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# Innovation through the implementation of technology in the context of school education: a systematic review

Thiago Freires,[1,*] Amélia Lopes[1]

[1] Centre for Research and Intervention in Education (CIIE), Faculty of Psychology and Education Sciences, University of Porto, Porto, Portugal
* Correspondence: tfreires@fpce.up.pt

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## Abstract

While the central role that technology currently plays in the different domains of society is acknowledged, it is pressing to understand how it also affects the compulsory education setting. The increasing technological richness of the world influences everyday life and brings about higher expectations for schools to take a lead in shaping competent citizens for the twenty-first century. The aim of this article is to advance knowledge of how innovation is taking place in schools when it admits the implementation of technology as a fundamental dimension. This review draws on the Preferred Reporting Items for Systematic Reviews and covers the period 2017–22 to identify 30 studies for inclusion. The analyses suggest that innovative practices are highly diverse in nature and that they target different disciplines and levels of compulsory education. Innovation is sensitive to place, historicity and time. It is often delayed by infrastructure issues (first-order barriers)

and beliefs (second-order barriers), while among its key drivers are leadership, support networks and professional development.

**Keywords** innovation; technology-based education; compulsory education; systematic literature review

## Introduction

Innovation plays a central role in present-day education (European Commission, 2018; OECD, 2010; UNESCO, 2023) framed within the context of a fourth industrial revolution (Schwab, 2016). This revolution is defined by the convergence of physical, digital and biological technologies that change what people do, how they do it and what it means to be human (Leahy et al., 2019). Hence, it is widely accepted that information and communication technology (ICT), including digital, mobile and smart technologies, works as a powerful tool in the innovation landscape (Morgado et al., 2021) and supports the efficiency of education systems (European Commission, 2018). Although it is clear that innovation in education practices can go beyond resourcing ICT or fostering technology-enhanced learning (Dron, 2018), recent policies, both at national and international level, have emphasised the crucial role that ICT and recent technological achievements play in promoting quality, effective education for all (UNESCO, 2023).

From the beginning of the twenty-first century, schools have experienced the influence of an increasingly digital world and, despite some scepticism, changes have taken place, both in pedagogical and curricular dimensions (Baruch and Erstad, 2018). New ways to teach and learn have incorporated technology, ranging from very basic resources in tools to more sophisticated strategies in which smart devices are implemented along with cutting-edge ICT oriented to teaching and learning (Jo et al., 2014). To some extent, all these adjustments in the educational setting have promised change and rebirth, with the focus now being on the challenge for schools to address what are understood as twenty-first-century competences and needs (OECD, 2010).

The implementation of technology in schools, in line with societal aspirations towards innovation, implies that the emergence of new methods requires collaborative cultures to be fostered and pedagogical and technical training to be provided for teachers, as well as institutional technical support, if the aim is a sustainable innovative mandate (Chandra and Mills, 2015). Because this array of demands is complex, innovation in schools might happen at different paces in different contexts. Moreover, innovation, despite being a ubiquitous topic in policy discussions, seems to remain a concept which is complex and blurred (European Commission, 2018). Bearing these assumptions in mind, in this article, we delve into the literature focused on innovation in schools to provide a framework of what it concretely means when technology is implemented in compulsory schooling. In other words, we clarify the meanings that innovation upholds and the existing ties with the implementation of technology, that is, the resource of information and technology tools towards dynamising digital and smart environments, with the aim of fostering change in school education (OECD, 2010).

Our departure point for the notion of innovation is somewhat broad; we understand it as any dynamic change intended to add value to the educational process and which results in measurable outcomes (OECD, 2010). As discussed in this section, technology plays an important role in the innovation landscape. There is often the perception that technology can address major educational challenges in a setting where education is often criticised as being slow to change and stuck in the past (Baruch and Erstad, 2018; UNESCO, 2023). Despite promising results from the use of (digital) technology and new pedagogical practices, the literature suggests that the recourse to technology has been mostly superficial and related to prevailing teaching methods (Illomäki and Lakkala, 2018). Likewise, it is recognised that to promote innovation within the implementation of technology demands that several dimensions that go beyond infrastructure must be addressed. Innovative practices as led by technology require attention to issues related to teacher training and different instances of pedagogy – methods, means and organisational culture (Bingimlas, 2009; Chandra and Mills, 2015; Lakkala and Illomäki, 2015; Orlando, 2014). Set against this background, this review seeks to answer three research questions to improve understanding of how technology supports innovation in the school arena:

RQ1: How does the existing literature conceptualise innovation in which the implementation of technology is a key part?

RQ2: What school practices/activities result from innovation via the implementation of technology?

RQ3: What can be learnt from current practices of innovation based on the implementation of technology?

Answering these questions is important to help combat myths and exaggerated claims about the implementation of technology in schools and extend knowledge on the ways in which this change occurs, in terms of conception and practices. In recent years, several systematic reviews have been performed on the topic of innovation. While some of them focus on the dimension of innovation as a culture (for example, Prenger et al., 2022), other discuss the ties with technology, but often within the scope of specific tools or disciplines (for example, Burden et al., 2019; Olvera-Fernández et al., 2023). Our review is original in the sense that it seeks a more comprehensive view of school innovation as fostered by the integration of technology. Moreover, the decision to problematise innovation is critical, since there is evidence that it is usually left untheorised (Ellis et al., 2023). By addressing this gap, our work can inform further action in this field.

# Method

The current study is informed by the systematic literature review methodology (Boland et al., 2014; Gough et al., 2012; Page et al., 2021). Its purpose is to provide an overview of how innovation has been addressed with the support of technology in the context of schooling up to secondary education. More specifically, as systematic reviews can facilitate the understanding of a topic as well as help identify common threads across studies (Tondeur et al., 2017), the aim of this article is to advance knowledge about how innovation is taking place in schools when it admits the implementation of technology as a fundamental dimension. Therefore, we address the literature, which is relevant to our research questions, using explicit methods to identify what can reliably be concluded on the basis of these studies (Gough et al., 2012). To ensure the quality of the revision process and its replicability, we followed the Preferred Reporting Items for Systematic Reviews (PRISMA) (Page et al., 2021), in line with the principles established by Boland et al. (2014). The principles underlying systematic reviews require at least four stages: definition of the question/problem; identification and critical assessment of the available evidence; synthesis of the findings; and the drawing of conclusions (Boland et al., 2014; Gough et al., 2012). Once our general research problem was established, as previously stated, we then established a review protocol that was not published or registered.

## Eligibility criteria

We included publications in English, Portuguese and Spanish, published between 2017 and 2022. Publications in Portuguese and Spanish were eligible, as the authors are fluent in both languages. It was decided to maintain a six-year time span, as innovation has a mobile character, which is accentuated when technology implementation is embedded, with tools becoming quickly obsolete within a scenario of constant change and transformation (Schwab, 2016; UNESCO, 2023). Due to the desire to capture work led by the field of education, the subject area was limited to 'education educational research' on the Web of Science platform and restricted to the 'social sciences' category in the Scopus database. This decision may have omitted interesting results due to the interdisciplinary character that articles can present, and by bias related to the narrow subject classification defined by Web of Science. The next decision was to select only peer-reviewed articles, focusing on open-access materials and acknowledging the quality inherent in the indexation of the databases (Abelha et al., 2020). Regarding criteria for content, all studies with an empirical dimension were included, since they addressed the implementation of technology as part of the innovation strategy in the school context. Articles not centred on the school level of education, and those that did not discuss the dimension or conceptualisation of innovation and related it to the implementation of technology, were excluded from the review. Likewise, impact and theoretical studies were also set aside. The following subsection provides details about these procedures.

## Information sources and search strategies

The included studies were located after a thorough search in the Scopus and Web of Science databases. These databases were chosen because they host a wide range of quality peer-reviewed publications in the field of education, and because they are the two most highly valued databases for the international scientific community, both for evaluation and for funding (Abelha et al., 2020). We performed a pre-planned search (Tong et al., 2012), employing comprehensive strategies to find all the studies available (Gough et al., 2012). Search terms were combined using Boolean operators and targeted the title, abstract and keywords in both databases. Pilot searches using synonyms for each term (for example, 'primary school' or 'elementary education') were performed until achieving a combination of words that provided the broadest range of results. The final keywords used in the literature search included 'innovation' combined with 'school' or 'elementary school' or 'basic education' or 'secondary school', as well as with 'technology' or 'ICT' or 'information communication technology' or 'smart education' (see Table 1 for detail).

**Table 1. Database search description including Boolean operators**

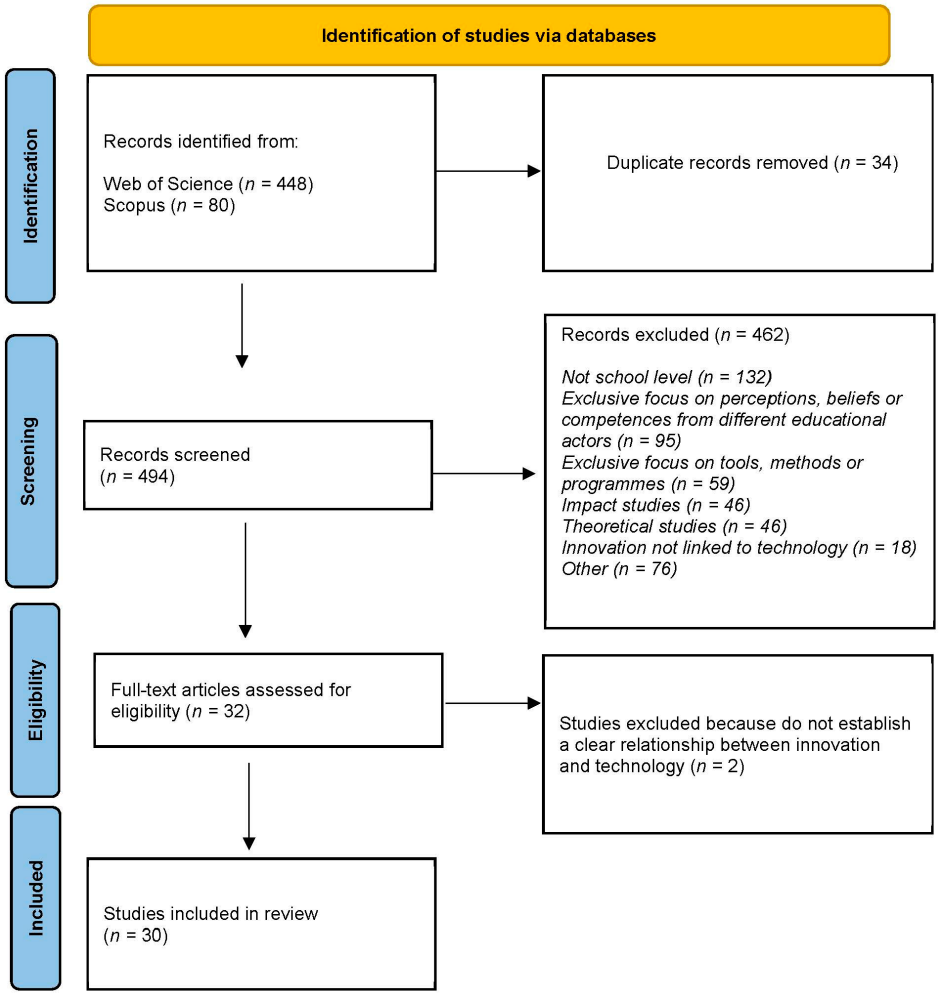
| Database | Field \| Line | Keyword | Description |
|---|---|---|---|
| Scopus | 1. Article title, abstract, keywords | Innovation | Innovation (AND) |
| | 2. Article title, abstract, keywords | School | School OR Basic education OR Elementary school OR Secondary school (AND) |
| | 3. Article title, abstract, keywords | Technology | Technology OR ICT OR Information communication technology OR Smart education |
| Web of Science | 1. Topic (title, abstract and author keywords) | Innovation | Innovation (AND) |
| | 2. Topic (title, abstract and author keywords) | School | School OR 'basic education' OR 'Elementary school' OR 'Secondary school' (AND) |
| | 3. Topic (title, abstract and author keywords) | Technology | Technology OR ICT OR 'Information communication technology' OR 'Smart education' |

## Selection process and data collection

Applying the search strategies, one of the authors carried out searches in Scopus and Web of Science and identified all available peer-reviewed articles on technology-based innovation in non-tertiary education published from 2017 to 2022. These articles were exported to EndNote, which allowed duplicates to be eliminated. After the completion of this first step, 494 records remained. Next, two researchers read the abstracts to confirm their appropriacy for the review. Discrepancies in opinion were debated until consensus was achieved. There were several reasons for the exclusion of records. The main one was that articles did not actually focus on the school level of education ($n$ = 132). Many studies also failed to link the implementation of technology with the framework of innovation. Some focused solely on perceptions, beliefs or competences regarding innovative practices, without a critical description of the action itself or with a vague reflection on its novelty ($n$ = 95), while others targeted the architecture of certain tools or methods, rather than their implementation ($n$ = 59). Impact studies (many of them targeting emergency practices during the Covid-19 period), which lacked a discussion on innovation or substantial data on its implementation rationale ($n$ = 46), and theoretical studies ($n$ = 46) were also set aside, as they provide no answers about how innovation led by the implementation of technology crosses over into everyday school practices. A series of studies which discussed innovation without actually linking it to technology ($n$ = 18) were put to one side as well. Finally, 76 (other) studies were removed because their argumentation failed to link the dimensions of innovation and technology. In general, these works focus either on the aspect of innovation or on technology implementation, in line with other topics. Examples include articles exclusively focused on science, technology, engineering

and mathematics (STEM) education processes, the impact of leadership in fostering innovation or the benefits of technology for promoting inclusive education (see Figure 1).

**Figure 1. Reporting items for the systematic review (Source: adapted from the PRISMA statement)**




By the end of the title and abstract screening phase, 32 reports had been selected for full review. In the final stage, the researchers read the full texts, coding broad themes of interest using NVivo12 (Release 1.0). When reading the articles, the researchers took the guidelines of the Critical Appraisal Skills Programme (CASP, 2018) for assuring quality, although no written evaluation was performed. Two studies were eliminated as they failed to establish a clear relationship between the implementation of technology and innovation.

## Data analysis process

The reading of the articles enabled us to address the research questions, namely the understanding in the literature of the concept of innovation, how it is translated into practice and what the related drivers and barriers are. Data extraction procedures were undertaken in two domains: (1) descriptive data, including information on the studies' year of publication, country of origin and methodological approach; and (2) analytical data, as targeted by our research questions (see Boland et al., 2014; Gough et al., 2012), comprising articles' theoretical foundation and the empirical discussion about innovative practices via the implementation of technology. The data were organised with the support of NVivo12 (Release 1.0). Descriptive content was addressed via case classification attributes, which benefited from previous

arrangements of the imported EndNote library; content organisation was also supported by the coding of articles' methodological sections. Analytical data are derived from coding based on thematic content analysis techniques (Vaismoradi and Snelgrove, 2019). After a pilot reading of five studies, the researchers agreed on a coding system based on three main top-level categories directly related to our research questions: innovation (including the theoretical standpoint); activity (reflecting on the nature of the empirical interventions under analysis); and reasoning behind the transformation (including drivers, barriers and challenges for innovating). Coding was applied to passages as context units, that is, whenever a passage expressed a full idea in terms of a theme, it would be registered in the respective category (Vaismoradi and Snelgrove, 2019). In the results section, we explore the syntheses of the analytical model in detail.

# Results

Consistent with our data extraction procedures, our results first address the descriptive data, including information on studies' publication date, country of origin and methodological approach. There is then a focus on analytical data, exploring the included articles' theoretical foundation and empirical discussion about innovative practices as activated by the implementation of technology.

## Descriptive data: general characteristics of included studies

### *Publication year*

The year with most studies within our search is 2020, with a total of seven. This is closely followed by six studies in both 2017 and 2019, demonstrating some balance in distribution over the five-year period of analysis. What really stands out is the publication of only two studies in 2022, which could be an effect of the Covid-19 pandemic, when schools may have been less able to invest in innovative approaches beyond emergency resources (Ulla and Perales, 2021). The identification of two articles originating from the same project is noteworthy (Genlott et al., 2019, 2021). Since these articles comprise different methodological approaches and involve different study participants, they were acknowledged as two studies and not two reports of a single study (Page et al., 2021). Table 2 presents a description of all studies included in our review.

**Table 2. General characteristics of the studies**

| Study short citation | Year of publication | Country where the study was conducted | Methodological approach |
|---|---|---|---|
| Baldoví and Alonso | 2020 | Spain | Qualitative |
| Baltodano-Enríquez | 2018 | Costa Rica | Qualitative |
| Blanco-García et al. | 2018 | Spain | Qualitative |
| Charania et al. | 2021 | India | Mixed method |
| Clark-Wilson and Hoyles | 2019 | United Kingdom | Mixed method |
| Cranmer and Lewin | 2017 | United Kingdom | Mixed method |
| Crawford | 2017 | Australia | Mixed method |
| Genlott et al. | 2019 | Sweden | Quantitative |
| Genlott et al. | 2021 | Sweden | Qualitative |
| Hatch et al. | 2022 | USA and Singapore | Qualitative |
| Hung et al. | 2017 | Singapore | Qualitative |
| Hutchison et al. | 2020 | Australia | Qualitative |

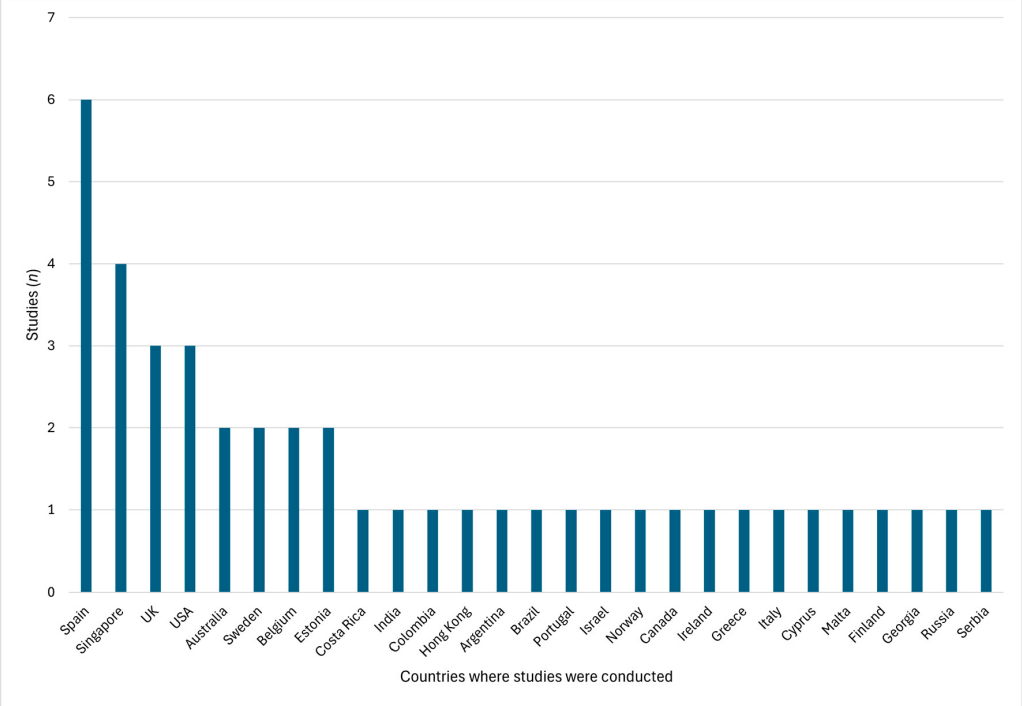
**Table 2.** *Cont.*

| Study short citation | Year of publication | Country where the study was conducted | Methodological approach |
|---|---|---|---|
| Jeladze and Pata | 2018 | Belgium, Estonia, Ireland, Greece, Spain, Italy, Cyprus, Malta, Finland, United Kingdom, Georgia, Russia and Serbia | Quantitative |
| Jiménez-Becerra and Segovia-Cifuentes | 2020 | Colombia | Mixed method |
| Law and Liang | 2019 | Hong Kong | Qualitative |
| Laya et al. | 2020 | Argentina | Qualitative |
| Leoste et al. | 2020 | Estonia | Qualitative |
| Martínez | 2019 | Spain | Qualitative |
| Nicolete et al. | 2017 | Brazil | Mixed method |
| Ortega-Rodríguez and Estrada | 2022 | Belgium | Qualitative |
| Pérez and Garcia | 2019 | Spain | Qualitative |
| Romeu-Fontanillas et al. | 2020 | Spain | Qualitative |
| Santos and Moura | 2021 | Portugal | Quantitative |
| Shamir-Inbal and Blau | 2021 | Israel | Qualitative |
| Sias et al. | 2017 | USA | Qualitative |
| Skaftun et al. | 2018 | Norway | Qualitative |
| Tan and Hung | 2020 | Singapore | Qualitative |
| Thumlert et al. | 2018 | Canada | Qualitative |
| Vaughan and Beers | 2017 | USA | Qualitative |
| Wang et al. | 2019 | Singapore | Qualitative |

### *Geography of studies*

Regarding the country where the studies were conducted, Spain has a clear lead, with a total of six articles. Studies involving Spanish schools are varied in nature, including discussion about integration of ICT (Romeu-Fontanillas et al., 2020) and the problematisation of organisational cultures in schools (Baldoví and Alonso, 2020). This lead seems to be related to a vast implementation of regional/national policies in the country aimed at strengthening the digital dimension of teaching practices (Llorent-Vaquero et al., 2023; Prieto, 2016). Singapore ($n$ = 4), the USA ($n$ = 3) and the UK ($n$ = 3) follow closely. In the case of one record, schools from Singapore and the USA are addressed simultaneously by a cross-country study comparing the evolution of innovative initiatives (Hatch et al., 2022). Similarly, schools in the UK are targeted by a quantitative study focused on the sustainability of innovation in digitally enhanced schools involving 12 other countries (Jeladze and Pata, 2018). Then, there is broad dispersion across countries and regions, suggesting that the approach to educational innovation through technology resources is a worldwide issue. Schools from different continents are addressed, with studies taking place in Brazil, Estonia, India and Australia, for example. A full report of countries is available in Figure 2.

**Figure 2. Geographical location where studies were conducted**




### *Methodology*

As shown in Table 2, the majority of the identified studies (21 of 30) use a qualitative research methodology. Another 6 articles employ a mixed-methods approach, while 3 are exclusively quantitative. As regards the general methodological strategy, the scenario is more complex, although case studies ($n$ = 10) (for example, Law and Liang, 2019) and multi-case studies ($n$ = 6) (for example, Ortega-Rodríguez and Estrada, 2022) prevail. The diversity in general methodological strategy is reflected in terms of data collection instruments, which mostly employ a combination of different procedures (observation, document analysis, questionnaires and so on), but with a common resource of interviews ($n$ = 19). This range of different techniques is understandable, given the consistency of evidence needed to infer innovation (Cranmer and Lewin, 2017). Further detail is given in the following sections.

## Analytical data

The reading of the articles included in the systematic review led to data being organised according to the three review questions, namely:

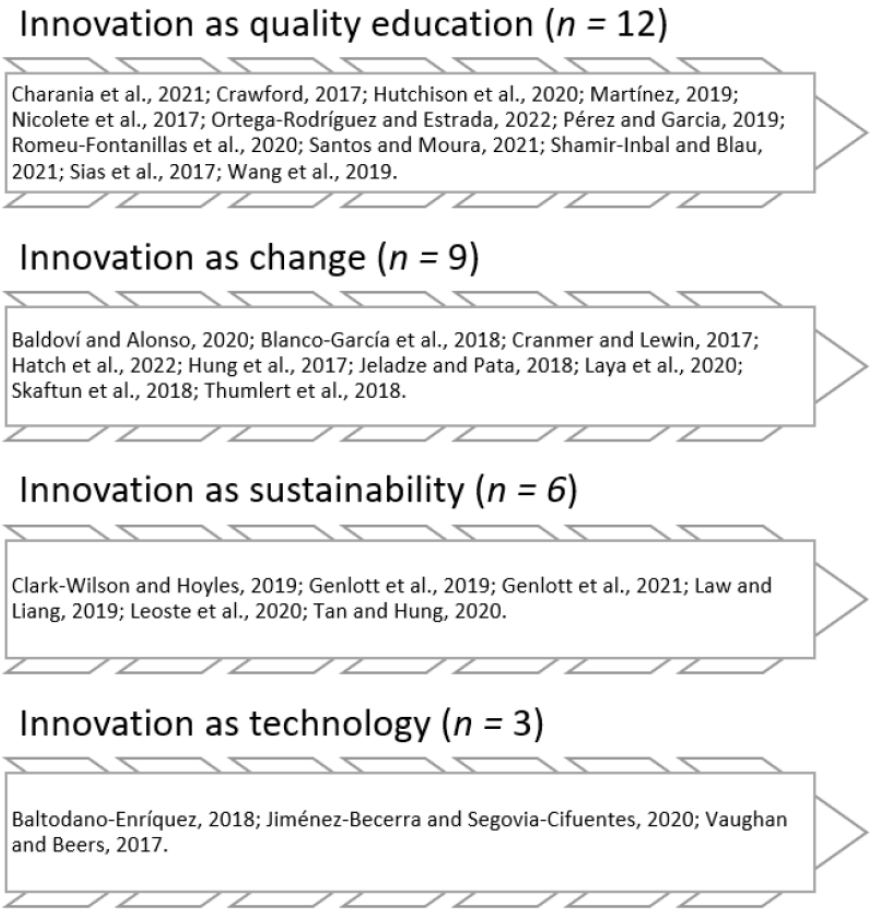
> RQ1: How does the existing literature conceptualise innovation in which the implementation of technology is a key part?
>
> RQ2: What school practices/activities result from innovation via the implementation of technology?
>
> RQ3: What can be learnt from current practices of innovation based on the implementation of technology?

Therefore, three main top-level categories were organised: (1) innovation, including a reflection on the articles' conceptualisation of it; (2) activity, which supports the identification of the disciplinary area in which activities were proposed and the tools mobilised; and (3) the reasoning behind the transformation, enabling an understanding of the drivers, constraints and challenges involved in the process of innovation when the implementation of technology is targeted. In the following subsections, we approach each category in detail.

## Innovation as a concept (RQ1)

The complexity of innovation as a multilayered concept is approached by the studies included in this review, which highlight different layers of it. Data extraction resulted in the identification of four rationales (subcategories) concerning the way the topic of innovation was approached in the papers: (1) innovation as quality education, where the core debate concerns the ways in which change improves learning environments; (2) innovation as change, with a focus on the processes and actors involved; (3) innovation as sustainability, including dimensions of scale, diffusion and transformation; and (4) innovation as technology, for which the potential of the tools represents the added value to innovate. Figure 3 shows all studies by category.

**Figure 3. The rationale of innovation in the reviewed literature**




### *Innovation as quality education*

Studies involving innovation as quality education are generally concerned with enhancement of students' achievements, and to a greater extent discuss notions of school improvement (for example, Crawford, 2017), meaningful learning (for example, Martínez, 2019) and teacher effectiveness (for example, Sias et al., 2017). As Nicolete et al. (2017) state, we are now living in new circumstances that demand that new teaching methodologies be found to connect to the environment shaping the landscape outside schools, and there is, therefore, a consistent turn to different emerging technologies. Crawford (2017) exploits the concept of Web 2.0 and its incorporation into formal education, which the author refers to as School 2.0, for instance.

Creativity is referred to as a key factor when innovation is aligned with the broad goal of improving education quality (Hutchison et al., 2020). In this sense, active methodologies acquire centrality in pedagogical practices due to their potential to globally foster the participation of those involved in

teaching/learning activities (for example, Santos and Moura, 2021; Shamir-Inbal and Blau, 2021). By enabling such practices, learning results are considered to be more meaningful (for example, Wang et al., 2019). Yet added responsibility is placed on teachers, who should be prepared to cultivate their students' motivation to learn (Pérez and Garcia, 2019). When committed to innovation, teachers become vectors of further innovative action (Romeu-Fontanillas et al., 2020). Much of the rationale in this theme concerns the idea that learners are not simply consumers of ICT, but creative producers of related artefacts, and therefore of their own learning and cultural expression (Charania et al., 2021).

### *Innovation as change*

The rationale of innovation as change considers in depth how the school culture works, focusing on the relationship of the different actors involved (Hung et al., 2017) and embracing the importance of context and history as important elements for the process of transformation (Skaftun et al., 2018). Therefore, the particularities of location are examined and assessed as pivotal in understanding the processes of change (Blanco-García et al., 2018). For the studies which take this perspective, quality education is obviously also understood as an end to achieve (Baldoví and Alonso, 2020), although their conception of innovation revolves more strongly around the idea of change. It is thus important to state that the different rationales proposed in this analysis are closely connected. Studies are placed into one subcategory or another according to the weight attributed to the elements that support each rationale.

Considering innovation as processes of change means that the complexity of environments in which education operates (Jeladze and Pata, 2018) and the role technology plays need to be acknowledged, prompting the emergence of new practices and approaches in terms of teaching and learning (for example, Laya et al., 2020). This happens regardless of the fact that what matters is how pedagogy is shaped rather than the instruments it incorporates (Cranmer and Lewin, 2017). Within this topic, the issue of educational reforms as a catalyst for change is raised (Baldoví and Alonso, 2020) in light of the incorporated means of operation, that is, action on a continuum from an empirical rationale to coercive-power strategies (Thumlert et al., 2018). The various modus operandi of change imply differences in the way practices are transformed; the diffusion of innovation can be perceived as a process of becoming in the context of lateral and vertical moves (Hung et al., 2017).

Successful innovation in the dimension of change is rooted in deep reflection on beliefs and practices (Thumlert et al., 2018), with professional identity being altered (Baldoví and Alonso, 2020), including that of leadership (Laya et al., 2020). The nature of innovation is context-oriented, although dialogically related to global history, and contained within a timescale that is likewise locally experienced (Skaftun et al., 2018) and presupposes a movement of becoming for which the character of the transition is forged among subjects, rather than aimed at them or their relationships (Hung et al., 2017). Adaptation is a key feature of the process (Jeladze and Pata, 2018), with innovation being understood not as a product, but as a new way to do things (Laya et al., 2020). This is why pedagogies are seen as fundamental for sustainable innovation (Cranmer and Lewin, 2017).

### *Innovation as sustainability*

A group of six other studies approach innovation as sustainability, problematising aspects of scale, diffusion and transformation of practices. They are strongly informed by Rogers's (2003) diffusion of innovation theory and they highlight aspects concerning the characteristics of innovation (Genlott et al., 2021) and the complexity involved in the adoption of new teaching and learning practices (for example, Law and Liang, 2019), as well as discussing how agendas mediate the incorporation and scaling of innovation (Leoste et al., 2020). According to Leoste et al. (2020), introducing technological innovations in education requires novel teaching and learning practices, which can only be achieved if teachers show readiness to implement technology-enhanced learning. Only then does the issue of sustainability emerge, a dimension which has been less targeted by research (Clark-Wilson and Hoyles, 2019).

On the grounds of sustainability, Genlott et al. (2019) recall that innovations are not necessarily fixed entities, but proposals for change that are susceptible to evolving and transforming in related processes of diffusion. Accordingly, Law and Liang (2019) add that the plastic nature of innovation is somehow shaped by the pedagogical practices of teachers and is ultimately the result of teachers' engagement in processes such as technology-enhanced pedagogical innovation. This means that human agency is at the core of technological transitions (Law and Liang, 2019). The locale, as observed in the rationale of

innovation as change, plays a special role in the way in which novelty is translated. In this regard, Tan and Hung (2020) affirm that schools adapt innovation given their needs and contexts (agendas), investing in a theoretical framework that reveals language as having multiple, contested meanings, while sustaining the diverse character of innovation.

The processes of scaling and diffusion in innovation must be considered in light of the different powers guiding the agendas, with the assumption that more common models of scaling work as top-down cascades (Clark-Wilson and Hoyles, 2019), a trend which some of the practices discussed in these studies seem to contradict. Conditions for scaling up innovation are mentioned, with consideration given to aspects such as change in work processes, investment in technical devices and the need for applied leadership (Genlott et al., 2021). While Tan and Hung (2020) point out that scaling innovations involve different levels of education – micro (teachers), meso (school) and macro (structural) – Law and Liang (2019) corroborate the fact that methodologies which favour the active engagement of all stakeholders who are part of teaching and learning activities can increase the challenge of achieving innovation effectiveness.

### *Innovation as technology*

Finally, a set of three studies focus on innovation as technology, meaning that they conceive novelty as resulting from the direct implementation of technology in educational practices. There is a recognised divide in the use of technology in school, justified by a sense of students' intense exposure to digital devices (Vaughan and Beers, 2017). Nevertheless, digital technologies, such as tablets, are understood in these studies as tools to foster meaningful learning environments and potentially restructure traditional teaching styles (Baltodano-Enríquez, 2018). This literature is sensitive to an over-problematisation of technology as tools. It places ICT as mechanisms which are useful for transforming social practices, with schools having an important role in promoting change regarding these experiences (Jiménez-Becerra and Segovia-Cifuentes, 2020). The general rationale seems to revolve around professional development as being purposefully focused on the resource of targeted tools, thus moving beyond simply envisioning change in pedagogy (Vaughan and Beers, 2017).

## The characteristics of activities resulting from innovation via the implementation of technology (RQ2)

A founding principle of our systematic literature review, corresponding to our inclusion criteria, was that studies should cover an empirical dimension in their discussion of innovation, with a focus on activities or original research implying possible innovative action in the school setting, oriented by the implementation of technology. In this subsection, we detail the actions centred on by the studies, with the aim of apprehending what innovation concretely means according to the given literature.

### *Context of activities*

The targeted interventions or research projects carried out are plural in character, with a range of initiatives or research, from small-scale action focused on one school only (for example, Pérez and Garcia, 2019) to transnational projects involving more than 10 countries (Cranmer and Lewin, 2017). Moreover, studies were identified for which the innovative projects under analysis encompassed more than one initiative (Hung et al., 2017), with a few instances of a cross-country perspective (for example, Hatch et al., 2022). In one very specific case, the innovation investigated was enabled by a central actor, the teacher, as they were recognised as outstanding (Romeu-Fontanillas et al., 2020).

Most of the innovation initiatives targeted by the studies included in our review involved practices in more than one school setting ($n$ = 24), either at the municipal level (for example, Skaftun et al., 2018) or the regional/national level (for example, Jiménez-Becerra and Segovia-Cifuentes, 2020). This means that only four studies were based on a single school, with a notable common interest in innovation – implementing technology in order to enhance student outcomes (for example, Santos and Moura, 2021).

Regarding the (content) area of projects/research under focus, primary education seems to be the preferred field for experimentation ($n$ = 8). Interventions often include embedding technology into pedagogical strategies, especially ICT, under the assumption that it can transform practices and improve

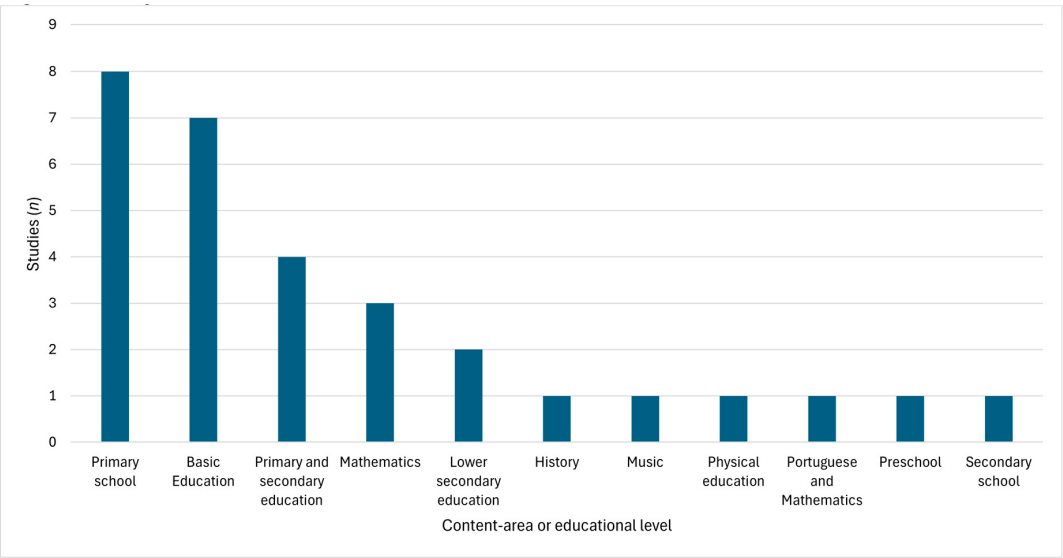
student outcomes. There are actions which target specific content learning, such as literacy (for example, Genlott et al., 2021), while other projects approached cross-disciplinary learning involving, for example, English, literacy, ICT, and critical and creative thinking (Hutchison et al., 2020).

Attention across disciplines is also at the core of identified innovative projects that take place during basic education (primary and lower secondary education, that is, ISCED 1 and 2) ($n$ = 7). In this case, a number of tools and strategies are set up: implementation of a 1:1 iPad to transform learning of Grades 4 through 8 via new pedagogical practices (Thumlert et al., 2018); the inception of a network of schools whose educational activities include programming and robotics in teaching practices (Laya et al., 2020); and professional development focused on leveraging innovation by showcasing ongoing practices (Sias et al., 2017), among others.

Four studies report on research centred on action involving both basic and secondary education (ISCED 1, 2 and 3). They share analysis of innovation deriving from external programmes, meaning that the authors were not directly involved in any of the projects or interventions, which may explain the broad cross-level approach. Two of these studies analyse initiatives with the purpose of reflecting on possible new school models, while being focused on processes of replication and scaling of innovation (Hatch et al., 2022; Tan and Hung, 2020), although the reason for change seems to be the focus for one of them (Hatch et al., 2022). Likewise, Law and Liang (2019), after exploring the character of change in fostering innovative educational action for a network of 10 special education schools, concentrate on the identification of regime-level changes to examine insights concerning the scalability of technology-enhanced learning innovations. Finally, Jeladze and Pata's (2018) work thoroughly explores the response of school leaders, teachers and students from 13 countries to improvements needed regarding the use of technologies for teaching and learning.

When specific disciplines are at the core of explored innovation projects, mathematics stands out, with three instances (for example, Nicolete et al., 2017). Action centred on content is driven by the purpose of transforming learning into something more meaningful with the mediation of technology. Different projects foresee the relevance of collaborative work, with teachers' professional development being a central aim for successful and sustainable initiatives. Other discipline-oriented innovation action involves the teaching of Portuguese (Santos and Moura, 2021), music (Crawford, 2017), history (Pérez and Garcia, 2019) and physical education (Martínez, 2019). They all consistently rely on a view of *innovation as quality education*, whereby these actions aim to improve the overall school culture. A full description of the projects/research area of the interventions (content area, or level of education, if referring to multiple disciplines) is given in Figure 4.

**Figure 4. Projects/research area of intervention**



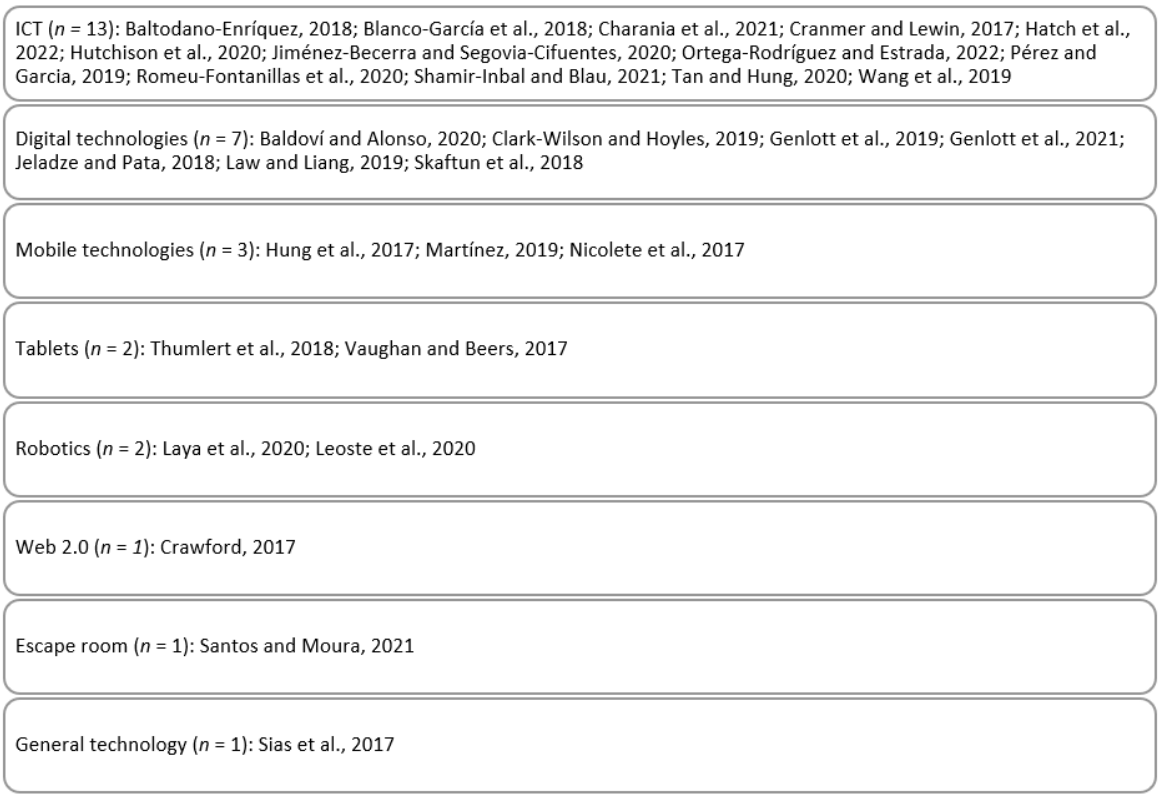
### *Technological tools used in activities*

An analysis of the technological component underpinning innovation interventions in schools within the included studies reveals a generalist discourse around ICT (*n* = 13). Studies tend to corroborate ICT as a tool that enables (for example, Cranmer and Lewin, 2017), assists (for example, Skaftun et al., 2018) and, less frequently, fully integrates strategies that nurture change in learning environments (for example, Baltodano-Enríquez, 2018). Together, they reaffirm the role of technology as a pedagogical means rather than an end. These studies value the way technology can promote personalised education (Hatch et al., 2022) and insist on the potential of participatory or active methodologies (Pérez and Garcia, 2019), while acknowledging that innovation comes up against a level of resistance to change (Shamir-Inbal and Blau, 2021) and that success requires a context-oriented adaptation (Tan and Hung, 2020).

Digital technology is the preferred discourse of another seven cases, the reasoning of which is not dissimilar to the general reports mentioning ICT. Digital technologies are also tackled regarding their potential for personalised and student-centred approaches (Law and Liang, 2019; Skaftun et al., 2018); time is understood as a necessary component in the assimilation of innovation (Vaughan and Beers, 2017); and professional development remains as a full dimension (Clark-Wilson and Hoyles, 2019), impacting the possibility of rethinking pedagogy to enable effective integration of technology (Genlott et al., 2019, 2021).

The remaining 10 studies reference technology by way of mobile devices (*n* = 3) (for example, Hung et al., 2017), with another two specifying the use of iPads (for example, Vaughan and Beers, 2017). Robotics (Laya et al., 2020; Leoste et al., 2020) is the core of innovation of two other studies. Finally, one study reports on technology in a broad sense (Sias et al., 2017), one discusses Web 2.0 technologies (Crawford, 2017) and a final case annotates a strategy rather than a tool – the escape room, as in gamification learning (Santos and Moura, 2021). A full view of the core reference of technology in the studies is shown in Figure 5.

**Figure 5. Technology core reference in the reviewed studies**



## Why is innovation relevant? (RQ3)

The reasoning behind innovation within technology-led practices in the literature reviewed is not unique or new. As discussed in this article, the reasons involve a series of well-established considerations in the literature in general: the character of innovation is clearer when technology is applied (Baldoví and Alonso, 2020); technology supports the implementation of active pedagogies and related methodologies (for example, Baltodano-Enríquez, 2018); technology fosters student agency and meaningful learning (for example, Jeladze and Pata, 2018); and technology enables broadened networks of collaboration with different educational stakeholders (parents, communities, industry and so on) (for example, Shamir-Inbal and Blau, 2021). Moreover, innovation through the implementation of technology is considered both a need and a consequence deriving from an information society framework which requires students to adapt to its demands, including acquiring appropriate skills (Jiménez-Becerra and Segovia-Cifuentes, 2020).

The reasons enumerated for promoting innovation in the school setting are reflected on, in tandem with the distinct projects/research goals, and against a scenario where drivers, constraints and challenges are sometimes identified as well. Importantly, as recognised by Law and Liang (2019), technological innovation is only one element in the complex web of changes in a given landscape. However, as our review corroborates, it has been very frequently used in schools, possibly because of its plastic nature, that is, the fact that technology can be applied to different school levels and distinct disciplines.

### *Technology-led innovation: a word on drivers*

The studies covered in this systematic review suggest three key drivers of innovation via the implementation of technology: leadership, support networks and professional development.

The debate on leadership is a central one, and it has distinct aspects in light of the interventions under focus. According to Genlott et al. (2021), when innovation is at stake, sustained leadership requires going beyond individuals' leadership skills to create and nurture shared goals throughout developmental processes (see also Ortega-Rodríguez and Estrada, 2022). Top management needs to be motivated (Genlott et al., 2019) and confident in the quality of the adopted methods, and must commit to all stages of implementation (Genlott et al., 2021; Law and Liang, 2019). Wang et al. (2019) call attention to leadership playing a role, not only concerning the provision of resources, but also providing room for experimentation, considering issues of time and teachers' autonomy. Finally, Hung et al. (2017) associate the diffusion of innovation with the identity projected by a particular innovation and the leaders in charge of it, who, together with teachers, are responsible for enacting it.

Support networks make up another distinct aspect of sustainable innovation. These networks are depicted as groups with whom teachers can discuss ongoing practices, exchange ideas and obtain feedback and support, both in terms of pedagogy and technical issues (for example, Leoste et al., 2020; Thumlert et al., 2018). These networks are forged within working groups, and they include key figures such as the school's technologist (Leoste et al., 2020), initiative champions (Thumlert et al., 2018) or ultimately other teachers, who together engage in movements of collegiality, sharing experiences (Vaughan and Beers, 2017) and safe spaces for experimentation (Tan and Hung, 2020). These networks support professional development, which is believed to favour teachers' engagement in innovative practices, through building agency and competences (for example, Wang et al., 2019). As Crawford (2017) puts it, the provision of professional development, such as continuing training, can help teachers increase their skills and confidence to apply changes in their work culture.

### *Technology-led innovation: a word on constraints and challenges*

As regards constraints and challenges concerning the implementation of innovation in education, the core barrier concerns infrastructure issues. Poor internet connection (for example, Charania et al., 2021), insufficient devices (for example, Shamir-Inbal and Blau, 2021) and insufficient technological infrastructure (Hung et al., 2017; Nicolete et al., 2017) are some of the examples. Following this sense of precarity, a possible lack of expertise (technical and pedagogical) comprises yet another issue. Baltodano-Enríquez (2018) states that both teachers and students have a mismatch between their regular use of technology and its appropriation in learning, while Law and Liang (2019) mention participants having difficulty in solving emerging problems concerning the tools used in implementing innovation.

Notwithstanding the technological dimension, there are reports of innovation being overdue because of pedagogical difficulties in applying student-centred approaches (Hatch et al., 2022), or in literally embedding technology into pedagogy (Wang et al., 2019).

Considering that innovation takes time, this is pointed out as another major dimension of challenge. Genlott et al. (2021) refer to teachers' hesitation to join an innovation initiative due to being concerned about time/workload. The time-consuming aspect of transformation in teaching is also found in reports of teachers limiting experimentation in favour of faster testing (Leoste et al., 2020), and that without addressing a different distribution of activities in space and time, changing methodologies becomes harder (Blanco-García et al., 2018). The problem of time may even be extrapolated to the school environment when other agents, such as parents, are targeted to become more engaged in the learning processes too, with frustration arising in terms of participation (Hutchison et al., 2020).

Overall, the literature addressing innovation in schools via the implementation of technology seems to present a certain balance between first-order (tools infrastructure, technical support and so on) and second-order barriers (beliefs, pedagogical practices and so on) to integrating technology (Genlott et al., 2019). These barriers are felt differently in each context – as discussed, innovation is forged in situ (Hung et al., 2017). Being aware of their existence and variety might support further innovative intervention, with a contingency plan in place. Moreover, an awareness of global factors is critical to achieve innovation as desired. Rather than resistance to change (Sias et al., 2017), there is evidence that the meaningful transformation of practices involves apprehending how local change can be achieved without compromising systemic policies and pressures concerning curriculum and evaluation regulations (Blanco-García et al., 2018; Hatch et al., 2022; Hung et al., 2017; Thumlert et al., 2018). Without perceiving technology-led innovation as added value to quality education, it is very unlikely that teachers and other stakeholders will adhere to the paradigm of change, with all its nuances (Jiménez-Becerra and Segovia-Cifuentes, 2020; Leoste et al., 2020; Shamir-Inbal and Blau, 2021).

## Discussion

The major contribution of this review lies in its potential to answer concretely how technology-led innovation is adopted into everyday life in schools. Having examined the nature of the action in the projects/research discussed, and their related features, as well as rationales for innovation, the architecture of such innovation processes can now be outlined. Not surprisingly, there is no stable definition of innovation. The definition is not exactly blurred as suggested in the related literature (European Commission, 2018), but it encompasses diverse, context-oriented contours, as proposed by Orlando (2014). Innovation, as this review suggests, does not translate into tools per se, although they facilitate the development of new practices, as argued by Jo et al. (2014).

First, innovation tends to emerge from a concrete, identified need in work contexts and the desire to promote change, either on a small or a large scale, as argued by Rogers (2003). In line with other studies (Baruch and Erstad, 2018; Chandra and Mills, 2015; Dron, 2018; OECD, 2010), the works included in this review suggest that innovation is usually driven by the intention to enhance students' results through changes in the school culture (Leoste et al., 2020; Ortega-Rodríguez and Estrada, 2022), regularly encourages active methodologies and favours active interaction among stakeholders in teaching and learning (Law and Liang, 2019; Santos and Moura, 2021; Shamir-Inbal and Blau, 2021). It is thus not surprising how often inquiry-related vocabulary is used in the literature (inquiry-based learning, inquiry-driven learning, teacher-as-inquirer) (Hung et al., 2017; Hutchison et al., 2020; Thumlert et al., 2018).

As demonstrated by the targeted literature, innovation in schools is sensitive to the place, its history and its own time (Skaftun et al., 2018; Tan and Hung, 2020). The same processes have different outcomes in distinct spaces, with adaptation being a key feature in scaling innovation (Clark-Wilson and Hoyles, 2019; Genlott et al., 2019). Employing innovation can emerge as a strategy to transform learning environments in vulnerable contexts (Thumlert et al., 2018), or as an intention to provide quality education to schools in rural or remote areas (Crawford, 2017). Innovation is thus also strongly inclusive in nature.

Moreover, the approach to working initiatives in the literature seems to prove that there is no such thing as a one-size-fits-all project. On the contrary, the interventions studied illustrate a huge diversity in topic and strategy – albeit with a similar approach in methodology. The methodologies play a vital role, as there is an understanding that what counts is changes to pedagogy within a technological rationale

(Baldoví and Alonso, 2020; Blanco-García et al., 2018; Cranmer and Lewin, 2017). In this regard, despite some criticism in the specialised literature about technology resourcing in education being mostly superficial (Illomäki and Lakkala, 2018), this review encompasses several initiatives in which reflection on intrinsic features of pedagogy extends beyond tool selection, integrating reasoning into either the epistemological or the practical aspects of teaching and learning issues (Skaftun et al., 2018; Tan and Hung, 2020), and thus showing potential to sustainably foster innovation (OECD, 2010; UNESCO, 2023).

The identification of drivers and barriers is not a surprising feature of this review. The literature addressed highlights aspects in line with previous studies which suggest that collegiality and interdisciplinary networks of support promote better outcomes for technology-led innovation (Lakkala and Illomäki, 2015; Orlando, 2014), while barriers can be systematised as first order (infrastructure) and second order (values and beliefs) (Bingimlas, 2009; Chandra and Mills, 2015). In this respect, it should be noted that innovation in schools is highly dependent on human agency, as argued by Dron (2018), which may explain the extensive concern that many studies showed with professional development (Clark-Wilson and Hoyles, 2019; Crawford, 2017; Martínez, 2019; Vaughan and Beers, 2017).

For this review, our search was limited to two databases, and we concentrated on articles emerging from the fields of social sciences and educational research, as well as aiming for open-access materials. We are aware that this decision may have hindered the inclusion of other eligible literature. Nevertheless, our chosen approach envisaged including publications from fields closely related to that of educational sciences and broadly available to the scientific community. Notably, a consistent number of publications persisted despite our decision to limit the field areas. The option to exclude materials such as theses, books, book chapters, proceedings or similar may also be viewed as a constraint. This decision is in tandem with the open-access factor, which informs our eligibility criteria. Finally, the reason for restricting publications to a period of six years could be questioned. This was based on the belief that innovation is ever-changing in character (UNESCO, 2023), especially when technology is involved. Thus, a shorter, recent period of time was chosen due to the wish to capture the most cutting-edge aspects of innovation. Also central in this review is that we were not interested in action taken exclusively in the context of the Covid-19 pandemic (Ulla and Perales, 2021). Such activities were understood as being emergency in character and not sustained enough in the framework of innovation.

## Conclusion

This article corroborates the idea of innovation as a complex and multidimensional concept. Despite differences identified concerning the focuses of the diverse interventions covered, there are a few characteristics that help shed light on how technology-led innovation in schools can be implemented. It is promising that innovation mostly seems to emerge as a response to challenges identified in local/regional contexts. It means that action is underpinned by concrete needs and embraces the human factor that forms the unique character of the school environment. Moreover, rather than relying on simplistic notions of change, innovation in schools, as reported by the literature reviewed here, acknowledges and scaffolds central aspects for promoting new ways to conduct teaching and learning processes. Specifically, the exploitation of innovation, as based on technology, appears to imply a thorough reflection on the role of pedagogy and the active engagement of different education stakeholders, including those outside the core school structure, such as parents, communities, enterprises and politicians.

The other positive aspect revealed in this review is related to the assumption that innovation in school is sensitive to a place, its history and time. Probably because the debate on scaling and diffusing innovation has matured sufficiently to affirm that there is no such thing as a one-size-fits-all solution to emerging challenges in education, initiatives around sustainability garner considerable attention to the role played by specificities within general architectures of change. The activities under focus proved to be diverse, involving various levels of education and a considerable amount of interdisciplinary work, probably fostered by the flexible character of technology, which can be mobilised in different ways according to the profile of targeted audiences.

Innovation, as led by the implementation of innovation, seems to be a growing phenomenon. While constraints mainly concern infrastructure issues, successful action appears to benefit from the combination of three central aspects: sustained leadership, guiding transformation processes; support networks, providing room for collective collaboration; and professional development, fostered by the

qualification of teachers in terms of skills and confidence. The advancement of novel practices implies the recognition of added value for pedagogical practices, broadly implying the feeling that implemented changes do not compromise systemic policies. Overall, innovation is a process that encompasses the entire educational community, and technology-led educational innovation is just one – notably strong – side of the coin. Our systematic literature review opens avenues to an understanding of the ways in which implementing technology may support processes of innovation, showing the diversity of current practices in terms of discipline and level of education, while revealing a growing maturity in the pedagogical thinking that feeds rationales for transformation in education. The fact that we focused only on peer-reviewed articles may have hindered access to other interesting actions in this domain. Future research involving a broader context could also feed this debate by digging into the interrelatedness of drivers for innovation and the barriers to enhancing it. An in-depth analysis of the nature of drivers, barriers and challenges, for example, could lead to a framework for supporting further innovation prompted by the implementation of technology.

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# Declarations and conflicts of interest

## Research ethics statement

Not applicable to this article.

## Consent for publication statement

Not applicable to this article.

## Conflicts of interest statement

The authors declare no conflicts of interest with this work. All efforts to sufficiently anonymise the authors during peer review of this article have been made. The authors declare no further conflicts with this article.

# References

Abelha, M., Fernandes, S., Mesquita, D., Seabra, F. and Ferreira-Oliveira, A.T. (2020) 'Graduate employability and competence development in higher education – A systematic literature review using PRISMA'. *Sustainability*, *12*, 5900. [CrossRef]

Baldoví, M.I.P. and Alonso, A.S. (2020). 'Technologies and organizational culture in schools: The labor relations' uberization?'. *Pixel-Bit: Revista De Medios Y Educacion*, *58*, 161–79. [CrossRef]

Baltodano-Enríquez, M. (2018). 'Analysis and implications of the results of a teacher leader's pedagogical practices in a pilot test on innovation in conectándonos project'. *Revista Electronica Educare*, *22* (2), 4. [CrossRef]

Baruch, A.F. and Erstad, O. (2018) 'Upbringing in a digital world: Opportunities and possibilities'. *Technology, Knowledge and Learning*, *23*, 377–90. [CrossRef]

Bingimlas, K.A. (2009) 'Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature'. *Eurasia Journal of Mathematics, Science and Technology Education*, *5* (3), 235–45. [CrossRef] [PubMed]

Blanco-García, M., Ramos-Pardo, F.J. and Sanchez-Antolin, P. (2018) 'State of the integration of ICT in secondary schools: A case study'. *Digital Education Review*, *34*, 27–43.

Boland, A., Cherry, G. and Dickson, R. (2014) *Doing a Systematic Review: A student's guide*. London: Sage.

Burden, K., Kearney, M., Schuck, S. and Hall, T. (2019) 'Investigating the use of innovative mobile pedagogies for school-aged students: A systematic literature review'. *Computers & Education*, *138*, 83–100. [CrossRef]
CASP (Critical Appraisal Skills Programme). (2018) *CASP Qualitative Studies Checklist*. Accessed 1 July 2022. https://casp-uk.net/checklists/casp-qualitative-studies-checklist-fillable.pdf.
Chandra, V. and Mills, K.A. (2015) 'Transforming the core business of teaching and learning in classrooms through ICT'. *Technology, Pedagogy and Education*, *24* (3), 285–301. [CrossRef]
Charania, A., Bakshani, U., Paltiwale, S., Kaur, I. and Nasrin, N. (2021) 'Constructivist teaching and learning with technologies in the COVID-19 lockdown in Eastern India'. *British Journal of Educational Technology*, *52* (4), 1478–93. [CrossRef]
Clark-Wilson, A. and Hoyles, C. (2019) 'A research-informed web-based professional development toolkit to support technology-enhanced mathematics teaching at scale'. *Educational Studies in Mathematics*, *102* (3), 343–59. [CrossRef]
Cranmer, S. and Lewin, C. (2017) 'iTEC: Conceptualising, realising and recognising pedagogical and technological innovation in European classrooms'. *Technology Pedagogy and Education*, *26* (4), 409–23. [CrossRef]
Crawford, R. (2017) 'Rethinking teaching and learning pedagogy for education in the twenty-first century: Blended learning in music education'. *Music Education Research*, *19* (2), 195–213. [CrossRef]
Dron, J. (2018) 'Smart learning environments, and not so smart learning environments: A systems view'. *Smart Learning Environments*, *5*, 25. [CrossRef]
Ellis, V., Correia, C., Turvey, K., Childs, A., Andon, N., Harrison, C., Jones, J. and Hayati, N. (2023) 'Redefinition/redirection and incremental change: A systematic review of innovation in teacher education research'. *Teaching and Teacher Education*, *121*, 103918. [CrossRef]
European Commission. (2018) *Study on Supporting School Innovation Across Europe: Final report*. Luxembourg: Publications Office of the European Union.
Genlott, A.A., Gronlund, A. and Viberg, O. (2019) 'Disseminating digital innovation in school-leading second-order educational change'. *Education and Information Technologies*, *24* (5), 3021–39. [CrossRef]
Genlott, A.A., Grönlund, Å, Viberg, O. and Andersson, A. (2021) 'Leading dissemination of digital, science-based innovation in school – a case study'. *Interactive Learning Environments*, *31* (7), 4171–81. [CrossRef]
Gough, D., Oliver, S. and Thomas, J. (2012) *An Introduction to Systematic Reviews*. London: Sage.
Hatch, T., Corson, J. and Van den Berg, S.G. (2022) 'New schools in New York City and Singapore'. *Journal of Educational Change*, *23* (2), 199–220. [CrossRef]
Hung, D., Toh, Y., Jamaludin, A. and So, H.J. (2017) 'Innovation becoming trajectories: Leveraging lateral and vertical moves for collaborative diffusion of twenty-first century learning practices'. *Asia Pacific Journal of Education*, *37* (4), 582–600. [CrossRef]
Hutchison, K., Paatsch, L. and Cloonan, A. (2020) 'Reshaping home–school connections in the digital age: Challenges for teachers and parents'. *E-Learning and Digital Media*, *17* (2), 167–82. [CrossRef]
Illomäki, L. and Lakkala, M. (2018) 'Digital technology and practices for school improvement: Innovative digital model'. *Research and Practice in Technology Enhanced Learning*, *13*, 25. [CrossRef]
Jeladze, E. and Pata, K. (2018) 'The model of self-organization in digitally enhanced schools'. *Interaction Design and Architectures*, *39*, 61–77. [CrossRef]
Jiménez-Becerra, I. and Segovia-Cifuentes, Y.D. (2020) 'Models of didactic integration with ICT mediation: Some innovation challenges in teaching practices'. *Culture Education*, *32* (3), 399–440. [CrossRef]
Jo, J., Park, K., Lee, D. and Lim, H. (2014) 'An integrated teaching and learning assistance system meeting requirements for smart education'. *Wireless Personal Communication*, *79*, 2453–67. [CrossRef]
Lakkala, M. and Illomäki, L. (2015) 'A case study of developing ICT-supported pedagogy through a collegial practice transfer process'. *Computers & Education*, *90*, 1–12. [CrossRef]
Law, N. and Liang, L.M. (2019) 'Sociotechnical co-evolution of an e-Learning innovation network'. *British Journal of Educational Technology*, *50* (3), 1340–53. [CrossRef]
Laya, N.F., Salguero, F.L. and Montilla, S.P. (2020). 'Design of knowledge and collaboration networks: A shared challenge'. *Virtualidad Educacion Y Ciencia*, *11*(20), 168–81. [CrossRef]
Leahy, S.M., Holland, C. and Ward, F. (2019) 'The digital frontier: Envisioning future technologies impact on the classroom'. *Futures*, *113*, 102422. [CrossRef]

Leoste, J., Heidmets, M., Ley, T. and Stepanova, J. (2020) 'Classroom innovation becoming sustainable: A study of technological innovation adoption by Estonian primary school teachers'. *Interaction Design and Architectures*, *47*, 144–66. [CrossRef]
Llorent-Vaquero, M., De Pablos-Pons, J. and Velez, I. (2023). 'Digital learning and public policy in schools: A transformative paradigm for a changing world'. *Policy Futures in Education*, *22*(4). [CrossRef]
Martínez, A.M. (2019) 'M-Learning in physical education: An innovation proposal in secondary education'. *Innoeduca-International Journal of Technology and Educational Innovation*, *5* (2), 167–77. [CrossRef]
Morgado, J.C., Lencastre, J.A., Freires, T. and Bento, M. (2021) 'Smart education as empowerment: Outlining veteran teachers' training to promote digital migration'. *Technology, Knowledge and Learning*, *26*, 897–916. [CrossRef]
Nicolete, P.C., Bilessimo, S.M.S., Cristiano, M.A.D., Simao, J.P.S. and Silva, J.B. (2017). 'Technology integration actions in mathematics teaching in Brazilian basic education: Stimulating STEM disciplines'. *Red-Revista De Educacion a Distancia*, *52*, 7. [CrossRef]
OECD (Organisation for Economic Co-operation and Development). (2010) *Inspired by Technology, Driven by Pedagogy: A systematic approach to technology-based school innovations*; Educational Research and Innovation Series; OECD. Accessed 15 October 2024. https://www.oecd-ilibrary.org/education/inspired-by-technology-driven-by-pedagogy_9789264094437-en.
Olvera-Fernández, J., Montes-Rodríguez, R. and Ocaña-Fernández, A. (2023) 'Innovative and disruptive pedagogies in music education: A systematic review of the literature'. *International Journal of Music Education*, *41* (1), 3–19. [CrossRef]
Orlando, J. (2014) 'Veteran teachers and technology: Change fatigue and knowledge insecurity influence practice'. *Teachers and Teaching: Theory and practice*, *20* (4), 427–39. [CrossRef]
Ortega-Rodríguez, P.J. and Estrada, F.J.P. (2022) 'Influential factors in the school improvement: A study case in Freinet schools'. *Revista Complutense de Educacion*, *33* (2), 181–9. [CrossRef]
Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E. and et al. (2021) 'The PRISMA 2020 statement: An updated guideline for reporting systematic reviews'. *Systematic Reviews*, *10*, 89. [CrossRef]
Pérez, P.C. and Garcia, A.P. (2019) 'The history professorship in the digital age: An experience in secondary education'. *Etic@net*, *19* (2), 171–93. [CrossRef]
Prenger, R., Tappel, A.P., Poortman, C.L. and Schildkamp, K. (2022) 'How can educational innovations become sustainable? A review of the empirical literature'. *Frontiers in Education*, *7*. [CrossRef]
Prieto, C.V. (2016) 'The role of ICT for supporting relationships between students: Evidence for Spain'. *Procedia – Social and Behavioral Sciences*, *228*, 123–30. [CrossRef]
Rogers, E. (2003) *Diffusion of Innovations*. New York: Free Press.
Romeu-Fontanillas, T., Guitert-Catasus, M., Raffaghelli, J.E. and Sangra, A. (2020) 'Mirroring learning ecologies of outstanding teachers to integrate ICTs in the classroom'. *Comunicar*, *28* (62), 31–42. [CrossRef]
Santos, I.L. and Moura, A. (2021) 'Educational escape room: A gamification strategy in the teaching and learning process'. *Revista Educaonline*, *15* (1), 134–52.
Schwab, K. (2016) *Fourth Industrial Revolution*. Geneva: World Economic Forum.
Shamir-Inbal, T. and Blau, I. (2021) 'Characteristics of pedagogical change in integrating digital collaborative learning and their sustainability in a school culture: e-CSAMR framework'. *Journal of Computer Assisted Learning*, *37* (3), 825–38. [CrossRef]
Sias, C.M., Nadelson, L.S., Juth, S.M. and Seifert, A.L. (2017) 'The best laid plans: Educational innovation in elementary teacher generated integrated STEM lesson plans'. *Journal of Educational Research*, *110* (3), 227–38. [CrossRef]
Skaftun, A., Igland, M.A., Husebo, D., Nome, S. and Nygard, A.O. (2018) 'Glimpses of dialogue: Transitional practices in digitalised classrooms'. *Learning Media and Technology*, *43* (1), 42–55. [CrossRef]
Tan, M.Y. and Hung, D.W.L. (2020) 'Models of innovation scaling in Singapore schools: Process objects as multi-level role clusters and outcomes – a multiple case study approach'. *Asia Pacific Education Review*, *21* (4), 553–71. [CrossRef]
Thumlert, K., Owston, R. and Malhotra, T. (2018) 'Transforming school culture through inquiry-driven learning and iPads'. *Journal of Professional Capital and Community*, *3* (2), 79–96. [CrossRef]
Tondeur, J., Braak, J., Ertmer, P.A. and Ottenbreit-Leftwich, A. (2017) 'Understanding the relationship between teachers' pedagogical beliefs and technology use in education: A systematic review of qualitative evidence'. *Educational Technology Research and Development*, *65*, 555–75. [CrossRef]

Tong, A., Fleeming, K., McInes, Oliver, S. and Craig, J. (2012) 'Enhancing transparency in reporting the synthesis of qualitative research: ENTREQ'. *BMC: Medical research methodology*, *12*, 181. [CrossRef]

Ulla, M.B. and Perales, W.F. (2021) 'Emergency remote teaching during COVID19: The role of teachers' online community of practice (CoP) in times of crisis'. *Journal of Interactive Media in Education*, *1* (9), 1–11. [CrossRef]

UNESCO (United Nations Educational, Scientific and Cultural Organization). (2023) *Global Education Monitoring Report Summary 2023: Technology in education: A tool on whose terms?* Paris: UNESCO.

Vaismoradi, M. and Snelgrove, S. (2019) 'Theme in qualitative content analysis and thematic analysis'. *Forum: Qualitative social research*, *20* (3), 1–14. [CrossRef]

Vaughan, M. and Beers, C. (2017) 'Using an exploratory professional development initiative to introduce iPads in the early childhood education classroom'. *Early Childhood Education Journal*, *45* (3), 321–31. [CrossRef]

Wang, L.Y., Victor, D.T.C. and Neo, W.L. (2019) 'Studying the enactment of School-Based Curriculum Development (SBCD) in Singapore'. *Educational Research*, *61* (3), 337–55. [CrossRef]