

Classroom dialogue and digital technologies: A scoping review

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Abstract This article presents a systematic scoping review of the literature focusing on interactions between classroom dialogue and digital technology. The first review of its type in this area, it both maps extant research and, through a process of thematic synthesis, investigates the role of technology in supporting classroom dialogue. In total, 72 studies (published 2000–2016) are analysed to establish the characteristics of existing evidence and to identify themes. The central intention is to enable researchers and others to access an extensive base of studies, thematically analysed, when developing insights and interpretations in a rapidly changing field of study. The discussion illustrates the interconnectedness of key themes, placing the studies in a methodological and theoretical context and examining challenges for the future.

Keywords Classroom dialogue · Talk · Collaboration · Digital technology · Edtech · Review

Highlights

- 72 studies, across 18 countries, mapped and analysed
- Characteristics of studies, including methodologies, determined
- Themes linking digital technologies and dialogue extrapolated
- Multiple affordances of technologies for enhancing dialogue evidenced
- Challenges of technology use, with dialogic pedagogy, identified

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1 Introduction

1.1 A systematic scoping review

This paper reports the first systematic scoping review of research that links school-based classroom dialogue and digital technology. While research on classroom talk and dialogue is well established, research into the use of digital technology in classrooms generally is a relatively new area; and research into interactions between classroom dialogue and technology is very recent. As this is the case, a scoping review is an appropriate tool for enabling the research community to access existing understandings evident in the literature.

Scoping reviews are a rigorous and transparent form of secondary research and have offered a popular approach to appraising, for example, healthcare evidence for a number of years (Levac et al. 2010). They involve collecting, evaluating and presenting available evidence (Arksey and O'Malley 2005). This is interpreted and analysed at a 'high level', which allows for the identification of clusters and gaps that can inform the focus of future research (Kitchenham et al. 2015). A stated strength of the methodology is its ability to identify the key features of a diverse body of research in a connected manner (Davis et al. 2009). Today, scoping reviews are an accepted means for reviewing educational research across a range of domains, particularly where those domains are 'breaking new ground' (e.g., DeLuca et al. 2015; McEvoy et al. 2015; Major and Watson 2017; O'Flaherty and Phillips 2015; Virtanen et al. 2017).

Other work that has reviewed studies related to Computer-Supported Collaborative Learning (e.g., Jeong and Hmelo-Silver 2016 and those included in a special issue of *Educational Psychologist*, 2013, 48, 1) has made a contribution to the development of theoretical frames associated with collaborative interaction in the context of technology use. This is fundamentally different, though perhaps complimentary, to the work undertaken in this review, as here the purpose is not to create or modify theoretical frames of understanding derived from specific studies. As explained both above and below, scoping reviews systematically examine a range of extant empirical work, presenting broad findings and relationships. Some studies take this further, contributing a thematic overview of the examined work; we have taken this path in the work presented in order to open up a 'space for dialogue' in our discussion.

This scoping review considers research that has a combined focus on classroom dialogue, dialogic pedagogies and digital technology, by identifying and reviewing 72 studies in the field. Such work is important given there is increasing professional and research interest in the role of dialogue in student learning (see below), and as interest in the role of technology in supporting and enhancing dialogue continues to grow (in part motivated by the increasing pervasiveness of digital technologies, such as tablet computers, capable of supporting classroom interaction; Major et al. 2017). Further, it is reasonable to assume that significant resources – not only financial but also, for instance, in terms of time – are likely to be invested (by schools, research organisations and other interested parties) in this area in the near future, and evidence is required for those making such investments. Thus, by combining these two themes in a single comprehensive review for the first time, stakeholders are able to draw upon a synthesis of existing research as a framing device for reviewing new developments in a rapidly changing field. In essence, this review is an interpreted map of existing understandings, where the underlying geography is the basis upon which landscapes might be reimagined.

The purpose of the review is twofold:

- i) to provide an accessible and summarised overview of extant studies (published between 2000 and 2016) to enable policy makers, practitioners and researchers to make effective use of the findings of existing research (Arksey and O'Malley 2005; Levac et al. 2010);
- ii) through a process of thematic synthesis, to identify opportunities and challenges in using digital technologies to enhance productive classroom dialogue. Thus, the conventional parameters of a scoping review are extended.

It should be made clear that this study is not a systematic literature review or meta-analysis. Systematic reviews are used to answer precise questions, with defined methodologies to assess and discuss study quality (O'Brien et al. 2010). Scoping reviews, on the other hand, enable a higher-level categorisation of knowledge (Kitchenham et al. 2015) in a way that supports a broader investigation and analysis of research with varying intentions and designs (Levac et al. 2010). In addition, this review is not intended to offer an exhaustive review of all literature involving student collaboration/communication and the use of digital tools; it is limited to studies with a specific focus on *school-based classroom dialogue and digital technologies*.

1.2 The connected fields of study

The examination of classroom talk has a long and rich tradition, including significant contributions from researchers working in the fields of Conversation Analysis, Discourse Analysis and Corpus Linguistics. For those considering learning from a socio-cultural perspective (Vygotsky 1962, 1978), the early work of Barnes (1976) is significant in defining a type of talk seen as effective for thinking and learning, and is part of a clear trajectory in academic discourse (Alexander 2008; Howe and Abedin 2013; Mercer and Dawes 2014; Schwarz and Baker 2016). This research into 'Exploratory Talk' (Barnes 1976, 2008; Mercer 1995, 2000), or 'Accountable Talk' (Wolf et al. 2006), has now become central in the examination of classroom dialogue and the pedagogical approaches that promote it. Shor and Freire (1987) offer the following definition:

Dialogue is a means to transform social relations in the classroom, and to raise awareness about relations in society at large. Dialogue is a way to recreate knowledge as well as the way we learn. It is a mutual learning process where the teacher poses critical problems for inquiry. Dialogue rejects narrative lecturing where teacher talk silences and alienates students. (Shor and Freire 1987, p.11)

Dialogue is more than 'just talk' (Cazden 2001; O'Connor and Michaels 2007); it is talk that is productive for learning in classroom settings or school subjects. With a focus on the sharing and evaluation of ideas, building ideas collectively, reasoning, providing justifications and elaborations, and employing evidence to support arguments, dialogue is intended to enable an understanding of one another's knowledge and perspectives, with the promise of their reconciliation (Michaels and O'Connor 2012).

Proponents of dialogic pedagogical practices maintain that classroom dialogue is "central to the meaning making process and thus central to learning" (Mortimer and

Scott 2003: 3). Here, ‘classroom dialogue’ is seen by some commentators as more dialectic than dialogic (see Wegerif 2008), as the eventual purpose is often pre-determined by the enculturating direction of the curriculum. Nevertheless, the idea of ‘dialogic teaching’, as proposed by Alexander (2008), emphasises classroom dialogue as a process through which pupils learn to reason, discuss, argue, and explain in order to develop their higher order thinking as well as their articulacy.

Research has demonstrated how students who were taught dialogic skills improved in their reasoning and collaborative problem solving (Howe and Abedin 2013; Kuhn 2015, 2016; Mercer 2013; Mercer et al. 2004). Dialogic pedagogy has a direct participatory imperative, seeking to legitimise and develop contributions from all parties in classroom interactions (Nystrand et al. 2003); a central intention is “to foster learner agency, whereby students collaborate with others in seeking understanding, building from their own ideas and allowing other ideas and opinions to mediate and modify their thinking” (Flitton and Warwick 2012: 3). There is also evidence of subject learning gains as a result of a dialogic pedagogy (Baines et al. 2007; Mercer et al. 2003; Rojas-Drummond et al. 2010; Rojas-Drummond and Mercer 2003). Indeed, encouraging findings described as being moderately secure have recently been reported from a UK-based efficacy trial involving almost 5000 students (EEF 2017). Following a Dialogic Teaching intervention involving children aged 9–10 years old, evidence of a positive effect on attainment in English, science and mathematics (judged to be equivalent to around two months additional progress) was reported.

In recent years, much attention has been paid to the interaction between, and possible interdependency of, a dialogic pedagogy and digital technologies, extending the idea of “interthinking” (Littleton and Mercer 2013) and expanding ‘dialogic space’ (Wegerif and Major 2018). A primary focus has been on the mediating role of digital technology – for instance tablet computers, interactive whiteboards and computer-mediated communication tools (Haßler et al. 2016a) – in enabling collective knowledge building in classrooms (Hakkarainen 2009; Rasmussen and Ludvigsen 2010; Scardamalia and Bereiter 1994). Proponents of Computer Supported Collaborative Learning (CSCL) – for instance Sfard (2008) and Wegerif (2006, 2007, 2013) – further suggest that “technologically mediated forms of discourse and interaction (can) provide new forms of discussion” (Stahl et al. 2014: 118). Therefore, the conventional conception of dialogue may be extended to include semiotic-mediated activity (Wells 1999; Twiner et al. 2010; Wikan et al. 2010); for example, when images on large interactive screens are manipulated and their subsequent positioning contributes to group thinking and dialogue (Beauchamp and Hillier 2014; Hennessy 2011; Hennessy and Warwick 2010; Warwick et al. 2010). Other studies show how digital technologies can enable dialogic interactions that are not face-to-face, or were asynchronous (e.g. Hoadley and Linn 2000; Pifarré and Staarman 2011). Thus, the alignment of classroom-based digital technologies with a dialogic pedagogy seems to suggest the possibility of ‘transformative’ learning; this alignment is the focus of the studies included in this review.

2 Methodological approach

The first methodological framework for undertaking a scoping review was published by Arksey and O'Malley (2005). This framework has since been clarified and enhanced

by Levac et al. (2010). Scoping reviews feature five main stages: (i) identifying the research question(s); (ii) identifying relevant studies; (iii) study selection; (iv) charting data; (v) collating, summarising and reporting results.

Our methodological approach was underpinned by this scoping review framework. As one strength of a scoping review is to provide an overview of studies in an emergent field, such a review is a sensible mechanism for considering the connections between educational dialogue and digital technology (Section 1.2). We therefore first identify the characteristics of extant research in this area (Section 3.2). Further, to extend this work, we address two thematic research questions (Sections 3.3 and 3.4 respectively) and, use the results in a discussion that opens a space for future dialogue for researchers. In devising our thematic research questions (RQs), we wished to examine what might be considered two of the recurrent themes evident in classroom-based empirical research; namely, how a combination of variables might be productive for learning, and the challenges that arise in introducing any form of classroom intervention. Our RQs were thus:

- i) in what ways does research suggest that use of digital technologies enhance productive classroom dialogue?
- ii) what challenges are reported that may impact on the successful use of digital technology to support dialogic teaching and learning?

2.1 Search process

Automated searches of selected digital libraries were used to identify relevant research. Following the development of a protocol detailing the search strategy, three digital libraries were searched: British Education Index (BEI), Education Resources Information Centre (ERIC) and Scopus.¹

Studies were screened based on their titles and abstracts. Searches were facilitated using three sets of keywords covering ‘dialogue’, ‘school’ and ‘digital technology’ (see Table 1). Keywords were iteratively developed after: (i) considering other reviews related to classroom dialogue and/or digital technology (e.g. Haßler et al. 2016b; Howe and Abedin 2013); (ii) appraisal of the search protocol by University Librarians; (iii) examining the titles, abstracts and keywords of several studies identified previously as relevant (Hennessy 2011; Kerawalla et al. 2013; Kim et al. 2007; Mercer et al. 2010; Staarman 2009).

Digital technology-related studies cited in Howe and Abedin’s systematic review of empirical research into classroom dialogue (i.e. Kim et al. 2007; Mercer et al. 2010; Staarman 2009), and the research identified as previously relevant, was located during pilot searches. Inclusion and exclusion criteria were applied to studies identified as being potentially relevant. Studies were *included* if they involve digital technology and relate to dialogic teaching and learning in schools (students aged 4 to 18), describe primary empirical research (i.e. that acquired by means of observation or experimentation), are written in English, were peer-reviewed, and were published between 2000

¹ Humanities and social science libraries only; only first 2000 returned articles, sorted by relevance, considered.

Table 1 Keywords used to facilitate automated searches of digital libraries

CONCEPT A: Dialogue (and associated terms)	CONCEPT B: Schooling (and associated terms)	CONCEPT C: Digital technology (and associated terms)
▲ Search terms used: OR backchannel; ▼ back-channelling; collaborative; collaboration; communication; conversation; cooperative; dialogic*; dialogic; dialogue; discourse; discussion; “exploratory talk”; feedback; “ground rules”; interaction; oracy; question; participation; reciprocal; “speaking and listening”; talk	Search terms used: class; classroom; child*; education; educational; elementary; group; instruction; instructional; K-12; kindergarten; learning; pedagogy; peer; pupil; pri- mary; school; secondary; stu- dent; teacher; teaching; “whole class”	Search terms used: blog; chat; computer; “computer uses in education”; “computer-supported collaborative learning”; CSCL; “digital technology”; “education technology”; “educational technology”; “electronic discussion groups”; “information communication technology”; ICT; “interactive whiteboard”; iPad; IWB; interactive; laptop; “learning technology” messaging; microblog; “micro-blog”; microblogging; “mobile technology”; padlet; PC; online; “online chat”; “social media”; tablet; web; wiki
◀ AND ▶		

and 2016. Studies were *excluded* if they focus on the role of digital technology in supporting dialogic teaching and learning in non-school-based contexts (e.g. higher education), provide a “lessons learned” account or offer a description of an approach without presenting any empirical evidence, or report on an analysis of the literature or the professional development of teachers with little consideration of the impact on practice in the classroom or student outcomes.

A ‘backwards snowballing’ search (i.e. checking the references of relevant studies) was also undertaken. Where the same author(s) clearly reports on the same study (e.g. in a preliminary conference paper followed by a more extensive journal article) the most comprehensive report was included. In situations where several articles are related (e.g. the authors draw on data collected during a professional development course), but each article has a substantially different focus, all were included.

2.2 Data extraction

A range of data were extracted from each study to gain a high-level overview of the body of existing research. This included details about the country of research, research aims, digital technology(s) used, ages of students involved, academic context, methodological approach and the number of students and teachers involved.

To address the two thematic RQs, data was required to be in a format amenable to synthesis. To prepare for this synthesis process (outlined in the next subsection) information judged to relate to the RQs was extracted from the abstract, findings or conclusion sections of included studies (where such information specifically related to data reported in the study). Two researchers (LM and VC) were involved in this

process. Extracted data was stored in an Excel spreadsheet (see Supporting Document 1) before being analysed using NVivo 11.

2.3 Data analysis and synthesis

Arksey and O'Malley (2005) describe how a scoping review allows a field of interest to be illustrated in terms of volume, nature and characteristics. Data extracted to gain a high-level overview of existing research has been classified and summarised using a variety of tabular and graphical forms. This helps to identify clusters and gaps in the evidence base (*ibid*) as well as its key features (Davis et al. 2009).

To address the RQs, an adapted version of the thematic synthesis method described by Thomas and Harden (2008) was applied. Thematic synthesis applies the qualitative method of thematic analysis to systematic reviewing, and has previously been identified as valuable for integrating qualitative and quantitative research findings (Snilstveit et al. 2012; Verhage and Dominique 2016). It typically involves (i) the coding of text “line-by-line” (i.e. coding verbatim the findings of studies); (ii) the development of ‘descriptive themes’.

Our method of establishing initial codes during the thematic synthesis differed from this, however, given the large number of studies identified as a result of our search process (as discussed in the next section, 72 studies were included in our review compared to the 8 analysed in Thomas and Harden’s original study). Instead, information identified during the data extraction phase was used to develop ‘descriptive themes’. This involved:

- two reviewers (LM and VC) independently analysing, categorising and coding extracted data;
- a collaborative review and discussion with a third reviewer (PW) to discuss the initial themes emerging;
- team members revising and refining themes to agree a final set of themes;
- collaboratively re-coding extracted data using the updated set of themes.

The NVivo 11 (2017) qualitative data analysis computer software package was used to store, categorise and compare data during this thematic synthesis process.

2.4 Methodological limitations

The focus of the study was highly delimited. The search only considered peer-reviewed English-language studies published from 2000 onwards. The choice of keywords used or omitted, or the selection and/or nature of digital libraries searched may have had an impact on the eventual findings. It is also possible that methodological decisions for data extraction and thematic synthesis may have introduced some subjectivity.

Actions to mitigate the potential impact of these issues include undertaking trial searches, examining the reference lists of included studies for other relevant work and speaking with senior researchers who have worked in relevant fields of study (who identified no further appropriate research suggesting a level of ‘saturation’ had been reached). Undertaking member checking on a sample of included studies also helps to alleviate concerns relating to the misapplication of the inclusion/exclusion criteria.

While research was found to have been undertaken in number of countries, a large proportion of included work emanates from a European context (and the UK in particular). Thus, the impact of cultural and social differences must be considered when interpreting results.

With respect to the RQs, these were intended to be as wide in scope as possible, yet focused on arguably two of the perennial issues in the connected fields of study: How is it possible to enhance productive classroom dialogue, and what is the role of mediating tools? What are the challenges to such potential enhancement in classroom settings (e.g. Kreijns et al. 2013)? The diversity of the studies also limited the extent to which the predictive validity of emerging sub-themes might have been examined. Thus, the RQs enable an aggregation of core themes and sub-themes that pervade the literature; no attempt has been made to further theorise these themes as presented, since this is not the purpose of a scoping review (Section 1.1).

3 Results

In this section, the results of the scoping review are presented. Section 3.1 outlines the search process, whilst Section 3.2 provides an overview of the core data extracted from the selected studies. Subsequent sections provide thematic syntheses in relation to the research questions presented above (Section 2).

3.1 The search process

Initial searches of the literature were carried out in June 2016 before an additional search, to ensure identification of all relevant studies published during the previous year, was completed in March 2017. Following implementation of the search procedure, **72 studies** were included in the final scoping review (see Fig. 1).

[Appendix 1](#) provides details of the included 72 studies and defines the IDs used to refer to these (e.g. [S1] refers to Study One - Andersson & Räsänen, 2014). All data extracted is presented in Supporting Document 1.

3.2 An overview of the field

In this subsection, a descriptive overview of the characteristics of existing research is presented.

3.2.1 *Digital technologies used*

A range of digital technologies are reported to have been used:

- Computer-Mediated Communication (CMC) tools (e.g. CSILE/Knowledge Forum or TC3) [22 studies]
- Interactive Whiteboards (IWBs) [17 studies]
- Multiple technologies used during the same study [10 studies]

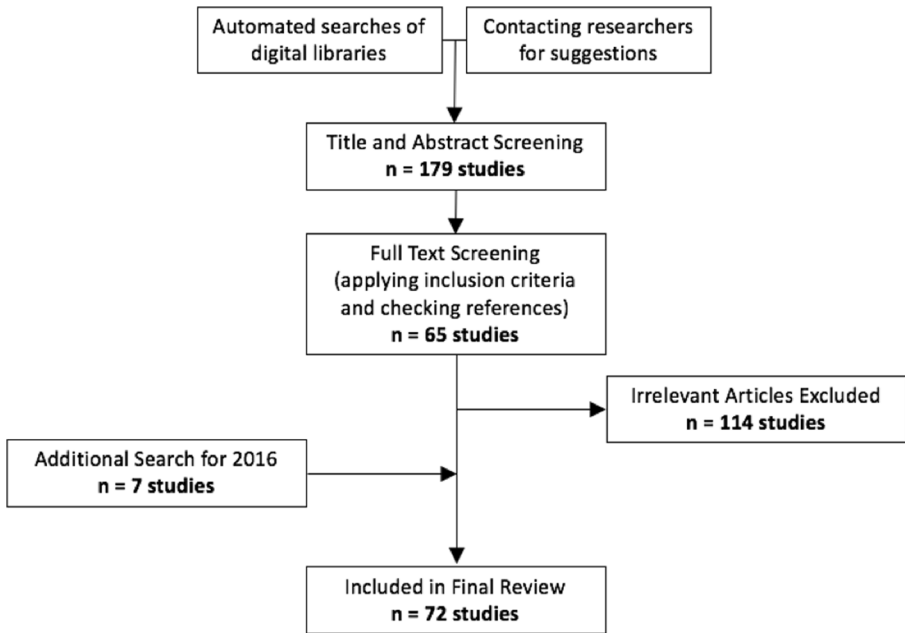


Fig. 1 The scoping review process

- Subject-specific learning tools (e.g. for learning about mathematical probability) [6 studies]
- Mobile applications/computer software (e.g. to support music composition and notation) [6 studies]
- Tablet computers (e.g. iPads) [5 studies]
- Blogging/Microblogging tools (e.g. Twitter) [4 studies]
- Wikis [1 study]
- Touch Table technology [1 study]

A detailed breakdown of school context, and digital technologies used, is presented in Appendix 2.

3.2.2 Research participants and context

Included studies report research undertaken in 18 countries: UK (24 studies), Netherlands (11 studies), Norway (6 studies), USA (6 studies), Finland (4 studies), Israel (3 studies). This is in addition to 2 studies undertaken in each of France, Mexico, New Zealand, Spain and Sweden and 1 study undertaken in each of Australia, Denmark, Greece, Singapore, South Africa and South Korea.

Sixty studies explicitly state the number of teachers involved in the research. For these, the number of teachers ranged from 1 to 50 with a median of 2 (interquartile range, 1–4.25). It is interesting that of all 72 included studies, 25 involved only one teacher (over one-third of all studies) and 47 involved five or fewer teachers. 50 studies explicitly state the number of students involved in the research. For these, the number

of student participants ranged from 6 to 290 with a median of 34 (interquartile range, 23.25–70).

The proportion of research undertaken in primary/elementary (defined as learners aged 5 to 11) and secondary/high (defined as learners aged 11 to 18) schools was relatively even while research also took place in both of these contexts at the same time: primary school (35 studies), secondary school (30 studies), both primary & secondary (7 studies). Further details of school and academic subject contexts are presented in Appendix 3.

3.2.3 Research designs of the examined studies

As demonstrated in Fig. 2, qualitative (33 studies) or mixed method (32 studies) research designs are reported in the majority of included studies. A greater proportion of this qualitative research took place in primary schools; more mixed methods research was in secondary schools. This is in comparison to a limited number of quantitative studies (7 in total).

In addressing our research questions, we consider the characteristics of included studies in greater detail by presenting an overview of the results of the thematic synthesis undertaken, along with some illustrative examples from the literature. It is important to note that this process classifies the interpretations and/or attributions made by researchers (or teachers) as reported in the reviewed studies; further investigation of

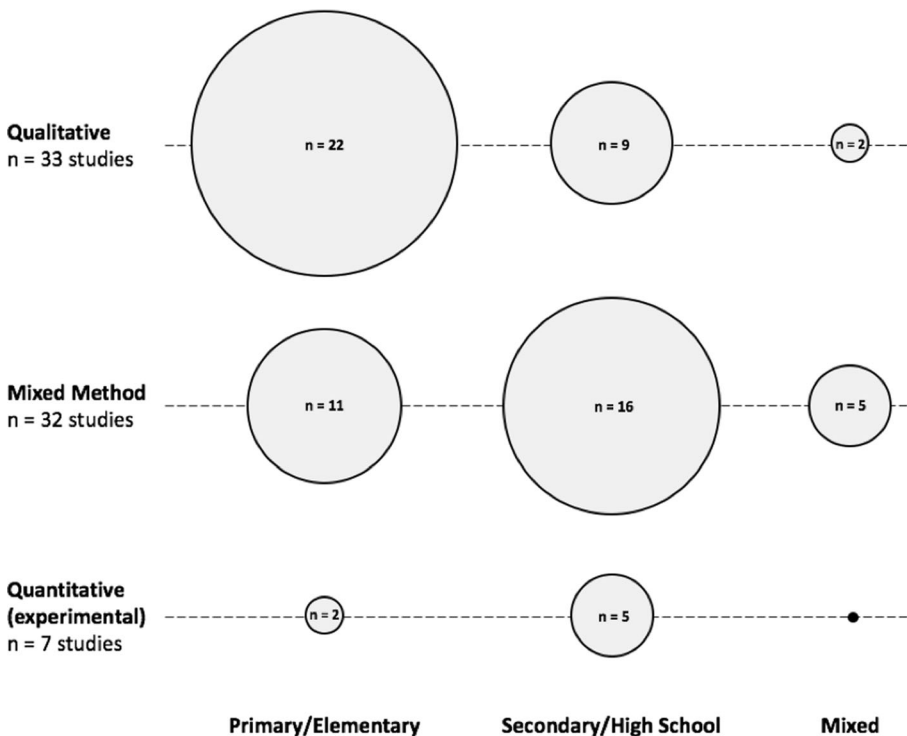


Fig. 2 Research designs reported by included studies according to school context

the claims made in each reviewed study may be required as the evidence presented is variable. We also refer readers to the supplementary information provided with this manuscript, in particular the themes identified in included studies (Appendices 4 and 5), and details of all data extracted (Supporting Document 1).

3.3 RQ1. In what ways does research suggest that use of digital technologies enhance productive classroom dialogue?

In this section, we present the results of our thematic synthesis to address RQ1. This established three high-level themes relating to how use of digital technologies enhances productive classroom dialogue: (i) ‘dialogue activity’, (ii) ‘technological affordances’ and (iii) ‘learning environment’. We consider each of these themes (and their sub-themes) in turn, presenting examples from studies that are considered to be particularly illustrative of the theme being considered. Importantly, the sub-themes ‘fit’ within the primary themes because these associations emerged directly from the examined studies. For example, ‘using dialogue to scaffold understanding’ is explicitly associated in a total of 16 studies with ‘dialogue activity’. All themes and sub-themes for RQ1 can be seen in Table 2.

3.3.1 RQ1 theme one - dialogue activity

This subsection discusses the theme of ‘Dialogue Activity’ addressing four main themes. 6 studies [S25, S35, S38, S43, S49, S60] identify how digital technologies can enhance dialogic activity by promoting exposure to alternative perspectives. This includes allowing students frequent opportunities to recognise that their peers hold alternative views (e.g. a study reporting an online asynchronous discussion, making alternative views of a science topic more memorable by modelling the process of distinguishing ideas [S25]). In addition, technology such as micro-blogging can allow students with limited background knowledge to tap into a pool of others’ perspectives (e.g. where readers or ‘followers’ can access and engage with a range of ‘contributions’ provided by others [S60]). The theme of taking into account the views of others appears across several studies [S7, S8, S39, S43, S53, S63]. Several examples include students being prompted to consider the ‘audience’ when explaining or commenting (for instance when contributing to an online forum where the process of externalising ideas pushes students to carry out deeper explanations [S39]).

Seventeen studies report how digital technology can support learners in knowledge co-construction, including in ways that are reported to be purposeful [S45], sustained [S47] and critically in-depth [S44]. From a perspective of co-construction, students can create a truly shared digital artefact as the product of their collaboration (e.g. a wiki [S53]) while social interactions supported by technologies such as the IWB can promote shared cognition (especially articulation, collective evaluation and reworking of pupils’ own ideas [S24]). Digital technology seems also to afford opportunities to transform students’ ‘local investigations’ (e.g. pairs working at a computer) into products which may be shared more widely, for example through peer teaching and learning [S13]. This is one example of cumulative peer knowledge construction (i.e. children building on each other’s artefacts and ideas), a process also reflected in other studies [e.g. S38, S44], sometimes through activities intended to promote reasoning and justification [S53].

Table 2 Overview of the thematic synthesis for RQ1 “In what ways does research suggest that use of digital technologies enhance productive classroom dialogue?”

Primary Theme	Sub-theme(s)	Studies
1) Dialogue activity	Alternative perspectives:	
	a) Exposure to alternative perspectives	6 studies
	b) Taking into account others' views	6 studies
	Knowledge co-construction	17 studies
	Using dialogue to express meta-cognitive learning	9 studies
	Using dialogue to scaffold understanding	
	c) Learner-Learner	7 studies
	d) Teacher-Learner	9 studies
	2) Technological affordances	Creation of a shared dialogic space
Mediating interaction:		
a) Accessibility		10 studies
b) Versatility		11 studies
Externalisation of ideas		5 studies
Informing teachers		5 studies
Multimodality		7 studies
Pace		5 studies
Provisionality		5 studies
Representation of content		12 studies
Temporal factors		9 studies
3) Learning environment	Learner autonomy	5 studies
	Learner inclusion & participation	13 studies
	Classroom atmosphere	10 studies
	Interpersonal relationships	5 studies
	Motivation & engagement	15 studies

Evidence of students using dialogue to express meta-cognitive learning [S7, S10, S14, S26, S29, S44, S53, S60, S67] is included in studies where, for example, classroom talk exhibits elements of reflective self-assessment [e.g. S26] or where students are encouraged to recognise their own lack of understanding (e.g. [S10]). Technology-mediated discussion has been shown to encourage metacognition as students are provoked to think about their own, and others', thinking when responding to a prompt (such as another individual's "tweet" [S60]). The benefits of using video-stimulated reflective dialogue to encourage students to explore and reflect on their learning is also reported [S67].

Learners using dialogue to scaffold understanding of their peers is discussed in 7 studies [S11, S26, S31, S35, S38, S49, S56]. This includes studies reporting different types of talk to provide technical guidance to support other's attempts to work with technology (e.g. iPads [S26]), and one explaining how specific features of the technology work [S35]. Focused dialogue can act as a 'priming' mechanism that allows students (without the involvement of a teacher [S56]) to trial their ideas prior to bringing them to the whole class (e.g. via a 'whole-class' technology such as an IWB [S11]). Research relating to teachers using dialogue to scaffold understanding

[S3, S6, S11, S27, S42, S44, S47, S70, S72] is also identified; these studies refer both to the scaffolding of subject knowledge and to the scaffolding of dialogic and technological skills. Technologies such as the IWB, for example, are shown to have a direct scaffolding utility in some activities (e.g. collaborative annotation of images and text, spotlighting and reveal tools for focusing, and ‘drag and drop’ for classification activities [S11, S72]). Positive effects on the way that groups collaborate using technology are reported where teachers’ focus on the effective use of talk scaffolds leading up to activities (e.g. with the setting of ‘ground rules’ for talk [S47]). Teacher contingent scaffolding (e.g. in a WhatsApp group intended to facilitate classroom communication [S6]) and guidance (e.g. during synchronous discussions [S3]) can also help to improve dialogue features.

3.3.2 RQ1 theme two - technological affordances

The notion of affordances (Gibson 1977), or action possibilities, is often used to refer to the relationship between the perceived and actual properties of technologies. Thus, in the context of the studies examined in this review, the ways in which technology affords possibilities for learning is often determined by the underlying pedagogy of the teacher. Put simply, the idea of affordances, and constraints, relates to how technologies might *potentially* be used (Linell 2009).

This subsection discusses the theme of ‘Technological Affordances’, looking at nine themes connecting classroom dialogue and digital technologies. 11 studies identify how digital technology can provide both a tool and an environment for the creation of a shared dialogic space (e.g. [S9, S72]). By opening up a ‘dialogic space’, ideas can be put forward, respected, scrutinised and challenged in a supportive discursive environment [S29], thereby enhancing students’ confidence in considering their differences [S28]. In doing so, technology enables learners to deploy joint action and a high level of collaboration when working on tasks (such as joint music composition [S51]). Additional channels for students to ‘talk’ (for instance, through sending messages to each other using software designed to support collaborative activities [S43]) may also be established.

The accessibility of digital tools, and the positive impact this has on mediating interaction, is reported in 10 studies. Familiarity is one reason identified for this, for both students (e.g. as they are comfortable using recognisable tools such as microblogging [S60]) and teachers (e.g. as it is possible to use technology during collaborative activities in ways closely related to more familiar classroom practice [S30]). The way in which intuitive and easy manipulation of digital technologies (e.g. iPads) facilitates students’ collaborative talk (rather than a focus on how the tool operates) [S35], and how such devices afford potential for easy sharing of content [S31], is also reported. ‘Accessibility’ also extends to include the way in which classroom dialogue can be supported by the use of readily available and ‘generic’ tools and software, such as the WhatsApp messaging tool [S6] and Microsoft Word [S45]. In addition, how digital technology can be used as the object of interaction, a participant in interaction, or a tool for interaction is indicative of its versatility [S5], an idea identified in 11 studies. Examples include enabling learning beyond a classroom’s borders (such as at home [S6]), computers being used not only as a source of information but also as a resource for joint activity [S45], and computer

software (such as Talk Factory Generic) mediating students' understanding of what an exploratory discussion might consist of [S28].

Five studies note how digital technologies can enhance productive classroom dialogue via the externalisation of ideas. Ideas can be visualised by, for example, posting text to a screen [S45]. Learners are then able to easily share and reflect on their own, and other people's, ideas (e.g., [S13, S39, S44]). 5 studies also identify how technology can be used to inform teachers, for instance through monitoring progress [S14] and evaluating students' work [S29]. In some cases, teachers can provide instant formative feedback as they can literally 'see' students' misconceptions [S43]. Alternatively, teachers may be able to use their students' ideas to elaborate, correct and question students [S54].

The multimodal nature of digital technologies, noted by 7 studies, allows for greater flexibility in the delivery of resources. For example, the IWB boasts visual, auditory and text-based functions [S46] and the technology is said to appeal to both visual and kinaesthetic learners [S11]. The use of digital technology can also have a positive impact on the pace of lessons [S19, S42, S45, S62, S72]. From a teacher's perspective, increased pace enables teachers to display information rapidly and spontaneously [S19, S42, S62]. From the students' perspective, students may feel that they have greater control over their learning as they may be able to dictate the speed at which they work [S72].

A further benefit of using digital technology is the ability to adapt or change ideas. The affordance seems often here to be situated in the visual support that the technology provides whilst, linked to this, the idea of 'provisionality' is identified in 5 studies. For example, ideas expressed using the IWB may be considered both fluid [S47] and transitory [S67], which helps to build students' confidence when working with their own, and other people's, ideas at the board. The ability to represent content in new and interesting ways is reported in 12 studies (e.g. [S5, S6]). The processes involved in summarising information in a "tweet" [S60] and the dynamic and colourful nature of digital objects on the IWB [S17] are both observed in this respect. Similarly, the interplay between diagrams and text may give rise to broader and deeper discussions [S68].

The final technological affordance that 9 studies identify is the ability to record and revisit ideas. These 'temporal factors' include the traceability of students' ideas, which enables dialogues to be sustained, and ideas to be built, over time (whether during an individual lesson or a series of lessons) [S28, S42, S46, S71]. Using technology can also allow students the ability to move back as well as forwards in some tasks [S30], whilst the ability to access all previous and current texts can allow for continuity between lessons [S44].

3.3.3 RQ1 theme three - learning environment

This subsection discusses the rather more holistic theme of 'Learning Environment', identifying studies where the complexity of the classroom environment is of importance. Here we identified five sub-themes in relation to connections between dialogue and digital technologies. 5 studies identify how digital technologies can enhance learner autonomy. Supported by digital technology and with an appropriate pedagogy in place, students may take increased ownership and responsibility for their learning [S43]; for instance, by collectively sharing decision making amongst themselves rather than

allowing authority to rest solely with the teacher [S44]. Additionally, students can monitor and guide their own progress and thereby claim responsibility for the exploration of a dialogic space [S28]. Digital technology may also promote learner inclusion and participation, the second sub-theme. A total of 13 studies report the contribution of digital technologies to collaborative group interactions (e.g. [S28] [S53] [S54]). For example: groups may generate rules for their interaction and decide democratically how to manage turn-taking in order that everyone has an equal opportunity for participation [S23]; online communication can increase participation as students do not feel inhibited by shyness or low social status [S32]; students' intrinsic interest in apps (such as those available on iPads) can serve to boost participation rates (e.g. [S35]).

Ten studies identify how digital technology may have a positive impact on the classroom atmosphere (e.g. [S6]). A sense of community can develop through shared work (e.g. on a wiki [S53]) whilst dialogue between students (whether spontaneous or directed by a teacher) can create an atmosphere of solidarity and cooperation [S6]. Increased levels of interaction [S44] and greater open questioning by teachers [S62] may also occur. 5 studies report positive developments in interpersonal relationships, most notably between teachers and their students as the quality of their interactions increases ([S6] [S20] [S44] [S67]), but also between students themselves [S38]. The final associated sub-theme is learner motivation and engagement, with 15 studies noting improvements in both as a result of the use of digital technology (e.g. [S5] [S9] [S23] [S47]). Students can be motivated by the novelty of a new technology [S30], which in turn drives their desire to explore and understand [S27]. Digital tools can also be appealing and fun to use (e.g. iPads [S31]), or may hold relevance and applicability due to their status (e.g. microblogging may be viewed as an 'app' [S60]).

3.4 RQ2. What challenges are reported that may impact on the successful use of digital technology to support dialogic teaching and learning?

In this section, we present the results of our thematic synthesis to address RQ2. Following a process of thematic synthesis, two high-level themes were established, this time relating to the challenges of using digital technology to support dialogic teaching and learning from the perspective of the users i.e. (i) 'students' and (ii) 'teachers'. As with the thematic synthesis reported for RQ1, these are broad categories and several studies mention more than one of these challenges. An overview of all themes and sub-themes for RQ2 can be seen in Table 3.

3.4.1 RQ2 theme one - challenges facing students

This subsection considers the possible challenges that face students where dialogue and digital technologies are in dynamic interaction. 17 independent studies discuss the influence of students' technical skills. The first sub-theme is students' ICT capacity ([S5] [S26] [S32] [S61]). One study on computer-supported collaborative writing reports how students were not familiar with how to use diagram tools and that they may not use a tool as intended if they are not first given the opportunity to explore and experiment with it [S14]. Students may also lack a basic toolkit of strategies necessary to use iPads and applications [S15]. Students' knowledge and understanding is the second associated sub-theme. For example, in one study of text-based online

Table 3 Overview of the thematic synthesis for RQ2 “What challenges are reported that may impact on the successful use of digital technology to support dialogic teaching and learning?”

Primary Theme	Sub-theme(s)	Studies
1) Students	Technical skills:	
	a) Knowledge & understanding	6 studies
	b) ICT capacity	12 studies
	Influence of prior experience & expectations	5 studies
	Learner inclusion & engagement	10 studies
	Technology as a source of distraction or frustration	8 studies
2) Teachers	Behaviour management	6 studies
	Pace & time management	9 studies
	Promoting successful collaboration	13 studies
	Resources	4 studies
	Technical skills	4 studies
	Pedagogy:	
	a) Establishing a new learning culture	9 studies
	b) Dialogic interaction	13 studies
	c) General	14 studies

discussions spelling errors affected students’ comprehension of messages [S32], whilst reading and writing skills can restrict the activity and quality of students’ participation [S41].

Learner inclusion and engagement can present significant challenges, influenced by factors such as unequal access to technology and low participation rates. In one study investigating the use of WhatsApp to facilitate classroom communication, not all students were found to possess a smartphone, or the application [S6]. Other studies report low participation rates in blogs [S1] and unsuccessful attempts to motivate students to join discussion groups [S25]. Additionally, work on students’ use of the IWB reports the influence of equitable physical access to the board for all students; for example, the size of the board may prevent small children using all parts of the screen easily ([S47, S71]).

The variable nature of students’ prior experiences and expectations presents different challenges. In one study, students expected active involvement from the instructor-moderator in synchronous peer discussions to keep their discussions focused [S2]. Students’ expectations of the potential value of technology in supporting their learning are similarly variable, with their views about the value of ICT frequently focusing on the superficial features of presentational tools [S67]. In one study on interactive argumentation, argumentative activity was not entirely interactive, with many students working independently (potentially due to them being accustomed to more ‘traditional’ school tasks and to working for grades) [S49].

The use of technology can also become a source of distraction or frustration for students. Some may be distracted by the physical aspects of using technology (e.g. the IWB, such as the capability to touch the board and erase people’s work) [S71], whilst technical issues have caused students to disengage with tasks ([S27] [S30] [S47] [S72]). And students can be frustrated by administrative activities, such as the need to remember their usernames and passwords [S32].

3.4.2 RQ2 theme two - challenges facing teachers

This subsection considers the possible challenges that face teachers. It addresses issues related to their classroom management of learning.

The pedagogical challenges confronting teachers include several related to the talk practices surrounding the use of technology. Most notable are the concerns regarding the overall quality of classroom interaction, which focus variously on the quality of teacher questioning (e.g. [S24, 62]) and student discussion [e.g. S34]. For example, studies of IWBs have reported that teachers frequently use closed questioning [S24] while ‘uptake questions’ (feedback that moves beyond evaluation to make connections with other ideas) are used less frequently [S62]. An associated sub-theme is one that presents ‘the other side of the coin’; rather than addressing a potential paucity of high quality interactions in classrooms, this theme considers the difficulties that teachers may face when trying to establish a new learning culture. For example, the review of belief systems in teachers is a fundamental issue [S17], whilst students’ use of the IWB may be constrained by systemic school and subject cultures, in addition to curricular and assessment frameworks that place further time pressures on teachers [S24]. One study on inquiry through computer-supported learning identifies the need for teachers to create a supporting social infrastructure for inquiry culture, and the difficulties associated with this [S21]. Several studies also report more general pedagogical challenges facing teachers, including the need for broader shifts in their pedagogical and epistemological practices (specifically [S40]) and the need to offer appropriate professional support for teachers who wish to integrate digital technology into their teaching [S20]. These include challenges relating to instructional design, for instance, complications due to it being possible to use the same function of a technology to support both dialogic or more traditional didactic strategies [S46], and ensuring that student use of a tool does not change over time (even if it is initially appropriated as intended) [S13].

Thirteen studies discuss the challenges facing teachers when successful collaboration is being promoted. Of particular concern is the need to develop the necessary resources and skills to promote collaboration. For example, the success of software to support productive classroom talk may partly depend on the creation of suitable contexts for learning in which students can share knowledge and challenge each other’s ideas ([S29] [S63]).

Challenges can arise as a result of the increased pace of technology-based lessons. For example, in the high pace of asynchronous group discussion, teachers’ attempts to guide and regulate the discussion may easily be disregarded [S3]. The increased pace of lessons in which technology is used may also limit opportunities for extended teacher-student dialogue [S19]. In addition, there are impacts on teachers’ time management, such as those generated by the increased pre-planning needed when using the IWB [S24], and the time-consuming nature of following threaded discussions in CSCLE environments [S40]. Teachers also noted their concerns regarding new behaviour management issues. For example, students may become disengaged when individuals are interacting with the IWB [S19], whilst some teachers may feel challenged by the manner of students’ expression when communicating digitally, including their use of slang [S6] and inappropriate language [S64].

The challenges resulting from teachers’ technical skills are a penultimate feature of included studies. 4 studies note that teachers need to possess a certain level of technical

competence when using digital technology to support dialogic teaching and learning. This, for example, will enable them to become fully attuned to the affordances of a technology's features ([S5], see also [S20] [S27] [S53]). Finally, 4 studies note the importance of having the necessary access to existing high quality digital resources to support teachers to employ technology effectively in the classroom ([S5] [S9] [S17] [S20]).

4 Discussion

Seventy-two studies were identified and analysed after following the criteria for undertaking a systematic scoping review. The characteristics of these studies were considered and discussed in relation to two thematic research questions: i) in what ways does research suggest that use of digital technologies enhance productive classroom dialogue? ii) what challenges are reported that may impact on the successful use of digital technology to support dialogic teaching and learning? The purpose was both to map peer-reviewed research (published between 2000 and 2016) and to identify opportunities and challenges in using digital technologies to enhance productive classroom dialogue. This discussion first highlights issues arising from the high-level characteristics of existing research; we then widen the discussion to consider issues of interest arising from the themes and sub-themes for the research questions, indicating how the scoping review may be a stimulus for further thinking.

At the outset, we need to consider the nature of the search process and its relationship to two broader findings that may seem curious. The largest proportion of studies were in science education (Appendix 3); this may be related to substantial interest on argumentation and reasoning in science enquiry (e.g. Bennett 2007; Dawes 2008; Simon et al. 2006), leading researchers to explore the dialogue/technology interface in this curriculum subject. Additionally, and somewhat surprisingly, the search strategy captured only a limited number of studies from the Americas. This may relate to the fact a number of identified studies focused on quite a limited range of technologies (e.g. the 17 relating to the IWB) and the preponderance of such research will have skewed the results to focus on countries where these technologies were most enthusiastically adopted.

It is interesting that many digital technologies used in educational settings are initially developed for other purposes, rather than for education-specific activities (Laurillard 2008). Thus, it is notable that a number of included studies are based on technology designed by researchers (e.g. CSILE/Knowledge Forum) or developed especially for the education sector (e.g. subject-specific tools such as the PICCO multimedia science learning platform [S36]). The scoping review also revealed that there are certain methodological and theoretical assumptions that seem to characterise research in classroom dialogue and digital technologies. The majority of studies are qualitative or mixed methods research design (see Section 3.2) and we note that this is somewhat unusual since, traditionally, quantitative methods have dominated empirical social science research (Teddlie and Tashakkori 2009). This can perhaps be explained by the nature of the focus on research into the interactions between classroom dialogue and digital technologies. Studies that seek to understand these interactions often focus on their micro-genetic characteristics, noting the ways in which the affordances of technologies either prompt 'conventional' dialogue or transpose the meaning of dialogue itself, sometimes considering semiotics as a way of understanding

communication with and through technologies. Thus, the majority of the studies included in the review might be characterised as being informed, either explicitly or implicitly, by a sociocultural framework of understanding, since this perspective emphasises the importance of the relationship between the individual and his or her surroundings, including the use of technologies. The seven quantitative studies identified during the scoping review varied in their aims, scope and theoretical framing. These studies adopted experimental designs (e.g. [S14] which investigates how task-related planning activities and collaborative coordination relate to the quality of the resulting argumentative texts) and correlational approaches (e.g. [S61] which compares the impact of chat versus face-to-face communication on performance within a collaborative computer-supported modelling task). Only one quantitative study overtly adopted a sociocultural orientation to the data [S60]; this involved a quasi-experimental pre- and post-test design to determine if microblogging, used in a writing activity, affected middle school students' engagement and critical thinking.

All of the studies, to different extents, focus on the interdependency between different components of learning. According to sociocultural perspectives, focus on how tools (mental and material) are used in human activity, and how humans construct knowledge and understanding by the use of tools, is central. Physical and social contexts are considered integral to the learning activity, implying that it matters where the learning occurs (Lund 2003). In terms of digital technologies, this importantly implies that learning does not necessarily become better or more efficient with the use of new technological tools; however, they may profoundly influence interaction (Säljö 1999).

Our thematic synthesis points up distinct themes surrounding dialogue and technology, and the ways in which they may interact to enhance learning. This is especially apparent in relation to RQ1. Thus, the review themes reveal the components of learning that are integrated in different ways in the different studies. Two high-level themes that emerged from the thematic synthesis are identified as productive for learning - Dialogue Activity and Technological Affordances - and these include numerous sub-themes. The studies that addressed the broader notion of Learning Environment capture other dimensions, including classroom atmosphere and relationships. This separation is a function of the approach to the review, rather than a repudiation of the sociocultural approach taken in a large proportion of the reviewed literature. Even a cursory review of the themes and sub-themes presented in Section 3.3 reveals myriad interconnections and interdependencies. If the intention of dialogic education is to encourage “attunement to others' perspectives and continuous co-construction of knowledge through sharing, critiquing and gradually reconciling contrasting ideas” (Hennessy et al. 2016: 16), how all of the elements and resources of the classroom are orchestrated to achieve this intention seems to be a central question linking the themes. But the combination of these components has many possible variants; so, what are some of the underlying factors that might combine to enable the “interanimation of ideas” (Scott et al. 2006: 611)?

In most sociocultural studies, language is seen as “the tool of tools” (Cole 1995); thus, the productive influence reported from digital technology is seen to either serve the imperative of encouraging spoken dialogue, or extend the conceptualisation of dialogue. For example, by including the semiotic and incorporating the use of the visual in contributing to collective understanding, as shown in work on classroom uses of the IWB (e.g. Hennessy and Warwick 2010; Warwick et al. 2010), the movement of images on the screen served to indicate understanding, sometimes

provisional in character and open to challenge through spoken dialogue. Such examples serve to demonstrate the complexity of the direct interaction between dialogue and digital technologies but, of course, an understanding of what constitutes productive talk for learning, shared between teacher and students, is also often central to the use of technologies for dialogic purposes. This shared understanding says much about participation structures in a dialogic classroom. With the development of student agency through dialogic practices being a central aim, this review demonstrates how the dialogic use of classroom technologies presents many challenges and opportunities in relation to existing power relationships in classrooms. These include considering the epistemic order of classrooms (Ruthven and Hofmann 2016); for example, is it the teacher or student who now initiates? Is it the teacher or student who now validates ideas? The role of the teacher, student or tool in placing limits on, or extending the scope of, interaction is therefore a genuine concern, for both teachers and researchers.

This all points to some of the challenges that arise with an intention to facilitate content learning, and dialogic interactions, directly and indirectly through mediating tools. In considering RQ2, it is unsurprising that the challenges relate to Students and Teachers; but again, the sociocultural perspective adopted in many studies points to the interconnectedness of the challenges reported. Some studies point to the idea that classroom experience does not match the potential of either the technology or young people's extensive use and experiences with such tools. Predominately, however, reported issues include the general challenges facing teachers in implementing a dialogic pedagogy; the ways in which this may, or may not, be exacerbated by the inclusion of digital technologies; the support that teachers may need in integrating technology use into their classrooms; and how technology functionality becomes affordance in the context of pedagogical intention. The first of these - the challenges facing teachers in developing and maintaining a dialogic pedagogy - is a constant and developing theme in literature concerned with research into initiatives designed to promote 'dialogic classrooms' (Howe and Abedin 2013; Osborne 2015). And certainly, there is evidence, in some studies that combine a dialogic intervention focused around digital technologies, that a fairly relentless focus on dialogic intentions over time is necessary for there to be a change in classroom culture (Warwick et al. 2010).

The notion of affordance is commonly used to point out the technological potential. However, a potential may not be actualised and there is sometimes a long way to travel from potential to realisation. It appears essential that technology use has a direct link to pedagogy. As with studies on the educational uses of social media (Manca and Ranieri 2013) or tablet computers (Major et al. 2017), it seems that affordances only become apparent in the context of developing pedagogy and that the fate for much technology that is 'parachuted' into schools is that it will be used to support existing pedagogies, or that surface features will be used to 'keep students happy', whilst the potential for learning is not fully explored. Thus, whilst the ways in which digital technologies are used can shape different types of thinking and reasoning, and whilst dialogues can be transformed by digital technology, these changes are not necessarily unidirectional or productive (Rasmussen and Ludvigsen 2010).

This discussion has built upon the literature that forms the data for the scoping review. It has drawn out various themes that constitute current thinking about the

interaction between digital technologies and classroom-based dialogue. As we have said, scoping reviews are retrospective and their central contribution derives from mapping the existing geography of a field of research. However, both in the text and, especially, in the discussion we have looked forward, using this existing geography as legitimation for indicating future possible areas of study and theoretical engagement. We suggest that affordance, interdependency and dialogue itself are key concepts that frame the social situation in which students build knowledge and meaning with and through digital tools. Since students' learning is tool dependent, the trends in this field of study will continue to expand, requiring further and continuing investigation into the nature of the interactional conditions under which new tools become productive for learning. The nature of the work to be undertaken may be quite different to many areas of 'traditional' social science research, requiring strong and purposeful collaborations between technology experts, designers, teachers, researchers and students to fully explore the potential of interactions between digital tools and classroom dialogue.

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Appendix 1: Studies included in the scoping review

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science in collaborative group activity at the interactive whiteboard. *Computers & Education*, 55(1), 350–362. <https://doi.org/10.1016/j.compedu.2010.02.001>

Appendix 2

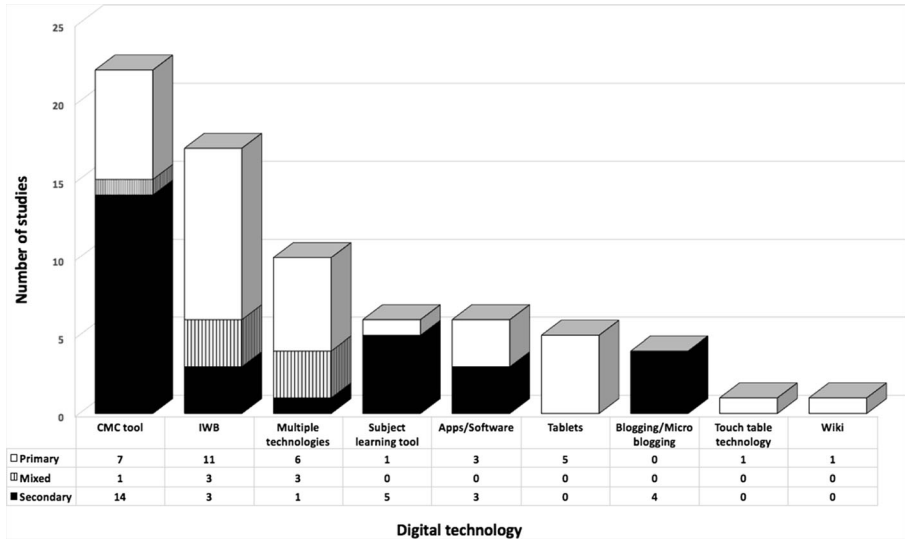


Fig. 3 School context and digital technology used

Appendix 3

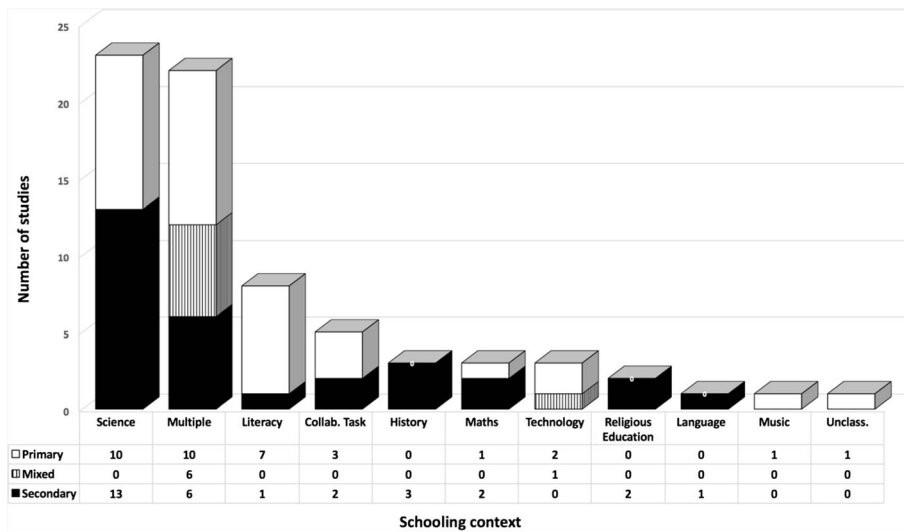


Fig. 4 School and academic subject contexts

Appendix 4: Themes identified in included studies

Table 4 RQ1. In what ways does research suggest that use of digital technologies enhance productive classroom dialogue?

Primary Theme	Sub-theme(s)	Studies	
1) Dialogue activity	Alternative perspectives:		
	a) Exposure to alternative perspectives	6 studies [S25, S35, S38, S43, S49, S60]	
	b) Taking into account others' views	6 studies [S7, S8, S39, S43, S53, S63]	
	Knowledge co-construction	17 studies [S10, S13, S14, S24, S36, S38, S44, S45, S47, S48, S51, S53, S54, S60, S61, S65, S68]	
	Using dialogue to express meta-cognitive learning	9 studies [S7, S10, S14, S26, S29, S44, S53, S60, S67]	
	Using dialogue to scaffold understanding		
	a) Learner-Learner	7 studies [S11, S26, S31, S35, S38, S49, S56]	
	b) Teacher-Learner	9 studies [S3, S6, S11, S27, S42, S44, S47, S70, S72]	
	2) Technological affordances	Creation of a shared dialogic space	11 studies [S8, S9, S20, S28, S29, S30, S31, S41, S43, S51, S72]
		Mediating interaction:	
a) Accessibility		10 studies [S6, S12, S27, S30, S31, S35, S45, S58, S60, S69]	
b) Versatility		11 studies [S5, S6, S11, S15, S20, S28, S44, S45, S56, S57, S68]	
Externalisation of ideas		5 studies [S13, S39, S44, S45, S54]	
Informing teachers		5 studies [S14, S29, S28, S43, S54]	
Multimodality		7 studies [S11, S17, S42, S46, S54, S71, S72]	
Pace		5 studies [S19, S42, S45, S62, S72]	
Provisionality		5 studies [S11, S46, S47, S67, S71]	
Representation of content		12 studies [S5, S6, S13, S17, S19, S24, S47, S54, S60, S67, S68, S71]	
Temporal factors		9 studies [S11, S25, S28, S30, S42, S44, S46, S64, S71]	
3) Learning environment		Learner autonomy	5 studies [S13, S27, S28, S43, S44]
		Learner inclusion & participation	13 studies [S23, S25, S28, S32, S35, S43, S48, S52, S53, S54, S56, S60, S62]
		Classroom atmosphere	10 studies [S23, S25, S28, S32, S35, S43, S48, S52, S53, S54, S56, S60, S62]
		Interpersonal relationships	5 studies [S6, S20, S38, S44, S67]
	Motivation & engagement	15 studies [S5, S9, S11, S16, S19, S23, S25, S27, S30, S31, S45, S47, S50, S60, S67]	

Appendix 5

Table 5 RQ2. What challenges are reported that may impact on the successful use of digital technology to support dialogic teaching and learning?

Primary Theme	Sub-theme(s)	Studies
1) Students	Technical skills: a) Knowledge & understanding b) ICT capacity Influence of prior experience & expectations Learner inclusion & engagement Technology as a source of distraction or frustration	6 studies [S12, S18, S32, S40, S41, S59] 12 studies [S5, S14, S15, S21, S26, S27, S32, S33, S34, S49, S61, S66] 5 studies [S2, S49, S50, S67, S68] 10 studies [S1, S6, S8, S19, S25, S47, S50, S56, S60, S71] 8 studies [S23, S27, S30, S32, S44, S47, S71, S72]
2) Teachers	Behaviour management Pace & time management Promoting successful collaboration Resources Technical skills Pedagogy: a) Establishing a new learning culture b) Dialogic interaction c) General	6 studies [S4, S6, S19, S38, S64, S72] 9 studies [S3, S9, S19, S24, S37, S40, S41, S45, S61] 13 studies [S8, S10, S16, S28, S29, S30, S32, S51, S55, S58, S62, S63, S72] 4 studies [S5, S9, S17, S20] 4 studies [S5, S20, S27, S53] 9 studies [S6, S17, S19, S21, S24, S39, S45, S47, S70] 13 studies [S9, S10, S24, S34, S39, S41, S45, S46, S48, S61, S62, S64, S72] 14 studies [S5, S9, S13, S14, S15, S20, S22, S26, S40, S46, S48, S49, S66, S72]

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