Italian Journal of Educational Technology

31
VOLUME

1
ISSUE

ISSN 2532-4632 (print) – ISSN 2532-7720 (online) – Sped. In abb. Post. – 45% - Art 2 comma 20/b Legge 662/96 – Filiale di Chieti – 66100

2023

Consiglio Nazionale delle Ricerche

Istituto per le Tecnologie Didattiche

FIRENZE UNIVERSITY PRESS

Italian Journal of Educational Technology (IJET)

Four-Monthly Journal

ISSN (print) 2532-4632
ISSN (online) 2532-7720

Editorial correspondence
should be sent to:

Italian Journal of Educational Technology (IJET)
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Website: https://ijet.itd.cnr.it

A publication of the National Research Council of Italy. Chieti Court Registration No. 8,25/11/1992

Direttore Responsabile
Donatella Persico

Italian Journal of Educational Technology

Vol. 31, no. 1, 2023

Firenze University Press

Italian Journal of Educational Technology

Published by
Firenze University Press – University of Florence, Italy
Via Cittadella, 7 - 50144 Florence - Italy
https://ijet.itd.cnr.it

Italian Journal of Educational Technology

Volume 31 / Issue 1 / 2023

Dossier

Children's Learning with Digital Technologies

Guest Editors: Francesca Maria Dagnino and Hanne Pedersen

Editorial

Dossier

Articles

Italian Journal of Educational Technology, 31(1): 5-7, 2023
ISSN 2532-4632 (print) – ISSN 2532-7720 (online)
DOI: 10.17471/2499-4324/1308
https://ijet.itd.cnr.it

Italian Journal of Educational Technology

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Editorial. Children's Learning with Digital Technologies

Tecnologie per l'apprendimento nell'infanzia

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HOW TO CITE DagniDagnino, F. M., & Pedersen, H. (2023). Editorial. Children's learning with digital technologies. *Italian Journal of Educational Technology,* 31(1): 5-7. doi: 10.17471/2499-4324/1308

Received: March 20, 2023; *Accepted:* March 31, 2023; *First Published:* March 31, 2023

This issue includes a dossier about children's learning with digital technologies, focussing in particular on early childhood (EC) education. ICTs are ubiquitous in the environment around children, and they are exposed to technologies in different contexts and ways; for this reason, concerns have been raised by parents and educators on their impact on children's health and development and the use of ICT in early childhood education has attracted a great deal of attention of different stakeholders, at educational and policy level. The use of ICT in children education, especially in EC, has been debated (Plowman & Stephen, 2003) due, indeed, to their potentially detrimental effects on children's cognitive, physical, social, and emotional development. Although concerns cannot be disregarded, the view that has prevailed over the years is that ICTs can usefully support children education provided that they are used appropriately.

A significant contribution to the field was yielded by the literature review commissioned in 2004 by the Ministry of Education of New Zealand (Bolstad, 2004), that concluded that ICT use can provide a context for collaboration, cooperation, and positive learning experiences between children, or between children and adults, as long as educators are well-aware of the kind of interaction they want to stimulate and adopt suitable pedagogical strategies to support them. An important principle expressed in the same years is that of developmental appropriateness (Siraj-Blatchford & Whitebread, 2003), which resulted in a framework based on nine general criteria to guide both teachers and decision-makers in the identification and application of the most appropriate ICT tools for EC education.

Another seminal work is the UNESCO report (2010) on ICT potential in EC education, analysing state of the art research in the field. The report highlights the capability of ICT to support some of the fundamental areas of development that should be stimulated during the preschool period (creativity, learning to learn, linguistic and mathematical skills, etc.). Besides the above-mentioned advantages, the report focuses also on the role of educators in the identification of the appropriate ICT resources and the pedagogical implications of their use. The trait d'union of these works reside not just in focusing the attention on the appropriateness of the technologies for the specific context but also on the peda-

gogical implications of technology integration in the curriculum and on the importance of educators' and teachers' professional development.

In 2015, Kerckaert and colleagues commented that, despite the open debate, research on the use of ICT in early childhood education was still in its infancy (Kerckaert, Vanderlinde, & van Braak, 2015); currently, as editors of this issue, we can observe that the call has attracted a limited number of contributions, this is perhaps indicative of the fact that, although some progress has been made, research in this specific area is not as far-reaching as in others.

This dossier stems from the efforts within the Animated Learning for Transitions - Early Recognition 2.0 (Alt-Er 2.0) Erasmus+ project[1] to stimulate the reflection on the use of ICTs and creative strategies to help children in their learning and development and includes three papers that deal with different aspects of ICT adoption.

In the first paper, Phakathi and Moll report an ethnographic study exploring the use of iPads for the documentation of *visible learning* in a classroom of a primary school where the Reggio Emilia pedagogy is applied. In the Reggio approach, pedagogical documentation is the way for making the learning process visible and is the primary methodology to grasp learning outcomes. The focus is, therefore, on the device and its affordances, analysed in the context of a well-defined pedagogical approach: as the authors point out, technology should serve pedagogy and not *vice versa*. The study suggests that the affordances of the iPad can provide students with possibilities for multimodal representations of knowledge and enhance the learning experience, in consonance with prevailing pedagogies and learning approaches. In the second contribution, Rosa investigates the use of ICT in EC education with the specific purpose of assessing geometric and emotional skills in five-year-old preschool children. The paper presents the process of assessing the usability of the software and dedicates particular attention to the organizational and educational implications of its use. Digital technologies offer interesting features for playful and interactive assessment activities and are helpful also in term of data collection and processing, but authors conclude that the development of these tools should actively involve the final users from the very beginning as they have done for Diligo 2.0. As in the first paper, there is a call by the authors for an informed use of technologies. In the third paper, Paidicán Soto and Arredondo Herrera shift the focus on teachers and report on systematic literature review, conducted on PhD thesis, concerning studies on the Technological Pedagogical Content Knowledge (TPACK) model in primary education. The model represents a reference framework for the fruitful integration of technology in teaching and learning and look at the TPACK as the specific form of knowledge resulting from the conjunction and overlap of the three knowledge domains (technological, pedagogical, and content). The authors highlight that in the panorama of the retrieved PhD theses only a limited number are focused on primary education, confirming a trend already detected in the scientific literature, and conclude that TPACK is under-investigated in this level compared to others, especially higher education.

The last two papers in this issue do not belong to the dossier. They shift the focus towards upper educational levels. Roffi and Cuomo's contribution is a scoping literature review on STEM teaching and learning with X-Reality technologies (e.g. Augmented Reality, AR, Virtual Reality, etc) in upper secondary school. The review shows that the use of these technologies for teaching STEM has been increasingly studied in the last years and the benefits are multiple both at motivational and knowledge acquisition level. In particular, what makes them powerful is the possibility they give to visualise abstract concepts that make these discipline so complex. On the other hand, authors highlight some

[1] https://earlyeducationgame.com

drawbacks linked to technical aspects and equipment needed that might limit the spread of these technologies in schools. The fifth and last paper is focused on the university context; Ballatore, Nascimbeni, Burgos and Tabacco, present a qualitative study in which they analyse the relationship between the actual and prospective use of open education practices (OEPs) and lecturers' background and preferences in terms of teaching modalities. Researchers have found relationships between teachers' characteristics and propensity toward OEPs, in particular, teachers who exhibit a culture of sharing and have collaborative attitudes seem more likely to adopt OEPs. Interestingly, most of the respondents consider OEPs as drivers of pedagogical innovation since they foster the exchange of innovative resources and approaches among university teachers.

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Italian Journal of Educational Technology, 31(1): 9-33, 2023
ISSN 2532-4632 (print) – ISSN 2532-7720 (online)
DOI: 10.17471/2499-4324/1294
https://ijet.itd.cnr.it

Italian Journal of Educational Technology

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Children's use of iPads to document their own visible learning

L'uso dell'iPad da parte dei bambini per documentare il proprio apprendimento visibile

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HOW TO CITE Phakathi, N., & Moll, I. (2023). Children's use of iPads to document their own visible learning. *Italian Journal of Educational Technology,* 31(1): 9-33. doi: 10.17471/2499-4324/1294

Received: July 27, 2022; *Accepted:* January 16, 2023; *First Published:* March 22, 2023

ABSTRACT This ethnographic study explores the use of iPads in the documentation of visible learning by children in a Reggio Emilia-inspired classroom. We report and draw on research conducted with nine- to ten-year olds in a Grade 3 class in the school, situated in Johannesburg, South Africa. "Visible learning" is a key theoretical concept in the Reggio Emilia approach to early childhood education. It envisages a collaborative pedagogy in which children, along with their teachers and parents, document and reflect on their own learning as it happens, thus maximizing its internalization by the children. The study investigates the affordances of iPads in actualizing the documentation of visible learning. The results show that iPads afford young learners with complex ways in which they can document their learning, also ensuring that the technology does not impose itself on them in an artificial manner. The article identifies an emerging language of description of the pedagogical affordances of iPads.

KEYWORDS Affordances; Classroom Ethnography; iPads; Reggio Emilia Schools.

SOMMARIO Questo studio etnografico esplora l'uso degli iPad nella documentazione dell'apprendimento visibile da parte dei bambini di sette anni in una classe ispirata all'approccio di Reggio Emilia. Riportiamo e attingiamo alla ricerca condotta in una terza classe di scuola primaria, con bambini di 9-10 anni, situata a Johannesburg, in Sud Africa. L'"Apprendimento visibile" è un concetto teorico chiave nell'approccio reggiano all'educazione della prima infanzia. Prevede una pedagogia collaborativa in cui i bambini, insieme ai loro insegnanti e genitori, documentano e riflettono sul proprio apprendimento mentre accade, massimizzandone così l'interiorizzazione da parte dei bambini. Lo studio analizza le potenzialità degli iPad per la documentazione dell'apprendimento visibile. I risultati mostrano che gli iPad offrono ai giovani studenti modi complessi per documentare il loro apprendimento, in modo tale che la tecnologia non si imponga artificialmente nel processo. L'articolo identifica un linguaggio emergente per la descrizione delle potenzialità pedagogiche degli iPad.

KEYWORDS Potenzialità; Approccio Etnografico in Classe; iPads; Scuole di Reggio Emilia.

1. Introduction

It is widely believed that information and communication technologies (ICTs) enhance classroom teaching and learning, although what this "enhancement" should be is contested terrain. When it is young children who use technology for learning, the issues become even more contentious. Much of the research on children's classroom learning suggests exciting, educative uses of ICTs. Nonetheless, the literature is generally cautious about the effects of digital technologies on children's cognitive growth, well-being and education (Plowman & McPake, 2013; Gottschalk, 2019). The imperative seems to be avoid hasty generalizations about children, computers and learning, but rather to focus research on classroom and online learning initiatives that suggest significant child development. This study was sparked by the introduction of iPads into a Reggio Emilia-inspired (hereinafter "Reggio") primary school classroom environment.

When we deploy ICTs in a classroom, it is important to bear in mind that "*we should not let the technological tail wag the pedagogical dog*" (Moll, 2012, p.17). In our current context, when the ideology of a "fourth industrial revolution" dominates thinking about education, we have to resist reductionist, *technology-driven* conceptions of digital pedagogy at every turn. The current research problem is how to integrate technologies in such a way that they do not dictate children's pedagogical engagement with knowledge. The imperative is to discover how best to use the often-remarkable affordances of ICTs to enhance classroom pedagogy appropriately. In our research, we find that children's use of iPads in Reggio classrooms allows us to *start* by considering child-specific principles about knowledge and learning, *and then* to question whether ICTs can appropriately enhance such a curriculum. This is the most compelling way to think about ICT affordances for young children in a non-reductionist manner.

2. Background to the study

Networked ICTs influence the everyday lives of children and ramify constantly into education practice. The way young children relate to and use technology is significant. Children these days are deemed "digital natives" or "the Net generation", terms used to describe growing up immersed in digital technology (Prensky, 2001; Tapscott, 1998), vicariously acquiring a pervasive digital consciousness. While the notion of "digital native" has more veracity in developed than in underdeveloped countries (Brown & Czerniewicz, 2010; Czerniewicz & Brown, 2012), research evidence continues to grow that deep seated digital literacies characterize "*the first generation of children growing up in Westernised societies surrounded by increasingly ubiquitous and powerful digital media*" (Flewitt, Messer & Kucirkova, 2015, p.291). Given that the present study took place in South Africa, with the world's most unequal distribution of wealth (World Bank, 2020), and only 58% Internet penetration (Internet World Statistics, 2021), it should be noted that this research was in an elite private school. Its pupils are as digitally connected and literate as any in the richest countries of the world. The study does not purport to make any claims about the more distributed "digital divide" (however one might interpret this) in South African education.

Recently, tablets have become the most popular digital devices in "education markets", with the Apple iPad most prominent amongst them. Upon release in 2010, over 300,000 iPads were sold on day one, and three million within 80 days (Henderson & Yeow, 2012, p.78). In South Africa, iPads accounted for 45% of the market share of 1,4 million tablets sold by June 2013 (Fripp, 2013). By 2013, in the

USA alone, 1.5 million iPads were used in educational institutions (Clark & Luckin, 2013). Today, also in the U.S.A., 99% of teachers use ICTs daily in their classrooms, and 82% of public schools provide each pupil with a computer in all or most grades (Gray & Lewis, 2021, A-1). Almost half of these are iPads (Simba Information, 2017). South Africa shows a similar trend towards iPads, albeit on a smaller scale. Most private schools, and a significant number of public schools, have adopted iPads in classrooms. For example, a roll out of 50 iPads in 50 primary schools per province was planned by 2015 (Tablets for Schools, 2013); South Africa's richest, most populous province justified its "paperless schools" by appealing to the educational prowess of "*digital media such as iPads and other electronic tablets*" (Nkosi, 2014; Falanga, 2015).

In this context, globally and locally in South Africa, the imperative to research the use of iPads in the classrooms of young children is strong.

3. Research aims and significance

The broad aim of this study was to produce an ethnographic "thick description" (Geertz, 1973) of the practices of junior primary pupils using iPads in a Reggio classroom, where *visible learning* is the primary methodology to realize learning outcomes. Then, by analyzing this ethnographic data, to distil a "language of description" of affordances of iPads for young children in their learning, to further understand pedagogical documentation using iPads.

The multimedia "digital documentation" enabled by ICTs offers new possibilities for the recognition, description and appreciation of children's learning (Khoo, Merry & Bennett, 2015; Formosinho & Pascal, 2017; Hooker, 2019). Yet there is little specific, research-based guidance on digital documentation, and a very slim literature on Reggio-inspired contexts (Bath, 2012; Neumann & Neumann, 2014; Cowan, 2019). There is also a dearth of research on the Reggio-inspired digital ethos necessary to facilitate dialogue in digital documentation (Cowan & Flewitt, 2021). This study seeks to make a modest contribution to these identified "research gaps".

3.1. Research question

The core question of the ethnographic study is: "*How do children in this classroom use iPads to document their own thinking?*" The secondary question is: "*What specific affordances of iPads are revealed in the course of these learning activities?*".

The broad expectation - the qualitative hypothesis, as it were - was that iPads add various affordances that bring both breadth and depth to this documentation process by learners. As Erickson (2008) points out, though, the conduct of data collection in an ethnography is progressive problem solving; the study was interpretive in that it assumed the social world of the classroom is continually constructed by children located in meaning-making activities. It sought to understand how children use iPads *meaningfully* to document learning and make it visible.

4. Literature review

The theoretical framework for this study is thus rooted in the principle mentioned earlier, that the integration of ICTs into our teaching and learning practices should commence with an understanding of how a specific pedagogy is structured and how it operates to recontextualize knowledge into the class-

room. The potentials that any ICT has to assist us in that task – that is, its affordances – become the nub of how we decide to use it any classroom. The pedagogy under investigation here, namely the Reggio inspired pedagogical documentation of visible thinking, looks to ICTs for distinctive affordances.

This section has four parts. First, it covers the Reggio educational system. Then it considers affordance theory and moves on to review literature on the affordances of ICTs for young children. Finally, it draws these elements together in consideration of how iPads might afford documentation of children's *visible learning.*

4.1. Reggio Emilia: the documentation of visible learning

The cornerstone of Reggio pedagogy is the *documentation of visible thinking*: children's thinking is made visible through a process of documentation using a range of media, and gathered in a variety of ways, including the children's own representations and observations made by adults. This systematically collected documentation of the children's developing ideas, theories and understandings actively shapes thought as children struggle to represent and reflect upon their ideas. Young children's thinking is seen as a collective process and, through discussion and "provocation", their existing theories and ideas can be reflected on, challenged and modified. (Robson, 2020, pp.98-99)

In the Reggio approach, the learning process builds on children recognizing and representing their own thinking, thus making it visible to themselves, and to their teachers and families in collaboration with them (Childress, 2020; Westerberg & Vandermaas-Peeler, 2021). A favourite metaphor used by Reggio educators is "the hundred languages of the child", connoting the multiple ways that children speak about and represent their experiences of the world.

Loris Malaguzzi (1993; 1994; Malaguzzi & Gandini, 1993) founded the Reggio schooling methodology in the Italian town of Reggio Emilia as part of post–Second World War reconstruction. Malaguzzi was influenced by constructivists like Piaget and Vygotsky (Edwards, 1995; Hewett, 2001; DeVries et al., 2002; New, 2007; Rinaldi 2021), and the progressive educator John Dewey (Dodd-Nufrio, 2011; Lindsay, 2016). From Piaget, he took the idea of the active, thinking, constructing child. Edwards, reviewing Malaguzzi's writings, suggests that the idea of "*cognitive conflict and disequilibrium in powering cognitive growth* […] *was deeply internalized by Malaguzzi*" (1995, p.4). From Vygotsky, Malaguzzi drew the idea that "*children's learning is situated in a socio-cultural context and takes place in interrelationships, requiring the construction of an environment that allows for maximum movement, interdependence, and interaction*" (Dahlberg & Moss, 2006, p.6).

The Reggio approach views children as capable individuals whose thinking must be taken seriously. They are able to research issues presented to them and construct their own understandings in the process. As social beings, they interact with others in constructing knowledge (Childress, 2020). Reggio schooling involves not only teachers and learners, but also parents who assist in providing children with a situated education. The development of children *in situ* is considered the foundation of this approach.

Malaguzzi's core pedagogical principle is that *learning is the consequence of thinking about one's actions on the world* (Ritchhart & Perkins, 2008; Childress, 2020; Rinaldi, 2021). The Reggio curriculum is designed as a series of opportunities for such thinking activity: this reflection by children must necessarily be located in a collective pedagogy of listening, observing and documenting their work (Kashin, 2016; Westerberg & Vandermaas-Peeler, 2021). Reggio values common activity between children, teachers and parents, viewed as "collaborators" in the pedagogical process, in which they develop shared

understandings of any child's learning (Hewett, 2001, p.97; Trepanier-Street & Hong, 2004, p.89; Harju & Åkerblom, 2020). Together they become *protagonisti*, characters in a community of "*gesture, language, mind, emotions, and interests*" (Kennedy, cited in Edwards, 1995, p.6; MacDonald, 2007).

One can see how important *pedagogical documentation* is in the Reggio system. It is "*a visible trace that captures what children did and said* […] *and becomes a tool for continuous reflection while making the learning process visible to teachers, parents, and members of the community*" (MacDonald, 2007, p.232). In principle, it positions the "voice" of the child as the centre of the pedagogical process (Formosinho & Pascal, 2017). Documentation is variously described by Reggio proponents as creating a disposition in the child toward rigorous critical reflection (Ritchhardt et al., 2011; Fernández-Santín & Feliu-Torruella, 2020; Rinaldi 2021).

4.2. Affordance theory

The concept of *affordance* was formulated by the ecological psychologist James Gibson (1977; 1979), to describe the properties of an object that enable a person to use it to carry out an action. More technically, "affordance" refers to action possibilities inherent in objects in the environment. While they are evidently related to the action capabilities of an actor, they are independent of the actor's perceptual abilities, experience, knowledge and cultural practices. Famously, the interpretivist Norman (1988) challenged Gibson, insisting that an affordance was purely a *mental representation*, a perceived possibility of an action, even though such potential may not actually exist in the object. Seemingly intractable theoretical and paradigmatic disputes regarding the use of objects dominated research on affordances for decades (McGrenere & Ho, 2000; Chong & Proctor, 2020).

Volkoff and Strong (2013), however, argue that there is increasingly a "*united front to oppose those who defined affordances as mental representations, arguing that such views directly contradicted Gibson's intention*" (2013, p.819). This emerging realist consensus regards affordances as properties of the environment, albeit "triggered" by actors who realize those affordances. Affordances are no longer widely construed as mental constructions. A number of authors identify the critical realist underpinnings of ecological psychology, and Gibson in particular (Michaels, 2003; Mingers et al., 2013; Jessop, 2015; Bygstad et al., 2016; Niemimaa, 2018), affirming Gibson's original sense that an *affordance* is a property, or a potentiality of an object. It recognizes the "*possibilities of action afforded, or offered by, a given material object or social network*" (Jessop, 2015, p.240). Affordances exist whether or not they are realized, perceived or acted upon by an agent.

The literature also highlights the affordances of social networks. Some authors (Costall, 1995; Kyttä, 2002; Reed, 2013) suggest a latent sociocultural theory in Gibson: other people, and our structured social engagements with them, offer us reciprocal, versatile affordances, such as those in a mother-child relationship:

> *Behavior affords behavior … What the male affords the female is reciprocal to what the female affords the male; what the infant affords the mother is reciprocal to what the mother affords the infant; what the prey affords the predator goes along with what the predator affords the prey; … and so on. The perceiving of these mutual affordances is enormously complex, but it … is just as much based on stimulus information as is the simpler perception of the support that is offered by the ground under one's feet.* (Gibson, 1979, p. 135)

This sociality of affordances (de Carvalho, 2020) is crucial in theorizing learning affordances for young children. Children do not necessarily perceive affordances independently; these are mediated to

them by adults and other children (Costall, 1995). The fact that children do things before they know how to do them, presents a significant challenge to parents and teachers, who must try to perceive affordances through the eyes of a child (Kyttä, 2002; Cordovil et al., 2015).

4.3. The pedagogical affordances of ICTs

A "pedagogical affordance" is not a pedagogy. We pose a threat to young children if we introduce ICTs into the classroom unthinkingly, believing that they bring with them some inherent, new, revolutionary pedagogy. Teachers use the pedagogical affordances of ICTs intuitively and unconsciously – as Gibson suggests all affordances tend to be – to enhance their teaching. ICTs provide affordances for teaching, *not the other way around*, as technocrats sometimes seem to think.

ICTs provide teachers with multiple affordances when they employ ICTs in their classrooms to enable their pupils' work. Battro (2004) describes the bottom-line affordances of computers in learning, such as the selection function of a mouse, a keyboard, a cursor, and buttons on a display monitor. These in turn produce the affordances of pointing, dragging, typing, font sizing, zooming, highlighting, viewing and clicking. There are two levels of affordance here, technological and pedagogical affordances respectively (Drennan & Moll, 2018). Battro's thesis is that the "*global impact of digital technologies on human society, and particularly on education, is related to* […] *the ability to decide to produce a simple change of state in a system" (2004, p.79).* He calls this the *"click option*".

Various authors discuss the affordances of ICTs in relation to complex, depth pedagogies. Laurillard's (2012) *conversational framework* describes the affordances of various media for teaching and learning, without implying that such affordances amount to pedagogies in themselves. The pre-tablet work of Conole and Dyke (2004) examined early online tools and compiled a taxonomy of ICT affordances in education. Drennan and Moll (2018) suggest that seven of these (accessibility; diversity; communication and collaboration; reflection; multimodality and non-linearity; risk, fragility and uncertainty; and immediacy) lie within the domain of classroom pedagogy. Moll et al. (2022) have extended these categories in a typology of the "pedagogical affordances of ICTs". Haßler et al. (2016) similarly claim digitally enabled affordances for teachers using "transformative pedagogical models".

There is a growing literature on ICT affordances in education. This deals mostly with iPads, which Nguyen et al. (2014, p.1) attribute to the "*fast and wide uptake of iPads among the younger generation*". Barreiro (2020, p.92) describes this as the "*child-iPad phenomenon*". Various authors (Valstad & Rydland, 2010; Kuby & Rucker, 2020; Flewitt & Cowan, 2019) point to the iPad's multiple affordances for *researching and learning*, and new possibilities for the representation of knowledge by teachers. Device mobility is a strong theme in this literature. Brand and Kinash (2010, p.147) describe iPads as *"mobile devices … that liberate the learner to realize … anywhere, anytime learning*" (polysynchronous learning). The small size of the iPad affords teacher-student and student-student interactions in multiple learning spaces inside and outside the classroom (Alyahya & Gall, 2012; Drennan & Moll, 2018). Echoing Battro's "click option", Reid and Ostashewski (2011, pp.1689-1690) praise the "*light finger touches (such as taps, swipes, pinch-zooms)*" of the iPad's "*robust textbook-sized screen*", and its display, audio and GPS affordances that constitute an "*information gathering* [and] *media library*".

Research suggests numerous iPad affordances for children's learning. The high level of interaction and spontaneous discussion encouraged by iPads seems to motivate children more than traditional lessons (Cox et al., 2003; Agostini & Di Biase; 2012; Meyer, 2013; Laidlaw & Wong, 2016). Furthermore, iPads enable pupils – even very young ones – more intuitive control of the learning process (Hender-

son & Yeow, 2012; Reed, 2013; Clarke & Abbott, 2016). Maher (2013) ties together different studies to demonstrate how iPads afford multiple learning pathways in the thousands of available iPad apps.

4.4. The affordances of ICTs in pedagogical documentation

There is a growing literature on ICT affordances for children in capturing and sharing learning (Reynolds & Duff, 2016; Rintakorpi, 2016). Formosinho and Pascal (2017) show that digital technology facilitates multimodal communication to integrate the voices of teachers, parents and children in unprecedented ways. Generally, research on e-portfolios demonstrates this capability (Gallagher, 2018; Hooker, 2019), including in the use of iPads (Khoo, Merry & Bennett, 2015).

Trepanier-Street and colleagues (Trepanier-Street, Hong & Bauer, 2001; Hong & Trepanier-Street, 2004), in investigating technology applications in the Reggio curriculum, show that ICTs make documented learning easier – they are cost-effective, save time for teachers and learners, and easily afford sharing children's work with parents. Several forms of multimedia technology can be integrated in the documentation process to enhance reflective thinking. Unfortunately, much of the Trepanier-Street research stops short at technological rather than pedagogical affordances of ICTs.

With regard to specific sources on the pedagogical use of iPads in documenting visible learning in a Reggio classroom, the recent work of Cowan and Flewitt stands out (Cowan, 2019; Flewitt & Cowan, 2019; Cowan & Flewitt, 2021). Beyond this, the literature seems sparse: articles by Mitchell (2007) and Parnell (2012) explore iPad use by teachers to document the visible learning of children in their classrooms. Then there is a handy blog entry by Kashin (2016), useful in conceiving how a digital portfolio, including children's writing and artwork, photographs, audio and video recordings, and computer graphics, can be stored and classified efficiently using iPad technology. The current study makes a small contribution to our knowledge in this area.

5. Research methodology

The study was framed as a small-scale classroom ethnography, in which researchers "visit the classroom intermittently as outsiders" (Erickson, 2010, p.320). The researcher (the first author) positioned herself as a *non-participant observer*, gathering detailed qualitative data in the classrooms of two teachers over a two-month period. She was guided by King (1979), recognizing that children tend to identify an aloof adult in the classroom as an outsider or surrogate teacher. She maintained social distance by showing no obvious interest in them, avoiding eye contact, and mostly sitting at the back of the classroom taking field notes. As Hammersley and Atkinson (1983, p.103) insist, there "*must always remain some part held back, some social and intellectual 'distance'. For it is in the 'space' created by this distance that the analytical work of the ethnographer gets done*".

There is ongoing debate about "backstage culture" of classroom participant observation (DeMunck & Sobo, 1998, p.43) in which bias often creeps in as researchers work with informants similar to themselves, and the latter mislead researchers by reporting what they want them to believe (famously demonstrated by Freeman, 1969, in his critique of Margaret Mead's ethnography). Merriam considers participant observation a potentially "*schizophrenic activity*" (1998, p.103), in the tension between immersion in the setting and the need to keep some distance from participants. However, she suggests, the question is how the researcher accounts for those effects in data collection. In this case, the researcher considered that her familiarity with the participants and with the school's Reggio approach (she taught

the participants a different subject) allowed her to recognise biases. As she positioned herself as observer, she constantly sought to level out biases and maintain an objective stance in the study.

5.1. Participants and location

The primary school in which this study was conducted was purposefully sampled. It is a private, English medium, denominational institution situated in one of the most affluent suburbs in Johannesburg, South Africa. It is amongst the topmost academic schools in the region. The school caters for pupils from diverse cultural backgrounds, who tend to be from affluent families, from early years through to matriculation. The school is known for its innovative curriculum policies and commitment to the pedagogic integration of ICTs. It had adopted a Reggio-inspired curriculum in its junior primary section a decade earlier. Coincidentally, iPads were introduced for each pupil three years later. The school's curriculum imperatives thus required the integration of the pedagogical and technological affordances of iPads into Reggio classroom activities and presented us with the opportunity to carry out this study.

Participants were 54 pupils, 27 in each class, and their teachers. Both teacher participants had recently completed the "Making Thinking Visible" online course offered by Harvard University. Regarding ethics clearance procedures, all participants (along with the children's parents) were invited to be part of the study, and all gave their informed consent / assent to do so. Formal ethics clearance was received from the Ethics Committee of the authors' University. The anonymity of the children is protected here, by using pseudonyms and obscuring their faces in photographs.

The adjacent classrooms are large, bright and airy spaces. Each has the same furnishings, consisting of bulletin boards, lockers, a carpet area, teacher desks, pupils' desks and chairs, smartboards, data projectors, and five networked desktop computers (Figure 1). They lead onto a fenced playground with outdoor furniture, where pupils congregate, and play on a climbing apparatus during their break time.

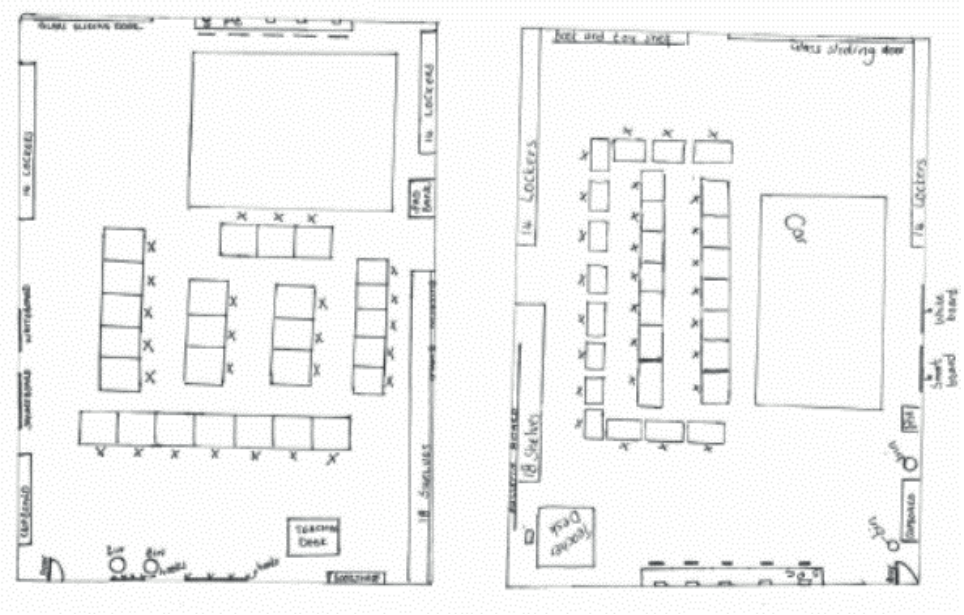

Figure 1. Classroom layouts (researcher field notes).

5.2. Duration and scope of the study

The first author was the sole, consistent observer in both classrooms. She sat in on all lessons in which the theme, "My Heritage", was taught to the two Grade 3 classes over an eight-week period (Table 1) – a total of 64 hours of ethnographic observation time. The teachers formulated the lessons in accordance with national Grade 3 curriculum policies (Republic of South Africa, 2011a; 2011b), and aimed to foster discussion of cultural diversity in the South African context. Prior to this, pupils had engaged in a Special Olympics theme on the "diversity of nations and people".

All lessons were purposefully designed to encourage pupils to make their learning visible using their iPads. Both Grade 3 classes were exposed to the same prepared activities, which included various kinds of online, offline and asynchronous communication events. In a sense, classwork and homework "blended" into each other in ongoing learning processes. The main activity and learning outcome of this eight-week block was the production of an e-book using the multiple affordances of the iPad.

The researcher concentrated on classroom activities, presented and mediated by the teacher, and engaged by pupils by means of and around iPads. She closely observed interactions between learners and learners, and the teacher and learners. When the opportunity arose, she had brief *in situ* discussions with teachers about what they were attempting to teach at any point in time.

5.3. Data gathering instruments

The ethnographic data gathered was textual data. Here "text" is used in its broadest sense. Field notes and children's writing are self-evidently texts, but so too are photographs and artwork. Texts are "*semiotic systems … of meaning, all of which interrelate*" (Halliday & Hasan, 1989, p.5). In this multimodal conception of textuality, visual, verbal and written texts are "read together" as they convey meaning. (Kress & van Leeuwen, 2006; O'Halloran et al., 2019).

The primary data was documentation produced by children themselves, in the form of writing and photographs with their iPads. In addition, the researcher gathered a range of ethnographic data, including children's work, transcripts of recorded classroom conversations, photographs, and field notes. A "thick description" (Geertz, 1973) was produced of ongoing activities in which iPads were used by learners to document their own learning. Such a methodology seeks to "*accurately describe observed social actions, by way of the researcher's understanding and clear description of the context under which the social actions took place*" (Ponterotto, 2006, p.543). It should be noted that learners did not produce work using only iPads, but they documented all of it using various iPad tools and apps.

Table 1. Outline of eight-week course content.

"MY HERITAGE" THEME	
Week 1	Discussion of traditional garments and food
Week 2	Discussion of different cultures
Week 3	Multiculturalism
Week 4-5	Planning the eBook Plan in the Life Skills books Use Popplet
Week 6-8	Creation of the eBook Use Book creator App

5.4. Data analysis

The qualitative method used was thematic, or relational, content analysis (Titscher et al., 2000). Textual data were analyzed by means of standard, cyclical coding procedures (Corbin & Strauss, 1998; Saldaña, 2009). Each cycle revealed patterns in classroom learning. As coding proceeded, we systematically analyzed the entire data set, including documents, observation notes, and classroom transcripts.

In the first cycle, *open coding*, we identified a set of nominal categories, or *codes*, to operationalize the research questions (Titscher et al., 2000, p.59). Words, concepts or significant elements were identified in each text in an inductive analysis involving repeated "sweeps" through the data. This first cycle continued until the data was saturated. The notion of "saturation" is a researcher judgment at a certain point in the coding process that "*no new properties, dimensions, conditions, actions, interactions, or consequences are seen in data*" (Corbin & Strauss, 1998, p.136).

In the second cycle, *axial coding,* we "collapsed" all the open codes into themes (Saldaña, 2009, p.20). We assessed connections and relationships between different elements, and identified patterns of interaction, sequences of events, and meanings understood by the children as they documented their own thinking and learning (see Table 2). The generation of further open and axial codes then proceeded iteratively until concepts emerged to constitute a language to describe the pedagogical affordances of iPads. Here, content analysis was both inductive and deductive. As Erickson (2010) points out, analysing ethnographic data is in principle inductive, but pure inductions are impossible. We strove not to determine *a priori* categories for observation. However, sitting in the background of this study was ongoing work by our colleagues on the pedagogical affordances of ICTs (see, for example, Ndlovu & Moll, 2016; Drennan & Moll, 2018; Moll et al., 2022).

5.5. Validity and reliability

In qualitative ethnographic research, "*reliability and validity are not simply declared by researchers themselves or awarded by reviewers. Rather, they are … built into the process of inquiry*" (Morse, 2018, p.1384). Researchers check the validity (or "trustworthiness") of data to ensure that it is *credible*, *confirmable, dependable* and *transferable* (Lincoln & Guba, 1985, p.300; Morse, 2018, p.1380). To achieve this, we employed multiple data checking strategies.

- *Credibility*: "Triangulation" is achieved by depth of description ("thick description") of multiple layers of observation, data sources and evidence (Plano Clark & Creswell, 2015). In this study, multiple devices and techniques were used to record and triangulate data of different kinds. During the coding process, an academic colleague who was not involved in the research sampled data extracted in the coding process and checked it for coherence and consistency against primary data.
- *Confirmability*: "Member checking" refers to the process where the researcher verifies the accuracy of the empirical observations with study participants (Plano Clark & Creswell, 2015). Regular, weekly debriefings with the participant teachers ("devil's advocates" – Carspecken, 1996, p.141) took place outside of classroom time to corroborate the researcher's interpretations of events.
- *Dependability*: Classroom ethnographers argue that data validity relies on "*repeated visits across substantial strips of time*" (Erickson, 2010, p.323). The researcher must become familiar enough with the classroom setting to be able to assume an *emic*, "insider perspective". However, no formula exists to determine the ideal participation hours. For example, Steele's (2001) ethnography in a mathematics classroom observed learning for a total 30 hours, whereas Smith and Geoffrey's early classic in a US inner-city classroom lasted a full year (Erickson, 2010). This too is a judgment the researcher must

make – depending on the scope of the study and how long it takes them to become immersed in the context. Our judgment in this study was that 64 hours of non-participant observation over eight weeks was appropriate, largely because the researcher (the first author) was a teacher in the school and familiar with the institutional context, although not these particular classrooms.

Regarding *transferability*: since this project was unique in the South African context at the time, we constructed the study simply as general qualitative research. Even "case-to-case implication" (a weak version of the transferability of findings) was not contemplated.

Reliability in qualitative research is not understood separately from validity. The question of the replicability of the results is not of major concern (Lincoln & Guba, 1985, p. 290). The coherence and consistency of data is more important, and the criteria of credibility, confirmability, dependability and transferability also establish reliability. As Lincoln and Guba put it, "*Since there can be no validity without reliability, a demonstration of the former is sufficient to establish the latter*" (1985, p. 316).

6. Results

As we identified emergent categories and themes from the full range of ethnographic data, in the axial coding processes, it became apparent that the children used the affordances of iPads in a number of ways to document their own thinking and learning. The first column in Table 2 records all the open codes (or equivalents) with a frequency greater than five that emerged in first-cycle coding. The second column contains the axial codes, or themes, into which we collapsed the open codes analytically. These indicate the affordances of iPads in documentation to make learning visible.

In each section below, we illustrate these emergent themes by detailing various segments of the "thick descriptions" of classroom activity. We then indicate what inferences about iPad affordances for children we were able to induce from them. Of course, we are not able to cover the full extent of the ethnographic data in this article.

6.1. Motivation and concentration

School learning is characterized by motivated, deliberate attention to the salient features of the task at hand. Piaget calls this "reflecting abstraction", and Vygotsky terms it "voluntary attention" (Piaget,

Table 2. Emergent codes and categories in the analytic process.

Open/first cycle codes	Axial/second cycle categories
Confident, easy, excited, googling, interested, long time, share with friends, stay on task, taking photos, using iPads	Motivation
Attention, focus, google, quick, research, salient feature, selected app, stay on task	Concentration
Active, argument, critical thinking, discuss visible learning, documenting, email, hypothesis, negotiation, reflection, sharing, taking photos	Reflexivity
Anytime-anywhere learning, asynchronous, flexible, free, homework, long battery life, mobile/portable device, movement, outside, seated, sharing, synchronous, tablet size, walking around	Flexible learning
App, colouring-in, data projector, design, drawing, making e-book, pencils, PowerPoint, project-based learning, represent knowledge, software, type of media	Multimodality and multimedia
Discussion, Dropbox, helping, shared focus, sharing resources, sharing skills, just-in-in time peer support, viewing peer work	Participation and collaboration

2001; Vygotsky, 1931, p.99). The outcome of successful school learning, in Reggio terms, is the *internalization* by a child of critical reflection on their visible thinking and learning. Piaget thinks of this as internalization of the consequences of cognitive actions, while Vygotsky emphasizes internalization of the cognitive structure of what is originally a social relationship between a teacher and a learner.

High levels of motivation and attention to task were often evident when pupils worked with iPads. From the classroom observations, when pupils were free to use apps of their choice, they seemed to discuss and experiment easily with potential apps. Pupils were noticeably motivated and fully immersed in their tasks, as evident in Figure 2. Researcher field notes:

Group of kids excited - ask teacher can we use iPads to brainstorm instead of Lifeskills book. Excited when teacher says yes

Sandy, Carly – work quickly, concentrate hard – selecting apps to use [on e-book] – going at it for 15 min!!

On the "dress up day", as part of Heritage Day celebrations, the children enjoyed talking about the various traditional attire they wore (Figure 3), and photographing each other, printing these out, and placing them on the bulletin board. Again, there was recurring evidence of focused, motivated attention to task using iPads.

Researcher field notes:

Take my picture, take my picture, take my picture. …. Lots of kids asking friends to do this

Neo & Abishola discuss how to create new traditional costumes 'to mix up the different cultures' They google on iPad to research in their cultures.

This ease representing ideas on their iPads suggested that pupils took responsibility for tasks, and grew in confidence and independence:

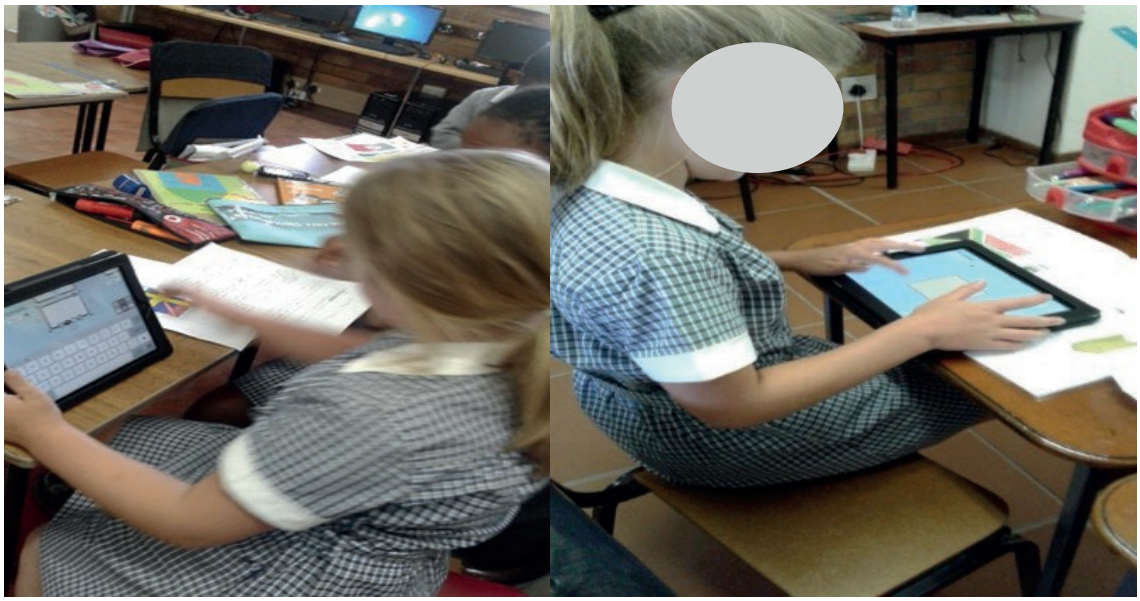

Figure 2. Motivated, staying on task.

Figure 3. Heritage day.

Recorded teacher's comment:

Look how the iPads make them creative, and to use their imagination and to critically think about the tasks they are working on. They are focused and interested. When they document and present their thinking is important because it leads pupils to feeling valued.

There was constant evidence of deliberate decision-making and operational thinking by pupils. While it is difficult for the observer to know what a learner is concentrating on, body language and disposition suggested many examples of prolonged engagement with tasks by learners.

Researcher field notes:

I watch Xoli as she encounters Rasta culture … she noticeably distances herself from kids around her as she concentrates. Facial expression is happy. I am fascinated that she hasn't spoken to anyone for 10 minutes, but downloading and working with images, food, clothing, seems very interested in rastafarian dress… check with teacher: 'yes, this one is very motivated by iPads. Her work is much better now, she likes to work alone' …. end of period, she has not stopped working. But not just random downloading, … CONCENTRATION.
Mindi keeps telling others around her to focus. They recentre around [iPad] *screen.*

From our analysis of the ethnographic evidence, a strong theme that describes learner activity is sustained concentration. We infer that an iPad affords a young child the deliberate focus required to *stay on task* in school learning.

6.2. Reflexivity

The "documentation of visible learning" was the ethos of these classrooms long before this study. It dates back to before iPads, when pupils compiled portfolios of their work. However, iPads have since taken over this function.

Researcher field notes:

Kids keep files- photos & copies of work on iPads. Obviously know how to do it.

Teacher helping a group to make files on iPad to put their documents.

Without exception, pupils took frequent photographs daily of the various kinds of work they produced.

Researcher field notes:

Classroom feels like it is full of photographers. But kids seem to understand they are documenting their work. One asks, 'did you take picture of your poster' 'Duh! Want my mom to see it.

Early on in classroom observations, the researcher noticed children sharing their work with their peers via iPads, *as they did it*. Across the eight weeks, she noticed frequent examples "*all the time, across all lessons*" (field notes).

The data reveal that pupils were inclined to use iPads to document their work. This lends support to the recognition that iPads help learners to think critically about learning tasks (Fernández-Santín & Feliu-Torruella, 2020) – as Krechevsky et al. (2016, p.14) put it, iPads can "*make children's hearts and minds visible to themselves, to their teachers and families*". This perspective on emergent critical thinking in Reggio also arises from the constructivism of Piaget and Vygotsky (DeVries et al., 2002; Stone, 2012). Reggio educators speak of a "spiral of documentation", in which children express ideas and listen to their peers in negotiating their own understandings (Thornton & Brunton, 2015). At the end of each week, the teacher facilitated a whole-class discussion in which pupils revisited their work to consolidate what they had learnt. They plugged their iPads into the data projector to share their documentation and posted their work on the school app for parents to view.

The complex affordances required for the documentation of the cognitive processes in learning are evident from this classroom ethnography. In a Reggio classroom, visible learning evident in these 'documentations' is the centre of the curriculum. Our evidence shows that the iPad provides significant affordances for such *pedagogical documentation*.

6.3. Flexible learning

The project work done by the children does not narrowly confine them to their desks in the classroom during timetabled lesson time:

Recorded teacher comment:

I'm giving them freedom to use any space they want … when they're comfortable in their own space we get better results rather than always telling them where to go.

Figure 4 illustrates this "anywhere, anytime" flexibility in the way pupils worked with their iPads. Some pupils chose to work outside the classroom; some opted to move from their desks while others remained in their seats. The portable iPads allowed them to move around in order to find a comfortable working space. Many engaged in polysynchronous (synchronous and asynchronous) online learning, in and out of timetabled lesson time, at school and at home. In this, they took advantage of iPad connectivity to work after hours (for example on their e-Books), collaborating with their classmates, sharing ideas and images for their projects and tasks.

Figure 4. Flexible work across multiple spaces.

Researcher field notes:

Teacher: 'Olo & Fifi & Mindi communicated abt eBook last night' …. girls show me the WhatsApps.

Teacher: my learners spend much more time than before – hours in fact – working on their projects at home. For this I must thank the iPad.

They are motivated to communicate with each other from home about their work.

Most girls unpack their iPads enthusiastically as soon as they get into class in the morning. Some talk about communication they had the night before.

One interesting illustration of the way iPads break boundaries was the introduction of new dimensions of cultural similarity and difference. Whereas the planned lessons concentrated on food and dress, reflections on differences in greetings (hugs, bows, handshakes, kissing, etc.) and families (nuclear, extended, polygamy, etc.) appeared in the work of some pupils. This obviously originated in iPad knowledge searches.

Analytically speaking, the iPad enables transcendence of the boundedness of the physical classroom. Pedagogy is possible over more extended periods of time, and the 'virtual' extensions of the

classroom made possible by iPads enable and constrain the possibilities for documentation of visible learning in significantly enhanced ways. iPads considerably enhance the teaching and learning methodology that starts in the classroom.

The ethnographic evidence of this study is that the iPad provides significant affordances for flexible and polysynchronous learning. Attributes such as size, long battery life and the touch screen, along with tools for digitalized communication, allow for multiple modalities and methods of learning anywhere, at any time.

6.4. Multimodality and multimedia

The notions of 'multimodality' and 'multimedia' in representing knowledge extend beyond (and predate) ICTs (Halliday & Hasan, 1989; Kress & van Leeuwen, 2006). Good examples of multimedia were produced by pupils without using iPads. Many in fact preferred very familiar paper and pencil (and pencil crayon) technology for certain kinds of tasks (Figure 5). However, the multimodality of the iPad offered these pupils an opportunity to produce complex, creative multimedia documents. They favoured iPads in documenting their visible learning, and shared this digitally with peers, teachers, parents, and all and sundry.

Pupils' presentations were thoughtful and easily focused on the digital screen. As a result of these engagements (in Reggio terms, "*making thinking and learning visible*"), their work on this theme developed in multiple ways, using multiple apps, beyond the introductory engagements in class. Most examples of multiple forms of presentation and representation in the ethnographic data, together provide us with a strong sense of the affordances of iPads in the documentation of visible learning in this classroom.

The iPad has a 'Book Creator' app, enabling learners to design and make their own e-Books. During the period of this study, the children worked in small groups to produce a book depicting cultural diversity amongst themselves, as represented by food. See an example in Figure 6. There was strong evidence that they utilized the multimedia affordances of the iPad in this task.

Researcher field notes:

Figure 5. Multimedia texts produced using technologies other than ICTs.

Mindi takes pics of her drawings to put in e-book.

Lots of them experimenting with colour background for pages – kids moving around and looking at others' work.

Lexi takes pics - iPad's camera – saves them & changes size and layout in eBook.

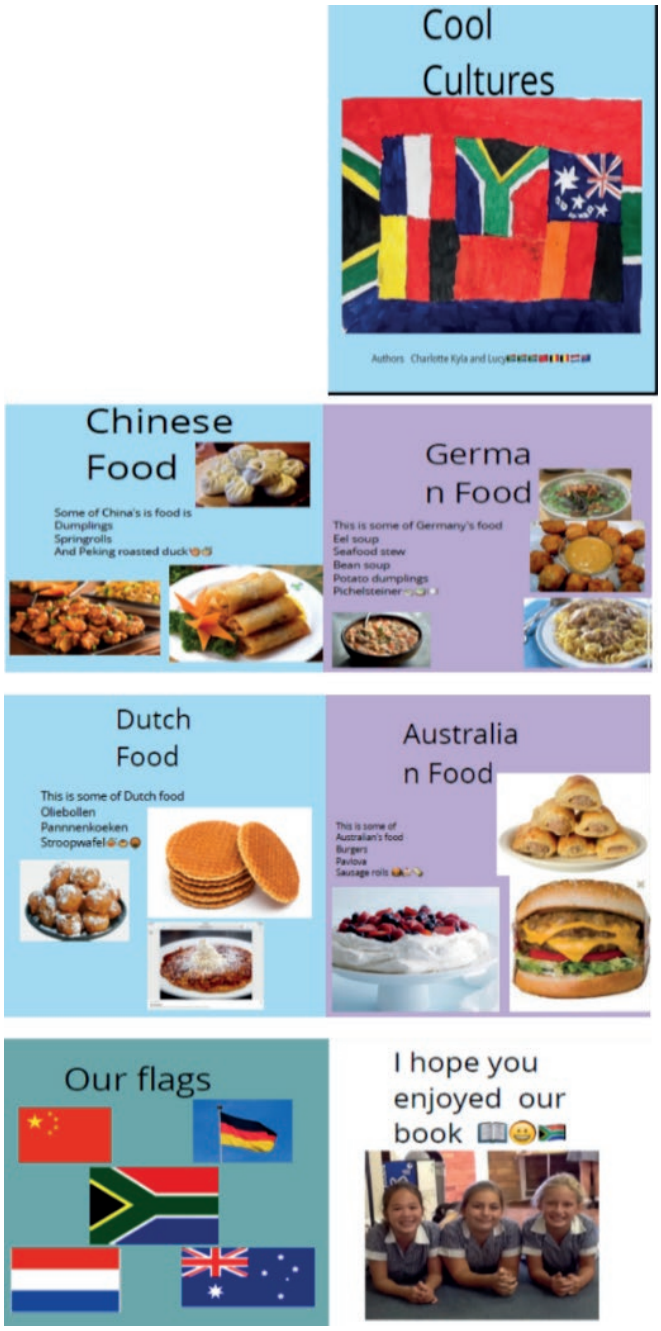

Figure 6. An example of one of the learner-created e-books.

3 girls transfer work from books onto iPads with Camera roll. they say 'easy to organize everything for eBooks.

Pupils used Airserver (screen mirroring software) to present their eBooks to the class. They evidently enjoyed taking the class through their books.

The e-Books seem to make study more project based, which is not just a function of the thematic presentation of content, but an overall affordance of the iPad itself. Instead of just revisiting work done on the iPads and discussing it in a constrained classroom space, it seems to make learning ubiquitous, distributed across their everyday lives. The way that the e-Book project produced reflection by children on their own learning was particularly notable. The researcher reported that they spent long periods of time pouring over their own e-Books, and often modifying them. As most of us do, they went back over their writing intensively during and after the process of producing a text. Many also used the voice-recording feature on the Book Creator app to do voice overs on some pages in their books, and then they revisited and listened to themselves.

There is strong ethnographic evidence here for the Reggio insistence that young children are capable thinkers able to research issues and construct their own understandings of them, and the ability of iPads to facilitate this. It emerges that iPads provide strong affordances for *learner construction of materials*. The multimedia representational affordances of iPads are realized continually in the work produced by pupils in and beyond lessons.

6.5. Participation and collaboration

Pupils generally shared many ideas in the observed lessons, encouraged by the teachers. They questioned and made suggestions to each other, viewing work on each other's iPads. As they did this, they frequently helped each other to use devices and access Internet information. There were a number of instances of pupils initiating learning activities related to a project together.

Researcher field notes:

eBooks - Abishola & Sandy help Daisy find sources on net. Obvious enjoyment finding stuf".

Division of labour – 'you look for this, I'll look for that' then share.

Pupils worked in groups and frequently discussed ideas online about the design of their e-Books. They airdropped graphics to the group's e-Book collator. Importantly, this was not a situation in which children *replaced* ordinary human contact with computer communication channels. Rather, they recruited iPads as tools to enhance normal interactions amongst themselves. This is a good exemplar of what Crook (1994) calls "*collaborative interactions at computers – the design of computers* […] *demands a narrow focusing of attention and action*. […] [their] *powerful graphic capabilities* [support] *shared reference amongst pupils* […] *as they collaborate*" (1994, p.186).

One of the teachers drew the researcher's attention to the way iPad connectivity enables collaboration with parents that is so important in the Reggio approach. Children shared work with parents, using the Dropbox feature, so that they keep in touch in an ongoing way with what their children do in class.

We infer that iPads afford significant *collaboration* and *resource sharing* between children, most commonly amongst themselves, but also with their teachers and parents.

7. Discussion

This article has considered the integration of iPads into teaching and learning in a Reggio Grade 3 classroom and identified emergent themes from coding analyses of classroom ethnographic data. The "thick description" of the practices of young children using iPads to learn and render their learning visible brings a number of the pedagogical affordances of the device into view. Bear in mind the character of an affordance adduced earlier, that it is a property or potentiality of an object that is identified and triggered by social actors. Teachers recognize iPad affordances for teaching as determined by their prevailing instructional practices, but "*these affordances are, ontologically speaking, in the technology, not in the teacher*" (Moll et al., 2022, p.9).

With regard to the first research question of this study, "How do children in this classroom use iPads to document their own thinking?", the discussion above has revealed how the multiple, complex affordances of the device enable and enhance learning. The multiple affordances of the iPad to record work and its products encourage the Reggio "spiral of documentation" and motivate concentration and attention to the salient features of task. Active multimodal representations of knowledge are perhaps the most significant of these affordances. They become ubiquitous in time, space and social context, simply because children are able to carry them around with them and tend to share their screens with each other. Learning is therefore extended beyond the classroom and characterized by much more spontaneous collaboration between learners.

With regard to the second research question, "*What specific affordances of iPads are revealed in the course of these learning activities?*", we suggest that the following technical and pedagogical affordances of iPads in use in this classroom emerge:

- *Polysynchronous learning.* One might say that the portability of devices enables a 'portability' of learning that young children naturally find interesting. Authentic learning at this age is situated culturally and cognitively in and beyond the classroom. The Reggio imperative that children's learning extends into, and is *made visible* in relation to, the broader community context, encourages flexible, ubiquitous learning in young children that is enhanced by iPads. The mobility of learners, inside and outside school, is a crucial aspect of this affordance, arising from attributes such as size, long battery life and touch screen, along with digital communication tools.
- *Deep representations of knowledge*: The Internet in its everyday use is horizontally scaled, with a *broad* information logic; it pops up a plethora of claims, images, speculations and lies that are often difficult to tell apart. It requires the deliberate guidance of a teacher to ensure children use it to realize the vertical, *deep* knowledge logic required in school learning. In Reggio classrooms, the documentation of learning is a very effective teacher strategy to keep learners focused in this way. Children gravitate to their iPads to find interesting affordances to represent new understandings and make their thinking visible.
- *Learner construction of materials:* The creative thinking and ownership of the learning process produced by the e-Book project is self-evident in this study. That children document and reflect deliberately on this learning as well, adds an even deeper dimension to their learning. iPads provide significant affordances for learner construction of materials.
- *Collaboration and resource sharing*: One of the characteristics of the third industrial revolution has been the unprecedented communication and resource sharing possibilities of networked ICTs, not least in collaboration between children, teacher and parent in schools. This Reggio classroom is in fact a fully networked learning community that makes full use of the enhanced digital networks

provided by iPad technology. The study reveals many instances of the collaborative work and community-wide sharing of digitized resources afforded by iPads.

- *Pedagogical documentation*: This affordance is actually an aspect of each of the previously mentioned ones. However, in the Reggio context, the gathering, classification and filing of children's writing and artwork, photographs of their work produced in class, other photographs of their activities, presentations and e-Books, is achieved easily by children using their iPads. Once these pupils were taught the basics of a computer filing system, they managed easily enough. This iPad affordance is much less cumbersome than the paper-based portfolios of old.

As indicated at the outset, the delimitation of this study confines it to a particular, elite, private school in South Africa. It contributes generally to the literature on the affordances of iPads in Reggio-inspired pedagogy and identifies and describes these in a bit more detail. However, the broader question of how such affordances might be recontextualized in the full diversity of schools in South Africa remains an open one in our research programmes (see Moll et al., 2022).

Broadly speaking, the findings of this study suggest a need for more intentional use of the digital environment by teachers to foster and document learning. Perhaps the most important finding, from the point of view of teachers, is the manner in which iPads encourage learners to *focus on task*. Malaguzzi drew from Piaget an understanding that the crucial role of a teacher is "*to create the situations and construct the devices which present useful problems to the child* […] [and] *compel reflection and reconsideration of over hasty solutions*" (Piaget, 1973, p.16); and from Vygotsky the notion that learning is mediated, systematic cooperation between a learners and a teacher, who is thus an active organizer of the frameworks of knowledge of learners (Vygotsky, 1978). The systematic, carefully designed tasks presented by the teacher from lesson to lesson are therefore crucial in establishing what the knowledge and learning focus should be – a matter of pedagogy and not technology. However, what the current study makes clear is that iPads provide teachers with a systematically integrated set of tools (multimedia, apps, Web exploration devices, etc.) that, as they instruct and guide children in their use, afford them the critical reflection and systematic cooperation that encourage them to stay focused on these tasks. It seems that the major recommendation arising from the study is to provide further education and support for teachers in using the pedagogic strategies afforded by iPads (and other tablet technologies) for developmentally appropriate learning.

8. Conclusion

We have shown that iPads afford young learners in a Reggio-inspired classroom complex ways in which they can deepen and document their own learning. In response to the core research question, we have demonstrated how they do this using a particular methodology to record their own visible learning that is well facilitated by iPads. Most notable is the variety and ease of the representation of knowledge that the technology integrated in the iPad affords to both the children and teachers.

We have offered insights related to the flexibility of iPads in enabling collaborative, teacher-mediated learning that is neither time- nor space-bound and emphasizes learner agency in constructing knowledge by producing materials and other artifacts. iPads not only enhance prevailing mainstream classroom teaching and learning, they also motivate children to extend this beyond the confines of the classroom, as iPads link them in unprecedented ways.

At a theoretical level, the study suggests that iPad affordances add a range of previously unrealized representational and learning possibilities into an early primary classroom, but not in such a way as

to undermine prevailing pedagogies and learning approaches. There is consistent evidence in this case study of a specific school that Reggio pedagogical principles are the foundation of curriculum delivery, and iPad affordances are mobilized to the extent that they enhance and enable the realization of these principles. The study suggests how we might avoid the technocratic destruction of teaching and learning cultures that ICTs often bring with them.

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Italian Journal of Educational Technology, 31(1): 35-55, 2023
ISSN 2532-4632 (print) – ISSN 2532-7720 (online)
DOI: 10.17471/2499-4324/1290
https://ijet.itd.cnr.it

Italian Journal of Educational Technology

itd ISTITUTO TECNOLOGIE DIDATTICHE

Assessment process for the usability of Diligo 2.0 in preschool

Il processo di valutazione dell'usabilità di Diligo 2.0 nella scuola dell'infanzia

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HOW TO CITE Rosa, A. (2023). Assessment process for the usability of Diligo 2.0 in preschool. *Italian Journal of Educational Technology,* 31(1): 35-55. doi: 10.17471/2499-4324/1290

Received: June 15, 2022; *Accepted:* January 27, 2023; *First Published:* March 28, 2023

ABSTRACT The transition from preschool to primary school can be a complex period for children. A good level of cognitive readiness in childhood gives them the ability to cope with learning challenges in future schooling. Diligo 2.0 is an agent-based game developed for Android devices aimed at monitoring two of the main skills related to school readiness in five-year-old children, namely geometric skills, and emotional skills. Diligo 2.0 also evaluates children's psychological and behavioural aptitude for engaging in slow and fast thinking activities. Given the innovative scope of Diligo 2.0 in terms of the survey method employed and how the app is used, this research project aims to verify the tool's usability in the preschool context. This paper presents the structure of the Diligo 2.0 usability assessment process involving teachers and children.

KEYWORDS Assessment; Geometric Skills; Emotional Skills; Preschoolers; School Readiness.

SOMMARIO Il passaggio dalla scuola dell'infanzia alla scuola primaria può essere un periodo complesso per i bambini. Un buon livello di preparazione cognitiva nell'infanzia permette di affrontare più serenamente le sfide di apprendimento della scuola primaria, per tale ragione è importante che tale preparazione sia oggetto di costate monitoraggio da parte dei docenti. Un possibile alleato educativo nei processi di monitoraggio è Diligo 2.0, un gioco per dispositivi Android finalizzato al monitoraggio di due delle principali abilità che fanno parte della preparazione scolastica, le abilità geometriche ed emotive. Inoltre, Diligo 2.0 valuta l'attitudine psicologica e comportamentale a impegnarsi in attività di pensiero lento o veloce. Data la portata innovativa di Diligo 2.0 sia in termini di metodo di indagine che di utilizzo, si è ritenuto utile avviare un'attività di ricerca volta a verificare l'usabilità dello strumento nel contesto prescolare. Questo articolo presenta la struttura del processo di valutazione dell'usabilità di Diligo 2.0 attraverso il coinvolgimento di insegnanti e bambini.

PAROLE CHIAVE Valutazione; Competenze Geometriche; Competenze Emotive; Bambini in Età Prescolare; School Readiness.

1. Introduction

Several studies have identified the transition to school as a potentially complex period for children and families. It involves negotiating and adjusting to several changes, including the new physi-

cal environment, learning expectations, rules and routines, social status and identity, and relationships between children and families (Hirst, Jervis, Visagie, Sojo, & Cavanagh, 2011).

Ensuring educational continuity for children, especially at an early age, also means supporting their well-being and serenity. In addition, continuity in education and schooling is functional to reducing socio-cultural differences and promoting the quality of their overall educational path. Scientific evidence affirms that children who do not have positive early transitions to school are those most likely to become inattentive or disruptive (Ramey & Ramey, 2004).

Working on school readiness can provide important support in this transition phase (Barnett, Lamy, & Jung, 2005).

The centrality of "school readiness" has grown in recent years due to the accumulating evidence revealing that children's performance during the nursery and primary school years has an important bearing on their later success in school and in life (Ladd, 2017).

School readiness is a complex concept that is foundational to early childhood systems and programmes (Majzub & Rashid, 2012).

Different models of readiness interpretation have followed one another over time, influenced by developments in pedagogical and psychological research (Eckert et al., 2008; Mariano et al., 2019; Potmesilova & Potmesil, 2021).

School readiness means that children are ready for school, families are equipped to support their children's learning (Chazan-Cohen et al., 2009) and schools are ready for children. The U.S. Head Start Approach[1] views school readiness as children possessing the skills, knowledge, and attitudes necessary for success in school and later learning and life (Bustamante, White & Greenfield, 2017). Physical, cognitive, social, and emotional development are all essential ingredients of school readiness. A good level of cognitive readiness provides tools for coping with the learning challenges of future schooling.

For the purpose of continuity, children must be given specific, engaging educational activities during preschool.

Literature on the subject (Zanetti & Beccarini, 2022; Raver & Knitzer, 2002) allows you to identify six fundamental areas of development that should be worked on during the preschool period:

1) perceptual skills and creativity;
2) cognitive and logical-mathematical skills;
3) linguistic abilities;
4) learning to learn and use executive functions;
5) socio-emotional and self-regulation skills;
6) psycho-motor development and general well-being.

Integrated development of these competencies gives children the ability to arrive at school cognitively and emotionally 'ready' and to participate in their new educational adventure. Hence, identifying ways to assess these competences is at the core of research in school readiness. Assessment in the early childhood field is not new. Decades of debate are in part summarized in "Reaching potentials: Appropriate curriculum and assessment for young children" (2003) published by the National Association for the Education of Young Children (NAEYC). Some authors stress the importance of prudence in using school readiness measures (Maxwell & Clifford, 2004), because they can derive from instruments featuring different levels of validity.

[1] Head Start programs prepare America's most vulnerable young children to succeed in school and in life beyond school. More details can be found at this web address https://eclkc.ohs.acf.hhs.gov

Other risks are related to crystallize the negative assessment for a long time or to make undue inferences from a single instrument. Finally, some authors also point out that there is great variability in children's abilities, so their performances are multidimensional, episodic and culturally and contextually influenced, which requires special caution in assessment (Coggi, & Ricchiardi, 2014; De Feyter & Winsler, 2009). A further possible limitation of preschool assessment is to make inferences from a single instrument, which cannot adequately account for the multifactoriality of the construct.

Sometimes readiness screenings are used to identify pupils with disabilities, without adopting appropriate tools for this purpose (Keating, 2007).

Although the pedagogical debate on early childhood assessment shows that the topic is currently highly controversial, it is undisputed that assessment is an ongoing process that includes collecting, synthesizing and interpreting information about pupils, the classroom and their instruction (Epstein, Lawrence, Schweinhart, DeBruin-Parecki, & Kenneth, 2004). In addition, the aim of this assessment goes well beyond measuring progress in children – as it may serve for programs evaluation, identifying staff development needs and planning future instruction (Coggi & Ricchiardi, 2014).

Early monitoring of basic skills can indeed help teachers recognise children's strengths and weaknesses, and plan educational interventions aimed at supporting proper development of skills and competencies within the personalized learning processes[2].

Classroom assessment refers to a practice wherein teachers use assessment data from a variety of tools or products to document and enhance student learning (Randel & Clark, 2013). Bonifacci and Tobia (2017) underline the importance to adhere to operating methods that are based on playfulness, interaction and exploration, when identifying the competencies listed above in preschoolers. In this regard, it is useful to recall that excessive use of pre-printed and often unoriginal worksheets dampens the child's creativity and expressiveness.

Observation and assessment of the child's emotional, relational and cognitive development must therefore use different tools and strategies (Bonifacci & Tobia, 2017). Among the many available tools, digital technologies offer significant development prospects for enhancing test administration, test scoring, test reporting and interpretation, and for links with individualised educational proposals (Koomen & Zoanetti, 2018). For example, alongside common survey methodologies supported by technology, many new tools offer interesting opportunities for educational evaluation; these include touchscreens with drag and drop and multi-touch features, augmented reality (AR), virtual reality (VR), mixed reality (MR), robots, and behavioural monitoring (e.g., voice recognition, eye gaze, face recognition, touchless user interface) (Neumann, Anthony, Erazo, & Neumann, 2019). Technology has the potential to improve the assessment process, both when its aim is to facilitate learning processes and when its goal is to summarise the status of students' knowledge and skills (Kashinath, Pearman, & Canales, 2015). In addition, technology offers significant advantages across the different stages of assessment, from test administration to data processing. At the same time a number of privacy concerns have also been raised in regard to technology-based assessment (Kumar, Chetty, Clegg, & Vitak, 2019).

Research underlines the use of information and communication technologies (ICT) in preschool settings as an important educational opportunity (Stephen & Plowman, 2003).

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[2] Personalized learning is a teaching and learning approach which is focused on the needs, aptitudes, and interests of those involved in learning process (Campbell, Robinson, Neelands, Hewston, & Mazzoli, 2010).

While the educational proposals for kindergarten are increasingly focused on the use of technologies (Rosa & Niewint-Gori, 2019), the use of technologies for skills evaluation and monitoring is less widespread (Dore & Dynia, 2020).

The theoretical framework and tools used for classroom assessment can have significant implications for teaching practices and student performance (Broadfoot & Black, 2004; Hodges, Eames, & Coll, 2014). Getting the right feedback is an important component of creating positive learning experiences and academic success. Recent American and Australian government reports call for the development of systems that use digital technologies to make educational assessment more effective and useful (Neumann et al., 2019).

This paper examines the use of an app for classroom assessment from the perspectives of students and teachers.

Apps allow you to integrate the powerful affordances of digital technologies with the many advantages of traditional playful activities. Moreover, mobile apps have proved to be familiar (Dini & Ferlino, 2016), highly usable and well accepted among young children (Panesi & Ferlino, 2019).

This paper examines the use of Diligo 2.0, an app for digital assessment of geometric and emotional skills in five-year-old preschool children, from the perspectives of students and teachers. The paper reports on the evaluation of the app usability by going through the whole assessment process of Diligo 2.0 in all different phases where both teachers and students were involved.

2. Diligo 2.0

Diligo 2.0[3] is a monitoring tool that assesses two of the main skills that are part of the school readiness evaluation of five-year-olds, namely geometric skills and emotional skills. Assessments can be both normative and ipsative. In the first case, the collected data can be used for inter-individual comparisons. In the second case, the collected data can be used for intra-individual assessment. The data allow teachers to keep track of an individual child's strengths and weaknesses, so they can support his/her dynamic developmental profile.

Diligo 2.0 also notes the psychological and behavioural aptitude for engaging in slow/fast thinking (Kahneman, 2011).

It is important to briefly explain the decision for Diligo 2.0 to focus on geometric skills and emotional skills, when, of course, other skills are also functional to school readiness. Geometry is the area of mathematics that concerns shape, size, position, direction and movement, and describes and classifies the physical world we live in.

During spontaneous play, children explore and employ a wide range of mathematical ideas and skills (Ginsburg & Seo, 1999). Historically, geometry was one of the first areas of mathematics taught to young children. In the 1850s, Friedrich Froebel designed a curriculum that proposed instructional practices based on the use of geometric forms and their manipulation in space (Balfanz, 1999). Today, extensive research shows that there is poor appreciation of preschool children's geometric skills (Balfanz, Ginsburg, & Greenes, 2003), despite geometric and spatial skills being highly predictive of mathematical skills and related to the development of executive functions (Verdine, Irwin, Golinkoff, & Hirsh-Pasek, 2014).

[3] Diligo was developed by the Natural and Artificial Cognition (NAC) laboratory under the direction of Professor Orazio Miglino. The section on the analysis of socio-relational competences was produced by NAC as part of its collaboration in the INDIRE research project entitled "PON Project Multidisciplinary Education 10.8.4.A2- FSEPON- INDIRE-2017-1, CUP B59B17000020006".

Table 1. Geometric skills monitored by Diligo 2.0 and the corresponding tasks.

Competence	Task
Knowledge of geometric space	Identifying a specific geometric shape in a picture
Acquisition of the concepts of big and small	Selecting big / small objects
Recognizing numbers	Saying whether or not two representations show the same number
Acquisition of the spatial concept of in and out	Selecting an item that is inside / outside a specific area
Acquisition of spatial concept of up and down	Selecting an item that is above / below a specific object
Acquisition of temporal order in terms of before and after	Selecting an item that is before / after another object in terms of arrival order
Acquisition of spatial direction left and right	Selecting an item which direction is left / right
Recognition of visual differences	Telling if two representations of the same object are the same or different

The geometric skills and the corresponding tasks considered by Diligo 2.0 were chosen in order to accomplish the learning goal for the development of the skills of the kindergarten named "Knowledge of the world" (Table 1). This goal, described in the Italian National Guidelines for Kindergarten (C.M. n. 31 April 18, 2012), states that children at the end of the preschool path must be able to: group and sort objects and materials according to different criteria (e.g., colour; shape; quantity) identify some properties, compare and evaluate quantities; use symbols. Perform measurements using instruments within their reach. In addition, children become familiar with the strategies of counting and operating with numbers and of identifying the positions of objects and people in space, using terms such as forward/back, over/under, right/left, etc.; following a path correctly based on verbal indications.

Turning now to emotional skills, the last several years have seen a blossoming of interest in the social and emotional spheres of early childhood development, as they are crucial to both current and later personal well-being, as well as to learning and academic success (Huffman, Mehlinger, & Kerivan, 2000; Peth-Pierce, 2000; Shonkoff & Phillips, 2000). More specifically, the disconnect between, on the one hand, social and emotional development in educational programmes and, on the other, assessment has long been lamented. New empirical research underlines the importance of socio-emotional skills when it comes to school readiness (Carlton & Winsler, 1999). Raver and Knitzer (2002) have conducted important evidence-based research on socio-emotional skills during the preschool years that is relevant to the need for socio-emotional assessment. Denham (2006) summarised Raver and Knitzer's evidence-based corollaries as follows:

1) Young children without appropriate emotional and social skills participate less in classroom activities and are less accepted by their classmates. Consequently, they enjoy school less;
2) Socio-emotional competence in young children predicts their academic performance in first grade;
3) Relational difficulties persist into the later elementary years.

After the Covid-19 pandemic and lockdowns, many teachers believe that it is important to monitor closely the development of social and relational skills (Panesi, Fante, & Ferlino, 2021; Parlatan & Gürler, 2021). The socio-emotional skills monitored by Diligo 2.0 and the corresponding tasks are summarised in the following table.

Table 2. Socio-emotional skills monitored by Diligo2.0 and the corresponding tasks.

Competence	Task
Recognising facial expressions and associating them with emotions	Recognising which pair of children are expressing the same emotion
Using and understanding the vocabulary of emotions	Selecting the face that matches the name of the emotion
Understanding situations that elicit emotions	Selecting the face that matches the emotion that applies to a specific situation
Awareness of emotions (in terms of intensity)	Selecting the face that matches the description of the intensity of a specific emotion
Knowledge of the cultural rules for displaying emotions	Selecting which illustration presents the best solution for a specific situation
Recognising bodily expressions and associating them with emotions	Selecting the illustration that matches the name of the emotion
Awareness of the emotions (and basic connection to specific kinds of thoughts)	Selecting the illustration of the thoughts that match the required emotion
Regulation and management of one's own and other people's emotions	Selecting which illustration presents the best solution for a specific situation

3. Structure of the Diligo 2.0 app

Diligo 2.0 is a serious game built for Android devices on the STELT platform – Smart Technologies to Enhance Learning and Teaching (Miglino et al., 2013).

Diligo 2.0 was designed and developed using an agent-based model (Helbing, 2012), meaning there are two main interactive agents. The first is the child, who performs all the tests while trying to help the main character in the game, that is, the second agent. The second agent is "Leo the Explorer", an artificial agent who guides the user through the different sections of the app, giving tips, instructions,

Figure 1. Diligo Geometric skills Home page.

Figure 2. Diligo Socio-Emotional skills Home page.

feedback and narrating the introduction to each level of the game (see the home pages of Diligo in Figure 1 and 2).

The interaction between the child and Leo the Explorer takes place against a narrative background.

As the explorer's assistant, the player is engaged in a treasure hunt on eight different islands. As the child begins the game, Leo the Explorer explains how to play it and the basic functions of the buttons. This modelling approach engages the child in the game, motivates him/her and provides constant feedback and reinforcement. The narrative approach enables the introduction of complex content to children (Smorti, 1994; Bruner, 1986; Casey, Erkut, Ceder, & Young, 2008).

In both cases for the geometric skills and the socio-emotional skills, the game is structured in eight steps (one for each skill for a total of 16 skills).

Each step (represented by an island) focuses on a different competence and the same gameplay but has four alternative forms differing in terms of setting, background story, and requests made by the player. In this way, the child can repeat the game several times without getting bored.

Finally, each step gives the child the option to choose between a fast or slow play mode. In fast mode, the player faces a "point-and-click" task, where Leo the Explorer asks him/her to touch a certain element on the screen. In slow mode, each evaluative item is followed by a narrated interval, in which the child is asked to make decisions that have no impact on the score, but which add to the narrative background of the activities he/she is involved in. This makes the game longer, when played in slow mode, and more challenging for attention spans. Scores are not affected by fast or slow mode: 1 point is assigned for every correct answer and 0 points for every wrong one. Children cannot choose the order in which they face the levels because the route of the game is pre-set. This design choice guarantees the validity of the test, since every child follows the same route.

The current prototype is also able to communicate with a server, linking the data from the children's test to a GUID (Globally Unique Identifier), a number used to identify the children anonymously

and protect their privacy. Only teachers are able to associate the identification codes with the children's names. Teachers can log into the child's profile in Diligo 2.0 using the GUID sent to them previously. The app tracks and stores the data of all the sessions of the child. The "Profile" button shows the teacher feedback about children's behavioural preferences and their slow or fast thinking. Aggregate data about geometric or emotional skills can be viewed in an analytics app for teachers and researchers.

4. Structure and instruments of the assessment process of the usability of Diligo 2.0

In this section the structure of the specific objectives of the research activity, the process of evaluating the usability of Diligo 2.0 and the chosen tools are presented.

4.1. Aims

Given the innovative scope of Diligo 2.0 in terms of the survey method employed and how the app is used, the aim of the research project was to verify the tool's usability in the preschool context.

In order to investigate the usability of the app the following objectives were identified:

- to determine what aspects of the app to improve based on the teachers' suggestions;
- to identify the compatibility of Diligo 2.0 with the technological and physical facilities in the nursery schools involved in the research;
- to detect issues and inefficiencies when Diligo 2.0 is used in the field;
- to analyse children's reactions to and opinions about the tool.

4.2. Participants

Taking part in this analysis were preschools in the Istituto Comprensivo "G. Solari" school cluster in Loreto, Italy, namely: Scuola dell'Infanzia "F.lli Volpi", Scuola dell'Infanzia "B. Gigli" and Scuola dell'Infanzia "San Francesco", each located in a different part of town.

Ten teachers (all women between 25 and 50 years old) took part in the project and all 66 of the five-year-olds in the listed schools were involved (30 females and 36 males, details for each school in Figure 3).

4.3. Evaluation process

To collect data on the usability of Diligo 2.0 it has been prepared an evaluation plan that involved both teachers and children. The evaluation plan was divided into two macro phases, each of which was articulated in different actions (Figure 4).

The first macro phase of evaluation was carried out during the finalization of the app and involved only teachers.

Teachers were asked to test the application, not yet definitive, and to suggest any adjustments by filling out an "evaluation card" (Figure 5) provided by the researchers, containing a checklist to be compiled.

The feedback collected through the evaluation card compiled by the teachers became the subject of a focus group that aimed to better understand the information provided and to support the com-

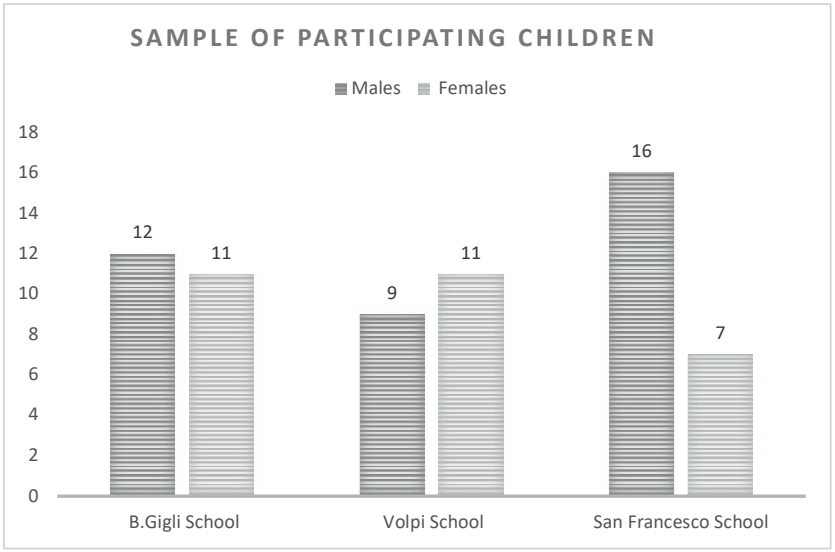

Figure 3. Sample of children participating in the study.

parison between teachers in the implementation areas. Through the discussion in the focus groups, it was possible to identify, as we will highlight later, a list of changes shared by the group of teachers, and used for the developers' implementation of the app. This part of the evaluation process is described in the next section, paragraph 4.3.1.

The second macro-phase had the objective of determining the conditions of organizational and educational use of Diligo 2.0 in the school context and both children and teachers were involved.

Diligo 2.0 was tested with children through 3 play sessions followed (in the case of the first and third session) by an activity (described in the paragraph 4.3.2) aimed at providing feedback to researchers. After the first game session, the children took part in focus groups (one for each class, involving around 66 kids total), later on during the second game session no feedback to children was required. After the third game session, the children were asked to draw a picture of the game session.

At the end of children's play sessions teachers were invited to a focus group finalised to gather information about the organisational aspects of the project. This second part of the evaluation process is described in the next section, paragraph 4.3.2. The research activity led to the systematisation of the app according to the indications gathered from the main users and to the definition of a usage protocol as a guide for other teachers that may use Diligo 2.0 in other classes and to facilitate the app's introduction into schools.

Figure 4 shows the steps of the whole evaluation process.

4.3.1. First macro phase: testing the application by teachers

Initially, the teachers were asked to test the app and suggest possible adjustments. To pursue this objective an evaluation checklist (Diligo 2.0 Card) had defined by researchers.

Creating an evaluation checklist for an educational application is not an easy process because the educational value of an application is not only related to its content, but also to the design, methods, and analysis used to meet the needs of the target group (Judge, Floyd, & Jeffs, 2014). This is even more difficult when the target is preschool children; as Chau (2014) underlines, to meet young children's

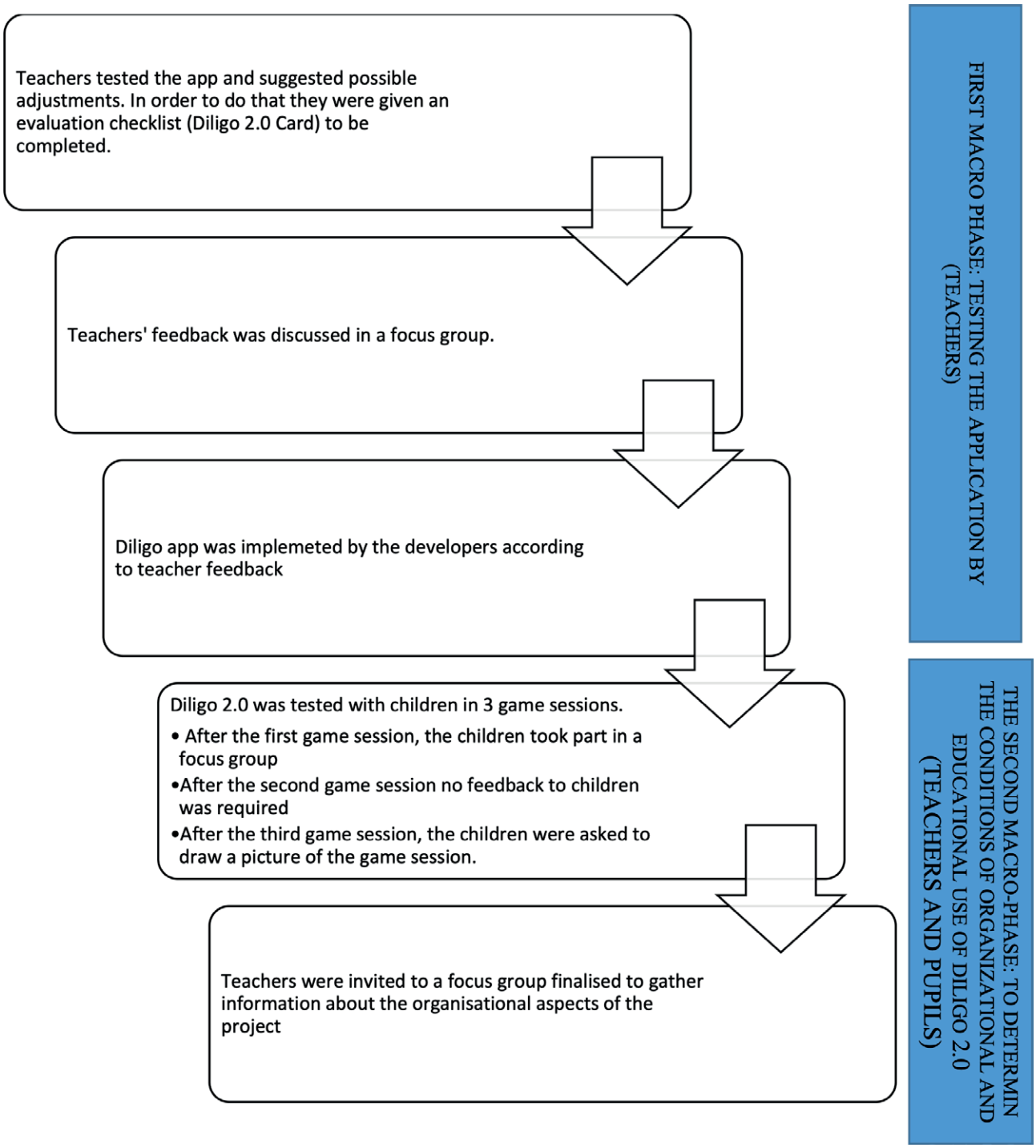

Figure 4. Structure of the assessment process.

developmental stage and cognitive abilities, apps need to adopt specific practices because these age groups have very specific characteristics and needs (Anthony et al., 2014). Based on the literature on the design and evaluation of educational apps, (Lee & Cherner, 2015; Papadakis, Vaiopoulou, Kalogiannakis, & Stamovlasis, 2020; Papadakis, Kalogiannakis, & Zaranis, 2018) seven areas of analysis

were identified. The checklist included thus the following areas: ease of use, functional design, graphics, the balance of difficulty, duration, efficacy, and overall quality. The purpose of the analysis card is to encourage evaluators to focus systematically on all the important aspects of the software's design. Using the analysis card prevents evaluators from inadvertently forgetting to address parts of the assessment. The evaluation process requires teachers to review the software and, from their knowledge of how they would present the software to pupils and how they learn, judge its suitability for the intended educational purpose, taking into consideration the interplay between usability and learning.

For each considered area guiding open questions were provided. These areas were chosen to give central and timely feedback without overloading the teachers with analysis work. The teachers responded to the guiding questions by writing their notes down and gave the card back to the researchers. Answers were carefully read by the researchers and were used to define the focus group track. The answers were divided into two groups: a first with the statements on which there was agreement between teachers and a second group with the statements highlighting disagreement. The contents of both areas were taken up and discussed with the teachers within a focus group which has been video recorded for subsequent analysis. The focus group's goal was to collect a list of changes shared by the group.

Researchers watched the recordings and transcribed the conversations. Teachers' statements were organised within the same macro areas of the analysis form (listed from 1 to 7 in Figure 5). There were no points of disagreement between the teachers and the various proposed changes were agreed by the whole group (for example, the change of the main character's metal voice). Then the actual proposals were outlined (for example, use a human voice, use the voice of a young adult and so on). The scheme thus built was entrusted to the computer experts who implemented the Diligo 2.0 App.

In evaluation research focus groups may be used to gather different kinds of evidence (e.g., opinion, tacit knowledge) (Ryan, Gandha, Culbertson & Carlson, 2014), in this case the focus group was functional to understand better the changes to the app required by the teachers and allow them to confront each other.

After that the changes indicated by the teachers were made in Diligo 2.0 it was possible to start the second macro-phase that will be described in the following sub-paragraph.

4.3.2. The second macro-phase: investigating the conditions for organizational and educational use of Diligo 2.0

When it came to verifying whether the proposed technology was compatible with the specific organisational and structural set-up of the schools, reference was made to the structure of the action research, whereby the teachers were the main stakeholders involved in defining the conditions of use and identifying issues and non-functional aspects affecting autonomous use of the tools. To understand the organizational conditions through which it is possible to use a technological product such as Diligo 2.0 within a kindergarten, the researchers provided guidelines to teachers that guided them in the game administration to children.

As for the game path the use of Diligo 2.0 was organized as follows: Diligo 2.0 was tested with children at school from February 2021 to June 2021 through a sequence of three game sessions that involved the same children, for a total of 66 pupils. In each school, pupils were placed in small groups and three game sessions were organised lasting 30 minutes each (including start-up). Each group contained about five 5-year-olds. Before the start of the activity, the teachers gave each child a nickname

DILIGO 2.0 CARD

1. Ease of use
Is Diligo 2.0 easy to use?
- For children aged 5 years (last year of preschool)?
- For children with early signs of SEN, SLA or physical and cognitive disabilities?
- For supervising teachers?

2. Functional Design
Do Diligo's activities and the flow of play have these characteristics? If so, to what extent?
- Are they usable (see the previous point)?
- Are they enjoyable? (also consider the graphics and multimedia content)
- Are they understandable? (for the age group and any atypical pathways)
- Does playing with Diligo 2.0 cause physical or sensory fatigue? (e.g. fonts are too small, annoying background music)
- Does playing Diligo 2.0 create cognitive overload? (e.g. too much information, unclear information, flow is too fast)

3. Graphics
- Are the graphics in Diligo 2.0 attractive to children?
- Are there elements that could be improved and/or replaced?

4. Balance of difficulty
- Is the difficulty of fast and slow activities comparable?

5. Appropriateness of duration
- Is the duration of individual activities and the game as a whole appropriate for the age group?
- Given the duration, is it possible to maintain a high level of attention and interaction?

6. Ability to assess the child's skills
- In your experience, are the proposed activities suitable for determining the level of competence in relation to the age group (secondary aspect) and the player's preference for fast vs slow activities (main aspect)?

7. Overall assessment
- State other relevant aspects that do not fall under the previous categories and give an overall evaluation of the game (select one of the emoticons)

Figure 5. Evaluation Card.

to use during the sessions of the game so to ensure anonymity. At this stage, the children's play preferences were also investigated in an interview with the children themselves and a questionnaire for their parents[4]. After the first game session, the children took part in a focus group whose purpose was to find out about their use of video games and their related preferences, as well as their expectations of Diligo 2.0.

In the focus group the following questions were asked:
- Did you expect us to play on a tablet at school?
- Do you play on a tablet at home? If yes, whose is it?
- And on mobile phones? (If yes, whose is it?)
- What games do you play on mobile phones?

[4] Analysis of their play preferences serves to answer the research hypothesis that there is an underlying relationship between the children's preference for fast and slow thinking and their propensity to play. Indeed, it has been hypothesised that children tend to choose the type of activity that is most similar to their everyday experiences. This paper does not analyse this aspect.

- What don't you like?
- Which do you prefer between playing in the park and using a tablet?

After the second game session no feedback to children was required, following the third game session the children were asked to draw a picture of the app. They could choose whether to draw something they liked about it or something they did not like. The teachers wrote up the children's information and opinions about the drawing activity. Qualitative instruments as unstructured interviews were used in order to gather as many details as possible. These were used to understand the content of children's drawings and their motives. Unstructured interviews are by definition open-ended tools. This flexibility can help gather detailed information on your topic, while still allowing you to observe participants' reasons. This survey instrument was chosen because it is a free-flowing and flexible type of interview. The questions and the order could not be set in advance because the interview should flow spontaneously, based on the participant's answers. Interviews were realised by the teachers because it was important (for the context and the child's age) to gather a deep connection between participants, encouraging them to feel comfortable revealing their true opinions and emotions.

The researchers were thus able to understand the contents of the drawings more explicitly and above all to read the reasons for the choices made by children. Finally, after the children's last game session, teachers were involved in another focus group, to gather information about the organisational aspects of the project and their opinions about how easy it was for the children to use the tool.

This focus group had aimed to collect information on the peculiarities and conditions of use of Diligo 2.0. The choice to use the focus group and not another tool was determined by the desire to support the comparison between teachers both to highlight different aspects of use and to identify different possible solutions.

5. Results

This section presents the data collected throughout the validation process described in the previous section. The data collected are organized in this presentation according to the subjects involved, teachers and children, to better focus the points of view and perspectives.

5.1. Teachers' considerations about Diligo 2.0

The analysis of Diligo 2.0 by the teachers, whose considerations were collected through the analysis form and the first focus group, was a very important step in the process. Their suggestions were accepted by the research team and the NAC (Natural and Artificial Cognition) professionals, that incorporated a large number of modifications. The teacher's suggestions were organised within the macro areas of the analysis form. Regarding easaboute of use, there was complete agreement among the teachers that the product is suitable for five-year-old children. User-friendliness for children with special educational needs was evaluated by two teachers in the group who had specific training and found the app to be suitable. However, they stressed that this depends on the individual child. The teachers pointed out that, on its own, the app was not sufficient for them to oversee the activity. Real observation needs more structured and more organised feedback. Their misgivings were resolved when it was explained precisely how the documentation collected by the app would display the information to teachers.

Most of the requests for changes and additions concerned the 'Functional Design' area, meaning for instance, in some cases, the images used to guide the children were considered inadequate. For

example, a cloud and a lightning bolt were initially chosen to represent the slow and fast routes but were not considered sufficiently understandable for children. The teachers recommended using pictures of animals the children can easily identify as being slow or fast, such as a tortoise for the slow route and a hare or leopard for the fast route. The hare and the tortoise are also familiar to children from traditional fairy tales. Thus, an attempt was made to establish continuity between more traditional activities, such as reading fairy tales, and more innovative activities supported by technology. In some cases, vocal reinforcement of the images proposed was needed from Leo the Explorer. Another example was the red round symbol with a cross and the green symbol with a tick, providing negative and positive feedback respectively. The teachers judged these symbols to be non-intuitive for the children and therefore in need of explanation.

Overall, the group found the graphics to be clear and usable, although not everyone liked the style. The protagonist's voice was considered too tinny and was asked to be changed. Regarding the flow of play and the tasks given to the children, the teachers identified which sections should be changed and what terms would be more understandable to five-year-olds. It also emerged that it would be useful to allow children to hear the recordings a second time. The teachers also recommended simplifying the "go back" and "exit" buttons. According to the teachers' feedback, playing with Diligo 2.0 does not cause any physical or sensory fatigue. The tone and volume of the background music were particularly appreciated. The cognitive load was also considered as sustainable in terms of content and game dynamics. Furthermore, the teachers appreciated the fact that the children are given plenty of time to respond.

During the review process, the teachers stated that some children would not know some of the proposed content, such as the semicircle or the pentagon, because the geometric shapes usually studied at preschool level are the circle, square, triangle and rectangle.

In the teachers' opinion, this first activity was particularly important, because it allowed them to reflect on aspects they had not previously considered. In fact, the updates and changes to Diligo 2.0 based on the teachers' recommendations and their involvement in the review process made the preparation activities for using Diligo 2.0 with the children more analytical. The research team was particularly impressed with the care and precision with which the task was completed, and was thus able to provide timely analytical feedback, which made the work proceed more smoothly. The teachers were very active and interested in using Diligo 2.0 also in the second focus group in which they were involved. In this case the focus group was oriented to evaluate usability of Diligo in the school. The difficulty reported by the teachers was finding co-presence sessions where they could work in a small group on the tablets. Another issue was the schools internet connection, which was not always efficient. Interestingly, teachers noted that the children were always very patient, even when they had to start the game session all over again because of a Wi-Fi connection failure. One difficulty encountered was related to sound: as the children did not use headphones, there was a lot of noise.

On the positive side, the teachers said all the children eagerly and without any tension did the test and asked several times to repeat the activity. Furthermore, the children's ability to concentrate was generally very high. It was interesting to note that, after being informed of the project, the children's families welcomed the opportunity to assess their readiness skills.

Thus, the teachers generally gave positive feedback on the experience and mentioned no further difficulties in the practical use of Diligo 2.0. Moreover, they considered the opportunity to obtain readiness data like those provided by Diligo 2.0 to be a valuable resource which they would like to extend to many other competencies and add to their observation tools and documentation practices already in use.

5.2. Children's feedback on Diligo 2.0 through the analysis of focus groups and drawings

During the focus groups, that were held only with 5 years old children in each single class, the teachers got all the children to talk, as they all had something to say about their experience doing an activity that was particularly interesting to them.

The answers given were organised within the same schools, as significant differences were detected that were potentially due in part to mutual conditioning and in part to the catchment area of the individual schools. Figure 6 summarises the children's statements. Expectations (Did you expect us to play on tablets at school?) were different in the three schools. This finding is particularly interesting because, although all three schools have extensive experience of using technology (e.g., 3D printers), at Gigli School, only a small number of the children were not surprised. The difference is that tablets provide a one-to-one relationship between the device and the child, whereas other technology-based learning activities involve group work.

The children had no issues using tablets during the Diligo 2.0 sessions, although only those at San Francesco School said they were accustomed to playing on a tablet at home. In all the schools, more than 50% of the children said they played video games on their mobile phones. However, only a small number of children said they had a mobile phone and all those who did were referring to old mobile phones used solely for playing games. When asked 'What games do you play on your mobile phone?', a small number of children mentioned games designed for children of the age group in question and, in several cases, these games were not rated on the PEGI system. Interestingly, the children carefully analysed the aspects of video games they disliked, especially at Gigli and Volpi schools. A small number of children said they liked everything about playing video games. Finally, almost all the children at Gigli School said they preferred playing outdoors to playing virtual games (96%) and the percentage was also very high in the other schools involved (62% at San Francesco and 74% at Volpi respectively).

This focus group involved a lot of children who said they were fairly familiar with video games. One interesting finding is the children's appreciation of and engagement with the logic and proposals of Diligo 2.0, which are different from the commercial games they mentioned.

Thus, as is evident from the descriptions and analyses made by children on their drawings and collected by teachers (through the annotation of children's comments) appreciation of Diligo 2.0 by children was not due to the consideration of video game as something new or unusual, but precisely because of the game itself.

The children's drawings were used as an aid for them to give their opinions about Diligo 2.0, which is why the task was general. "Draw something you liked or something you did not like". None of the children chose the option to draw something they did not like, and they all drew the things they liked the most or at least that amazed them. It is interesting to note that, except for two very similar drawings, all the others were the result of the children's independent work and reworkings capturing different aspects and perspectives. Two drawing examples in Figures 7 and 8.

The contents of the drawings were aggregated under labels (Figure 9). A total of 64 drawings were considered, as two children were absent during the activity. In agreement with the teachers, it was decided not to repeat the activity for these individuals, as they would be playing in a very different context (background noise, the possibility of getting the teacher's attention, etc.). Only 3% of the children drew Leo the Explorer without contextualising him within the game action, while 44% portrayed him within the context of the game as he completed the different adventures. About half of the chil-

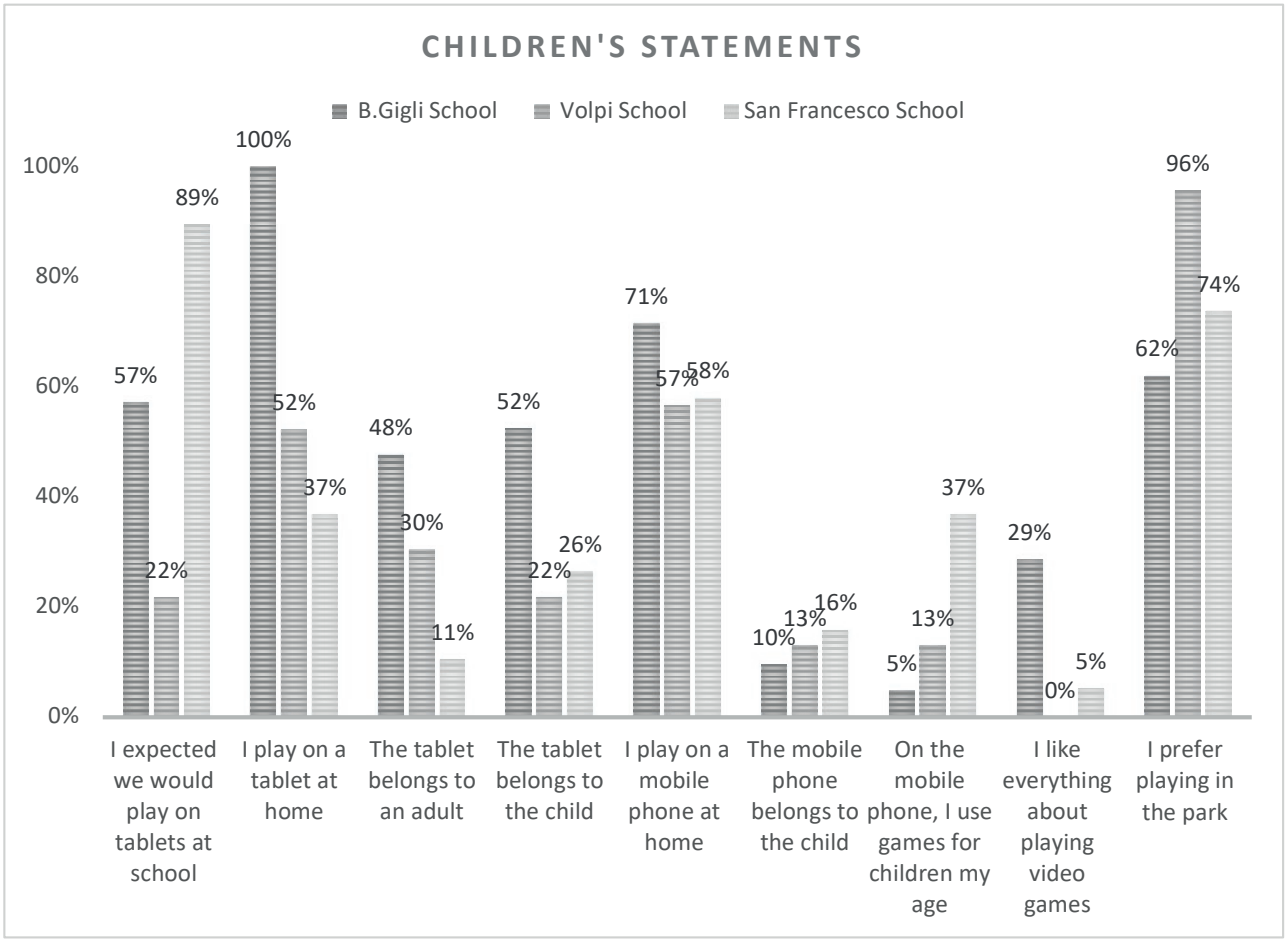

Figure 6. Children's statements.

dren drew Leo the Explorer in the final step as he found the much-anticipated treasure. The teachers reported some excitement from the children as they described what they had drawn, as Leo's victory represents the child's victory.

When the children drew Leo the Explorer during the game, they used one of two criteria to make their choice: the game they liked best or the game that was more complicated. A total of 6% of the children drew themselves in the role of helpers supporting Leo the Explorer's efforts to complete his adventures. It is also noteworthy that three children drew the action inside the tablet, from their own point of view. A total of 39% of the children preferred not to draw the protagonist; rather, focusing on the setting, they drew the islands, animals, geometric shapes and treasure. Much of the children's attention was on the background settings, both with and without the character in action, and their use of colour accurately reflected the game. Finally, two drawings showed characters from a different video game that was not Diligo 2.0 and were therefore considered irrelevant.

As they commented on their drawings, the children talked about the problems the game had posed and the solutions they had found, accurately recalling the various steps to arrive at the solutions, in a process of metacognitive reflection. On the whole, the children reflected enthusiastically on the activity. It is interesting to note that they asked for sections to be added to the game, but not for further

Figure 7. Leo the Explorer.

Figure 8. Children drew themselves in the role of helpers.

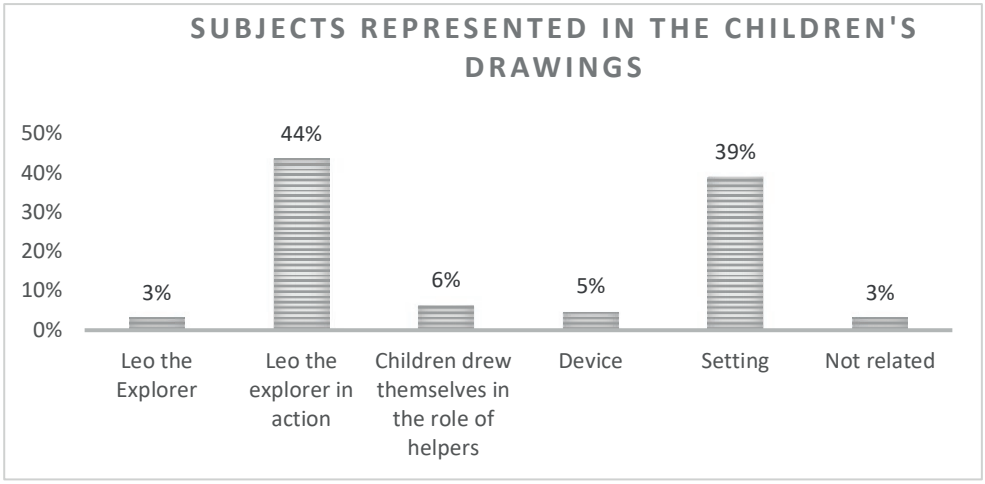

Figure 9. Subjects represented in the children's drawings.

diversification of the adventures, which retained a high level of interest for them, even though they had already been completed.

6. Conclusions

This paper reports on the results of a usability test of the Diligo 2.0 app carried out with 66 5-years old students in three different schools. The data were collected from teachers and students and led to fine-tuning the app before and after use. The results corroborate the app usability and future work will aim at evaluating its ability to assess students' school readiness.

The assessment of readiness skills can be a foundation for designing and creating the conditions for children to develop their individual physical, cognitive and emotional potential. This was the premise guiding the design of Diligo 2.0.

As Gonski (2018) states, it is important to "use new technology not for its own sake, but to adopt ways of working that are more efficient and effective" (p. 99). In this perspective innovative education theory, psychology, computer science and engineering can come together to optimise classroom assessment practices and provide clear links between assessment, teaching and learning.

Although the data presented on the usability of Diligo 2.0 refer to a small number of subjects and cannot be claimed to apply outside this sample set, they do represent a first step in the app's implementation.

Through this initial research work it was possible to involve teachers in the tool definition phase. This step was defined within the focus group by the teachers themselves, who appreciated its importance, realizing how decisive their experience was in defining the educational product intended for children. Often teachers try out different products offered by the market, but they are rarely involved in the tool construction phase.

The role of the teachers was then fundamental in testing the conditions of use of Diligo 2.0. Kindergarten is characterized by very different times and working methods from subsequent levels. Therefore, it was important to acquire information from those who work in this kind of reality every day and know the educational dynamics well.

In addition to this, children were comfortable and freely expressed themselves with the teachers, and for this reason researchers were able to acquire different information.

For instance, the patience shown by children, the involvement in the dynamics of the game and their affection towards the main character, were not dynamics that could have been taken for granted before using Diligo 2.0

The data on game dynamics are currently being reworked, along with the correlation between the games preferred in a family context and the game dynamics (slow or fast) chosen through Diligo 2.0. These data will guide future developments of the app.

In conclusion we can say that the only way to acquire direct information from real users is to involve children and teachers. The possibility of monitoring children's competencies through playful tools that are fun and reflect the state-of-the art knowledge of a multidisciplinary team lays the foundation for new and varied research applications. Since one of the aims of the app was to sustain teachers in assessing young children in geometry and emotional skills, in the future, researchers will explore whether the teachers felt that the assessment provided them with information about young children's learning and whether it could discriminate among children.

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Italian Journal of Educational Technology, 31(1): 57-76, 2023
ISSN 2532-4632 (print) – ISSN 2532-7720 (online)
DOI: 10.17471/2499-4324/1285
https://ijet.itd.cnr.it

Italian Journal of Educational Technology

itd ISTITUTO TECNOLOGIE DIDATTICHE

The Technological Pedagogical Content Knowledge (TPACK) model in primary education: A literature review

Il modello TPACK (Technological Pedagogical Content Knowledge) nell'istruzione primaria: una revisione della letteratura

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HOW TO CITE Paidicán Soto, M. A, & Arredondo Herrera, P. A. (2023). The Technological Pedagogical Content Knowledge (TPACK) model in primary education: A literature review. *Italian Journal of Educational Technology,* 31(1): 57-76. doi: 10.17471/2499-4324/1285

Received: June 3, 2022; *Accepted:* February 13, 2023; *First Published:* March 14, 2023

ABSTRACT This article presents the results of a systematic literature review conducted on the research works of doctoral students concerning the TPACK model in primary education and considering multiple roles, including those of teachers, students, and of the educational community. The procedure used was the one proposed by Kitchenham (2004). The selection of 15 doctoral theses was carried out after a search in the repositories TESEO, DIALNET, Doctoral Dissertations on the Net (TDR), Open theses, and Theses and dissertations (OATD), considering the period from the publication of the model by Mishra and Koehler (2006) until April 2020. The review was carried out analyzing open access, full text doctoral theses focusing on primary education. It is concluded that only 6,52% of the total number of theses about TPACK available on the data bases concerns primary education. Furthermore, 53,3% of the research related to the TPACK model in primary education is focused on teachers. These results are in line with those of a previous literature review carried out on the same topic that did not consider this type of literature (Paidicán & Arredondo, 2022b). It is recommended that research on TPACK be expanded, focusing on aspects related to educational management, initial education, and its articulation with primary education.

KEYWORDS Teachers' Competence; Educational Technology; Technological Pedagogical Content Knowledge (TPACK); Primary School Teachers; Teacher Training; Integration of Technology.

SOMMARIO Questo articolo presenta i risultati di una revisione sistematica della letteratura scientifica limitata a lavori di dottorato e associata al modello TPACK nell'istruzione primaria, che considera il ruolo degli insegnanti, degli studenti e della comunità educativa. La procedura utilizzata è quella proposta da Kitchenham (2004). La selezione di 15 tesi di dottorato è stata effettuata a partire da una ricerca negli archivi online TESEO, DIALNET, Doctoral Dissertations on the Net (TDR), Open theses, and Theses and Dissertations (OATD), considerando il periodo dalla pubblicazione del modello da parte di Mishra e Koehler (2006) fino ad aprile 2020. I criteri di inclusione erano: accesso aperto, testo completo, tesi di dottorato incentrate sull'istruzione primaria. Si è concluso che solo il 6,52% del numero totale di tesi sul TPACK disponibili nelle banche dati riguarda l'istruzione primaria. Inoltre, il 53,3% delle ricerche relative al modello TPACK nell'istruzione primaria è incentrato sugli insegnanti. Questi risultati sono in linea con quelli di una precedente revisione della letteratura condotta sullo stesso

argomento ma che non includeva lavori di dottorato (Paidicán & Arredondo, 2022b). Si raccomanda di ampliare la ricerca sul TPACK, concentrandosi sugli aspetti legati alla gestione dell'istruzione, alla formazione iniziale e alla sua articolazione con l'istruzione primaria.

PAROLE CHIAVE Competenze degli Insegnanti; Tecnologie Educative; Conoscenza dei Contenuti Pedagogici Tecnologici (TPACK); Insegnanti della Scuola Primaria; Formazione degli Insegnanti; Integrazione della Tecnologia.

1. Introduction

Teachers need a series of competencies to successfully design and conduct the teaching and learning process. The technological, pedagogical, and content knowledge model (TPACK), which proposes a way to look at the interaction between pedagogical, technological, and content teachers' competence, supplies a solid construct for integrating technology in the classroom (Koh & Chai, 2011; Koehler, Shin & Mishra, 2012; Mishra & Koehler, 2006). In TPACK, three central dimensions can be distinguished and the intersection between them allows for the identification of four others, as shown in Figure 1.

1) Technological Knowledge (TK): These are the skills needed to use ICT tools such as computers, projectors, cameras, digital video, whiteboards, the internet, and the skills needed to use different software programs (Koehler, Mishra, Kereluik, Shin, & Graham, 2014; Munyengabe, Yiyi, Haiyan, & Hitimana, 2017).
2) Content Knowledge (CK): These are skills related to the content to be taught. It should be noted that teaching and learning processes are enhanced if teachers are able to present knowledge in meaningful contexts (Mishra & Koehler, 2006; Munyengabe et al., 2017).

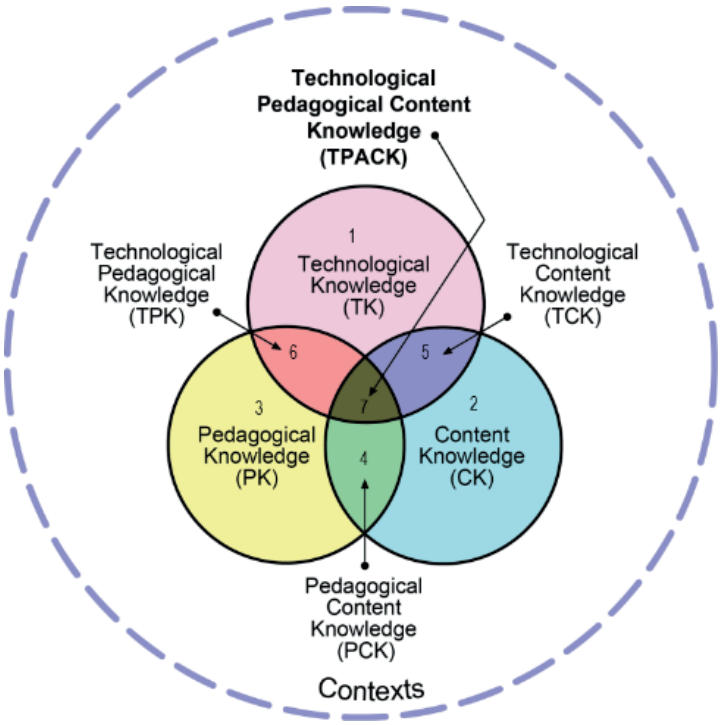

Figure 1. TPACK Model. Reproduced by permission of the publisher, © 2012 by tpack.org.

3) Pedagogical knowledge (PK): Teachers need knowledge of teaching and learning processes, which should include classroom management, planning, and evaluation of teaching and learning processes (Munyengabe et al., 2017; Schmidt et al., 2009).
4) Pedagogical Content Knowledge (PCK): Occurs at the intersection of CK and PK, as PCK prepares CK for the teaching process (Munyengabe et al., 2017; Koehler et al., 2014; Shulman, 1986).
5) Technological Content Knowledge (TCK): The result of the combination of TK and CK, TCK relates to how technology depicts specific content (Koehler et al., 2014; Munyengabe et al., 2017; Schmidt et al., 2009).
6) Technological Pedagogical Knowledge (TPK): The result of the combination of TK and PK, TPK refers to how various technologies can be used in education (Mishra & Koehler, 2006; Munyengabe et al., 2017; Schmidt et al., 2009).
7) Technological Pedagogical Content Knowledge (TPACK): It corresponds to the result of the intersection of CK, PK, and TK, which teachers must have to integrate ICT in the teaching and learning process (Koehler et al., 2014; Munyengabe et al., 2017; Schmidt et al., 2009).

Over the last few years, the TPACK model has consolidated its importance in educational research by presenting theoretical and practical guidance on teacher education in the field of technologies (Erdoğan & Sahin, 2010; Graham, 2011; Jang & Tsai, 2012; Lescano, 2013; Lye, 2013; Nordin, Davis, & Tengku, 2013; Voogt, Pieters, & Handelzalts, 2016; Wang, Schmidt-Crawford, & Jin, 2018). As suggested by Mishra and Koehler (2006) and So and Kim (2009), TPACK is the pedagogical way of knowing how to teach a certain content using the most proper technology. Other authors, such as Kim, Kim, Lee, Spector and De-Meester (2013), Lin, Tsai, Chai, and Lee. (2013), and Koh and Chai (2014) underline that the usefulness of the TPACK model lies in favouring the integration of ICT, considering teachers' feelings as a guide for the development of the process.

So far, systematic reviews of TPACK in primary school address aspects related to the application of the model, learning designs, and the development of professional training programs, but they cover the topic only partially, and usually regard different educational levels rather than look into the specificities of primary level (Rodríguez, Agreda, & Ortiz, 2019; Voogt et al., 2016; Yeh, Chan, & Hsu, 2021). The exception is Paidicán and Arredondo (2022b) whose systematic literature review (SLR) focuses specifically on primary school, although it analyses only a few databases such as: ERIC (Educational Resources Information Center), Google Scholar, SCOPUS and WoS (Web of Science) and hence does not cover PhD theses. The above SLR analyses 19 articles (3.05%) of the total selection (622), covering the period from the presentation of the model to May 2019. The results of the SLR show that most of the studies are oriented toward teachers, and self-assessment of teachers' knowledge is the most studied topic (42,8%). There are also studies focused on students and educational communities, incorporating students' families. It should be considered that there are no studies of the TPACK model in Latin America.

Aim of this study is to extend the results of the above SLR by covering databases of PhD thesis, in the belief that this type of work is an important component of state-of-the-art research trends. It should be noted that the present SLR is developed as part of the doctoral research of the "Education and Society" program at the University of Barcelona.

This study aims to examine the recent PhD works related to the TPACK model focused on primary education, considering the following research questions:

- Question 1 (RQ1): What are the characteristics of the PhD thesis on the TPACK model in primary education?

- Question 2 (RQ2): What approaches describe studies on the TPACK model in primary school focusing on teachers, students, and the educational community?
- Question 3 (RQ3): What recommendations do the PhD theses suggest for the TPACK model in primary education focusing on teachers, students, and the educational community?
- Question 4 (RQ4): To what extent are the results of this review in line with those obtained by its complementary study, by Paidicán and Arredondo (2022b)?

2. Methods and materials

Systematic literature reviews aim to evaluate the scientific literature using critical and structured protocols to limit bias (Petticrew & Roberts, 2008). The present study is carried out using the steps defined by Kitchenham (2004), whose protocol is widely used in the social sciences, as described in Table 1.

Table 1. Stages described in this SLR.

Stages	Activities
Stage 1: Planning the SLR	Activity 1.1: Identifying the rationale of the SLR Activity 1.2: Developing a protocol for the SLR
Stage 2: Conducting the SLR	Activity 2.1: Identifying the purpose of the SLR Activity 2.2: Selecting primary study sources Activity 2.3: Evaluating the quality of study sources Activity 2.4: Data collection and monitoring Activity 2.5: Data synthesis
Stage 3: Reporting the SLR	Communicating results of the SLR

2.1. Planning and conducting the SLR

As a preliminary stage for the SLR, a search was carried out in Google scholar, SCOPUS and WoS databases to identify previous SLR related to the TPACK model in primary education. The string used was (technological AND pedagogical AND content AND knowledge) OR TPACK. The string was adapted to the format required by the different databases.

A total of 15 SLR were obtained, only three of which partially met the established requirements. The study by Paidicán and Arredondo (2022b) deals entirely with studies of the TPACK model in primary education. In addition, two SLR partially address this educational level, Yeh et al. (2021) consider 27,2% of the articles, and Rodríguez et al. (2019) include 35,3% of the publications on this educational level. It should be noted that the three SLRs preferentially select WoS, SCOPUS, ERIC, and Google scholar databases.

Given the above background, it was established that our review is different and complementary to previous reviews related to TPACK. It addresses doctoral theses, considering usually less selected repositories for SLR. Moreover, it allows us to obtain a broader view of the development of TPACK. According to Caballero, Torres-Salinas and López-Cozar (2011), studying doctoral theses is advantageous as it reflects the trends, lines of research, and potential of universities. It is also a suitable way to analyse the evolution of a specific area. Therefore, we conducted a SLR in the repositories TESEO,

DOI: 10.17471/2499-4324/1285

Table 2. Summary of the papers analysed by extant SLR on TPACK.

Author	Period of years	Article numbers	Databases consulted	Research focus
Abbitt (2011)	2005-2010	20 publications	EBSCO Academic Search Premier, ERIC and EDITLib.org	Instruments and methods used to measure TPACK and potential purposes and uses for TPACK-based assessment.
Wu (2013)	2002-2022	24 articles	WoS Social Science Citation Index (SSCI)	Review empirical studies on TPACK, including samples, methods, and thematic areas.
Chai, Koh and Tsai (2013)	Start in May 2011	74 articles	WoS, SCOPUS, Education Research Complete and ERIC (EBSCOhost).	ICT integration from the TPACK framework, according to place of study, publication medium and research methods.
Voogt et al. (2013)	2005 to September 2011	55 articles and books	ERIC, WoS, SCOPUS and PsychINFO	Theoretical basis of TPACK, concepts, specific subject areas, and teaching beliefs.
Rosenberg and Koehler (2015)	2005-2013	74 articles	ERIC, PsychINFO and Electronic Sources	The TPACK model and its development context (micro, meso, and macro)
Willermark (2018)	2011-2016	107 articles	ERIC, SCOPUS and SSCI	General aspects of TPACK, research design and methods, research samples, subject areas, etc. In the context of teachers.
Wang et al. (2018)	January 2006 to September 2015	88 articles	ERIC, PsycINFO and Mendeley (Grupo de investigación TPACK)	Types of methodologies, development, and results in TPACK studies
Voogt et al. (2011)	1988-2009	9 articles	SCOPUS, WoS and ERIC.	TPACK teacher training programme design teams.
Voogt et al. (2016)	2009-2015	14 doctoral theses	No data	The effects of teachers' participation in vocational training programme design and development teams
Malik, Rohendi and Widiaty (2019)	2008-2018	30 articles	SCOPUS, ScienceDirect, SAGE Journal and Taylor & Francis	A new ICT integration model based on TPACK.
Paidicán and Arredondo. (2022b)	Since 2006 May 2019	19 articules primary	SCOPUS, WoS, ERIC and Google scholar	Analyze the scientific literature related to TPACK in primary education.
Rodríguez et al. (2019)	2014-2017	37 articles 13 de primary (35,3%)	WoS and SCOPUS	Current vision of the application of the TPACK model in education.
Young (2016)	2002-2015	65 articles	JSTOR, ERIC, EBSCO, Pych INFO and ProQuest	Characterising the effectiveness of technology in the mathematics classroom using TPACK.
Yalçın and Yayla. (2016)	2009-2015	543 papers	Wos and SCOPUS	Reveal the scholarly communication of the researchers, to specify the documents and authors efficient in the field and to reveal extensive conclusions in the context of document and author by examining the researches that are conducted about TPACK.
Yeh et al. (2021)	Until 13 February 2020	11 articles, 3 primary (27.2%)	WoS and SCOPUS	Learning by design

DIALNET, Doctoral Theses in Network (TDR), Open Theses and Theses and Dissertations (OATD) to find scientific documentation related to the TPACK model for primary education.

This SLR analysed doctoral theses from the presentation of the model until April 2020. Keywords were checked in the ERIC and UNESCO thesauri before searching. Table 3 shows the protocol used in the search in each database.

Table 3. Specific keyword protocol in each repository.

Repository	Keyword protocol
TESEO	Modelo TPACK
DIALNET	Modelo TPACK
Tesis doctorales en red (TDR)	TPACK
Open Thesis	"Technological Pedagogical Content Knowledge" or "tpack"
Theses and dissertations (AOTD)	(Technological AND Pedagogical AND Content AND Knowledge) AND ("tpack")

The search equation only considers the term TPACK and not TPCK, because according to Mishra and Koehler (2006) and De Rossi and Trevisan (2018), the acronym TPACK depicts an integrative perspective, avoiding focusing on one or two components of the model. In addition, the term primary education is excluded to be able to access a broader body of research. Inclusion criteria are the following: open access, full text, doctoral theses focused on primary education. The exclusion criteria set out restricted access, abstracts only, editorials, press releases, conference papers, reports, dissertations, bachelor's and master's research, and other educational levels.

Figure 2 shows that 230 doctoral theses were found, with the largest number in Theses and Dissertations (AOTD) 171 (74,3%), followed by Doctoral Dissertations on the Net (TDR) 31 (13,4%). Titles, keywords, and abstracts are reviewed according to the inclusion criteria. In some cases, it was necessary to read the full text.

Fifteen doctoral theses were studied, 11 (73,3%) found in Theses and Dissertations, 2 in DIALNET, and 2 in TDR (13,3%) respectively. It should be noted that the theses were reviewed by systematically obtaining information related to the previously defined research questions. Table 4 shows the list of selected studies.

3. Results

Initially, theses were analysed in relation to year of publication, geographical distribution, university of origin of the research, type and design of research and instruments used. Secondly, the studies on the TPACK model were analysed according to the focus of the studies, on teachers, students, and the educational community.

3.1. Characteristics of the thesis about the TPACK model in primary education

The first part of the analysis is organised according to the first research question (RQ1). It is observed that there are no publications between the start of the TPACK model and 2012 and during

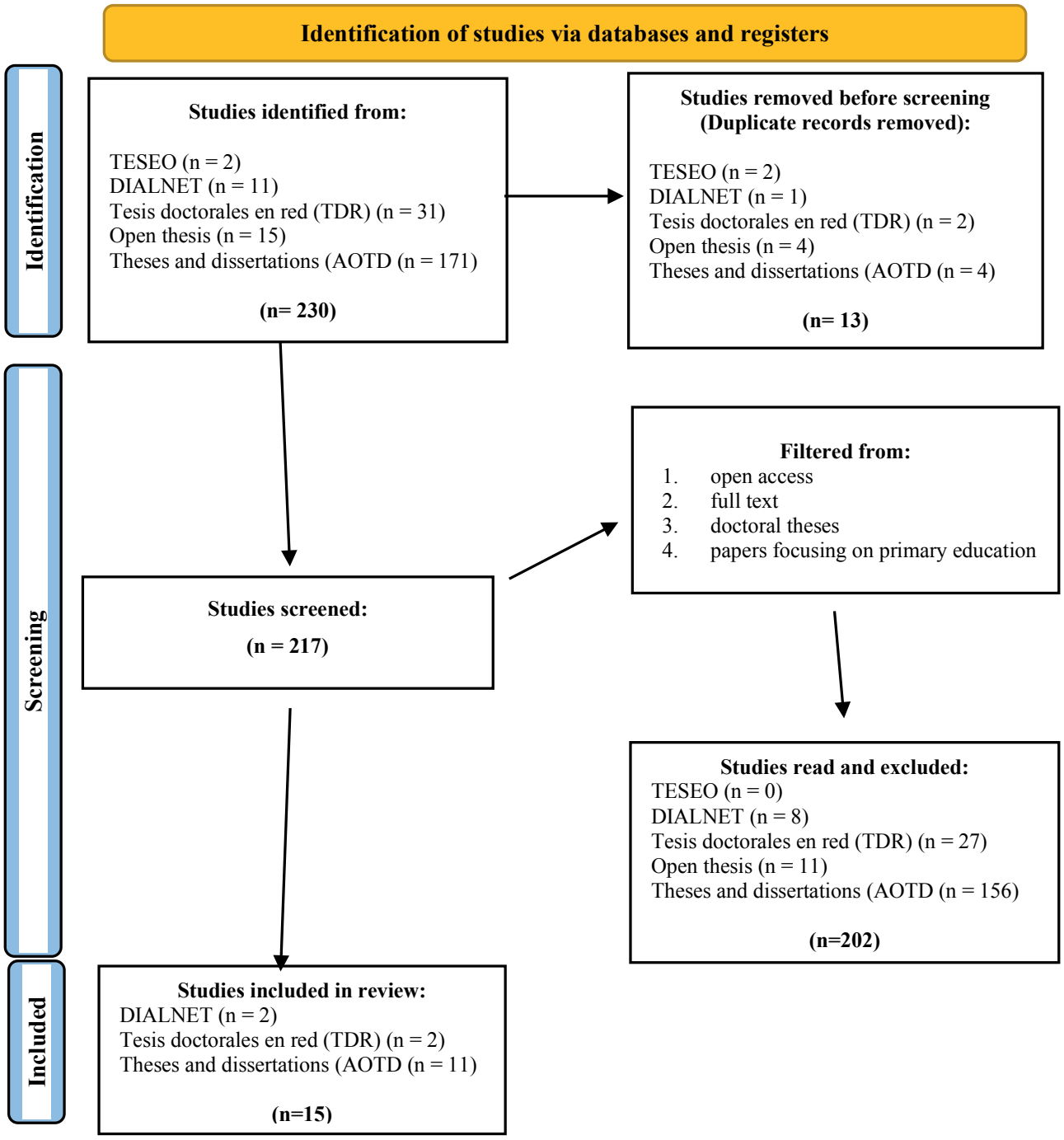

Figure 2. Summary diagram of selected doctoral theses.

2018 and 2019. In addition, year 2016 presents the highest production, 6 theses (40%), followed by 2017 (20%), see Figure 3.

The first part of the analysis is organised according to the first research question (RQ1). It is observed that there are no publications between the start of the TPACK model and 2012 and during 2018 and 2019. In addition, year 2016 presents the highest production, 6 theses (40%), followed by 2017 (20%), see Figure 3.

Table 4. Doctoral thesis included in the SLR.

Nº	Author	University	Country	Type of study	Research design	Sample	Instruments	Working area
1	Mañas (2017)	Alicante	Spain	Mixed	Case study	255 students	Questionnaire	Music
2	Martínez (2016)	Murcia	Spain	Mixed	Quasi experimental	53 students, 16 teachers and 49 families	Questionnaires and Field Diary	Spanish Language
3	Ufartes (2016)	Autónoma de Barcelona	Spain	Qualitative	Case study	28 students	Interview, participant observation, field diary, individual recordings and focus group discussions.	Music
4	Masdeu (2015)	Lleida	Spain	Mixed	Descriptive	16 experts and 1.371 experts	Questionnaire and Interview	Music
5	McCann (2015)	Hawái	USA	Qualitative	Case study	1 teacher	Interview	English language and literature, mathematics, science and social sciences
6	Ontiveros-Karr (2017)	Liberty	USA	Qualitative	Phenomenology and hermeneutics	9 teachers	Interviews, reflections and representations	Not stated
7	Monroe-Ossi (2016)	North Florida	USA	Quantitative	SEM (structural equation modelling)	42 school principals and 75 teachers.	Questionnaire	Not stated
8	Alqallaf (2016)	Northern Colorado	USA	Mixed	Descriptive	562 teachers	TPACK-based questionnaire (mathematics) and interview	Mathematics
9	Woodward (2016)	Iowa State	USA	Qualitative	Verbal reporting methodology	58 students and 3 teachers	Verbal reports	English language
10	Mallernee (2017)	North Central	USA	Quantitative	Case study	82 teachers	Questionnaire	Technology education
11	Mishne (2012)	Pepperdine	USA	Mixed	Ex post facto	44 teachers	TPACK-based questionnaire	Not stated
12	Montes (2016)	Houston	USA	Qualitative	Caso study	3 teachers	Observations and interviews	Technology education
13	Perry (2018)	Yeungstown State	USA	Mixed	Regression analysis	49 professionals	Observation	Technology education
14	Fanni (2014)	Dellas Svizzera	Italy	Mixed	Case study	218 teachers	TPACK Questionnaire	Not stated
15	Jones (2012)	Texas	USA	Qualitative	Case study	72 teachers	Interviews, lesson plans, group meetings, field diaries and focus groups.	Not stated

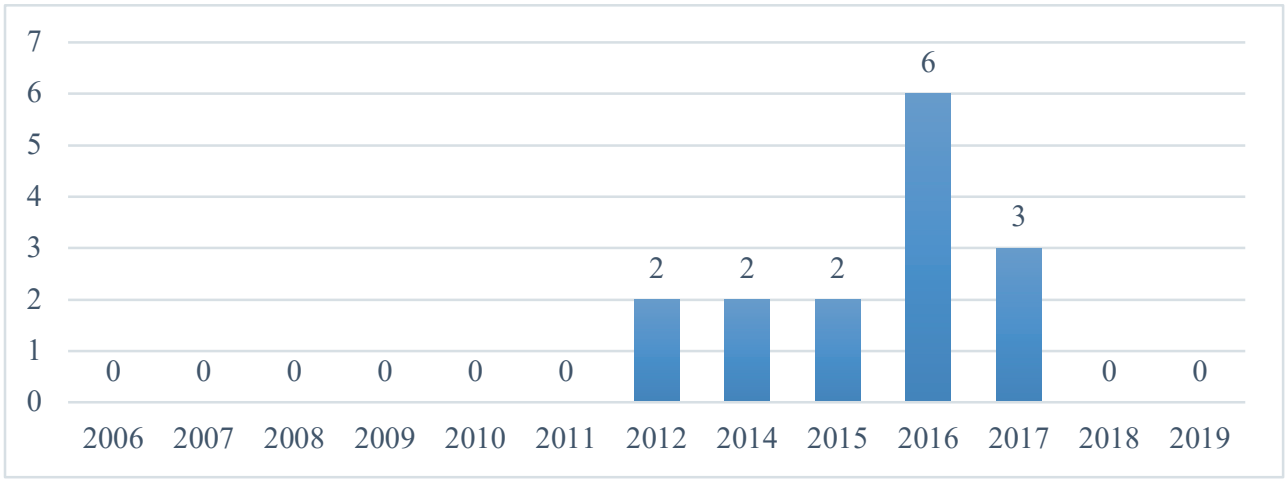

Figure 3. Doctoral theses on TPACK by year of publication according to SLR.

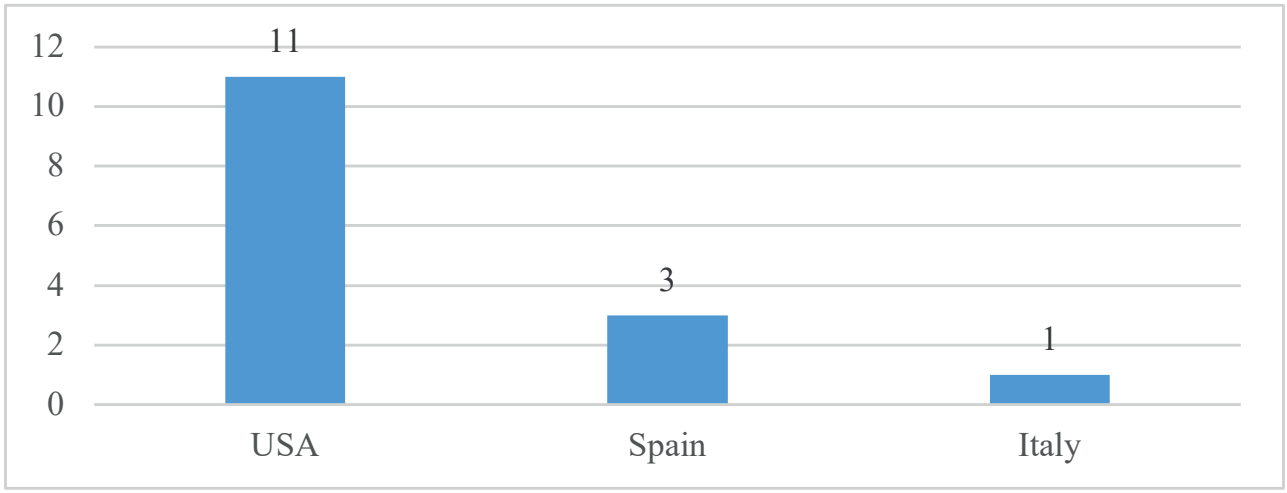

Figure 4. Geographical distribution of selected publications.

In terms of geographical distribution, the largest number of doctoral theses were published in the United States 11 (66.6%), followed at lower rates by Spain 3 (20%) and Italy with 1 (13.3%), as shown in Figure 4.

When referring to the type of research, 7 (46,6%) are mixed studies, 6 (40%) are qualitative and, 2 (13,3%) are quantitative, as shown in Figure 5.

Within the seven (45,1%) case studies, two (13,3%) descriptive investigations were found. Other studies, such as quasi-experimental, phenomenological, and hermeneutic, SEM (structural equation modelling), verbal report, ex post facto, and regression analysis, were observed with one, respectively: 29 instruments were used, including questionnaires (8), interviews (7), field diaries (3), and observations (3). In addition, recordings, discussion groups, reflections, representations, reports, lesson plans, meetings, and focus groups were used, with one each.

In terms of samples, they vary between one and 1.371 cases. The largest samples of Masdeu (2015) with 1.371 experts, Alqallaf (2016) with 562 teachers, and Mañas Pérez (2017) with 255 students stand

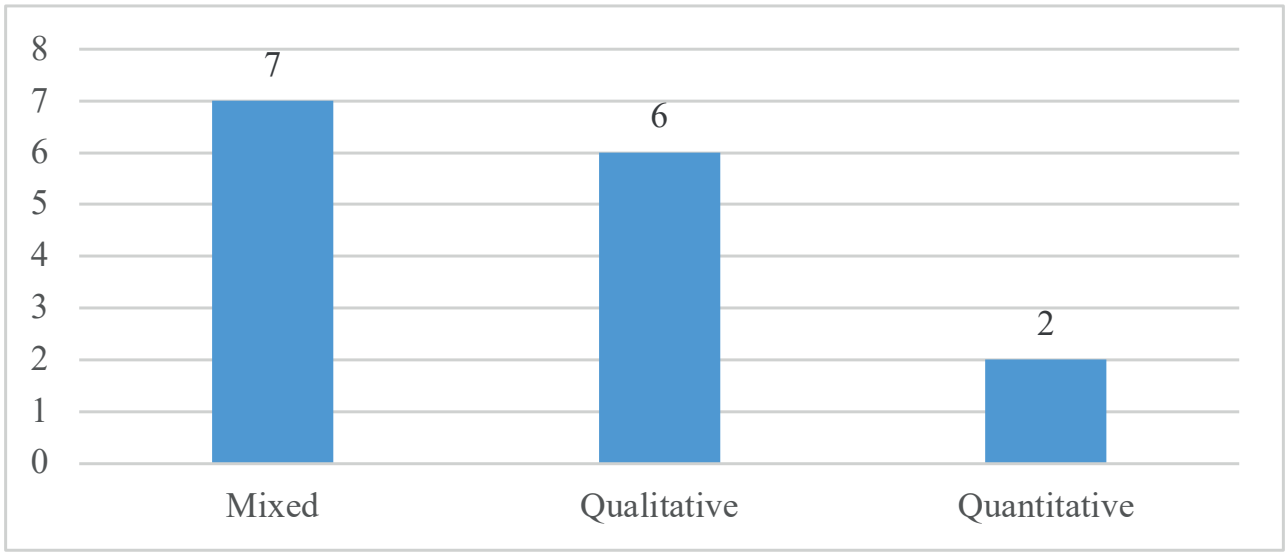

Figure 5. Types of research found in this SLR.

out. In addition, the study by Martínez (2016) considers the participation of 53 students, 16 teachers, and 49 families.

3.2. The TPACK model in primary education by the targets of the studies

The second part of the analysis addresses the research questions 2, 3 and 4 and is organized taking into consideration elements of the study classifications of Paidicán and Arredondo (2022b), Wang and colleagues, (2018), and Willermark (2018), namely according to the focus of the studies (teachers, students, and the community).

3.2.1. Teacher-centred studies of the TPACK model

Among the selected doctoral theses, 8 (53,3%) studies focus on teachers, classified in self-report of knowledge, training, experience, and development of TK and their TPACK relationship, as shown in Table 5.

As far as the methodological approach (RQ2), the studies focusing on teachers were mostly qualitative and mixed. The samples, that are mostly non-probability samples, ranged from one (McCann,

Table 5. Teacher-centred approach to TPACK research.

TPACK perspective	Authors	Quantity/ percentage
Self-reporting of teachers' technological, pedagogical, and content knowledge (TPACK)	Ontiveros-Karr (2017), Alqallaf (2016), Mallernee (2017) Mishne (2012), Fanni (2014)	5 (62,5%)
TPACK teacher training	Jones (2012)	1 (12,5%)
TPACK teaching experiences	Montes (2016)	1 (12,5%)
TK development and its relationship with TPACK	McCann (2015)	1 (12,5%)

2015) to 562 teachers (Alqallaf, 2016). When referring to the research instruments, reflections, task representations, field notes, focus groups, planning, interviews, and questionnaires were used, the latter two being the most frequently used.

In the self-reporting approach, Ontiveros-Karr (2017) conducted a qualitative, phenomenological, and hermeneutic research study, whose aim is to describe the attitudes of teachers in integrating ICT in the framework of TPACK. The results show that teachers with more experience in CK and PK increase their confidence, and this allows them to increase their TK. In addition, teachers report they use ICTs for communication and training over teaching and learning processes.

Alqallaf (2016) conducts a mixed and descriptive study, aiming to examine teachers' feelings on integrating teaching practices in an M-learning environment. The results show confidence in integrating ICTs through YouTube and Instagram. They say that there are difficulties in integrating ICTs if there is no clear model for their integration.

Mallernee (2017) develops a quantitative case study, which aims to explore the effects of teacher professional development on integrating iPads. The results show that 72,6% of teachers have above-average scores on the TPACK. However, there is no correlation between the development of training seminars and teachers' TPACK knowledge.

Mishne (2012) conducts a mixed, ex post facto investigation, the aim of which is to examine whether teacher self-efficacy, knowledge, and experience influence levels of technology integration. The results show that teachers with higher TK also report higher ICT use and higher digital competencies. Moreover, an elevated level of teacher TPACK requires more than just supplying access to ICT tools and resources.

Fanni (2014) develops a mixed case study, which aims to investigate the relationship between teachers' self-efficacy and their use of ICT. About the results, the use of TPACK positively predicts teachers' self-efficacy and ICT use. In addition, experienced teachers report less confidence when using ICTs. Teachers who have taken part in extensive training processes report higher levels of self-efficacy.

About teacher education with TPACK, Jones (2012) carried out a qualitative study. The aim is to understand how teachers in a lesson study professional development (LSPD) with technology change their beliefs and practices. The results show teachers feel confident to use ICTs, however, their use is limited by lack of PK and CK. In addition, the use of technology is affected by the limited availability of technology in the classroom.

Referring to teaching experiences with TPACK, Montes (2016), carried out a qualitative case study, which aims to examine the decisions taken by teachers when planning the integration of portable technology. The results show that effective ICT implementation requires effective planning and that teachers have increased their technological, pedagogical, and content knowledge (TPACK). It is found that the regular use of ICT does not imply that it is planned by teachers.

Regarding the development of TK and its relationship with TPACK, McCann (2015), conducted a qualitative study, which aims to study the support that teacher's TPACK can give in designing and delivering instruction based on the UDL.

As far as RQ3, namely recommendations deriving from studies, self-report research on teachers' knowledge recommends the development of qualitative, mixed, and longitudinal studies (Fanni, 2014; Ontiveros-Karr, 2017; Mishne, 2012). In addition, the use of various data collection tools is recommended, such as interviews, reflective diaries over time, observations, and analysis of curriculum documents, in secondary and adult education contexts and different subjects (Alqallaf, 2016; Ontiveros-Karr, 2017). It is also recommended to investigate aspects related to curriculum-ICT alignment and

contextual factors affecting ICT use (Alqallaf, 2016; Mallernee, 2017). Finally, it is recommended feelings, motivations, and influence of teaching behaviors when using ICT need to be explored and understood (Fanni, 2014; Mishne, 2012).

Jones' study (2012) related to teacher training recommends understanding the motivations behind teachers' resistance to the use of ICTs, exploring the role of parents and guardians and the support of the educational community.

Likewise, research led by Montes (2016), which was focused on teachers' experiences, recommends exploring and understanding TPACK levels and teachers' beliefs during planning in different contexts, to understand the strengths and weaknesses when integrating ICT.

McCann's (2015) research, based on the development of TK and its relationship with TPACK, recommends that, in consideration of increasing numbers of students with special educational needs, TPACK development should be complemented with UDL in order to collaborate transdisciplinary.

3.2.2. Student-centred approaches to the TPACK model

Regarding the methodology adopted in the studies, of the two studies (13,3%) focusing on students retrieved, one uses mixed methods while the other is qualitative. The samples range from 28 to 255 cases, with the participation of students from fourth to the sixth grade being the most representative sample (Mañas Pérez, 2017). Both studies were conducted about music. The data collection instruments were questionnaires, interviews, participant observation through a field diary, individual recordings, and discussion group, and the study by Ufartes (2016), which used various instruments, stands out.

Mañas Pérez (2017) conducts mixed research through the observation method. Its aim is to improve the quality of music education with the creation of an interactive musicogram. The results show that teachers and pupils have a positive view of the incorporation of interactive activities in music education.

Ufartes (2016), develops qualitative and interpretative research, its aim is to analyze the implications that the adoption of mobile devices in music education has on the didactic process. The results show teachers require training and the exchange of experiences related to mobile devices. In addition, the didactic proposal has shown the change of roles between teachers and students, with the latter being the true protagonist of the teaching and learning process.

As far as RQ3, the research focused on students recommend the development of mixed studies, which would lead to the deepening of the theoretical framework of TPACK, including the exploration of international experiences (Mañas Pérez, 2017; Ufartes, 2016). Furthermore, it is recommended the use of research as a feedback tool (Mañas, 2017).

3.2.3. Approaches to the TPACK model with a focus on the school community

There are five studies (33,3%) focused on the school community, including the participation of teachers, students, school principals, families, educational administrators, schools, and external experts, see table seven.

The research on the school community was mixed, quantitative, qualitative, and quasi-experimental. All the samples are non-experimental, the sample being representative (Masdeu, 2015). The research work is carried out in the subjects of the Spanish language, English, technology, and music. Different instruments were used for data collection, with the questionnaire being the most used.

Table 6. School community participation in TPACK studies.

Authors	STU	TEA	DE	FA	EA	SC	EE
Martínez (2016)	53	16		49			
Monroe-Ossi (2016)		75	42				
Woodward (2016)	58	3					
Perry (2018)		49			N/D (*)		
Masdeu (2015)						1.371	16

Note: STU (students), TEA (teachers), DE (educational directors), FA (family), EA (educational administrators), SC (schools) EE (external experts). (*) There is participation of education administrators, but no specification of the number of education administrators.

Martínez (2016), develops a mixed and quasi-experimental study, whose aim is to incorporate enriched e-books in an integrated model of education to improve the understanding of information and the development of a critical attitude. The results allowed Martínez to state that incorporating TPACK as a complement to the e-book increases linguistic communication by 82%.

Monroe-Ossi (2016) carried out a quantitative, which aims to examine in-service teachers' beliefs about how they use ICT in the classroom. The results suggest positive predictive relationships between technological leadership support and the development of technological skills. Thus, a technology leader has the opportunity and responsibility to communicate a positive view of ICT.

Woodward (2016) conducted qualitative research and verbal report, the aim of which is to examine the processes used by teachers when planning the integration of ICT. The results show that teachers' incorporation of ICT strengthens certain instructions, despite the lack of clarity of purpose. Teachers do not need to be experts to use certain ICT tools.

Perry (2018) conducts mixed research with regression analysis, which aims to Measure the factors that influence ICT integration. The results show that the complementation of SMART and TPACK confirms that teachers effectively implement ICT. Sometimes, teachers obtain results that are on the upper scale of SMART. In addition, science teachers show a higher frequency of ICT use.

About the development of TK and its relationship with TPACK, Masdeu (2015), develops mixed, descriptive research with the interpretative paradigm, to study the digitization of music classrooms in public schools in Catalonia. The results show that teachers need to consciously incorporate ICT and understand that technologies support digital literacy, and in no case are they a replacement for traditional teaching practices.

Research, based on the school community, recommends the development of comparative, mixed, longitudinal, and case studies, to collect more information on ICT-mediated learning environments (Masdeu, 2015; Monroe-Ossi, 2016). Besides, studies focusing on professional development and sustainability over time are recommended (Perry, 2018) as well as studies examining teachers' beliefs when integrating ICT and the decision-making process when planning instruction (Monroe-Ossi, 2016; Woodward, 2016). Finally, Martínez (2016) recommend the creation of a bank of free ICT tools to adapt to the student needs.

Finally, in relation to the results obtained in the present SLR and its complement with the previous study by Paidicán and Arredondo (2022b) (RQ4), it can be affirmed that both SLRs present a greater scientific production between 2015 and 2017. In relation to geographical distribution, the United States and Spain have the highest scientific production, in both SLR. It should be noted that this result

depends largely on the databases selected for SLR, as some of them deal only with national research. With regards to the type of research, there is agreement on the existence of mixed, quantitative and qualitative studies in both SLR. Moreover, mixed studies are the majority in this SLR and allow access to a broad and complementary view of the TPACK model. About research instruments, there is a noticeable trend in the use of questionnaires and interviews. In this regard, it can be noticed that the use of the TPACK questionnaire by Schmidt et al. (2009) is widely observed in both the SLR, for its application in the original form but also for the adaptation and creation of new questionnaires.

In terms of samples, both SLR retrieved studies involving mainly teachers; the largest studies include 881 and 662 teachers, respectively (Alqallaf, 2016; Magen-Nagar & Peled, 2013). On the other hand, the studies involving students present similar sample sizes; the largest include 255 and 259, respectively (Mañas Pérez, 2017; Wong, Chai, Zhang, & King, 2014).

About subjects of the studies, there is a greater development of research focused on teachers, with values between 68.14% and 53.3%. At the same time, the majority are self-report studies of TPACK with the former SLR (Paidicán & Arredondo, 2022b) presenting 35.29% and the present one reaching over 60%. In the case of the studies focused on students, both SLR consider participation from first to sixth grade, being higher in fourth-grade students (Angeli, et al., 2016; Lye, Wee, Kwek, Abas, & Tay, 2014; Mañas Pérez, 2017; Sáez & Cózar (2017); Ufartes, 2016; Wong et al., 2014). In addition, the studies include different subjects, including music education, computer science, social sciences, and the Chinese language. Considering studies based on educational communities, the present SLR has greater teacher, student, and family participation. Besides, this SLR is complemented by the inclusion of studies involving school principals and external experts. Likewise, there is a coincidence in the subjects addressed in the research, among them: Spanish language, English, music education, and technology education.

4. Discussion

The scientific production about the TPACK model has advanced in recent years. However, in primary education does not present the same development (Paidicán & Arredondo, 2022b; Rodríguez et al., 2019; Yeh et al., 2021). For Margerum-Leys and Marx (2002) the cause lies in the focus of studies on secondary and university levels of education over primary education.

Previous SLR on the TPACK model in primary schools address specific topics such as the vision of the TPACK model in education, the effects of teacher participation in the design and development of training programs and learning by design (Rodríguez et al., 2019; Yeh et al., 2021). Although Paidicán and Arredondo (2022b) address TPACK in primary school in general, the selection only considers a few databases, making it impossible to obtain a broad view of TPACK at this educational level.

This SLR shows that most teacher-centred research on TPACK uses self-report to measure teachers' knowledge of ICTs use, as argued by Bingimlas (2018), Chen and Jang (2013), Kazu and Erten (2014), Magen-Nagar and Peled (2013), Paidicán and Arredondo (2019; 2022a; 2022c). Furthermore, the preferred instrument is the five-level Likert-type questionnaire, the construction of which considers Schmidt et al. (2009) as well as Cabero Almenara, Roig-Villa, and Mengual-Andrés (2017) and Roig-Vila, Mengual-Andrès and Quinto-Medrano (2015), as main references.

As for studies on students, both have been conducted in the field of music education. It should be noted that the importance of developing student-centred teaching processes lies in the fact that they promote the achievement of greater learning by students, as stated by Harris and Hofer (2011), Koehler and Mishra (2005; 2009), Hughes (2005), Niess (2005) and Yeh et al. (2021).

Concerning the studies involving the school community, they include the participation of various educational agents such as students, teachers, principals, family, educational administrators, and external experts. Furthermore, the research is developed considering different subjects such as Spanish language, English, technology, and music, which is in line with previous studies by Angeli et al. (2016), Chen and Jang (2013), Hansen, Mavrikis, and Geraniou (2016), Liu (2013), Lye et al. (2014), Maboe, Smith, Banoobhai and Makgatho (2018), Paneru (2018) and Tai (2015).

When referring to the recommendations, there is agreement in studies on the need for comparative, mixed, and longitudinal research, to deepen theoretical and methodological aspects, incorporating various instruments that facilitate the triangulation of data.

About teachers, it is recommended investigating feelings, motivations, and contextual factors presented by teachers when using ICT. In addition, curricular, contextual, and planning aspects of ICT-mediated instruction should be addressed. Concerning students, it is recommended using research as a feedback tool within schools. Likewise, the educational community needs a bank of free ICT resources.

Considering the contribution of the TPACK model in the integration of technologies, the research focused on the educational community suggests the development of studies to explore the beliefs of the school community about the integration of technology, investigate teachers' planning decisions and their impact on student learning, and develop models of lifelong learning to determine the long-term benefits.

5. Conclusions

On the basis of the results obtained, it can be concluded that the scientific production about the TPACK model in primary education is lower than at other educational levels, such as university education. The present SLR only obtains 15 doctoral theses analysed, out of a total of 230, representing 6,52%, none of which are carried out in Latin America. Moreover, the doctoral theses are published for a limited period between 2012 and 2017. Regarding the geographical distribution, almost two-thirds were published in the United States.

In addition, the existence of different research approaches related to the TPACK model is confirmed, highlighting aspects related to students and the school community, in mostly mixed and qualitative studies.

The use of the TPACK framework to analyse ICTs integration in different pedagogical contexts as Montessori, the substitution augmentation modification redefinition (SAMR) model, and Universal Design for Learning (UDL) stand out. About Montessori, Jones' research (2012) concludes that the use of ICT under this method is limited by teachers' levels of knowledge of PK and CK and not by their levels of confidence in ICT.

On the other hand, Perry's research (2018) through SAMR and TPACK allows us to affirm that their use together facilitates the implementation of ICT, where teachers reach levels of redefinition, the highest of SAMR. McCann's (2015) study related to UDL reveals the complexity of ICT integration through TPACK in inclusive contexts; however, the author concludes that teachers with high levels of TPACK have access to technologies and strategies to serve students from diverse backgrounds.

In addition, the use of TPACK is presented in seven different subjects with a prevalence of music and technology. TPACK has proven to be a useful framework for integrating new technologies as a complement to traditional classes. There is a clear need to incorporate TPACK studies related to school management teams and to address issues of educational management.

The present SLR has added value, reflected in the incorporation of samples with students between first and sixth grade, new studies focused on the school community, including the participation of school principals and external experts, and a greater variety of topics such as music education and technology education.

The literature review provides a different view of TPACK research, although there are limitations that should be considered. For example, other types of analysis, focused on the characteristics of the research instruments, the subjects considered, and the student characteristics, among others, could be considered for future reviews. Finally, searching new databases such as DIALNET, SCIELO, REDALYC, Yök National Thesis Center and CNKI (China National Knowledge Infrastructure) among others could provide insight into how TPACK is being studied in different contexts.

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Italian Journal of Educational Technology, 31(1): 77-88, 2023
ISSN 2532-4632 (print) – ISSN 2532-7720 (online)
DOI: 10.17471/2499-4324/1291
https://ijet.itd.cnr.it

Italian Journal of Educational Technology

itd ISTITUTO TECNOLOGIE DIDATTICHE

STEM teaching and learning with innovative technologies in the upper secondary school: A scoping review

Didattica delle STEM e tecnologie digitali innovative nella scuola secondaria di II grado: una revisione della letteratura

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HOW TO CITE Roffi, A., & Cuomo, S. (2022). STEM teaching and learning with innovative technologies in the upper secondary school: A scoping review. *Italian Journal of Educational Technology,* 31(1): 77-88. doi: 10.17471/2499-4324/1291

Received: March 6, 2022; *Accepted:* June 8, 2022; *First Published:* July 8, 2022

ABSTRACT The integration of digital technologies in the school context has now become a necessary and fundamental process in daily teaching practices. In particular, innovative technologies such as the so-called X-Reality seems effective to promote student learning, to encourage the acquisition of skills and interest in scientific disciplines, although their potential and possible drawbacks are still under inquiry. Based on these premises, the purpose of this literature review is to outline the state of the art of the use of X-Reality in STEM education in the context of upper secondary school, without limitations regarding the country, to understand the benefits, the critical aspects and the challenges faced by researchers in this field. To answer these Research Questions, a scoping review was conducted based on the Scopus and ERIC databases. The results highlight how the use of X-Reality in STEM teaching offers many opportunities for learning concepts and acquiring scientific skills. At the same time, however, an accurate balance of these positive effects with the related risks is also required, in order to allow a critical and conscious use of these innovative technologies.

KEYWORDS STEM Teaching and Learning; X-Reality; Digital Technologies; Secondary School.

SOMMARIO L'integrazione delle tecnologie digitali nel contesto scolastico è diventato ormai un processo necessario e fondamentale nelle pratiche didattiche quotidiane. In particolare, le tecnologie innovative come le cosiddette X-Reality sembrano particolarmente efficaci per promuovere l'apprendimento degli studenti, per favorire l'acquisizione di competenze e promuovere l'interesse per le discipline scientifiche, anche se il loro potenziale e le criticità del settore sono ancora oggetto di studio. Sulla base di queste premesse, lo scopo di questa rassegna della letteratura è quello di delineare lo stato dell'arte dell'utilizzo delle X-Reality nell'educazione STEM nel contesto della scuola secondaria di secondo grado, senza limitazioni geografiche, per comprendere i benefici, gli aspetti critici e le sfide da affrontare in questo campo. Per rispondere a queste domande di ricerca, è stata condotta una revisione della letteratura sui database Scopus ed ERIC. I risultati di questo lavoro mettono quindi in evidenza come l'utilizzo delle X-Reality nella didattica delle STEM offra molte opportunità per l'apprendimento dei concetti e l'acquisizione delle competenze scientifiche. Al tempo stesso però è richiesto anche un accurato bilanciamento di questi effetti positivi con i rischi correlati, per poter arrivare ad un utilizzo critico e consapevole di queste tecnologie innovative.

PAROLE CHIAVE Didattica STEM; X-Reality; Tecnologie Digitali; Scuola Secondaria.

1. The use of innovative digital technologies in the school context

The integration of digital technologies in the school curricula has now become a necessary and fundamental process in the daily teaching practices. In particular, innovative technologies such as the so-called X-Reality, i.e. Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR) or 360° video, used both in the traditional 2D and immersive 3D modality, are particularly effective to promote student learning, to encourage the acquisition of skills and to foster the interest in scientific disciplines (Roffi, Cuomo, & Ranieri, 2021; Ranieri, Bruni, & Luzzi, 2020; Shu & Huang, 2021; Chavez & Bayona, 2018; Ibáñez & Delgado-Kloos, 2018).

In fact, one of the added values of these technologies is the possibility to take advantage of the visual component for teaching scientific concepts or phenomena not easily explored in class, resulting in improved effectiveness than the traditional methods (Arici, Yildirim, Caliklar, & Yilmaz, 2019).

The positive results related to the use of these technologies, in particular in the teaching of STEM (Science, Technology, Engineering and Mathematics disciplines), have been reported both in primary and secondary schools, in terms of improving learning outcomes, attitude and motivation (Roffi, Cuomo, & Ranieri, 2021), although their potential and possible drawbacks are still under inquiry. Besides these positive effects, Fidan and Tuncel (2019) described how X-Reality is able to promote the retention of knowledge up to 3 weeks after the educational intervention. Moreover, these technologies are also able to increase the scientific aspiration in particular of female students, thus favouring the reduction of gender differences in learning STEM subjects (Makransky, Petersen, & Klingenberg, 2020).

However, despite this positive evidence, there are still many questions that require further investigation, for example whether X-Reality could be appropriate for each teaching context and for all students. In this regard, a recent review of the literature (Pellas, Kazanidis, & Palaigeorgiou, 2020) highlighted that in secondary education the use of MR learning environments leads to benefits in terms of student learning outcomes, but in the context of primary school this improvement is limited to student participation and involvement.

Moving to teaching strategies, Inquiry Based Learning (IBL) was found to be the most used for STEM teaching also in virtual contexts (Pedaste et al., 2015; Ibáñez & Delgado-Kloos, 2018; Arici et al., 2019). IBL is an educational strategy that promotes the discovery of knowledge through the formulation of hypotheses and subsequent verification through experiments or observations (Pedaste et al., 2015). Students are involved in reproducing methods and practices similar to those of the scientific method, focusing on the characteristics of scientific thinking, and drawing inspiration from the principles of Situated Cognition (Brown, Collins, & Duguid, 1989) and experiential learning (Kolb, 1984). However, this teaching strategy presents some challenges for students and teachers, especially in the design phase (e.g. in relation to dependent and independent variables; Arnold, Kremer, & Mayer, 2014). Digital technologies could therefore provide support to overcome the above mentioned difficulties (Kyza, Constantinou, & Spanoudis, 2011). In particular, X-Reality can support situated and experiential learning, simulating the real context where knowledge is applied and integrating authentic activities even when access to real situations is not possible. Coiro, Castek and Quinn (2016) have developed a framework that integrates the IBL strategies with the use of digital technologies, called Personal Digital Inquire (PDI), providing suggestions for teachers on how to structure educational interventions that involve the use of PDI to meet the student's needs (Ranieri, 2022).

Another aspect that requires careful consideration is the digital well-being of students and teachers (Luzzi, Cuomo, Roffi, & Ranieri, 2022; Melo et al., 2020). In fact, the use of these environments

requires an appropriate balance between opportunities and risks (Melo et al., 2020) and must be addressed from a multidisciplinary point of view. Following the model proposed by Cuomo and collaborators (2022) related to the educational context, digital well-being in immersive environments can be declined according to 4 perspectives: the cognitive perspective, considering the implications deriving from isolation during the immersive experience, the physiological perspective, considering the physical implications (nausea, headache) deriving from the use of wearable devices, the social perspective, considering the relational dimension especially in teaching activities in groups, and the educational perspective, which considers the learning opportunities that these innovative technologies offer.

Therefore, it is not only necessary to promote the use of new digital technologies in STEM education, but it is equally important to take into account the dimensions of digital well-being, allowing critical use of these tools. Furthermore, from a technical point of view, usability and the possible cognitive overload are the main challenges for the correct design and implementation of X-Reality in education (Altmeyer et al., 2020).

Finally, it is also necessary to consider aspects related to the digital skills of teachers and students, which can constitute a barrier to the integration of these technologies in the classroom. The pandemic has certainly brought to light the difficulties of teachers in terms of these skills, underlining the lack of training regarding the adoption of digital technologies in the daily teaching practices (Carretero Gomez et al., 2021). In fact, the recent literature relating to the didactic changes introduced in the pandemic period highlights how the main difficulties encountered by teachers during online teaching can be related with the lack of competence needed to re-design teaching with the use of digital technologies (Carretero Gomez et al., 2021).

Based on these premises, the purpose of this literature review is to outline the state of the art of the use of X-Reality in STEM education in the context of upper secondary schools, to understand the benefits, the critical aspects and the challenges to be faced in this field.

In particular, the following Research Questions (RQs) have been formulated:

- RQ1: What are the characteristics of the published studies in the field of STEM teaching with technologies using X-Reality in the upper secondary schools?
- RQ2: What are the disciplines involved, the teaching strategies and the innovative digital technologies used for STEM learning in the upper secondary schools?
- RQ3: What are the benefits, critical aspects and challenges for teachers and students in using these technologies for STEM learning?

2. Methodology

To answer the RQs, a scoping review (Grant & Booth, 2009) has been conducted in accordance with the PRISMA guidelines (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009), except for those items that are specific of meta-analyses. In fact, although it is not a systematic review, the scoping review shares the characteristics of transparency, reproducibility and systematicity (Grant & Booth, 2009).

The review has been conducted on the Scopus and ERIC (Education Resources Information Center) databases with the following search string: (stem OR steam OR science OR technolog* OR engineering OR mathematics) AND (education OR learning OR teaching) AND ("digital technolog*" OR "mixed realit*" OR "virtual reality" OR "augmented reality") AND ("secondary education" OR "secondary school"). The papers published in the last 5 years have been considered due to the rapidly changing technological scenarios.

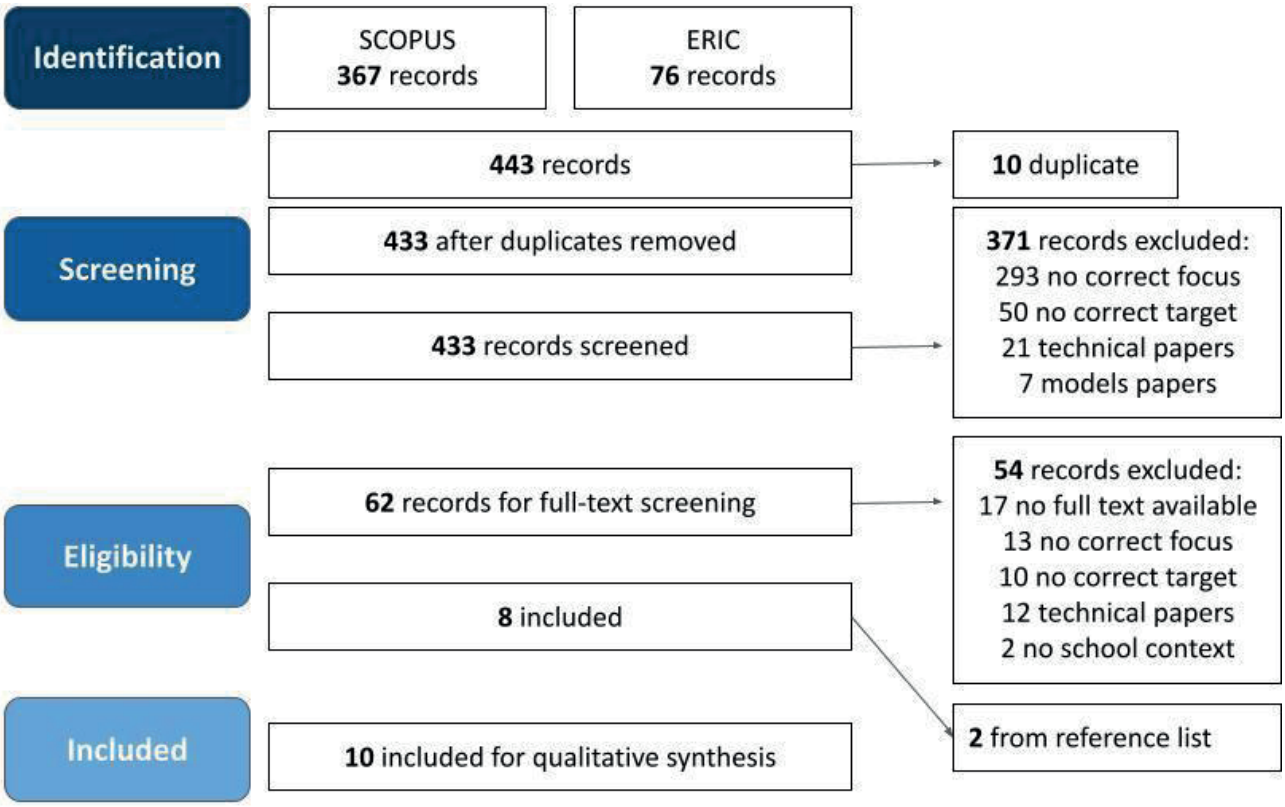

Figure 1. Workflow for papers selection according to PRISMA.

A summary of the inclusion and exclusion criteria is shown in Table 1. After the selection of papers by title and abstracts screening, the complete available full text has been analyzed and the useful information was extracted. Reference lists of selected papers were also searched for further relevant articles. Initially, 443 papers were found, of which only 10 were included, due to the strict criteria of inclusion and exclusion and aimed at selecting papers specifically focus on STEM teaching in upper secondary school. As we can see in the Figure 1, about 300 have been excluded because although the STEM and digital technologies were mentioned in the title and in the abstract the focus of the paper was out of the scope of this literature review. For the analysis of the papers, a coding table has been designed in order to identify the categories for the study description. According to the research questions, 4 categories have been identified with the relative sub-categories, as shown in Table 2.

3. Results

3.1. RQ1: What are the characteristics of the published studies in the field of STEM teaching with technologies using X-Reality in the upper secondary schools?

As for the year of publication, most of the papers were published in 2021 (7/10), the rest in 2020 (2/10) and in 2019 (1/10).

The selected papers presented researches conducted in different geographical areas: 3 in China, 1 in Greece, 1 in Taiwan, 1 in Cyprus, 1 in Bulgaria, 1 in Finland, 1 in Spain and 1 in Indonesia.

Table 1. Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
Papers on STEM teaching with digital technologies	Technical papers (i.e. describing software or app development without application phase in the classroom)
Peer-reviewed journals	Papers not dealing with the school context
Papers in English	Papers with an exclusive focus on the usability of digital technology
Books, book chapters, conference proceedings, empirical papers	Papers with an exclusive focus on didactic models
Upper secondary school	Other targets (teachers, primary and lower secondary students, universities)

Table 2. Coding table for papers description.

Categories	Subcategories
Characteristics of publications	Authors
	Year
	Title
	Journal
	Geographical Area
Technical information	Technology type
	Technology equipment
Research Design	Study Design
	Teaching Strategy
	Duration of educational intervention
	Subject
	Training before experience
Results	Learning outcomes
	Learners' reactions
	Benefits and drawbacks

Regarding the type of X-Reality technology used in STEM teaching, 7/10 articles describe the use of AR and 3/10 of VR. No articles describing experiences with MR or 360 video for STEM education. For this reason, in the current analysis we will explicitly refer to the technology used (AR or VR) instead of using the general term X-Reality.

Even if the papers analyzed refer to different school systems, the target of each article is the upper secondary school, in accordance with the criteria for inclusion of the research, with different ages ranging from 14 to 19 years old. Moving to the types of experimental designs, 3/10 articles have a quasi-experimental design, 3/10 experimental, 3/10 a pre-experimental design, and 1/10 a case study. A synthesis of these data has been reported in Table 2.

Table 3. Characteristics of the studies.

Authors	Year	Technology used	Experimental design
Cai, Liu, Wang, Liu, & Liang	2021	AR	Experimental
Del Cerro Velázquez & Morales Méndez	2021	AR	Quasi-experimental
Georgiou, Tsivitanidou & Ioannou	2021	VR	Pre-experimental
Liu, Yu, Chen, Wang & Xu	2021	AR	Experimental
Ling, Zhu & Yu	2021	AR	Quasi-experimental
Niittymaki, Christopoulos & Laakso	2021	VR	Case study
Shu & Huang	2021	VR	Experimental
Petrov & Atanasova	2020	AR	Pre-experimental
Weng, Otanga,Christianto & Chu	2020	AR	Quasi-experimental
Tomara & Gouscos	2019	AR	Pre-experimental

3.2. RQ2: What are the disciplines involved, the teaching strategies and the innovative digital technologies used for STEM learning in the upper secondary schools?

As for the disciplines involved in the educational experience with AR/VR, Physics is the most represented (4/10), followed by Biology (3/10), Chemistry (1/10), Information and Communication Technologies (1/10), and Mathematics (1/10), as shown in Figure 2.

The teaching strategies used are various, 3/10 describe the use of collaborative educational strategies, 2/10 report the experience with AR to guide learning processes by discovery, in groups or individually, and 1/10 uses a directive strategy.

Another aspect to be analyzed is related to the duration of the educational interventions, which represents a variable parameter in the analyzed papers: in 4 studies the experimental design foresees only one lesson lasting about one hour, while in 5 studies they refer to sequence of lessons over a time lapse of a few weeks or even months.

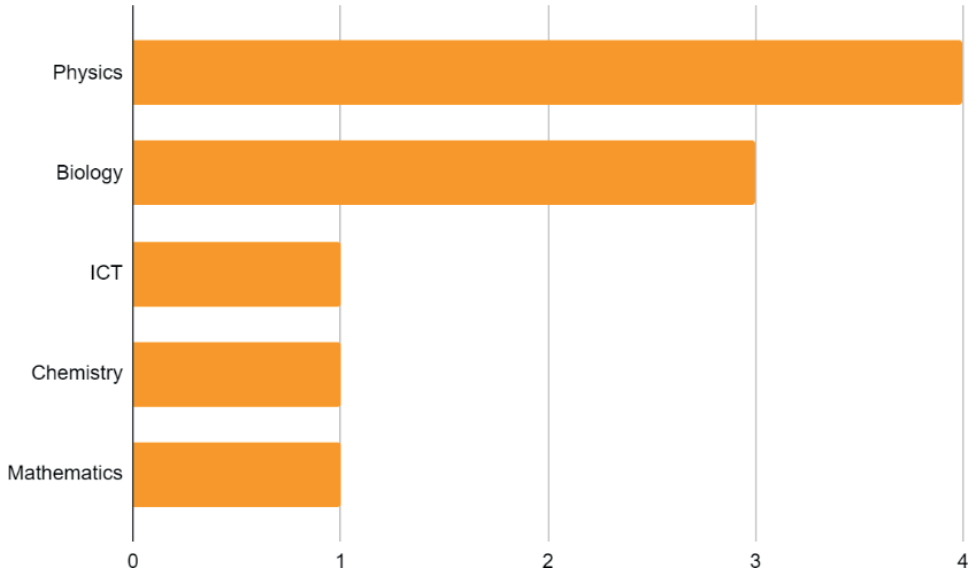

Figure 2. Frequency of STEM disciplines in the papers analysed.

The use of digital technologies, especially the immersive ones, which require the use of a special headset that alienates the user from the surrounding world, can lead to the novelty effect on students, in particular for those who do not regularly use these technologies (Liu et al., 2021). This bias could prevent the effectiveness of the educational intervention supported by innovative technologies and therefore it is an aspect that needs to be considered. Only two articles deal with this aspect: one by devoting some training time before the actual learning intervention, to allow students to improve their confidence with the technology used, the other by choosing a target of students already confident with X-Reality.

3.3. RQ3: What are the benefits, critical aspects and challenges for teachers and students in using these technologies for STEM learning?

The effects of using the technologies identified for this literature review (AR and VR) in teaching practice are reported below, highlighting benefits, critical aspects, and future challenges.

3.3.1. Attitude, motivation and interest

As concerns the use of AR in teaching practice, one of the positive effects is related to the improvement of attitude towards STEM disciplines, as demonstrated by Weng and collaborators (Weng et al., 2020). The results achieved by the research team demonstrate how this innovative technology can make biology's learning interesting and fun. Similarly, Petrov and Atanasova (2020) describe the use of AR in a biology lesson, making the learning process simple and at the same time interesting and motivating. Always within the sphere of interest and motivation, VR is also able to promote them. In particular, the research by Niittymäki, Christopoulos and Laakso (2021) has shown that VR positively impacts on interest, motivation and attention to details in biology teaching. However, it is important to pay attention to the level of difficulty of the proposed topics when planning educational interventions, as well as the number of activities to be completed. This is needed to avoid negative impact on motivation and interest which could in turn hinder performance (Niittymäki, Christopoulos, & Laakso, 2021).

3.3.2. Learning and knowledge retention

AR and VR also offer benefits in terms of knowledge retention and improving the learning of STEM disciplines. Liu and collaborators (2021) described significant improvements in students learning in the field of physics: these have been larger with the use of AR compared to 3D animations and traditional study materials (such as real magnets and other objects to explore magnetism) with long-lasting learning outcomes (Ling, Zhu, & Yu, 2021) and better visuo-spatial skills (del Cerro Velázquez & Morales Méndez, 2021). On the other hand, it has also been shown that these positive learning outcomes seem to be limited to the analytical dimension, thus not involving the memory and understanding dimensions (Weng, Otanga, Christianto, & Chu, 2020). Finally, not all students can benefit from the use of AR technologies for learning, as reported by Ling and collaborators (2021): their research highlights that "high foundation of learning"[1] and excellent visual-spatial skills are characteristics that would allow students to use AR effectively, reaching long-lasting learning outcomes. On the contrary,

[1] The author defines this term as an important representation of previous content knowledge.

students with poor pre-existing competence and visual-spatial skills, the use of AR for learning is not effective, even if there is a good attitude towards this technology.

Similarly, VR used in the teaching of physics has proven effective in achieving significant learning outcomes. Furthermore, the students underlined how the realism of the immersive experience combined with the process of knowledge construction have increased their involvement in learning (Georgiou, Tsivitanidou, & Ioannou, 2021).

3.3.3. Cognitive load

Liu et al. (2021) described a lower mental load in learning physics with the use of AR, also accompanied by a lower mental effort that makes students able to better process the complexity of experimental activities.

3.3.4. Improvement of understanding

Still in the field of physics, it has been documented (Cai et al., 2021) that the use of AR promotes an improvement in self-efficacy in students, makes them better able to reach high levels of understanding of complex concepts and thus stimulates their motivation for deeper learning.

Improving understanding of study material is another positive aspect of using AR: Petrov and Atanasova (2020) reveal that AR use improves students' understanding of study material compared to traditional materials based on texts and graphics.

3.3.5. Technological aspects

The novelty of X-Reality applications implies a relative technological immaturity that may cause critical aspects and barriers to their adoption. Cai and colleagues (2021) underlined some drawbacks related to the software prototypical status and in particular to an exceedingly slow response of the applications. In the case of VR, the main aspect that requires further reflection concerns the poor quality of the experience that caused a decrease in enthusiasm, as mentioned by Niittymaki and collaborators (2021). According to the authors, these critical aspects are attributable to the use of low-cost equipment. In addition, in this research, two students were not included in the experiment due to the incompatibility of the VR software with the operating system of their mobile phones. Finally, a further drawback underlined (even if not directly linked to the technology itself) is the language barrier due to a software interface in English, which is considered difficult by many non-native English students.

4. Discussion

This scoping review has analyzed the use of so-called X-Reality (AR, VR, MR and 360° Video) in STEM teaching in the context of upper secondary schools, identifying 10 relevant papers that focus on the use of AR and VR technologies. It should be noted that the lack of papers on MR and 360° Video is probably due to the relative novelty of these technologies; in particular with regard to 360° Videos, even if their use in educational practice is increasing, especially in higher education (Ranieri, Luzzi, Cuomo, & Bruni, 2022).

The studies published in the field (RQ1) describe experiences in different geographical areas, with China most represented. Seven articles (7/10) focus on research on the use of AR in the teaching of

scientific disciplines and 3/10 on VR. As for the research designs, more than 50% of the articles have an experimental (3/10) or quasi-experimental (3/10) design, underlining the research effort aimed at understanding the benefits and critical aspects of these innovative technologies in comparison with long-established educational strategies with traditional school materials.

Only 6 out of 10 articles specifically indicate the educational strategy used in interventions supported by AR or VR and, among these, the collaborative strategies and IBL are the most represented. Physics and Biology are the disciplines most frequently dealt with in the papers. In this regard, in fact, Cai and colleagues (2021) underlined how physics education is going through a period of change towards a more active dimension of students involvement in the scientific investigation process and in the acquisition of knowledge through self-directed processes, and at the same time how some topics (for example optics, electrical forces - Tomara & Gouscos, 2019 or magnetism - Liu et al., 2021) require complex equipment for demonstrations that would be difficult to use in the classroom or laboratory. In this context, X-Reality provides a valid support to the IBL process, making abstract concepts visible and interactive (Cai et al., 2021). Similarly, the use of these technologies can also offer benefits in the context of biology learning, a discipline more effectively taught with technologies due to the need to visualize invisible aspects (Weng et al., 2020).

The dimension of time is another important point to be considered: this literature review showed experiences involving individual lessons or several ones over some weeks, depending on the type of discipline and the teaching strategy used. In particular, it is necessary to pay attention to the duration of the experience with X-Reality in terms of digital well-being, according to the 4 perspectives identified by the model of Cuomo et al. (2022) previously described. In this perspective, the distracting effect of X-Reality on students, which occurs by introducing immersive technologies not frequently used in daily teaching practices (novelty effect) (Liu et al., 2021) should be countered since it hinders the effectiveness of the educational intervention itself. Few articles (2/10) have taken this aspect into consideration, implementing strategies to mitigate this effect (a short training phase before the teaching experience) or selecting a target with a good degree of confidence with this type of technology.

As for the learning outcomes derived from the use of X-Reality in STEM teaching (QR3), it can be said that the benefits are multiple and linked to different aspects. First, positive effects have been reported on attitude towards discipline, interest, and motivation, as well as on learning and knowledge retention, although further research is needed in order to prove the long-term effect.

Secondly, a further benefit is related to the impact on cognitive load, in particular for AR. It has been reported that the use of X-Reality has led to a decrease in mental load, promoting in turn a better processing of the complexity of the experimental activities. Moving to the reactions of the students, in general the use of X-Reality in STEM teaching has been appreciated, with a request to extend its use in other scientific subjects. However, it should also be considered that the positive effects of X-Reality are not simply generalizable and could be influenced by the characteristics of students. Indeed, Ling and collaborators (2021) investigated the relationship between levels of foundation of learning and visual-spatial skills, and the use of AR and its effect on learning, identifying that a solid competence base and excellent visual-spatial skills are characteristics that would make possible to use AR effectively, reaching long-lasting learning outcomes. Also in this case, further research is needed to deepen the issue of when using X-Reality in STEM teaching is appropriate and when it is not, by striking a balance between, on one hand, the characteristics of the students, and on the other, their training needs.

Finally, two reflections arise on the technical dimension, concerning the limitations that can affect the effectiveness of these technologies in the educational context (the proper operation of devices and

applications) and the need to make sure students have the necessary equipment to conduct learning activities with these innovative technologies. The former has to do with difficulties regarding interactivity due to the typical slow response time of the software, which had a negative impact on the learning outcomes. It is therefore necessary to take into account this aspect in the design phase of STEM learning by including, for example, a test-phase before their use.

The latter concerns the equipment needed for conducting educational interventions with this type of innovative technologies. In the articles considered, tablets, PCs or smartphones and, in some cases, wearable devices (head-mounted displays) were used for a complete immersive experience, showing that these innovative technologies do not always require technologically sophisticated equipment. Nonetheless for a wider adoption of X-reality in school curricula, and particularly for the immersive technologies, careful consideration must be given to the strong dependence from technological devices and their fast obsolescence, as well as the difficulties that some students, especially those with some impairments, may have in using these devices, thus limiting the full exploitation of the potential of the technology.

5. Conclusions

The results of this literature review highlight how the use of X-Reality technologies in STEM teaching, and in particular AR and VR, offers many opportunities for effective learning and acquiring scientific skills by promoting interest, engagement and knowledge retention. At the same time, however, some drawbacks are reported, particularly related to the immaturity of the technology, that should be overcome to allow a wide adoption in upper secondary school curricula.

In terms of future research perspectives, some points can be underlined from a pedagogical point of view. Firstly, it is important to further investigate the long-term effect of the use of X-Reality for STEM education, especially in relation to the implication on knowledge retention. Secondly, it is also necessary to deepen the knowledge on when the use of X-Reality in STEM teaching is appropriate and when it is not, taking into account the characteristics of the students and their training needs. Thirdly, particular attention should be given to the inclusiveness of these technologies so that their use does not create a boundary between the students with the effect of excluding the disadvantaged or impaired ones. These aspects, at present not completely addressed in the literature, can be seen as a relevant research perspective in the next future. Finally, from a technological point of view, it is necessary to carefully consider the phase of testing after the development of these digital environments, in order to limit any possible technical problem resulting in a negative impact on students' learning.

6. Authors' contributions

This contribution can be attributed for paragraphs 1, 2, 3 to Alice Roffi and for paragraphs 4 and 5 to Stefano Cuomo.

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Italian Journal of Educational Technology, 31(1): 89-100, 2023
ISSN 2532-4632 (print) – ISSN 2532-7720 (online)
DOI: 10.17471/2499-4324/1295
https://ijet.itd.cnr.it

Italian Journal of Educational Technology

itdi ISTITUTO TECNOLOGIE DIDATTICHE

Multiple roads towards openness: Exploring the use of open educational practices within an Italian university

Molteplici strade verso la scienza aperta: un'esplorazione dell'uso di pratiche educative aperte all'interno di un'università italiana

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HOW TO CITE Ballatore, M. G., Nascimbeni, F., Burgos, D., & Tabacco A. (2023). Multiple roads towards openness: Exploring the use of open educational practices within an Italian university. *Italian Journal of Educational Technology,* 31(1): 89-100. doi: 10.17471/2499-4324/1295

Received: July 27, 2022; *Accepted:* January 26, 2023; *First Published:* March 31, 2023

ABSTRACT This investigation was performed to determine whether and how the implementation of Open Educational Practices (OEP) is directly influenced by lecturers' backgrounds and preferences in terms of teaching modalities. In particular, we have analysed the use of OEPs from a social perspective to understand whether the habit to work in online and blended settings is connected to the use of open teaching approaches. Exploring this relationship has evidenced common patterns that suggest how lecturers can be further motivated to explore areas of openness where they are not advanced concerning classroom diversity and increase the social impact of their teaching. This research shows two main approaches to openness: one focused on open educational resources only and another one with a broader perspective that embraces other aspects of openness, such as access or practices. This work will help understand the relevance of contextual variables and further explore enablers for building open education capacity across universities.

KEYWORDS Open Educational Practices; Higher Education; Teaching Contexts; Open Educational Resources.

ABSTRACT Questa indagine è stata condotta per determinare se e come l'implementazione di Pratiche Educative Aperte (OEP) è direttamente influenzata dal background e dalle preferenze dei docenti in termini di modalità di insegnamento. In particolare, abbiamo analizzato l'uso delle OEP da una prospettiva sociale per capire se l'abitudine a lavorare in contesti online e blended è collegata all'uso di approcci didattici aperti. L'esplorazione di questa relazione ha evidenziato modelli comuni che suggeriscono come i docenti possono essere ulteriormente motivati a esplorare le aree di apertura in cui non sono avanzate per quanto riguarda la diversità della classe e aumentare l'impatto sociale del loro insegnamento. Questa ricerca mostra due approcci principali all'apertura: uno focalizzato solo sulle risorse educative aperte e un altro con una prospettiva più ampia che abbraccia altri aspetti dell'apertura, come l'accesso o le pratiche. Questo lavoro aiuterà a comprendere la rilevanza delle variabili contestuali e a esplorare ulteriormente i fattori abilitanti per la costruzione di capacità di istruzione aperta nelle università.

PAROLE CHIAVE Pratiche Educative Aperte; Formazione Universitaria; Contesti di Insegnamento; Risorse Educative Aperte.

1. Introduction and background

Open educational practices (OEPs), which can be defined as "*practices which support the (re)use and production of Open Educational Resources through institutional policies, promote innovative pedagogical models, and respect and empower learners as co-producers on their lifelong learning paths*" (Ehlers, 2011, p. 4; Tlili et al., 2021), are generally recognised as potential enablers of quality, access, and effectiveness within universities (Stracke et al., 2021; Weller et al., 2015). In line with this understanding, universities are increasingly putting in place programmes to build their educators' capacity to work with OEPs (Stracke et al., 2021). However, for these initiatives to be effective, university leaders would need to know their educators' existing ability to work with open approaches within their academic practice to be able to understand who needs training and support and how to provide this capacity within the institution (Nascimbeni & Burgos, 2016). The problem is that reaching an understanding of the level of OEP adoption within an institution, and therefore being able to set clear capacity-building objectives, is a rather complex exercise for three main reasons:

- (a) openness is a social construct that evolves over time (Veletsianos, 2015);
- (b) there is not a single definition of open education, so different users can have different visions, and all of them might be valid (Burgos, 2017); and
- (c) openness is connected with educators' individual attitudes, personalities, and cultural behaviours (Cronin, 2017; Cronin & MacLaren, 2018; Ferrer et al., 2022).

Also, issues related to data protection, combined with the nebulous nature of OER usage, create a challenging landscape for researching the impact of openness on educational practices (Rooney, Gray, & O'Farrell, 2019; Weller et al., 2015).

Because of this, only a few studies have managed to provide empirical evidence to demonstrate what proportion of teaching staff at a given university have actually adopted open practices and why this is the case (Anderson & Leachman, 2019; Veletsianos, 2015). A recent study (Nascimbeni, Burgos, Campbell, & Tabacco, 2018) has mapped the overall OEP capacity of an Italian university (Politecnico di Torino, PoliTo) by examining individual educators' levels of adoption of open practices by focusing on four different areas of academic practice: learning design, content, teaching, and assessment, and demonstrating that a degree of openness capacity is present in all four areas. As might be expected, content is the area where open practices are most widely adopted among educators at PoliTo, with more than 65% of respondents being familiar or proficient with the use of OER, while assessment is the area where traditional methods are still the norm for most respondents. This study also highlights that:

- (a) OEP capacity is scattered across the university and the individual lecturers, with very few educators being highly practised in all four areas explored in the study;
- (b) some forms of OEPs are more common than others; for example, the use of OER and collaborative design practices is much more widespread than the use of open assessment methods;
- (c) the motivation and capacity to adopt OEPs is only marginally connected to age and discipline but rather stems from collaborative group dynamics where a culture of sharing already exists among colleagues; and
- (d) teachers' personalities and attitudes are the keys to the adoption of OEPs.

Finally, by covering diverse levels of OEP awareness and adoption in different practice areas, the study shows that openness is not a binary concept where educators are either open or not, but it is instead a multidimensional continuum where "open" can mean different things to different educa-

tors in other contexts (Narima, 2022; Nascimbeni et al., 2018). Also, the study confirms an important consideration emerging from research (Cronin, 2017): that teachers' approach to openness depends on contextual factors such as national legislation and institutions' receptiveness to open approaches, but also on their personal approach to balancing attitudes to privacy and sharing.

One of the limitations of this study was connected to its quantitative nature: given the complexity of quantifying openness, quantitative self-reported data may, in fact, not be sufficient to draw sound conclusions about educators' attitudes toward openness and adoption of open approaches (Cronin, 2017; Otto, Schroeder, Diekmann, & Sander, 2021). Indeed, scholars from the open education field have suggested that more qualitative empirical research is needed to understand the phenomenon (Borthwick & Gallagher-Brett, 2014; Hare & Sullivan, 2020; Littlejohn & Hood, 2016; Schuwer & Janssen, 2018). The present research was performed to complement and enrich this preliminary study (Nascimbeni et al., 2018) by adding a qualitative research dimension, which can help determine how lecturers' backgrounds and preferences directly influence the implementation of OEPs in the teaching practice in terms of teaching modality. In particular, we have taken a social perspective to understand whether a choice to use online and blended learning is connected to the use of OEPs. Exploring this relationship might evidence common patterns that suggest how lecturers can be further motivated to explore areas of openness where they are not proficient concerning classroom diversity and increase the social impact of their teaching. It may also help us understand the relevance of contextual variables and further explore enablers of building open education capacity across universities.

2. Methodology

2.1. Design and participants

This study started from the results of the quantitative research performed by Nascimbeni et al. (2018) and aimed to draw more profound conclusions about OEPs through qualitative research. The study adopted an interpretivist perspective under a subjectivist's query; in particular, the phenomenological methodology was adopted. The study was performed through semi-structured interviews using a process-focused method that required an open mind toward relevant outcomes and an absence of a priori knowledge of the phenomenon under study.

The population was the academic staff of the Politecnico di Torino (PoliTo), an Italian technical university offering courses in the fields of engineering and architecture. The participants were recruited from Nascimbeni et al. (2018) sample using typical-case sampling (a purposive non-probability sampling). According to the results of the previous research, it is unusual for an individual educator to have OEP expertise in design, content, teaching, and assessment at the same time. Hence, trying to have a representative sample of PoliTo in terms of age, academic career, and scientific field, the reference criterion is that participants must be considered "Open" in at least one of these four areas, following the results of the analysis previously carried out by Nascimbeni et al. (2018). Precisely, 13 lecturers, five females and eight males, were selected and interviewed: four from the industrial engineering field, four from ICT, three from building and architecture, and two from basic science. The sample represents the academic staff distribution at PoliTo, considering the career position (six full professors, four associate professors, three assistant professors) and seniority (three less than 10 years, seven between 11 and 20 years, and three more than 20 years). Considering their highest score on the OEP map (see Table 1), three of them were "Open" in design, four in content, three in teaching, and three in assess-

ment. They were currently teaching in the different programmes available at PoliTo: bachelor's, master's, and PhD. None of them was directly involved in open education networks.

2.2. Data collection

Each interview took place at PoliTo, was around 40 minutes long, and was audio-recorded. The language used was Italian, the mother tongue of all the interviewees. The same interviewer conducted all 13 interviews. After some ice-breaking questions to confirm their general academic position, the participants were asked to state their definition of OEPs. Then, after showing their map related to their results in the four open pillars (see Table 1) (Nascimbeni et al., 2018), we structured the interview into three main parts regarding the factors of influence on OEP adoption: context, personal background, and teaching style. In terms of context, we investigated the participants' understanding of the PoliTo open access policy and its impact on their teaching activities, asking for any desired additional support. We addressed both the interviewees' background and their vision of open education, starting from personal motivation regarding their personal background. Other related topics investigated in this part were the relationships between OEPs and social media and between OEPs and blogging practices, either for teaching purposes only or for more general aims. In both cases, we asked the interviewees to define the nature of the relationship, either positive or negative. Considering the teaching style, we started by asking about the participants' personal preferences regarding teaching methodology.

Table 1. Four open pillar map (Nascimbeni et al., 2018).

	Design	Content	Teaching	Assessment
Open collaboration	Open designer	OER expert	Open teacher	Open evaluator
Bilateral collaboration	Collaborative designer	OER novice	Engaging teacher	Innovative evaluator
Individual work	Individual designer	OER-null	Traditional teacher	Lone evaluator

Then, a generalised opinion was sought by looking at teaching methods (if existing) that strongly supported and could be directly linked to OEPs. Also, in this case, the interview focused on two relationships and their natures: the relationships between OEPs and the use of technology and between OEPs and the adoption of active and student-centred learning. Finally, the interview ended by asking about the time dedicated, or needed, in order to move toward more OEP teaching and if the interviewee considered themself an open educator. The interview questions are presented hereby:

- *Ice-breaking questions*
  - What is your current position?
  - How long have you been in service at PoliTo?
  - What subject do you teach?
  - Have you worked on other courses in the past?
  - Have you been or are you part of international networks linked to the open world?
  - If you had to explain what is meant by open education practice, how would you define it?
- *Part 1 – Context*
  - Is the adoption of OEPs in your teaching practices influenced by PoliTo's conditions and context?

  - In your opinion, what are the resources and supports that the university makes available to encourage OEPs?
  - What additional resources would you find helpful to have?
  - Do you know the university's policy for open access to scientific publications?
  - Are there other factors that you consider fundamental outside the institutional environment?
- *Part 2 – Personal background*
  - Is the adoption of OEPs in your teaching practices influenced by your background and vision of sharing?
  - How important do you think the lecturer's motivation is?
  - In your opinion, is there any relationship between the use of social media for educational and non-educational use and the adoption of OEPs? Would you define this relationship positively or negatively?
  - In your opinion, is there any relationship between using a blog, be it of a private or business nature, and adopting OEPs? Would you define this relationship positively or negatively?
- *Part 3 – Teaching style*
  - Is the adoption of OEPs in your practices influenced by your preferences in terms of teaching methods?
  - In general, what do you think are the teaching methods that most facilitate adoption?
  - In your opinion, is there any relationship between using technologies in teaching and adopting open practices? Would you define this relationship positively or negatively?
  - In your opinion, is there any relationship between active and participatory teaching and the adoption of open practices? Would you define this relationship positively or negatively?
- *Final questions*
  - How much time do you dedicate to OEPs in your teaching practices?
  - Do you consider yourself an open educator?

2.3. Data analysis

We analysed the data using a general inductive approach which involved coding responses and grouping codes into common themes via an iterative process. First, we grouped two main subsets of the interviews based on the understanding of OEPs given by the interviewees. Two main definitions of OEPs emerged from the interviews:

OEPs as teaching with OER, connected to general or thematic sharing of open resources and experiences.

OEPs as open teaching, connected to the use of innovative teaching approaches such as flipped classroom or knowledge co-creation by and with students.

Definition A was adopted by eight people, and Definition B by five. For each subset, two researchers coded the data independently. Then, the research group reviewed and revised the data, and a researcher finalised the codes based upon consensus and grouped them by themes, ensuring that the subsets were not disjointed and shared some common features. After the inductive coding was completed and confirmed by the entire research group, themes were established using a deductive approach to relate the themes to the theoretical framework presented above in Table 1.

3. Results

We summarise the results obtained according to the macro themes identified as the track for the interviews. When we found a relevant difference between the participants who understand OEPs as teaching with OER (Group A) and the ones who see OEPs in a broader perspective (Group B), we have clearly stated the key features of both groups. For those dimensions that seem not to be affected by the interviewers' perception of OEP, the results are described without distinction.

3.1. Features that stimulate and discourage the use of OEPs

When OEPs are connected to teaching with OER (Group A), the significant factors that impact their application are, in order of importance, organisation conditions independent of the lecturer's willingness, human resources, and colleagues.

PoliTo has a centralised organisation that determines, among others, the following teaching features: class composition, technological support, and exam planning. Interestingly, participants stated that these elements could either stimulate or discourage the use of OEPs. Six people (out of the eight in Group A) experienced how obligations in some specific aspect of teaching could represent an opportunity for new reflections and innovations toward openness. The most cited example was the polling system that PoliTo makes available to teachers through its mobile app. Other aspects, such as the number of students per course, were mentioned as barriers to the adoption of OEPs. Seven people focused their attention on the role of human resources, stating that the teaching staff made available were bound to specific projects and often too limited in number. There was a mismatch between the needs of the lecturers and their skills. Three people positively emphasised librarians' support to incentivise OEPs. The third aspect, the role of colleagues, was considered by three participants as an incentive and two as a limiting condition. In terms of general context, all respondents emphasised the critical role of the scientific community and the university department, noting how the degree of openness of these environments towards OEPs strongly influenced the choices of the individual lecturer.

When lecturers see OEPs as open teaching (Group B), the relationship with the students mainly drives the decision to adopt open approaches. One respondent said: "*All the actions and decisions that I take in the context of teaching are guided first of all by the interaction with the students and by the results that will be obtained. So it's a work of successive approximation to improve those aspects from year to year that proves to be critical.*" (translated from Italian). The student becomes the point of reference for both adopting and evaluating practices, the primary factor being the involvement of the whole class in the teaching activities. On the contrary, a discouraging feature is the absence of institutional incentives, including human and technical resources. Two respondents underlined the importance of structurally avant-garde classrooms and web services but complained about the difficulty to personalise the existing support tools to the needs of individual teachers, which disincentivised experimentation with open approaches.

Interestingly, both groups claimed that more significant support from human resources trained on the use of OEPs would be needed. Almost all interviewees (11 people) had heard about the university's open-access policies but considered them useful only for advanced courses (master's or graduate ones). The knowledge and experience exchange with the scientific community on topics related to teaching often used other channels that are not addressed by the university's open-access policies.

3.2. External factors and environmental conditions

The most cited external factor that can favour the introduction of OEPs was the industry's role. The relationship between the needs of teaching and employment requires a higher degree of openness, and sometimes it has been addressed as the starting point for course revision. This perception was common in all the interviews and represented a rather interesting finding, probably connected to the kind of university analysed. Also, the existence of freely available teaching resources of good quality - and the lecturers' knowledge of their existence - stimulates the educators' motivation, within Group A, in particular, to experiment with OEPs. On the contrary, some limitations linked to the subject itself were mentioned, such as the rigidity of technical standards (e.g., UNI EN ISO, CEI) that need to be used inside the classroom.

In general, most external factors are directly connected to the institutional features presented in the previous paragraph, especially regarding the environmental condition. For example, PoliTo offers an online service called "Portale della Didattica" in which teachers can upload materials and interact with students. However, the degree of openness of this tool is limited either to the students of a specific course or to the entire PoliTo student community. This was considered a limitation, particularly by Group B educators. Some of these factors can be overcome with creativity and willingness, but this requires additional time and effort.

3.3. Internal factors and personal background influence

Group A educators agreed that personal motivation plays a key role in adopting OEPs, followed by the individual experience with these approaches. These features influenced each lecturer's method as a reference for their teaching. At the same time, many lecturers mentioned personal attitudes as a key part of open teaching. This mix of internal factors is a key motivational aspect and, at the same time, a reward for implementing a new teaching methodology, which can include OEPs.

For Group B, the most cited internal motivation was the importance of providing high-quality education. This creates the stimulus for producing OER that can be shared with colleagues and usable by a broad audience. This consideration brings to light the ethical aspect linked to the use of OEPs, and underlines that the lecturer's personal attitude is fundamental to implement these properly is.

A common aspect among both groups was the interest in sharing education among both colleagues and students. It was said: "*For example, I have always used the open material I found here and there with great satisfaction. So morally it is also right to contribute in the other direction.*" (translated from Italian). This attitude originated from the experience that respondents had when they were students (meeting educators that cared about openness), as well as knowledge in the scientific field and the stimuli collected from their students, who are now increasingly connected and willing to work in open settings.

3.4. Social media and blogging

Eight interviewees reported that they used some form of personal blogging, disconnected from the official channels offered by PoliTo. This choice was due to the higher flexibility of non-institutional tools, requiring a lower effort to maintain. Three lecturers reported positive blogging experiences in the scientific community as practical tools for finding new ideas and valuable comparisons.

As far as the use of social media is concerned, Group A clarified that openness does not necessarily imply interaction; therefore, most of them considered social media as leisure time-space and for per-

sonal relations. The only exception was YouTube, where the creation of good-quality teaching materials was perceived as a service for the community, even if creating video content requires more time and effort than creating other types of materials. One said: "*I feel a bit the YouTube competition because there is a lot of stuff on YouTube, and not all of it is low quality, honestly. Then students use it and the question arises <<what do I give more?>>*" (translated from Italian). Group B did not show a clear opinion about social media, stating that they did not generally use them but recognised their potential.

3.5. Pedagogical approaches

The reasons behind the personal choice of a specific teaching technique are a mixture of different features: teacher's and students' attitudes, environment, and personal experience. Technology integration is part of this choice, but lecturers believed it does not interfere with the adoption of OEPs. In particular, Group B specified that the lecturer's role is not that of a technological innovator but of a methodological guide that makes good use of the technical resources available.

In general, respondents from both groups favoured active and student-centred learning. The majority thought that the crucial point is to teach how to be able to read and understand reality: courses need to drive students to practically apply theoretical knowledge. Both groups underlined the importance of revising their courses every year, including the teaching resources, based on the student cohort. This idea of tailored teaching, particularly strong within Group B, is related to OEPs because having access to a large pool of OERs can help tailoring their existing materials to new cohorts within the available time. This interpretation is strongly associated with the group understanding of OEPs as a way to establish a dialogue to improve all aspects of teaching (design, content, evaluation).

3.6. Time

Eight interviewees stated that sometimes it was already hard to find the appropriate amount of time for traditional teaching, stating that implementing OEPs requires additional time. This effort was quantified as around +10–15% compared to regular classes, but it is not constant over the years and the semester: when a new course needs to be redesigned more openly, the effort can reach +25%. Respondents from both groups confirmed that OEP implementation requires time in both the design and implementation stages, with a ratio of around 2:1, noting that the better one can design and prepare in advance, the more straightforward the implementation is. In our sample, the actual use of OEPs clearly correlates to the career stage: more senior educators have more time to spend on these topics.

3.7. Rewarding and feeling as an open educator

Within PoliTo, institutional and career rewards connected to the use of OEPs do not exist. Still, other motivations push the choice to invest effort into the adoption of OEPs. First of all, the personal reward: interviewees found themselves satisfied when they put more effort into open education. This element correlates with the second reward, the social one. The availability of high-quality open materials and the support for a mind shift in students produce a benefit for all society. In the end, when students are exposed to OEPs, they become more curious about the topics and learn more productively.

Even though the interviewed educators applied some sort of open approach in one or more of the dimensions of Table 1, none of them were confident in defining themselves as open educators, and six

had never reflected on their open teaching attitude. Two interviewees suggested asking their students, since they were the ultimate judges, independently of the lecturers' efforts and personal perceptions.

4. Discussion

The results of the present research, by adding a qualitative perspective, enrich the findings of the previous quantitative analysis (Nascimbeni et al., 2018), which profiles OEPs in four areas – design, content, teaching, and assessment – presenting a relatively large significance of openness in every area except assessment, where the presence of openness is scarce.

Based on that analysis, this research provides results that confirm that two understandings of OEPs exist among the group of interviewed teachers, which somehow reflect two views that coexist in the open education community (Cronin, 2017). One – adopted by 62% of the respondents – corresponds to the act of teaching with and through OER and is, therefore, more connected with the use of openly licensed resources and the improvements and innovations that such resources can bring to the teaching process (similar to the early definition of Geser, 2007); the other goes beyond the use of OER to embrace openness as an ethos and a holistic teaching practice (as in Dalsgaard & Thestrup, 2015). In this second group, 'open' is not just a set of resources but a way of practice (a way of life, in a sense) that involves every single practice on teaching and learning. For instance, like Burgos (2017a, 2020) refers as (11) pillars, namely: content, methodology, research data, research results, policies, licensing, technology, access, accreditation, certification, interoperability, and practices (as in OEP).

Altogether provide a cohesive, interwoven approach to learning and teaching beyond the simple use of content in the form of OER.

Whatever the understanding, in the eyes of the respondents, OEPs are perceived as an integral part of the teaching work, as shown by the fact that the interviewed educators, even if they were among those that used open approaches more frequently within the university, did not refer to themselves as open educators. However, they corresponded to the profile; they were simply not aware they fit it. Indeed, the findings confirm that open practice in higher education looks different for each individual and that educators are more open in some areas of work than in others: the perception is that OEPs are useful to "teach better", with only a few respondents focussing on the inclusivity impact of such practices, somehow contradicting several research findings in the area (see for example Santana-Valencia & Chávez-Melo, 2022, or Schreurs et al., 2014). OEPs are in fact perceived by the majority of our sample as a catalyst for pedagogical innovation, which can enable faculty to access one another's new materials and approaches, providing greater diffusion of innovation within the university (Paskevicius, 2018). Indeed, for this shift to happen, the second understanding of OEPs should be promoted, making sure that lecturers perceive that OEPs, although being based on OER, are approaches that can make teaching activities more transparent and accessible, opening up the classroom – or the online environment of the university – beyond its traditional walls (Nascimbeni & Burgos, 2016).

It also appears that respondents knew well the potential enablers and the existing barriers that prevented the continued use of OEPs. While all the respondents referred to institutional and contextual barriers, three noted some problems in sharing their intellectual property and some reluctance to use resources produced by others (Hodgkinson-Williams, 2010). In contrast to the results of the quantitative analysis run in 2018, the research discipline seems to be an important factor, with the reuse of resources seeming to be more common in scientific domains such as physics than in social sciences. When it comes to the relation between the use of OEPs and the career level of lecturers, the study

confirms that individuals' role within the university does influence the use of open practices: the more advanced teachers are in their career, the more willing they seem to experiment with open approaches, even though younger lecturers might have a more natural tendency to use open digital tools. Personal maturity and/or professional expertise seem to play a crucial role in the transversal approach and understanding of openness. Respondents explained this was because implementing open practices takes time, and researchers early in their careers are often not in the position to experiment with these innovations. Indeed, the time and effort needed to implement OEPs – usually connected to the time needed to find high-quality OERs, especially for respondents in Group A – seemed to be the highest barrier. This issue is well known in the literature (Allen & Seaman, 2016; Kanjilal, 2013) and confirms that universities should incentivise the use of OEPs by offering educators the necessary time to prepare them, especially with large classes, as well as to support students in openly publishing their work (Highton, Fresen, & Wild, 2011; Paskevicius, 2018). Interestingly, a direct relationship between the use of social media and the habit of blogging and the willingness to use OEPs did not appear for the majority of the sample, confirming the "fragmented nature" of social media usage among educators, who often do not consider the possible impact that such an activity could have on their teaching practices (Kimmons & Veletsianos, 2014).

Finally, an important finding is the role given to OEPs as a component of course design. Respondents agreed that, by designing their courses through open approaches, mainly involving students and external actors such as companies, they could offer learners an opportunity to develop the knowledge and skills needed in today's labour markets. This idea of "OEPs for employability" is relatively new in the literature and should be further explored.

5. Conclusions

This research aimed to determine whether and to what extent the implementation of OEPs in a specific academic setting is directly influenced by lecturers' backgrounds and preferences in terms of teaching modalities. By exploring the relationship between the actual and prospective use of OEPs and some characteristics of the sampled respondents, we have noticed some common patterns that can help to further motivate educators to explore different areas of openness. Also, this study clearly shows that two main understandings of open teaching practices exist among university lecturers: one focused on teaching with open educational resources and another that embraces other aspects of openness, such as open pedagogies and open assessment. Also, the research does show some correlation between specific characteristics of respondents and their propensity to adopt open educational practices. Firstly, openness seems to flourish within small collaborative groups and stem from the sharing culture that naturally exists among close colleagues, particularly concerning the use of resources produced by others. This observation is in line with the findings of Lopukhova and Makeeva (2017) and Veletsianos (2015), who claim that both individual and systemic barriers exist to adopting open approaches and that close collaboration can strongly influence individual agency in the practice of openness. Secondly, openness is closely connected to collaborative attitudes; across all four areas of practice, the data confirms that a strong relationship exists between the use of open approaches and the collaborative attitudes of university teachers, where open online identities and networks seem to be key to developing open teaching strategies (Nascimbeni & Burgos, 2016). As noted by Weller (2012) and Cronin (2017), a relationship exists between educators' positive attitude towards openness and their collaboration practice, confirming that the use of OEPs can impact educators' personal networks and vice-versa.

It is interesting to compare our findings with Cronin's analysis of openness within an Irish university, that found that a well-developed open digital identity, the use of social media, the use of institutional and open tools, the familiarity with OER were the main characteristics connected to the use of OEP (Cronin, 2017). While these dimensions are present in our findings as well, it seems that in the perception of our sample OEP are seen mostly as a way to foster engaging and tailored learning and are therefore connected to aspects that are connected to quality teaching and the related incentives. At the same time, our results fully resonate with Cronin's findings in terms of two key enablers of OEP: the importance of balancing privacy and openness attitudes and the need to foster the porosity across staff-student boundaries.

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Italian Journal of Educational Technology, 31(1): 101-102, 2023
ISSN 2532-4632 (print) – ISSN 2532-7720 (online)
https://ijet.itd.cnr.it

Italian Journal of Educational Technology

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