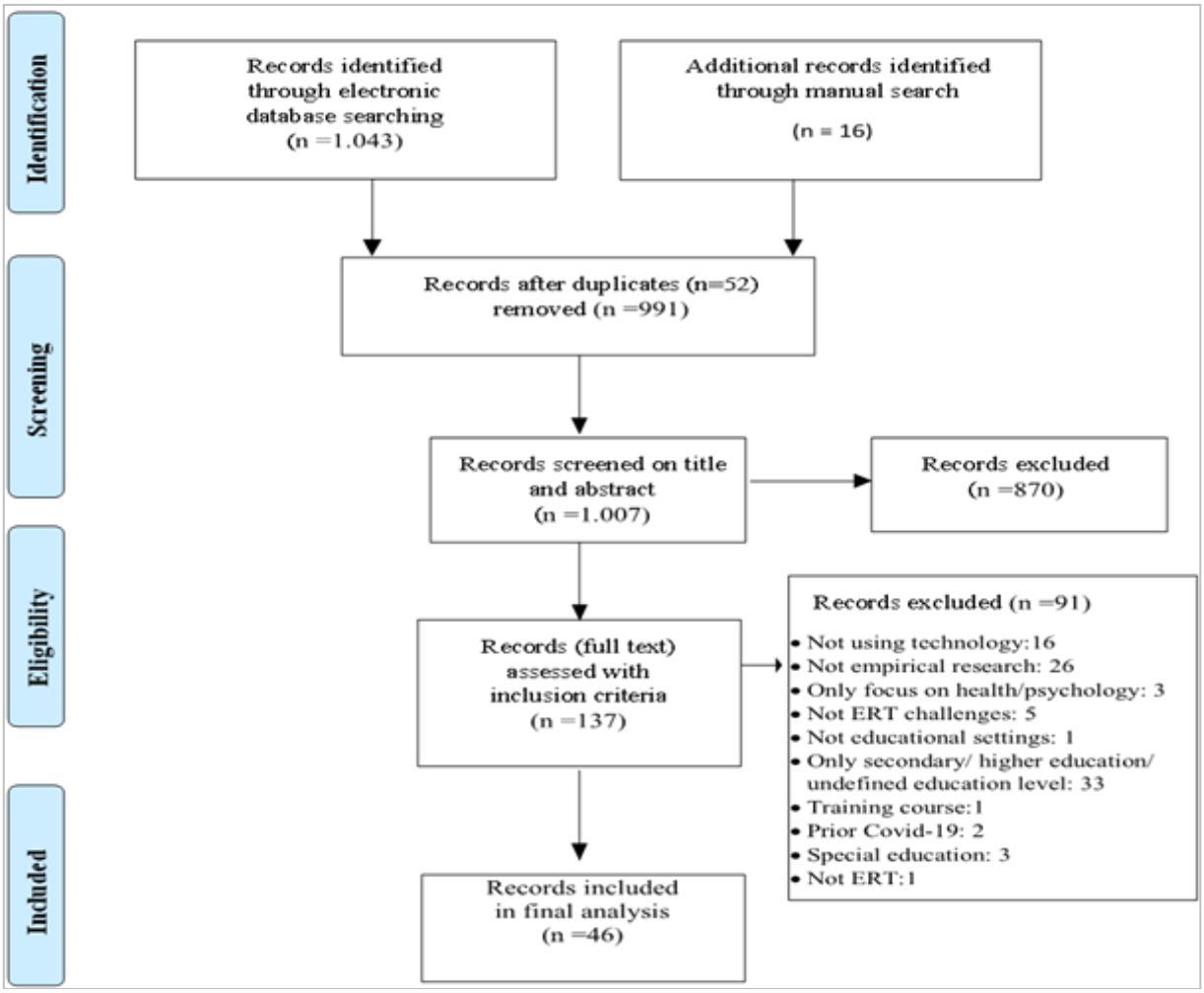


Figure 1: PRISMA flow diagram (Moher et al., 2009)

4. Results

4.1 What was the research identity and methodology of studies included in the review (countries, publication year, research period, educational level, sample, research tools)?

To begin with countries of research, 11 of them took place in Turkey, 6 in China, 6 in Indonesia and 3 in USA. 22 out of 46 studies were conducted in different countries each, such as Canada, Italy, Greece and S. Korea, while only one study was on a global scale (Figure 2). As for the time variable, it was strictly defined between 2020-2021 due to Covid-19 conditions. 39 studies were published in 2021. 37 studies were designed and implemented in the school year 2019-20, while only 5 took place in the following school year, namely 2020-21 (Figure 3).

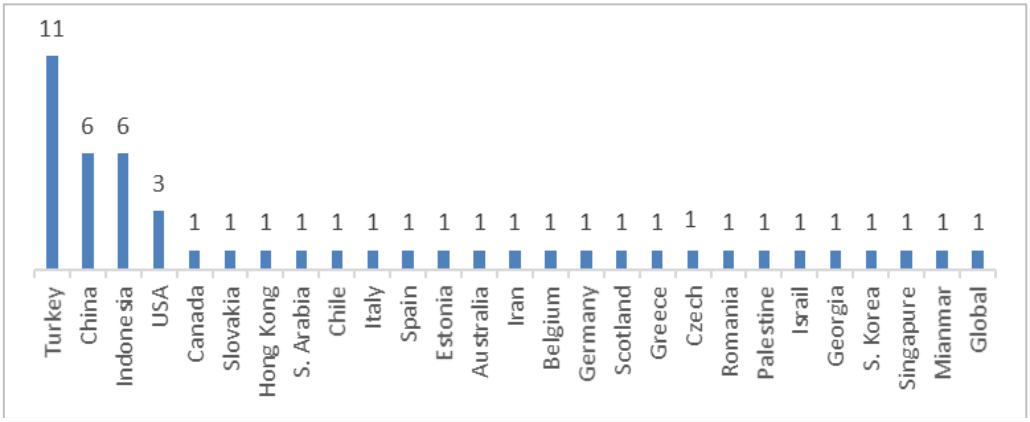


Figure 2: Countries of research

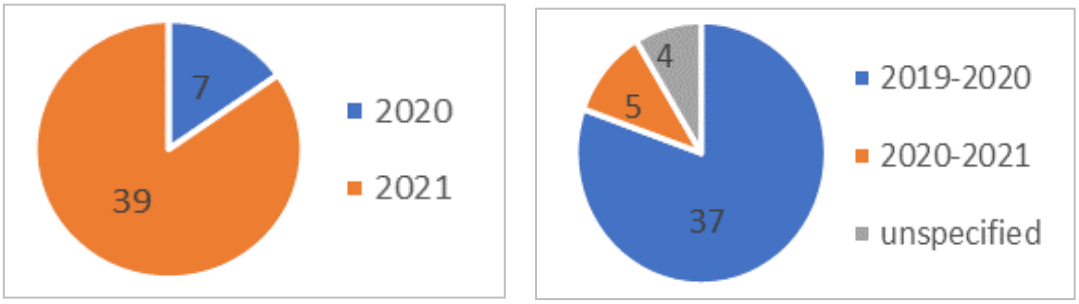
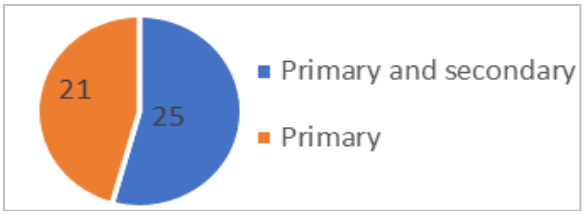


Figure 3: Publication year (left) and research period (right) of studies

25 studies covered the whole K-12, while 21 focused only on primary education. Two of the latter were conducted on pre-school level. As for the research sample, 21 studies selected teachers, 6 parents and 3 school administrators. When a mix of participants was chosen, different combinations emerged, such as teachers and students (3 studies) or students and parents (1 study). Only one study included all subcategories (Figure 4). For data collection, in 34 studies only one research tool was chosen. Among them, 20 studies used a questionnaire, 12 an interview and 2 observations (Figure 5). All of them were implemented online due to Covid-19 pandemic.



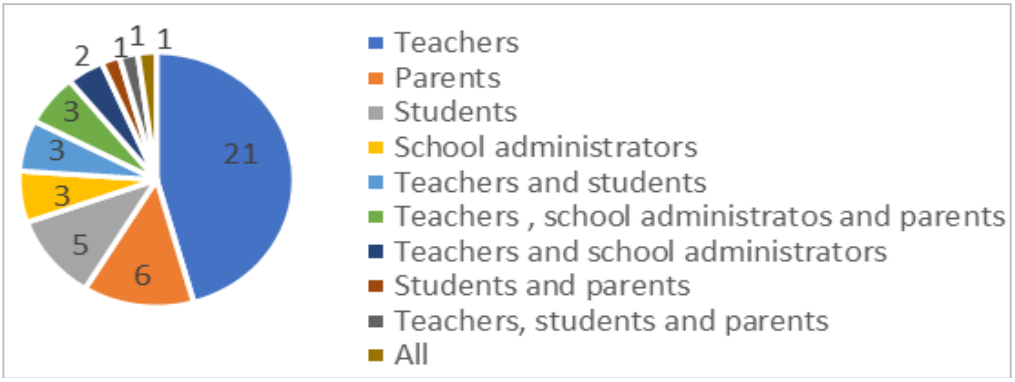


Figure 4: Education level (up) and research sample (down) of studies

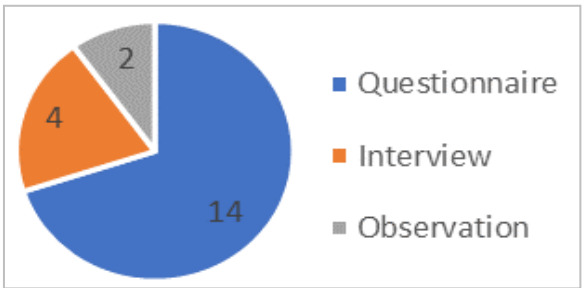


Figure 5: Research tool at one method studies (n=20)

4.2 What kind of technological tools and applications were selected and what was their pedagogical role?

Starting with technological means used for the needs of ERT, 21 studies referred to one or more of them. 14 studies referred to phones (landline or mobile), 12 to PCs or laptops, 9 to television, 8 to tablets and only one to the radio (Figure 6).

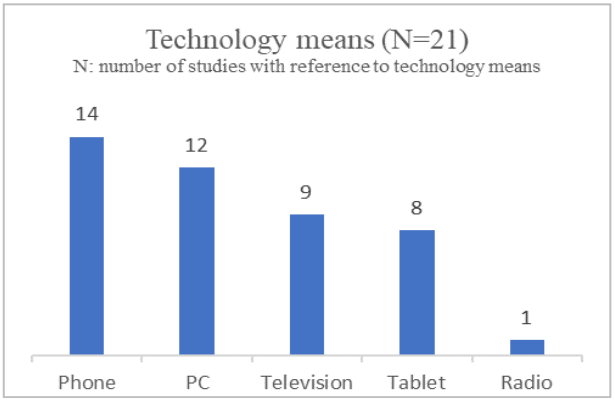


Figure 6: Means of technology used for ERT

Regarding technological applications, Figure 7 shows all of them utilized for ERT. Among them, the five most preferred were ZOOM (22 references), WhatsApp, e-mail (15 references each), Google Classroom (13 references) and Google Meet (9 references). Table 4 shows data about their pedagogical role. The two most frequent functions were teaching conduct (22 references) followed by communication, interaction and feedback (15 references). It is observed that 11 studies did not mention any specific educational role of applications.

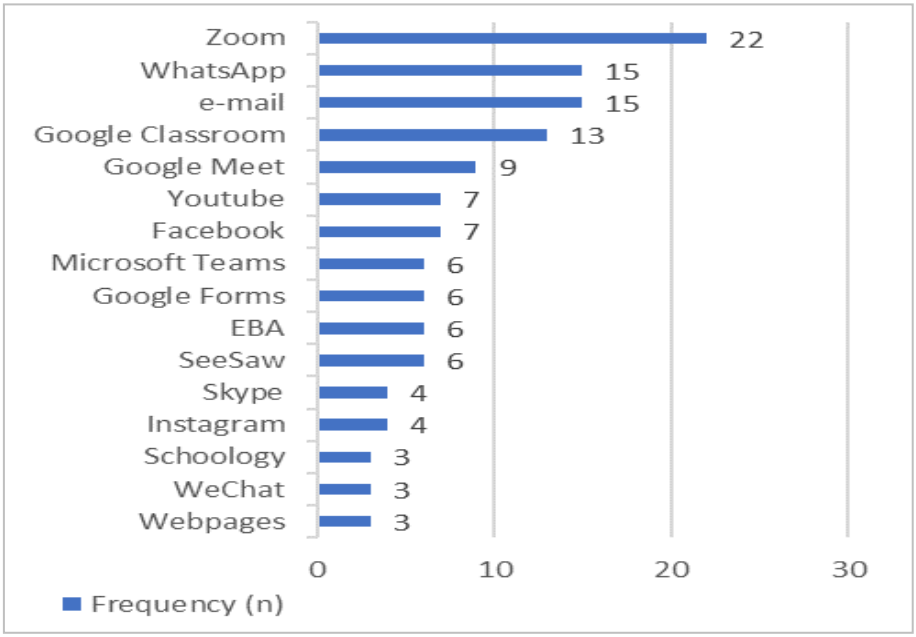


Figure 7: Applications used for ERT

Table 4: Pedagogical role of applications

Function	Frequency (n)
Teaching conduct (synchronous or a synchronous)	22
Communication, interaction, feedback	15
Production and material share	11
Unspecified	11
Organization and e-classroom management	4
No reference	3
Teacher training	2
Assessment	2

4.3 What problems emerged and how could they be categorized?

Both problems and future practices were grouped and put into categories for easier and more efficient analysis of the data. Thus, three categories were created, taking into account at the same time what is mentioned in the literature (Ferri et al., 2020). These categories are specialized as follows:

- Category 1 (technology): technical issues, technological equipment, digital skills
- Category 2 (pedagogic procedure): distance teaching, relationships between educators-students-parents

- Category 3 (health-psychology): physical, emotional and psychological condition of education members during ERT

The first two categories dominated. Category 2 precedes as it appeared in 41 studies compared to Category 1, which had 40 references. On the contrary, Category 3 stayed far behind with 16 references (Figure 8).

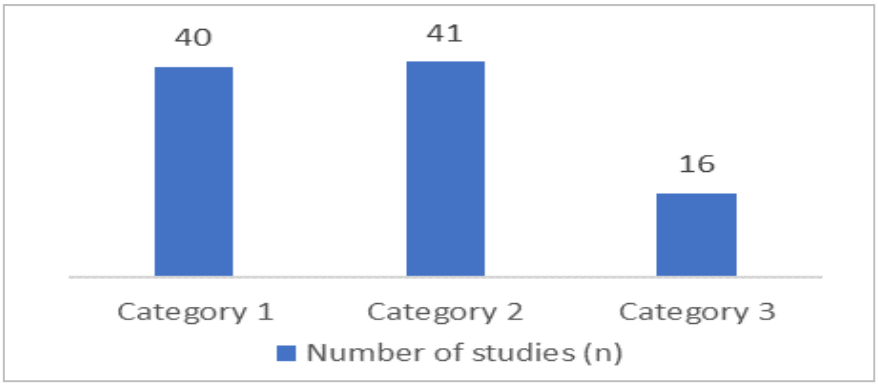


Figure 8: Problems-challenges of ERT per study (N=46)

In order to find specific problems per category, in Category 1 the most frequent challenge was lack of training and experience in digital skills (26 references), followed by low or unstable internet connection (20 references), unequal access to technological equipment (19 references) and insufficient infrastructure (18 references) (Figure 9). In Category 2, first place was the absence of physical contact (24 references), followed by low levels of lesson participation (20 references), difficulties in assessment and classroom management (17 references) and excessive homework (14 references) (Figure 10). In Category 3 (health-psychology), problems detected include physical and psychological fatigue, health problems (mainly eye pain), negative emotions (anxiety, distress, worry, sadness, lack of confidence, anger, fear), as well as behavioral problems (laziness, aggression, confrontation, hyperactivity).

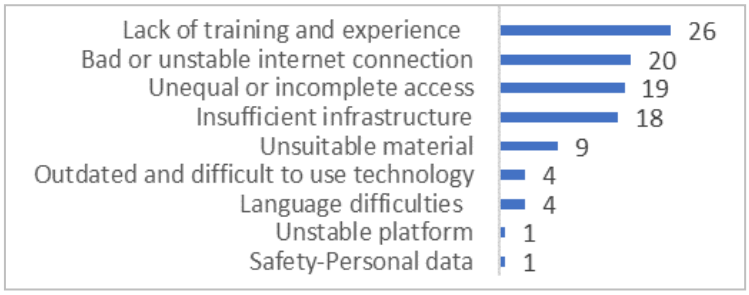


Figure 9: Problems-challenges of ERT (Category 1)

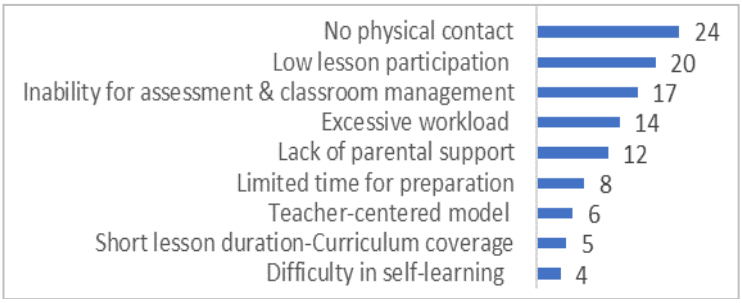


Figure 10: Problems-challenges of ERT (Category 2)

4.4 What suggestions were made about the effective management of ERT in the future?
The first two categories retained the leading role. Category 1 appeared in 41 studies Category 2 in 39 studies and Category 3 in 9 studies (Figure 11).

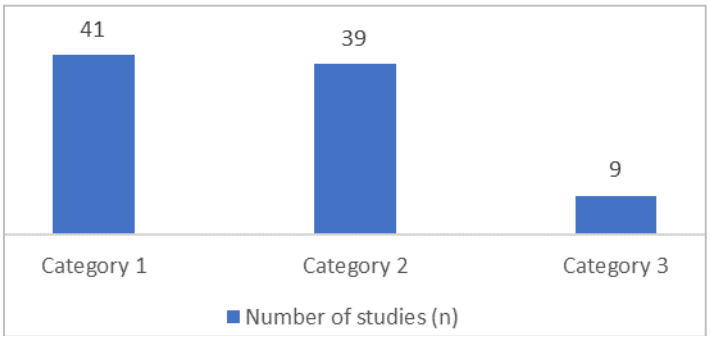


Figure 11: Suggestions for future management of ERT per study (N=46)

As for specific suggestions per category, in Category 1 training in digital skills concentrated the most references, namely 23. Construction of applications and digital tools had 22 references and equal accessibility in digital equipment had 14 references (Figure 12). In Category 2 most frequent suggestions were the implementation of student-centered model (16 references), more opportunities for communication and feedback between teachers and students (13 references), cooperation between school and parents (11 references) and motivation for enhancement of lesson participation (11 references) (Figure 13). In Category 3 future practices were related to increasing students' emotional involvement in teaching, creating a climate of mutual understanding, social and psycho-emotional support of teachers and parents, and cultivating positive behaviors.

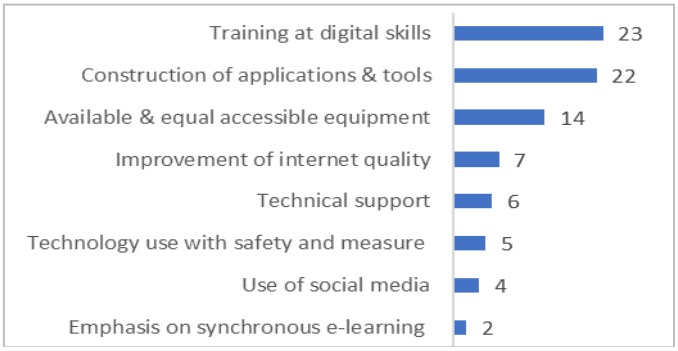


Figure 12: Suggestions for future management of ERT (Category 1)

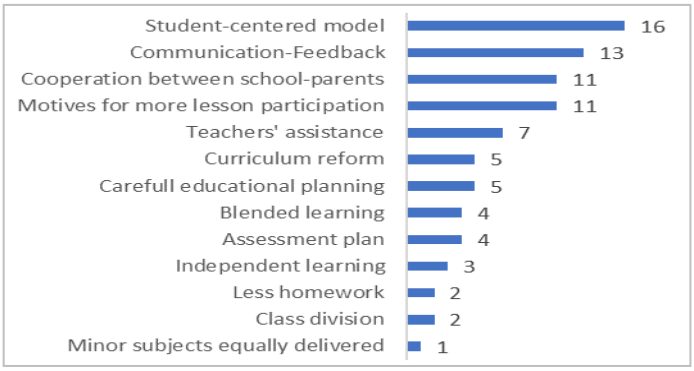


Figure 13: Suggestions for future management of ERT (Category 2)

5. Discussion

5.1 Identity and research design

Most of the studies included in the systematic review were conducted in Asia (69.5%). The reason may be that Covid-19 originated on the Asian continent in March 2020 (WHO, 2020). At the same time, the increased research interest may be explained by the fact that distance education in its conventional form was already widely applied before the pandemic in Asian countries (e.g China) (Kelenidou et al., 2017; Miminou & Spanaka, 2016). On the other hand, no articles from Africa were included in the sample, despite the fact that significant problems were referred to and initiatives undertaken to address them (Bozkurt et al., 2020; UNESCO, 2021a; UNESCO, 2021b; UNESCO, 2021c). The reason for this could be either a lack of research or non-compliance with the criteria of a systematic review. The majority of articles are published in 2021 (84.7%) with most surveys being implemented in the school year 2019-20 (80.4%). One possible explanation for this may be that scientific articles have to be approved and published until August 2021. Literature confirms the difficulty of finding articles focusing exclusively on the first educational grade (45.6%) (Bond, 2020; Crompton et al., 2021). The lack of research was even greater in pre-school education (only 2 studies).

There was an imbalance in the subjects of research. The predominant trend was teachers exclusively or partly chosen as the sample (67.3%). In contrast, a small number of researchers selected students (10.8%), while only one study took into account all stakeholders of the educational process, including parents, whose role proved to be crucial in the implementation of ERT (Bozkurt et al., 2020; Sofos, 2021). As for the data collection tool, in 73.9% of studies, one was selected and this was in the majority of cases (70%) questionnaire, which was made in electronic form and distributed online, due to public health protection measures.

5.2 Technological means and applications

According to research data, reference was made to all possible technological means which can be used for the needs of ERT (PC, tablet, landline or mobile phone, television, radio). This could be explained by the fact that countries included in the systematic review varied in the level of economic and technological development. For example,

educational television and radio were mainly chosen by developing countries as a more affordable solution. In 54% of studies, no specific technological mean was mentioned.

In terms of technological applications, 43 of 46 studies described the use of one or more of them for synchronous or asynchronous distance learning. Among the first options were Zoom, WhatsApp, e-mail, Google Classroom and Google Meet, while social media's contribution was also remarkable. Data confirmed literature. Their main pedagogical role was the smooth conduct of distance learning courses. Other functions were unhindered communication between the main actors of the educational process (teacher, students), including parents, and production-distribution of digital educational material (Bozkurt et al., 2020; Hodges et al., 2020; UNESCO, 2021a).

5.3 Problems and challenges

The abrupt removal of teachers and students from their physical space, school classroom, in order to implement ERT had led to a series of problems for both the pedagogical process itself and its recipients. Among three categories, the first two related to technological issues (Category 1) and pedagogical process (Category 2) dominated. We come to a similar conclusion from the literature review, where the emphasis is put on problems related to social isolation and low levels of technological readiness and competence. In Category 3 (health and psychology), the low representation of its problems in the research sample seems to be disproportionate to the theoretical impact they have on the effectiveness and quality of ERT (Bozkurt et al., 2020; Hodges et al., 2020; UNESCO, 2021a; UNESCO, 2021c).

5.4 Suggestions for future management

The articles included in the sample made various suggestions for the effective management of ERT in the future. The vast majority of them (96%) were also from Categories 1 and 2, which are treated equally. Category 3 lags far behind. In the first category, the most common suggestions made were training in digital skills and the construction of new and easy-to-use technological applications. The second category that stands out is the shift to alternative teaching methods (e.g playful learning, project), where students have the dominant role. Furthermore, it is important to create open communication channels between teachers and students for frequent feedback on students' work and teaching effectiveness. Similar suggestions concerning technology and pedagogical procedure are found also in the literature (Ferri et al., 2020).

Both problems and future propositions were not statistically represented. The reason for this was their statistically significantly lower number of citations to the articles' content, compared to the other two categories. In particular, in terms of problems, although Category 3 appears in 16 of 46 studies (34.7%), its total reports within the content of each study are only 19 (8.2% of total reports), compared to 102 reports in Category 1 and 110 in Category 2. As for future practices, they appear in 9 of 46 studies (19.5%), while their total reports remain 9 (5.1%), compared to 83 of Category 1 and 84 of Category 2.

6. Limitations

This article provides an answer to a number of research questions about the application of ERT during the Covid-19 pandemic. However, there were a number of limitations that need to be taken into account in future research efforts. These were the following:

- All selected articles were written in English;
- Articles were published until August 2021, while Covid-19 is a dynamic phenomenon that is still in full progress;
- Search was performed in three databases and the list of scientific journals was indicative;
- Studies without access to the full text excluded;
- Studies specified in special education were not included in the sample.

In any case, it seems necessary to conduct more systematic studies about ERT in the future, in order to draw as many as possible useful conclusions in favor of the educational community and pedagogical process.

7. Conclusion

The Covid-19 pandemic had obvious consequences in the field of education. It led governments around the world to implement ERT by prioritizing the protection of public health (Bozkurt et al., 2020; Hodges et al., 2020; Sofos, 2021; Toquero, 2021). However, the sudden transfer of teaching from a classroom to an electronic environment created many problems related to issues of technology, pedagogical process and health-psychology (Ferri et al., 2020). In order to meet challenges arisen, various initiatives have been taken by international organizations (e.g UNICEF, UNESCO) with their primary goal to be equal access to the educational process and a smooth return to the natural school environment (UNESCO, 2021b; UNICEF, 2020). Although such initiatives have been commendable, the best way to deal with such emergencies in the future, such as Covid-19, is prevention (Hodges et al., 2020).

With a view to Greek reality, practices that would make sense for the management of future emergencies would be the following:

- Upgrade technological infrastructure and ensure equal and free access to it
- Organize more educational activities in order to enhance the digital skills of teachers students and parents
- Application of student-centered teaching methods with emphasis on frequent feedback and two-way communication

Conflict of Interest Statement
The authors declare no conflicts of interest.

About the Authors

Paschalis Saroglou is a primary school teacher at Greek public schools. He is currently a PhD candidate at the Aristotle University of Thessaloniki, Early Childhood Education Department. He holds two Master's degrees in Semiotics & Communication and Educational technology. For the latter, he received a scholarship from Onassis Foundation. His research interests involve social representations in education, semiotic analysis of school textbooks and the use of technology in a school classroom.

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