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An explorative review

Marco Capasso and Sabine Wollscheid

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Preface

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Both authors operationalized research questions and objectives and the single stages of the review process. Sabine Wollscheid was mainly responsible for research design and method, while Marco Capasso was mainly responsible for the data analysis and synthesis.

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Oslo, February 28th, 2022

Michael Spjelkavik Mark
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Summary

Particularly in 'early' or 'major' adopting countries of digital technologies research on digital transformation in schools has been expanding. Such research, however, is fragmented for 'late' adopting countries with a disadvantaged context for digitalization. Identifying and summarizing this research, this working paper presents the results of an explorative review of studies on the implementation of digital technologies in compulsory schools in countries with a disadvantaged context for digitalization. Our aim is to understand the specific contextual constraints met by these countries when adopting digital technologies in their education system. Limiting the scope to one main source for recruiting a purposeful sample of studies of high quality, we review studies published in Computers and Education, a high-quality scientific journal. We find that physical infrastructure or hardware, as expected, is a potential 'first-order barrier' in countries with a disadvantaged context. In addition, teachers play an even more dominant role, when technology is implemented in a country which is a late adopter for 'digital technologies'. Moreover, the students' families can transmit a positive attitude towards the technology; and the local context should be valued in terms of culture, tradition and habits. Lastly, collective knowledge should be gathered from analogous experiences on technology implementation in similar contexts; and in countries with a disadvantaged context, the adoption of technology in education might let pupils acquire a pioneering role. The review further informs the design of primary studies in these countries and identifies research gaps. Limitations and implications for further research are discussed.

Keywords: digital technologies, primary education, disadvantaged context, explorative review.

1 Introduction

Digital transformation of societies has been impacting education systems for several decades (e.g., Elstad, 2016b; Marcum, 2014). In many countries over the world schools have been implementing digital technologies in class, although at a different pace (e.g., Elstad, 2016a; Islam & Gronlund, 2016; Olofsson, Lindberg, Fransson, & Hauge, 2015; Selwyn, 2012). Being 'early adopters' (Rogers, 2003), the Nordic countries (e.g., Ottestad, 2010; Tømte, Wollscheid, Bugge, & Vennerød-Diesen, 2019; Vahtivuori-Hänninen & Kynäslahti, 2016) have been implementing digital technologies in schools much faster than those countries classified as 'late adopters' or 'laggards', the latter being the last in implementing such innovations (Rogers, 2003).

The literature dealing with implementation of digital technologies in schools often refers to 'first order' and 'second order' barriers. While 'first order barriers' are about external barriers, such as lack of access to the right equipment and lack of knowledge of how it works, 'second order barriers' touch upon cultures, attitudes, and motivations for adopting new technology. These are more difficult to overcome than the former (see e.g., Rienties, Brouwer, & Lygo-Baker, 2014). Similarly, change can be understood as a two-step process: 'first order change' means doing the same with a new one technology; 'second order changes', however, imply a redefinition or transformation of activities. While first order changes might comprise relatively simple processes to optimize established practices, second order changes involve the introduction of radically new practices replacing the old. To succeed with implementation of digital technologies in school, the school leader plays a role to initiate understandings of what the implementation of digital technologies means for pedagogical practice (Genlott, Grönlund, & Viberg, 2019; Wollscheid et al., 2021). While most of the implementation literature is mainly about advantaged contexts, in this working paper we address the implementation of digital technologies in countries with a disadvantaged context for digitalization, here defined as countries which might be described as 'late adopters' or 'laggards' according to the implementation of new technologies.

There are various ways of defining disadvantaged contexts that may range from the dominant approach of focusing on resources, such as income and gross domestic product, to reliance on subjective measures. Amartya Sen identifies a limitation with the dominant approach used to define disadvantaged contexts, since people may have different needs and thus may require different levels and types of resources to achieve the same outcomes (Sen, 1987, 1999). The more disadvantageous a setting is, the less likely successful educational outcomes become (see also Rubagiza et al., 2011). From a conventional sociology of education perspective (Bourdieu, 1971, 1974, 1977), the theory of disadvantage is useful for framing the contexts in which this review is conducted and can improve its relevance for use in other disadvantaged settings.

Research on the impact of digital technologies in an educational context has increased rapidly during the last years, with 61 review articles on the topic published on Web of Science (WoS) only in 2020 (e.g., Acquah & Katz, 2020; Jamshidifarsani, Garbaya, Lim, Blazevic, & Ritchie, 2019; Spiteri & Rundgren, 2020). Most reviews, however, comprise studies in countries classified as 'early adopters' or 'early majority', while only a few address countries denoted as 'late adopters' or 'laggards' (e.g., Choudhury & Pattnaik, 2020; Kibuku, Ochieng, & Wausi, 2020).

One of these exceptions is Kibuku et al. (2020), who have reviewed the literature on challenges faced during implementation and provision of e-learning in universities in Kenya. Some of the challenges they found include lack of adequate e-learning policies, technical infrastructure, and technical and pedagogical competencies and training; budgetary constraints and sustainability issues; negative perceptions towards e-learning; and quality issues. Further, Choudhury and Pattnaik (2020) have reviewed emerging themes on e-learning methods in organizations in an Indian context by investigating advantages, challenges and theories from the perspective of stakeholders. They conclude that stakeholders should keep up with changing trends of technology and the associated learning environment, and that rapid technological advancements and aligned changes in the learning environment is the unremitting challenge that stakeholders face.

Another literature review by Dodson et al. (2012) found that top-down, technology-centric and goal-diffusive approaches to information and communication technologies development add to unsatisfactory development results. They argue for careful consideration of development objectives, perspective and focus to be crucial in all phases of an information and communication technology development project. Further, focusing on 48 African countries, Tchamyou et al. (2018) investigate the importance of digital technologies in affecting the impact of education and lifelong learning on income inequality and economic growth. They show that digital technologies interact with primary and secondary education and have a positive effect on the reduction of inequalities.

None of these examples, however, addresses the implementation of digital technologies in compulsory education in countries with a disadvantaged context. However, drawing on Sen's capability approach and a Rwandan context, Rubagize et al. (2011) found that the policy initiative on the implementation of digital technologies in schools appeared to disadvantage certain groups, like female students and students from rural communities.

Given the dynamically developing field of research, there is now an increasing number of primary studies on digital technologies also in the context of countries with a disadvantaged context. At the same time, for this specific context no review over literature of high scientific quality has been published in English. Therefore, we limit the scope of our review to the well-indexed and highly cited journal Computers & Education, one of the leading journals for our topic of study, to ground our review on a mindfully generated sample of studies that reach high scientific standards. To add to the knowledge gap on the use and implementation of digital technologies in primary education in countries with a disadvantage context, we undertake a literature review combining systematic and explorative elements.

Primary education is fundamental for children's further educational career, and it is also the origin for possible educational inequalities (Dämmrich & Triventi, 2018). Our specific aim is to understand the specific contextual constraints met by these countries when adopting digital technologies in their education systems, to further inform the design of primary studies in the countries and to identify research gaps.

2 Research question and method

2.1 Research question

Previous research shows that the school context, where digital technologies are implemented, may be crucial for digital transformation. Such a context might comprise factors such as teacher competencies, digital skills, technical infrastructure, teacher attitudes and willingness to implement new devices (Genlott, Grönlund, & Viberg, 2019; Tømte et al., 2019; Tømte, 2013). Drawing on the research on the implementation of digital technologies in early adopting countries and the lack of systematic synthesis of studies in countries with a disadvantaged context, this review addresses the overarching question: What is the overall knowledge on the impact of digital technologies in primary education in countries with a disadvantaged context, and what additional challenges do these countries face in the implementation of digital technologies?

2.2 Research methodology for the literature review

In general, systematic reviews draw on scientific methods to identify, appraise and synthesize a representative sample of studies addressing a mostly pre-defined research question, to limit systematic error ('bias') (Petticrew & Roberts, 2006). Each stage requires specific decisions, dependent on scope and epistemology underpinning the question, and the available time and resources (Gough et al., 2017). The research methodology for this review is informed by a meta-synthesis approach, which is a systematic review approach addressing qualitative primary studies (Saini & Shlonsky, 2012). Here, the review stages unfold in an iterative manner, reflecting the logics of a configurative approach. Such an approach considers potential relationships of themes across studies, critically focusing on findings that are both contradictory and complementary (Thorne et al., 2004; Walsh & Downe, 2005; cit. in Saini & Shlonsky, 2012) while aiming to keep the original meaning of each primary study (Walsh & Downe, 2005). Our approach started with a pre-defined research question and assumptions guided by previous research. This was followed by pre-determined strategies for literature search, study

selection, study description, data coding, extraction of themes, their comparison and contrast, and synthesis of findings (see Thorne et al. 2004).

2.3 Literature search and selection of studies

Limiting the scope to peer-reviewed articles of high scientific quality, we restrict our review to studies published in the journal Computers & Education, which is considered as a central source for international literature on this subject. Drawing on an explorative scoping search in WoS, we found that a high number of potentially relevant articles was published in the journal. Moreover, we assume that the peer review process of the journal adopts similar quality standards for all published articles. Thus, limiting our sample of studies in the journal, we chose a 'purposive sampling strategy' (Ames, Glenton, & Lewin, 2019) with the aim to exclude studies that do not hold certain quality standards. At the same time, we cannot rule out some bias in the sample as we focus on one single journal, even though we have not aimed for exhaustivity in the sample.

For further inclusion criteria, we chose to be relatively inclusive on study location (geography), and more restrictive on technological and educational concepts. Thus, in our search strategy, we focused on mobile technologies (e.g., tablet computers) and game-based solutions and primary education. The keywords for the main concepts and synonyms were truncated and combined with the Boolean operators AND and OR. Below, we provide the final search string for WoS that was previously tested to reach a balance between sensitivity (many hits and few relevant hits) and specification (few, but many relevant hits):

TS=((digitali* OR "digital device*" OR ICT OR app* OR computer* OR laptop* OR game-based OR "game based" OR mobil*)) AND TS=("primary education" OR "primary school" OR "elementary school" OR "elementary education") AND SO=("Computers & Education"). Timespan: 2000-2020. Indexes: SCI-EXPANDED, SSCI, A&HCI, ESCI.

The search resulted in 308 references, that is a reasonable starting point for a review drawing on a meta-synthesis approach. To identify relevant studies for inclusion, we carefully read titles and abstracts of all references for identification of relevant studies. This selection process was an iterative rather than a linear process. First, the first and second authors pre-screened a sample of 50 titles and abstracts, looking for any type of hint that could suggest a peculiarity of a disadvantaged context, in the face of the education technology. The goal was to refine the notion of the multi-dimensional concept of 'disadvantaged context', for use in the final screening of the whole set of abstracts (an accurate description of this explorative screening stage is reported in Appendix A). Then, in the final screening, we used location, infrastructure and policy, which are the criteria developed during

the first explorative screening stage. According to the literature on 'early adopting country' contexts, for example Norway (Tømte et al. 2018), we assumed that these three criteria might be of specific relevance for the implementation of digital technologies in countries with disadvantaged context. Using these criteria, we aimed to select a subset of articles to be read in full length. When talking about location specificities, we refer to specificities at country level (as for the case of a country with disadvantaged context) or at lower geographic scale (as for the case of an underdeveloped area within a country).

Finally, informed by our research question, we included 15 studies for further analysis and description. As our research question is of explorative nature, our aim was rather to recruit a purposeful sample and reach a point of saturation, than to reach a certain exhaustivity and representativeness. In the following section, we briefly describe the study aim of the included articles and present them in a table.

2.4 Analysis

2.4.1 Mapping

The analyses include a map of studies for the following characteristics: author and publication year; country; the core topic according to the research question; information on educational context and main findings. Such a mapping approach can be characterized as a descriptive analysis, inspired by document and content analysis techniques (e.g., Robson and McCartan 2011). We read the included studies, applying a wide reading strategy to screen titles and abstracts and capture basic information on authors, publication year and publication channel and country context.

2.4.2 Meta-synthesis approach

During narrow reading, i.e., a re-reading of specific parts (e.g., introduction, method, findings and conclusions) of the included studies, we coded corresponding text with respect to the research question (Robson and McCartan 2011). Informed by a meta-synthesis approach, we coded main phrases and themes across findings. The analysis was supported by means of the computer-assisted qualitative data analysis software (CAQDAS) NVivo to facilitate data management and increase transparency and rigor (Richards 2009). This coding process was informed by our assumptions based on previous research, and careful reading of the included studies, and can be characterized as both deductive and inductive. Most included studies draw on qualitative epistemology. For those drawing on

quantitative epistemology we used the authors' conclusions for synthesis, rather than statistical findings.

For a first coding, the first and second authors coded parts of the text using the three concepts - location, infrastructure, and policy, with some overlap. After the first coding, the first and second authors discussed the results for validation and revision of the codes. They ended up with a more fine-grained coding scheme with the following categories: hardware at school; hardware out of school; teacher competencies; school strategy; culture at school; local culture; urban/rural context; urban or regional policy; national policy; international policy; student outcome; and other. A second coding was performed by the first author and the resulting code file was sent to the second author for validation and further revision. We ended up with the following three main categories and sub-categories.

- School: hardware at school; teacher competencies; school strategy (including subcategories: school-home cooperation; role of technology team/coordinator; other); culture at school
- Context: hardware out of school; local culture; other
- Policy: urban or regional policy; national policy; international policy.
- A fourth category named 'other' might cover remaining concepts which appear only sporadically in the reviewed papers, for instance differences in outcome across student genders, or the effect of individual psychological traits and development among students.

The first main category "school" comprises now some of the previous coding categories: "hardware at school", "teacher competencies", "school strategy", and "culture at school". In turn, under "school strategy", we include the subcategories of "school-home cooperation" and "role of technology team/coordinator". We need, however, to mention that the technology team coordinator could, for some municipalities, be external to a specific school and working across different schools. As for the subcategory "culture at school", less obvious elements such as the role of the teachers, as well as their attitudes and frustrations, were coded under this subcategory. This category was informed by the literature (see e.g., Fu & Hwang, 2018; Nousiainen et al., 2018; Steyn, 2016; Tondeur et al., 2018).

The second main category "context" comprises the subcategories "hardware out of school" referring to technological devices and infrastructure available for the students at home and "local culture" referring to local traditions as well as institutional norms and unwritten rules. (e.g., Asongu & Odhiambo, 2019). The remaining subcategory "other" might now comprise geographical characteristics like remoteness and low population density, but also social economic background

of the students and their families, as well as location in low rural areas and in less privileged urban areas.

Finally, the overarching category “policy” covers all the previous policy-related coding categories (e.g., Tchamyou et al., 2019; OECD, 2001). With regard to this category, we need to mention that, on several occasions, policy appears in the text without an explicit geopolitical scale, and therefore the coding author had to exert some discretion over the scale at which policy might be decided or implemented.

2.5 Study descriptions

In the following, we provide a brief description of the included studies, both narratively and as a table.

Investigating student interactions in classrooms in a Cyprian context, where local culture has limited proactive initiatives from the students, Anastasiades (2003) shows a combination of new educational technologies with a traditional learning pedagogical model, in an effort for implementing a novel policy (further details are in Appendix A). Similarly, Al-Huneini et al. (2020) points to the disadvantages of a geographic area in Oman, in this case, even in relation to the standards of the whole country. Both the rural context and the lack of infrastructures are under investigation in this study. Here the concept of "digital divide" is considered, since the remoteness of the place under study lowers its attractiveness to teachers leading to high employee turnover in schools severely affecting the preparation of teachers to use new technologies. Further, Castro and Alves (2007) describe how scaling up policies for technology and education in Brazil may be hindered by the existing digital divide within the country.

Eteokleous (2008) evaluates computer technology integration in Cyprus by paying special attention to the educational context, considering personal, professional and organizational factors that influence teachers, in applying computers in their classroom practices. Fidalgo-Neto et al. (2009) studies the use of computers in Brazilian primary and secondary schools, while Wainer, Vieira, and Melguizo (2015), investigate the association between home computer access and the educational achievement of primary students in a Brazilian context.

Goktas, Gedik, and Baydas (2013) refer to infrastructure deficiencies in a context of primary schools in Turkey, including variables like “lack of hardware, “lack of appropriate software materials”, “limitations of hardware”, “lack of an in-service training” and “lack of technical support” as potential barriers to the use of ICT in primary schools. Karaca, Can, and Yildirim (2013) presents technology integration as a complex process in Turkey, which might be especially useful for practitioners and researchers in countries with disadvantaged contexts. Further,

Ozdemir (2010) aims instead at finding the reasons for the recurring problems in relation to Turkey's e-learning efforts in compulsory school.

Policies addressing countries with a disadvantaged context, motivated Hansen et al. (2012), who conducted a field experiment to compare abstract reasoning of Ethiopian children equipped with a laptop with a matched control group. Analogously, Yang et al. (2013) analyse results from three randomized field experiments of a Computer Assisted Learning program and One Laptop Per Child program. The field experiments were carried out in three kinds of schools, serving poor communities in China: Shannxi rural public schools, Qinghai minority public schools, and Beijing migrant schools. The digital divide in China is an object of study also for Li and Ranieri (2013), who address the problem of digital inequalities between rural and urban children. Gyabak and Godina (2011) examine instead the context of a rural community school in Bhutan, where the use of new media tools, in particularly digital storytelling, has helped bridging digital divides. They ended up with a general reflection on technology instruction and infrastructure in positioning "ethical and cultural differences between researchers, education personnel, school children and their families".

Moreover, Vekiri (2010) looks at the influence of socioeconomic status in Greece, a country which has recently been hit by an economic crisis and can thus be associated to a disadvantaged context. Finally, we included one study that compares national contexts within a heterogenous set of countries. Erdogdu and Erdogdu (2015) investigated the impact of access to ICT, student background and school/home environment on academic performance of students in Turkey, Germany, France and United Kingdom.

Table 1, shown below, maps the study according to review descriptors (first author, publication year; country context; core topic and educational context).

Table 1: Description of included studies

First author; year	Country/ context	Core topic (addressing our review question)	Educational context	
			Population (age; grade)	Device
Al-Huneini, 2020	Oman	Studies the introduction of tablet computers into a rural primary school.	Elementary school	Tablet computers
Anastasiades, 2003	Cypros	Implementation of the first pilot program on distance learning in elementary schools	Elementary school	Distance learning
Castro, 2007	Brazil	Impact of the implementation of computers in public school	Elementary to high school	computers
Erdogdu, 2015	Turkey; Germany; France; UK	Impact of access to ICT, student background and school/home environment on academic performance of students in Turkey, Germany, France and United Kingdom.	Students	Access to ICT
Eteokleus, 2008	Cypros	Evaluation of computer technology integration; context where education takes place, considering personal, professional and organizational factors that influence teachers, in applying computers in their classroom practices	Teachers	Technology integration
Fidalgo-Neto, 2009	Brazil	the use of computers in Brazilian primary and secondary schools	Primary and secondary schools	computers
Goktas, 2013	Turkey	Infrastructure deficiencies, that it includes variables like “lack of hardware, “lack of appropriate software materials”, “limitations of hardware”, “lack of an in-service training” and “lack of technical support” as potential barriers to the use of ICT in primary schools.	Elementary school teachers	ICT infrastructure
Gyabak, 2011	Bhutan	Examination of the use of new media tools, and in particular digital storytelling, for bridging digital divides.	Elementary school children	Digital storytelling
Hansen et al., 2012	Ethiopia	Comparing abstract reasoning of Ethiopian children equipped with a laptop with a matched control group	Elementary school children	Laptop
Karaca et al. 2013	Turkey	Technology integration as a complex process	Elementary school teachers	Technology
Li, 2013	China	Digital divide; addressing the problem of digital inequalities between rural and urban children	Elementary school children	Computer access
Ozdemir, 2010	Turkey	identifying the “reasons behind the repetitive problems which occur in the context of Turkey's e-learning efforts in primary and secondary learning”	Education	e-learning
Vekiri, 2010	Greece	influence of socioeconomic status in a country	Elementary school children	Computer access
Wainer, 2015	Brazil	association between home computer access and the educational achievement of primary students	Primary students	Computer access
Yang, 2013	China	analyze results from three randomized field experiments of a Computer Assisted Learning program and One Laptop Per Child program.	Pupils	Laptop

3 Results

This section describes the general results from the literature review and the results that are organized according to the three main codes and sub-codes (the correspondence between coding categories and reviewed articles is further summarised in Appendix B).

3.1 School

In the following section, we describe our findings based on our data related to the macro-category "school" and its related subcategories: "teacher competencies"; "school strategy"; "culture at school" and "hardware at school".

3.1.1 Teacher competences

When children are in a weak position because of their socio-economic or cultural background, their teachers' digital training is fundamental to guarantee the necessary support (Li & Ranieri, 2013). The physical presence of digital devices must be accompanied by an increased technological literacy of teachers (Fidalgo-Neto et al., 2009), which can translate into a higher student computer use (Eteokleous, 2008). Veteran teachers may have a better experience and higher situational understanding for predicting the students' reactions and approaches to the new technology (Al-Huneini, Walker, & Badger, 2020). At the same time, they may require more attention for the integration process and more opportunities for in-service training (Karaca et al., 2013), since many of them may have not had the opportunity to attend computer classes through their college years (Eteokleous, 2008).

Obstacles to an adequate teacher training may come from financial difficulties and lack of educated instructors (Eteokleous, 2008), as well as from timetable clashes with the teachers' lessons (Al-Huneini et al., 2020). Some teachers might indeed have difficulty in attending the courses (Castro & Alves, 2007) or in following up on the courses because of high workloads (Goktas et al., 2013). Moreover, technology might be feared by some teachers (Al-Huneini et al., 2020) and the most 'technophobic' teachers are often the ones who are far from being computer

literate (Eteokleous, 2008). Indeed, together with computer literacy and skills, the personal attitudes of teachers seem to be determinant of a successful technology adoption (Eteokleous, 2008).

The teachers' security and confidence can be increased by the presence of a technology coordinator (Eteokleous, 2008; we will later come back on this aspect), but also by colleague support (Karaca et al., 2013). The implementation of digital technologies might also facilitate the collaboration between colleagues in terms of technological issues (Al-Huneini et al., 2020). Examples are joint activities where more experienced colleagues guide the less experienced ones (Karaca et al., 2013) and the formalized introduction of "multiplier" teachers who train other teachers, as in Brazil's National Program for Computers in Education (Castro & Alves, 2007). Low experience of teachers in a school could be overcome by implementing the right changes of practice and by having determination at the level of headteachers, even if the headteacher herself is likely to have low experience in disadvantaged locations (Al-Huneini et al., 2020). Teacher training needs to be aligned with the needs of different subjects (Goktas et al., 2013) and needs to integrate technological knowledge into the standard teaching curricula (Hansen et al., 2012). In general, teachers should know how to fit the technology into their lesson plans (Al-Huneini et al., 2020). Otherwise, even technologically experienced teachers might use the device only as a supporting tool, sporadically (Eteokleous, 2008), to overcome 'first order barriers' (see also Rienties, Brouwer, & Lygo-Baker, 2014). The principal could provide support to teachers for technology integration into the curriculum; at the same time, the "tyranny" of the curriculum could constitute an important obstacle to the fruitful implementation of technology (Eteokleous, 2008). Instead, technology could help teachers to develop the range of assignments, with the opportunity of assigning exercises to students based on their level of knowledge and understanding (Eteokleous, 2008).

3.1.2 School strategy

Even if administrators seem to show more positive attitudes toward digital technologies (Goktas et al., 2013), teachers might downplay school leadership as a factor to promote computer usage in class (Eteokleous, 2008). Principals are often viewed more as managers than instructional leaders (Eteokleous, 2008), and an analysis of the direct effects of principal support on technology integration seem to support this view (Karaca et al., 2013). However, principal support shows a strong indirect effect on technology integration, due to its high influences on colleague support, technology competencies, and teacher attitudes and belief (Karaca et al., 2013). In particular, the principal may have a substantial role in creating a collegial school environment and can promote teachers' positive attitudes for

using technologies by praising and supporting teachers who use technologies effectively (Karaca et al., 2013). Moreover, the vision and determination of headteachers can be used to cope with the 'technology fear' of some teachers, also with the help of specific courses (Al-Huneini et al., 2020).

While lack of time could limit the possibilities for teacher training, a decrease in the course load, has not been found to be as a significant enabler for technology implementation. This suggests that teachers need to receive better solutions to time barriers beyond decreases in course load (Goktas et al., 2013). To decrease the student per teacher ration might help, in particularly for countries with a disadvantaged context, since a lower ratio has been found to favor technology integration in Turkey (but not in Germany; see Erdogdu & Erdogdu, 2015). Part of the school strategy could also involve the recruitment of ICT experts (Goktas et al., 2013).

The study by Castro and Alves (2007) indicates that any initiative to set up a computer laboratory should at a minimum plan to contract an informatics instructor, who would be responsible for maintenance of the computer laboratory, to organize the schedule, and to help the subject teacher with routine problems in the laboratory. Goktas et al. (2013) confirms that some personnel should be hired only for technology integration, while Anastasiades (2003) stresses the importance of hiring specialized technical personnel to support the instructor on technical matters. Eteokleous (2008) further hints, through the words of an interviewed teacher, that technology coordinators should advise, consult teachers, give ideas and guide them through the process of integrating computers in the classrooms and not just resolve technical issues. A computer technology team, possibly organized at district/local level, should help in developing teaching materials and also to provide teachers with guidance (Eteokleous, 2008).

In 'late adopting' countries, the introduction of new technologies may sometimes raise critiques from parents; for instance, Al-Huneini et al. (2020) described the parents' concern that the use of technology in schools would generate new sources of distraction for children. A school strategy could include the organization of activities that promote parent awareness of the use of digital technologies (Goktas et al., 2013). Moreover, before children join a pilot program, brief seminars could get parents avoid exaggerations (overwhelming pressure to get the child adjusted, negative predisposition and indifference towards the undertaking) and also be trained in order to support their child as needed (Anastasiades, 2003). Schools can even capitalize on parental interest in student learning: the quality of parental involvement could be increased in students' school and out-of-school activities, like homework assignments that utilize family resources and invite parental participation (Vekiri, 2010). Since pre-primary education appears to affect student achievements in relation to education technologies, parents could also be

encouraged to send their children to pre-primary educational institutions (Erdogdu & Erdogdu, 2015), even though we can assume that there is no full coverage of these institutions in countries with a disadvantaged context. Education improvements could be considered for the parents themselves, who might have a lower educational background than their counterparts in 'early adopting' countries. Such improvements could be made, by for instance using distance education and lifelong learning techniques, in order to exploit the apparent relation between education level of parents (both mother and father) and student's performance at school (Erdogdu & Erdogdu, 2015).

3.1.3 Culture at school

Obstacles to school-home cooperation come from school culture as well as from general local practices. Al-Huneini et al. (2020) shows a case in which the headteacher prefers not to involve parents in the project activities since it is 'a project for the school alone', following an attitude shared by the parents themselves. The influences of school culture on technology integration appear even stronger when considering the effects of teacher colleague support on the integration outcome (Karaca et al., 2013). Notably, both collaborative teaching and a stronger pupil involvement are conventional practices for countries with an advantaged context. These practices might be enhanced in countries with a disadvantaged context by the means of technology integration. The introduction of a new technology can bring teachers to work together and accept pupils as equal partners in problem solving (Al-Huneini et al., 2020). Indeed, a change of teaching styles may be needed to allow a creative engagement of students, in situations where memorization is the only learning technique and where teachers are viewed as absolute authorities for knowledge (Gyabak & Godina, 2011).

Technology integration should allow teachers to change their role in class, towards a facilitator approach, shifting the control of learning onto students as active learners (Eteokleous, 2008). This can happen when teachers are sufficiently confident and willing to change their pedagogical practices, to discuss their errors and successes, to take new paths, and to restart anew after encountering each successive difficulty (Castro & Alves, 2007). The dominant teaching methodology could then be adjusted to the scene of the new learning environment, by spotting good practices that should be promoted further (Anastasiades, 2003).

3.1.4 Hardware at school

An optimal combination of new educational technologies and traditional pedagogic methodologies could also be attempted (Anastasiades, 2003). A transition

methodology would ensure an equal participation of all the students in the class of the new learning environment, without altering the relation of the students to the existing structure of the traditional schedule. The availability of hardware at school is, of course, a primary concern, in particularly in countries, classified as 'late adopters' and 'laggards'. Lack of hardware and limitations of the hardware appear to be significant first-order barriers that teachers meet in their attempt to integrate technology into their class (Goktas et al., 2013). These barriers comprise not only the number of available devices (Yang et al., 2013), but also internet access (Castro & Alves, 2007; Hansen et al., 2012). Even when necessary, the provision of internet access could be delayed with respect to the device delivery and could be accompanied by a mismatch between number of routers and number of connectable devices (Al-Huneini et al., 2020). However, some of the technical difficulties faced by students, also in relation to internet access, might enable pupils to practice solving problems through trial and error: the students' imagination and persistence in searching for solutions might positively affect the culture in the class (Al-Huneini et al., 2020).

Apart from computers, devices and internet, it is important to stress that a whole appropriate physical environment might be needed (Goktas et al., 2013), like a laboratory or 'interactive room' made safe for the equipment (Al-Huneini et al., 2020; Castro & Alves, 2007), whose conditions are regularly checked by technicians (Anastasiades, 2003). In some rural areas, such a dedicated room could be the only one in the school where electricity is made available, through on-site generators (Gyabak & Godina, 2011). Lack of electricity might indeed represent an additional infrastructure problem (Al-Huneini et al., 2020) in countries with a disadvantaged context. However, even in a country like Brazil, where a majority of schools own computers with access to Internet, there is evidence for controversies about the impact of these technologies in reaching educational goals (Fidalgo-Neto et al., 2009). Sometimes the reason might lie in the lack of appropriate educational software (Eteokleous, 2008; Goktas et al., 2013), which appears necessary given the current shift from computer-as-tutor and computer-as-topic toward computer-as-tool (Fidalgo-Neto et al., 2009). For instance, students should not learn how to use the computer applications as an end in themselves, but they should learn how to use them as tools that help them to execute their tasks and projects (Eteokleous, 2008). This might be difficult when, for instance, teacher consider tablets only as a way to get rid of heavy book bags (Al-Huneini et al., 2020) or when doubts arise whether Internet is really used for academic purposes at schools (Erdogdu & Erdogdu, 2015).

We must, however, not forget that, in some countries with disadvantaged contexts, the school might be the only context where students can develop technological expertise (Vekiri, 2010). Thus, the more opportunities children have to access

the Internet, the better they can use it autonomously by choosing where and when accessing it (Li & Ranieri, 2013). This motivates policy interventions that are both in-the-home (like "OLPC") and in-the-school (like "CAL") (Yang et al., 2013).

3.2 Context

In the following we describe the findings from the included studies related to the second main category context and its related subcategories: "hardware out of school"; "other context elements"; "local culture".

3.2.1 Hardware out of school

On a global level, the adoption of digital technologies in schools has not kept pace with their use at home, indicating difficulties of integrating new media into school practices (Li & Ranieri, 2013). This may be especially true in rural areas with little access to digital technologies, and countries with disadvantaged contexts, where students have low social support and do not see themselves as skilled users of technologies which might impair their digital performance (Li & Ranieri, 2013). When students do not even have a practical understanding about computer use, they may rely only on memorized instruction given by their teachers (Gyabak & Godina, 2011). This issue can become dramatic in countries with a disadvantaged context, as teacher technology competencies are also strongly affected by computer use in years (Karaca et al., 2013). Further, in those countries, defined as 'late adopters' or 'laggards', providing children with laptops is more likely to affect children's learning experience, especially in terms of abstract reasoning abilities: to these children, a laptop is a source of new experiences in an environment where, normally, their exposure to new information is severely restricted (Hansen et al., 2012). Moreover, when pupils have at least some experiences of using digital devices for learning, either at home or in school, they lack the preconception that these are only for entertainment (Al-Huneini et al., 2020). With a progressive integration of technologies at home, a whole country can accumulate experience from students together with parents, teachers, siblings (Wainer et al., 2015). Nonetheless, massive computer integration cannot remove the digital gap in absence of an accompanying education (Fidalgo-Neto et al., 2009).

About the effect of internet access at home, there are conflicting findings. Having regular access to internet might increase the self-reported level of Internet self-efficacy (Li & Ranieri, 2013) as well as performance at school (Erdogdu & Erdogdu, 2015). However, for students with low socioeconomic status background (low SES), Internet access at home might have a negative effect on grades, even if having a computer at home is associated to higher grades within every

socioeconomic class (Wainer et al., 2015). The latter finding seems confirmed by a "One laptop per child" (OLPC) project (Yang et al., 2013). On average, giving students access to computers (with preinstalled learning software) at home helps raising standardized math test scores. Students from upper-middle-SES families are more likely to have a computer at home and internet access than students from middle- and low-SES families (Vekiri, 2010), which might be true particularly in countries with a disadvantaged context. Differences in the opportunities to use digital technologies and develop digital competences might lead to a lower confidence in digital skills for students in low-SES families, who also report less parental involvement in their ICT activities (Vekiri, 2010).

3.2.2 Other content elements

The students' academic performance at school is affected by their personal characteristics and social background (Erdogdu and Erdogdu, 2015). Socio-economic inequalities may also add up to uneven distributions of resources within a country (Fidalgo-Neto et al., 2009). A digital divide can often appear as a division between urban and rural areas, possibly due to a lower level of education of parents and to lower access to PCs and Internet for children (Li & Ranieri, 2013). As previously mentioned, urban schools might to a greater degree succeed in recruiting high quality teachers than their rural counterparts (Li & Ranieri, 2013). In rural areas teachers tend to consider local schools as an intermediate stop of their career, resulting in a low teacher experience on average (Al-Huneini et al., 2020). Remote rural areas might also constitute a more conservative context, affecting the ways that people think, how they raise their children and how they want their children to be educated (Al-Huneini et al., 2020). Moreover, policymakers may prefer to avoid rural areas for technology trials, to allow more frequent official visits (Al-Huneini et al., 2020). Some characteristics of rural areas, however, might appear also in urban settings. Migrant schools in China, where children's parents often are farmer workers who have left rural areas, could present low levels of digital access and social support (Li & Ranieri, 2013). In China, both rural areas and urban migrant areas can present imbalances in gender ratio, as well as heterogeneity in ethnicity and native language (Yang et al., 2013). Having a different native language could limit the possibilities to use some types of software (Yang et al., 2013) and correlate negatively with academic performance (Erdogdu & Erdogdu, 2015).

3.2.3 Local culture

Since technology integration is highly influenced by social, cultural, and organizational contexts, it is especially important to explore local contextual and school

related factors that hold significance in achieving success in technology integration (Karaca et al., 2013). As already mentioned, local context affects the attitude of parents towards technologies and the will of schools to collaborate with parents (Al-Huneini et al., 2020), while the socioeconomic status may influence parental regulation and guidance of students' technology use (Vekiri, 2010). The public sentiment in a country towards the current state of the education system might constitute an engine for change (Erdogdu & Erdogdu, 2015). However, religious and political tradition could also motivate more cautious approaches to new technologies (Gyabak & Godina, 2011). Also, and especially in this case, pedagogical interventions might draw on existing prior knowledge, build upon local traditions, and contribute to articulate issues which are relevant to local communities (Gyabak & Godina, 2011).

3.3 Policy

In the following we describe the findings from the included studies related to the third main category policy and its related subcategories: "international policy"; "national policy"; "urban or regional policy".

3.3.1 International policy

International policy has shown its potential by contributing through funding from the World Bank and the European Bank for Reconstruction and Development to Turkey's substantial increase in hardware and related training (Ozdemir, 2010). Also, in Turkey, a fruitful public debate was generated by the assessments of another international initiative: The Programme for International Student Assessment (PISA), conducted in 2012 by the Organisation for Economic Cooperation and Development (Erdogdu & Erdogdu, 2015). The 'One Laptop Per Child' initiative and relative Intel donations has instead helped, in Bhutan, to create momentum for subsequent purchases of laptops (Gyabak & Godina, 2011). However, despite of high investments, the overall knowledge of the effectiveness of these programs is somewhat fragmented (Hansen et al., 2012). For a 'late adopting' country, information about the return to investments would help to confirm, also in the face of foreign funders, the effectiveness of technology on learning (Ozdemir, 2010). From their side, foreign funders should preserve organizational memory of projects, for instance by creating a database with lessons learned from different projects around the world, for the access and use of borrower countries (Ozdemir, 2010).

3.3.2 National policy

Organisational memory is essential also at national level; it could be achieved by digitization of projects, decreases of staff turnover and recorded experiences of key employees (Ozdemir, 2010). Indeed, employees are the main bearers of organisational memory, but a frequent change of ministers and top managers might translate into the change of project managers, employees, regulations and preferences (Ozdemir, 2010). National policies may also be helped by experience gained through pilot programs and small-scale introductory stages (Al-Huneini et al., 2020), as well as by close collaboration with other public institutions and research organizations (Anastasiades, 2003). Teachers should be involved in the decision-making process, since any kind of changes in the educational settings are directly related to implementers (Eteokleous, 2008). The teachers' opinions can even be the force behind the evolution of the education system (Al-Huneini et al., 2020), whose adoption of technologies often results by a holistic systemic change (Eteokleous, 2008) and by a pedagogical approach shift (Karaca et al., 2013). Time and wage of teachers may be determinants of a policy's success (Fidalgo-Neto et al., 2009; Karaca et al., 2013), especially to allow and orient the necessary training (Eteokleous, 2008). National budget should also cover infrastructural changes (Goktas et al., 2013), since the provision of internet access (Erdogdu & Erdogdu, 2015) and computer ownership (Wainer et al., 2015) can lead to a 'societal' understanding on how to better use computers in children education. Policies should be able to combine centralization (of management) and decentralization (autonomy to schools) (Eteokleous, 2008), also exploiting a dialogue between headteachers and national authorities (Al-Huneini et al., 2020).

3.3.3 Urban or regional policy

Regional offices should help the mediation between schools and national authorities (Al-Huneini et al., 2020) and hold responsibilities for the technology coordinators, to facilitate the introduction of computers in classroom practices (Eteokleous, 2008). Schools located in the same provinces could also be motivated to create mutual projects and to share ICT materials through common material units (Goktas et al., 2013).

3.4 Other elements

In addition to the three main codes, we defined a fourth, more open category, denoted 'other elements' including for example gender differences and other individual differences among pupils. Almost no gender differences emerge in relation to internet inequality indicators (Li & Ranieri, 2013) and in relation to benefits

from computer-based learning (Yang et al., 2013). Parental engagement positively affects the children's value beliefs and confidence about computer abilities (Li & Ranieri, 2013). While self-efficacy might not correspond with real abilities, it might affect student outcomes together with other less apparent variables like student motivation and teacher enthusiasm (Erdogdu & Erdogdu, 2015). In turn, self-confidence and motivation might be boosted by technology integration (Eteokleous, 2008). While motivation to go to school seems to be less affected in countries with disadvantaged contexts, including developing countries (Hansen et al., 2012), the sense of a privilege created by access to technologies in places where opportunities are rare, might increase students' motivation to learn (Gyabak & Godina, 2011). At the same time, we should not neglect the ethical concerns emerging from programs which privilege some children over others (Hansen et al., 2012). Technology can enable creativity (Al-Huneini et al., 2020) and enhance pupils' ability to uncover regularities and structures in the world around them through analogies and categorization (Hansen et al., 2012). Specifically, for pupils in countries with a disadvantaged context, this might be a unique occasion to achieve sufficient abstract reasoning for performing a variety of intellectual tasks (Hansen et al., 2012). As a complement, teachers' expectations for the future of their students should be widened correspondingly (Li & Ranieri, 2013). Notably, technology integration could also increase the chances that children with special educational needs can reach their full potential (Fidalgo-Neto et al., 2009).

4 Conclusion and implication

The main aim of this review was to describe and synthesize research on the impact of digital technologies on compulsory education in countries with a disadvantaged context, comprising of 'late adopters' and 'laggards. While there is already a huge amount of research on the implementation of these technologies in countries, defined for instance as 'innovator', 'early adopter' and 'early majority', research on this topic in countries with a disadvantaged context is fragmented and an overview of the state of the knowledge scant.

Drawing on a meta-synthesis approach, we reviewed the knowledge of a purposefully collected sample of one journal of high scientific quality to better understand possible contextual factors in these countries when adopting digital technologies in primary education. Such contextual factors might differ from those in countries with an advanced setting and might include policies on different levels, infrastructure and socio-demographic variables.

4.1 Implications for further research and practice

Across studies, we identified some main points and implications for further research and practice. First, physical infrastructure or hardware is, as expected, a potential 'first-order barrier' to the success of technology implementation. Internet access may be necessary for some devices, while a sufficiently constant supply of electricity may be required by many devices. Moreover, the reparation of malfunctioning devices often presents prohibitive costs. A successful policy thus needs investments in hardware far beyond the devices themselves.

Second, teachers play an even more dominant role when technology is implemented in a 'late adopting country'. There exists a large body of international literature that predicts and explains the use of technology use among teachers by using technology acceptance models in general (e.g., Scherer & Teo, 2019; Gamage & Tanwar, 2018). According to Spiteri and Rundgren (2020), it is crucial for technology implementation that teachers are active and realize the potential of digital devices by using it in daily teaching practices. Thus, teachers should not only be involved as passive receivers of specific training, but also as active proponents of

technology implementation through adaptation of curricula and evolution of the pedagogical approach to the students. A recognition of teachers' essential role and empowering their relations with the technology, as shown in this literature (Spiteri & Rundgren, 2020), would allow win over possible initial fears and reluctance, especially from those who have been less in contact with the technology previously. A positive attitude may be reached by gaining the required knowledge through training, as well as by having an easy access to other more knowledgeable people through collaboration between teachers, collegiality within the school, employment of technical experts at school- or municipality-level. All such measures would contribute to prevent a sense of isolation of teachers in front of the technology. More recent research has specifically looked at teacher acceptance of the implementation of digital technologies in school during the Covid-19 pandemic, also in developing countries (e.g., Utai et al., 2022). Thus, further research might focus on this specific period of the pandemic by asking whether this disruptive event has contributed to more technology acceptance among teachers in countries with a disadvantaged context.

A similar issue can arise when considering the role of the students' families. The family can transmit a positive attitude towards the technology. Therefore, the family should be, at least, informed and, at best, trained to become more acquainted with the technologies used in the education system. Few studies, however, have investigated technology acceptance in the classroom by including parents' perspective, and these are from early adopting countries (e.g., Eutsler & Antonenko, 2018). In some countries with a disadvantaged context, the family might constitute the core institution of the society. Thus, the connection between the implementation of the technology in education, on the one hand, and the general development of the country, on the other hand, may often pass through the family as an institution, and thus, further studies on these contexts might investigate technology acceptance at schools from the perspective of parents and teachers.

The local context should also be valued in terms of culture, tradition and habits. A place might exhibit unique characteristics which could help a technical device develop an educational value. In order to leverage on such characteristics, the technology implementation must be based on a deeper knowledge of the context, so that technology would not represent only a discontinuity with the past but also a tool to preserve and expand the local culture. Practices of digital storytelling are one example of how the adoption of new technologies can be harmonized with the existing local culture.

Collective knowledge should also be gathered from analogous experiences on technology implementation in similar contexts. Political instability may often translate into a high turnover of both managers and participants even within the same project leading to a loss of institutional memory. In order to preserve such

memory, it is important to keep track of experiences from existing and past projects by interviewing key individuals or by keeping a database of project logs and reports. Common experiences across organizations, in the form of mutual projects involving several schools within a municipality, or several municipalities within a country, can facilitate the establishment of a collective memory which would serve future projects.

Finally, we need to emphasize that, in countries with a disadvantaged context, the adoption of technology in education might let pupils acquire a pioneering role. On the one hand, their exposure to technology at school might constitute an important occasion to stimulate abstract reasoning. On the other hand, pupils might feel particularly 'special' when being part of a technology adoption project, and thus generate an enthusiasm which can help in the educational process.

4.2 Limitations

Conducting an explorative literature review on a broader topic within education and social science, where human interaction and cultural contexts require nuancing rather than a strict boundary-setting, is challenging. Informed by a meta-synthesis approach, a qualitative method of literature review, this paper sheds light on the complexity of policies and other contextual factors on technology use in education in developing countries. According to scholarship on systematic reviews of qualitative studies (e.g., Thorne et al. 2004; Sandelowski and Barroso 2007; Saini and Shlonsky 2012), we aim to balance the importance of conducting syntheses with necessary rigor, transparency and consistency and an iterative process.

Some of our methodical decisions, however, did necessarily impact our findings, for example, the decision to limit our search to relevant articles in just one core journal, "Computers & Education". At the same time, we can argue that this journal is one of the most leading journals in the field publishing articles of high scientific quality and that we have achieved some kind of saturation in our sample of articles. Moreover, the inclusion of studies published only in English creates a certain linguistic, thematic and geographical bias.

By including studies published between 2000 and 2020, we covered a relatively wide range of time. Given a highly and dynamically developing field, we identified surprisingly only three studies published in 2015 and 2020. However, we can assume a higher share of non-published research and other research in this field, published in other channels and providing a more updated picture.

For coding, we used an approach that was both inductive from the data and deductive. At the same time, the coding process might have been affected by the two reviewers' research background.

However, despite these shortcomings, we regard our explorative review over the literature on the implementation of digital technologies in primary education in developing countries as highly important to contribute to the literature on implementation and use of digital technologies in disadvantages contexts, and thus, addressing an emerging topic in an area where more primary research is needed.

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Appendix A: Explorative screening stage

To identify relevant findings for our review, we needed to identify possible peculiarities of a disadvantaged context, in the face of education technology. Such peculiarities could in principle be observed in the developed world, but, to be relevant for the purposes of our review, should suggest some degree of comparability with similar issues and problems arising in the developing areas of the world. The notion of "disadvantaged context" may, however, be too vague to define the manual search process. Even if the expression "disadvantaged context" can recall situations of poor income, of struggling education systems, and of logistic issues deriving from geographic, the notion was still in need of a better definition. Which of the 308 articles, retrieved in the first stage of selection, could belong to the sample of articles to be thoroughly reviewed?

To revise and validate the criteria for the final selection of articles, in relation to relevant locational factors, the first and second authors conducted a pre-screening of the titles and abstracts for only 50 of the 308 articles retrieved. The goal was refining the notion of “location context”, so that, when moving later to the final screening of the whole set of abstracts, the readers could look at specific context attributes to drive the final selection of each article. The 50 titles and abstracts read during this pre-screening phase, which we call exporatory screening stage of our selection process, were chosen following the alphabetic order of the first authors’ name. This stage, together with the discussion between the two reviewers, led to the following reflections.

There are indeed contextual factors, described in the abstracts, which could constitute elements to consider when elaborating policies for disadvantaged countries, even when the abstracts describe studies from developed countries. A recurrent theme seems to be, for instance, the education of the pupils’ parents (Aesaert & van Braak, 2015). In the face of new education technologies, child-parent interactions acquire special importance (K. H. Cheng & Tsai, 2014). Parents with higher education can help to create a support structure for the learners, particularly relevant when facing new technologies during the educational process. A higher

parental educational background contributes to orienting a pupil through new events and experiences, which require flexibility and adaptability. In places where the average parental education level is low, this issue becomes endemic, and pupils may feel threatened by the impossibility of finding support at home or among the closest social contacts.

In particular, a family without ICT literacy, and not used to advanced technologies, cannot be able to supply the knowledge required to help a pupil outside of the school environment, even when the pupil is exposed to technologies at school (Aesaert et al., 2015). In places where given technologies are not only new to the pupils, but to most of the inhabitants living in the same geographic area, the consequent lack of ICT literacy could create additional difficulties for the implementation of new technologies in the pupils' environment.

The role and responsibility of teachers would then be even more determinant to secure the knowledge base needed by the children. Teachers who have not previously been exposed to similar technologies, and for whom a preparation to the technology implementaton is either poor or completely missing, could fail in making the school a fertile ground for the children's learning (Archer et al., 2014). Moreover, preparing preservice teachers to become technology competent is difficult (Angeli, 2005) and the exposition to new technologies, and to the systems in which they are embedded, may constitute an additional source of stress and frustration for teachers (Al-Fudail & Mellar, 2008), especially in environments where obstacles to learning occur on a daily basis. This phenomenon could be further exacerbated by cultural adversity to technology, which can be strong in particular locations and vanify policies aimed at the teachers' preparation (Bordalba & Bochaca, 2019). Similarly, frustration could appear in students of difficult areas, who would be exposed to similar education technologies as the students of privileged areas, without having the same educational backgrounds and possibilities (this could be suggested by the study of H. N. H. Cheng, Wu, Liao, & Chan, 2009, about different opportunties across students). Moreover, technological competences can influence the pedagogical ones (Almerich, Orellana, Suarez-Rodriguez, & Diaz-Garcia, 2016); technologies could then reverse vicious dynamics in the classrooms of some countries, and influence positively both the working culture and the pedagogy of a specific location (see, e.g., the model by Chen, Yu, & Chang, 2007). For instance, they could stimulate student interaction in classrooms where the local culture has set a brake to proactive initiatives from the students (see also Barendregt & Bekker, 2011).

This last aspect comes forward in the article by Anastasiades (2003) about Cyprus, showing a combination of new educational technologies with a traditional learning pedagogical model. This is the first article we decided to include in the final subset, to be reviewed thoroughly in its full length. The article abstract

presents several other clues which point at potentially relevant findings for our review. First, there is an explicit reference to the country in which the study is conducted, and the reference is to a country, Cyprus, which, relative to the European Union standards, could be qualified as more challenged in the light of the current economic situation. Secondly, the abstract explictly refers to a pilot program, and in particular to an effort for implementing a novel policy. The nature of pilot programs could also hint at the possibility that particularly disadvantaged areas, within the country, could have been chosen to lead the policy implementation.

We also selected a second article which points at the disadvantages of a geographic area, this time even in relation to the standards of the whole country where the study is conducted: the paper in question is about a remote area of Oman (Al-Huneini, Walker, & Badger, 2020). Both the rural context and the poverty of infrastructures are brought forward in the abstract of the article. Here the concept of "digital divide" is taken into account, since the remoteness of the place under study lowers its attractivity for teachers; the consequent high employee turnover in schools severely affects the preparation of teachers to the use of the new technologies.

Notably, an adequate teacher training could be difficult to reach even for privileged areas of countries marked by strong income inequalities. For instance, the article by Castro and Alves (2007) on Brazil (the third article we included in our final selection) describes a study on policy implementation in an area where technology and education have been prioritized; however, the internal divides within the country might still suggest possible hindrances to a possible scale-up of the policy target.

Overall, after reading this subsample of 50 abstracts, a first possible criterion that emerged for defining the final selection of articles to review, is the explicit reference, in the title and abstract, to: a less developed country, or a country troubled by strong internal inequalities, or less developed area within a more developed country. A major element of underdevelopment would be constituted by a severe deficit in infrastructures. Other sociodemographic references, especially in connection to rural areas, could also motivate our selection. Finally, works that explicitly focus on elaboration and implementation of policies could provide us with important suggestions. A detection of these themes, during the screening of the remaining 258 titles and abstracts, translated into the inclusion of new articles in our final reading list, as described in Section 2.3.

Appendix B: Correspondence between coding categories and reviewed articles.

Categories	No.Ref.;	References
School	31	
Teacher competencies	7	Al-Huneini et al., 2020; Castro & Alves, 2007; Eteokleous, 2008; Fidalgo-Neto et al., 2009; Goktas et al., 2013; Karaca et al., 2013; Rienties et al., 2013
School strategy	7	Al-Huneini et al., 2020; Anastasiades, 2003; Erdogdu & Erdogdu, 2015; Eteokleous, 2008; Goktas et al., 2013; Karaca et al., 2013; Vekiri, 2010
Culture at school	5	Al-Huneini et al. 2020; Castro & Alves, 2007; Eteokleous, 2008; Gyabak & Godina, 2011; Karaca et al., 2013
Hardware at school	12	Al-Huneini et al., 2020; Anastasiades, 2003; Castro & Alves, 2007; Erdogdu & Erdogdu, 2015; Eteokleous, 2008; Fidalgo-Neto et al., 2009; Goktas et al., 2013; Gyabak & Godina, 2011; Hansen et al., 2012; Li & Ranieri, 2013; Vekiri, 2010; Yang et al., 2013
Context	20	
Hardware out of school	10	Al-Huneini et al., 2020; Fidalgo-Neto et al., 2009; Gyabak & Godina, 2011; Hansen et al., 2012; Karaca et al., 2013; Li & Ranieri, 2013; Wainer et al., 2015; Vekiri, 2010; Yang et al., 2013
Other context elements	5	Al-Huneini et al., 2020; Erdogdu & Erdogdu, 2015; Fidalgo-Neto et al., 2009; Li & Ranieri, 2013; Yang et al., 2013
Local culture	5	Al-Huneini et al., 2020; Erdogdu & Erdogdu, 2015; Gyabak & Godina, 2011; Karaca et al., 2013; Vekiri, 2010
Policy	10	
International policy	3	Erdogdu & Erdogdu, 2015; Gyabak & Godina, 2011; Ozdemir, 2010
National policy	4	Al-Huneini et al., 2020; Anastasiades, 2003; Eteokleous, 2008; Ozdemir, 2010;
Urban or regional policy	3	Al-Huneini et al., 2020; Eteokleous, 2008; Goktas et al., 2013
Other elements	5	Al-Huneini et al., 2020; Fidalgo-Neto et al., 2009; Gyabak & Godina, 2011; Hansen et al., 2012; Li & Ranieri, 2013

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