'Affordances for dialogue': the role of digital technology in supporting productive classroom talk

Louis Major*[a] & Paul Warwick[b]

Faculty of Education, University of Cambridge, 184 Hills Road, CB2 8PQ

*[a] lcm54@cam.ac.uk https://orcid.org/0000-0002-7658-1417

[b] https://orcid.org/0000-0002-0463-150X

Abstract

Recent technological advances and the enhanced availability of digital tools in classrooms have seen increasing attention paid to the interaction between, and possible interdependency of, a dialogic pedagogy and digital technology. In this chapter, we reflect on the role of digital technology in supporting productive classroom dialogue by presenting an overview of the first systematic scoping review to investigate the interactions between classroom dialogue and digital technology (Major, Warwick, Rasmussen, Ludvigsen & Cook, 2018). Identified as a key theme by this review, we also further consider the concept of technology 'affordances'. Reflecting on research involving the implementation of a micro-blogging tool developed to support classroom dialogue (Talkwall), we demonstrate how an understanding of affordance as broad categories pertaining to a range of 'action possibilities', as has traditionally often been the case, can inform more empirically-based analyses of the 'enacted affordances' of specific technology. In particular, we suggest the idea of 'affordances for dialogue' enables a reinterpretation that may helpfully inform researchers, practitioners and developers interested in the role of digital technology in dialogic contexts.

1. Introduction

The place of language as a cultural tool for learning is central to sociocultural perspectives on social and cognitive development (Vygotsky, 1962, 1980), and a clear trajectory in academic discourse has been to consider dialogue as a particularly important tool for learning within classrooms (Barnes, 1976; Alexander, 2008; Howe & Abedin, 2013; Mercer & Dawes, 2014; Schwarz & Baker, 2016). As this Handbook makes evident, classroom dialogue is 'more than just talk'; rather, there is a specific focus on sharing and evaluating ideas, building ideas collectively, reasoning, providing justifications and elaborations, and using evidence to support arguments.

Recent technological advances and the enhanced availability of digital tools in classrooms (e.g. iPads - see Major, Haßler & Hennessy, 2017) have seen increasing attention paid to the interaction between, and possible interdependency of, a dialogic pedagogy and digital technology. A particular focus has been on the mediating role of digital technology in enabling collective knowledge building (e.g. Hakkarainen, 2009); here, it is suggested that digital technology has the potential to extend conventional conceptions of dialogue to include semiotic-mediated activity (Wells 1999; Twiner et al. 2010) and dialogic interactions that are not face-to-face or are asynchronous (Hoadley and Linn 2000; Pifarré and Staarman 2011).

In this chapter, we present an overview of the first systematic scoping review to examine the interactions between classroom dialogue and digital technology (Major, Warwick, Rasmussen, Ludvigsen & Cook, 2018). The outcomes of this review allow us to reflect on the role of digital technology in supporting productive classroom dialogue, and to provide a springboard for other Handbook chapters in this section.

Identified as a key theme during the scoping review, we go on to examine how conceptions of technology *affordances* are considered in relation to a dialogic pedagogy. Examining the use of digital technology in classrooms, we demonstrate how an understanding of affordance as broad categories pertaining to a range of 'action possibilities' presented by an object or scenario, as has traditionally often been the case, can inform more empirically-based analyses of the 'enacted affordances' of specific technology. In particular, we suggest that this conceptualisation of a relationship between action possibilities and enacted affordances provides a novel lens through which the idea of 'affordances for dialogue' may be examined

by researchers, practitioners and developers interested in the role of digital technology in dialogic contexts. Reflecting on research involving the implementation of a micro-blogging tool developed to support classroom dialogue (Talkwall[1]), we demonstrate this idea by considering how Talkwall is implicated in promoting dialogic interaction for learning. This is significant in exemplifying how the affordances associated with technology-mediated dialogue can be specifically, as well as broadly, analysed by researchers.

2. Two connected fields of interest: classroom dialogue and digital technology

For those considering learning from a sociocultural perspective (Vygotsky 1962, 1980), ideas relating to the mediation of thinking and action by cultural artefacts, and recognition of the interdependent relationship between thought and language, are central. Vygotsky argues that language is both a cultural tool (for the development and sharing of knowledge amongst members of a community) and a psychological tool (for structuring the processes and content of individual thought) (Mercer, Hennessy & Warwick, 2017). Thus the theory not only links the social and the psychological in an account of cognitive development, but also provides a theoretical basis for the primacy of language as a cultural and cognitive - and hence educational - tool (Mercer & Howe, 2012).

This recognition of the key role of language in cognitive development has led to a focus on the modes of interaction that occur within classrooms (Calcagni & Lago, 2018). Supporters of dialogic pedagogical practices assert that classroom dialogue is "central to the meaning making process and thus central to learning" (Mortimer & Scott, 2003: 3). The idea of 'dialogic teaching' (Alexander, 2008), that arises from a wider understanding of dialogue as a social phenomenon (Shor & Freire, 1987), emphasises dialogue as a process through which students learn to reason, discuss, argue and explain.

Dialogic pedagogy has a direct participatory imperative, seeking to legitimise and develop contributions from all parties in classroom interactions (Nystrand, Wu, Gamoran, Zeiser, & Long 2003; Michaels & O'Connor, 2012); a central intention is "to foster learner agency,

[1] http://www.talkwall.net

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 & Warwick, 2012, p. 3). Through the use of a dialogic pedagogy a 'dialogic space' may be opened up, in which difference is both created and explored (Wegerif, 2010).

Today, a robust body of research demonstrates how students who were taught dialogic skills improved in their reasoning and collaborative problem solving (e.g. Howe & Abedin, 2013; Kuhn, 2016; Mercer, 2013). Indeed, encouraging findings have been reported following an efficacy trial involving around 5000 students (aged 9-10) where, after a 'Dialogic Teaching' intervention, a positive effect on attainment in English, science and mathematics was found (judged equivalent to around two months additional progress; Jay, Taylor, Moore, Burnett, et al., 2017; Alexander, 2018). A large-scale naturalistic investigation of whether more 'dialogic' teaching relates to children's (aged 10-11) learning gains on standardised tests in mathematics and literacy, and to scientific reasoning and general reasoning, also identified several aspects of teacher-student dialogue to be positively associated with performance (Howe, Hennessy, Mercer, Vrikki, & Wheatley, 2019).

The enhanced availability of digital tools capable of supporting young people to engage in constructive dialogue through or around digital platforms (e.g. iPads; Major et al., 2017), have led to increasing attention being paid to the interaction between (and possible interdependency of) a dialogic pedagogy and digital technology. A key focus has been on the mediating role of digital technology – for instance tablet computers, interactive whiteboards and computer-mediated communication tools (Haßler, Major, Warwick, Watson, Hennessy & Nicholl, 2016) – in enabling collective knowledge building (Rasmussen & Ludvigsen, 2010; Scardamalia & Bereiter, 1994), extending "interthinking" (Littleton & Mercer, 2013) and expanding "dialogic space" (Wegerif & Major, 2018).

The pervasiveness of technology capable of supporting dialogic processes, and the fact that the alignment of classroom-based digital technology with a dialogic pedagogy seems to suggest the possibility of 'transformative' learning, means professional and research interest in the role of technology in supporting and enhancing dialogue is a legitimate and growing field. In order to explore this, we undertook a systematic scoping (mapping) review of literature focusing on the interactions between classroom dialogue and digital technology. This mapped extant research and, through a process of thematic synthesis, enabled us to offer

the research community a means of accessing existing understandings, in addition to drawing together central ideas for further consideration. In the next section, we present a brief summary of our methodological approach and report our main findings to provide an overview of the characteristics of extant research in this area.

3. Scoping extant research to consider how digital technology supports classroom dialogue

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 recent. By combining these two themes in a single comprehensive review for the first time, we provide a framing device for reviewing new developments in a rapidly changing field.

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, Colquhoun & O'Brien, 2010). They involve collecting, evaluating and presenting available evidence (Arksey & 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, Budgen & Brereton, 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, Drey & Gould, 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., Major & Watson, 2017; Virtanen, Haavisto, Liikanen, & Kääriäinen, 2017).

The first methodological framework for undertaking a scoping review was published by Arksey and O'Malley (2005) and later 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. During our review, a systematic search was undertaken to identify relevant research published since 2000. A range of data were extracted from studies considered to be relevant including 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. An adapted version of the thematic synthesis method described by Thomas and Harden (2008) was also applied to develop 'descriptive themes' to characterise the body of extant research.

The scoping review reveals how 72 studies (from the year 2000 onwards) report on the use of various digital technology to support classroom dialogue (Major et al., 2018). Studies were undertaken across 18 countries and involved both small and larger scale analyses. Technology investigated include Computer-Mediated Communication tools, Interactive Whiteboards (IWBs), subject-specific learning tools, mobile 'apps', tablet computers, blogging/microblogging tools, wikis and touch table technology. The schooling context of this research is mixed with the proportion of research undertaken in primary/elementary (35 studies) and secondary/high (30 studies) schools being relatively even, with some research taking place in both of these contexts at the same time (7 studies). Finally, 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). See Major et al (2018) for a detailed account of our methodological approach and findings.

In addition to enabling the broad characterisation of existing research, a process of thematic synthesis established three inter-related and inter-dependent high-level themes relating to how use of digital technology is reported to enhance productive classroom dialogue: *(i)* 'dialogue activity', *(ii)* 'learning environment' and *(iii)* 'technological affordances'[2].

'*Dialogue activity'* consists of four sub-themes: alternative perspectives (both exposure to alternative perspectives and taking into account others' views); knowledge co-construction (including in ways that are reported to be purposeful, sustained and critically in-depth); using dialogue to express meta-cognitive learning, for example, classroom talk exhibiting elements of reflective self-assessment; and using dialogue to scaffold understanding (both learner-learner and teacher-learner).

[2] For comprehensive details of the studies making up each theme and sub-theme, see Major et al., 2018.

The rather more holistic theme of *'learning environment'* identifies studies where the complexity of the classroom environment is of importance. Here five sub-themes were identified in relation to connections between dialogue and digital technology: learner autonomy; learner inclusion & participation; classroom atmosphere; interpersonal relationships; motivation and engagement.

A third and final theme - *'technological affordances'* - consists of nine sub-themes in total: creation of a shared dialogic space; mediating interaction; externalisation of ideas; informing teaching; multimodality; pace; provisionality; representation of content; temporal factors.

These three overarching high-level themes identified by the scoping review are indicative of the close interaction between dialogue activity, the learning environment and the affordances of various technology. Broadly, the ideas of 'dialogue activity' and 'learning environment' can be viewed to be what digital technology enables. 'Technological affordances', on the other hand, attempt to offer a means of explaining the properties technology has (Oliver, 2005). In the remainder of this chapter, we focus in particular on the ways in which research suggests that the affordances of digital technology may enhance productive classroom dialogue.

4. Unpacking the key theme of 'technological affordances'

We begin this section by providing a brief introduction to the origins of the concept of affordance, highlighting how affordances have typically been conceptualised in terms of 'action possibilities' in relation to educational uses of digital technology. We then report and expand on the findings of the scoping review, which enabled a characterisation of broad technological affordances across a range of dialogic settings.

4.1 Origins of 'affordance'

First attributed to perceptual psychologist James Gibson (1977), affordance was introduced to describe how individuals derive meaning from the world around them, what things in the world 'afford' them, in a relational sense (Osborne, 2014). Affordances are part of a

relationship between an actor and artefacts, with these two parts of a whole system (Kaptelinin & Nardi, 2012). Linell (2009) writes how Gibson thought of perception as being about 'values' rather than 'stimuli', and how he made a distinction between the 'physical reality' and that reality as an 'environment' for a living species (p. 25). That is, the environment is the material world as perceived and apprehended as something (Wittgenstein, 1958/2009). In this sense, affordances are 'enabling conditions' that are part of an environment in a way that is meaningful (Linell, 2009, p. 332). The environment is not simply 'physical reality'; affordances are interrelations between object and subject that take place in the 'interworld' (Merleau-Ponty, 1973).

The concept has proven to be powerful, as reflected by it being taken up in a range of fields including artificial intelligence and robotics (Lemaignan, Warnier, Sisbot, Clodic, & Alami, 2017), education (Bower, 2008) and human-computer interaction (Turner, 2005). However, the translation to other disciplines has not been without difficulty and understanding of Gibson's original notion of affordance has changed as different views have been added to it (Vyas et al, 2006). Whilst it is of course common for ideas to evolve over time, multiple interpretations and definitions of affordance now exist resulting in ambiguity as to what the term means (Magnusson, 2010).

Affordance in the context of educational technology is perhaps most commonly understood today in terms of 'action possibilities', which denote the possibilities that an environment provides to an actor (Kirschner, 2002). This is despite such an idea being absent in Gibson's original definition. Indeed, it appears that this now widespread understanding of affordance arose around the time when the concept was first adopted into the field of design, primarily through the work of Norman (Norman, 1998). Osborne (2014, p. 66) writes:

> Throughout the literature on affordances, it seems that Gibson's original concept is repeatedly and pervasively confused with the later work by Norman, and commonly re-defined solely in terms of action possibilities… search(es) of Gibson's actual text from the Ecological Theory of Visual Perception reveals that the concept of 'action possibilities' or 'possibilities for action' is never actually mentioned[3].

[3] Taking his analysis deeper, Osborne goes on to attribute the term 'action possibilities' to Heft (1989), an ecological psychologist. He also suggests that the linking of affordance and action appears to have been further embedded by Gaver, a student of Norman, in work that attempted to understand the role of affordances in regard to the design of technology (Gaver, 1991).

An interpretation of affordances as action possibilities can be helpful, particularly when designing new technology, or considering the potential implementation of existing technology in new settings. Indeed, one way 'affordance' offers a distinctive perspective on the use of technology in education is because it can be used to consider possibilities for action (Hammond, 2010). When investigating the impact that technology has on actual learning processes and outcomes, however, such as those relating to the interactions between classroom dialogue and technology, viewing affordances as 'action possibilities' is of more limited value. Furthermore, it has been asserted that primarily concentrating on action possibilities can lead to a narrow focus on functionality because viewing affordances as action possibilities can be argued to "fixate (on) technologies as tools, 'things' to be prodded, pushed or pulled" (Osborne, 2014, p. 412) rather than exploring "the meaning that is provided by the environment with respect to a specific individual and at a specific moment in time" (ibid, p. 69). This is an idea we return to in Section 5. First, however, we consider the 'technological affordance' sub-themes identified by the scoping review.

4.2 'High-level' affordances identified by the scoping review

Nine 'affordance' sub-themes were established by the scoping review. These can be seen in Table 1, along with the number of studies reporting each affordance.

Affordance	No. of studies reporting
Representation of content	12
Creation of a shared dialogic space	11
Mediating interaction: a) Versatility b) Accessibility	 11 10
Temporal factors	9
Multimodality	7
Externalisation of ideas	5
Informing teachers	5

Pace	5
Provisionality	5

Table 1. The nine 'affordance' sub-themes identified by the scoping review.

Eleven studies identify how digital technology can provide both a tool and an environment for the *creation of a shared 'dialogic space'* where ideas can be put forward, respected, scrutinised and challenged in a supportive discursive environment (Kerawalla, Petrou & Scanlon, 2013). 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 [Nikolaidou, 2012]). Additional channels for students to 'talk' (e.g. through sending messages to each other [Looi, Chen, & Ng, 2010]) 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 [Singleton, 2016]) and teachers (e.g. as it is possible to use technology during collaborative activities in ways closely related to more familiar classroom practice [Kershner, Mercer, Warwick & Staarman, 2010]). The manner in which intuitive and easy manipulation of digital technology (e.g. iPads) can facilitate students' collaborative talk (Kucirkova, Messer, Sheehy & Fernández Panadero, 2014), and how such devices may afford potential for easy sharing of content (Khoo, Falloon & Nguyen, 2016), 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, such as WhatsApp (Bouhnik & Deshen, 2014). 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 (Beauchamp & Kennewell, 2008), an idea identified in 11 studies.

Five studies note how digital technology can enhance productive classroom dialogue via the *externalisation of ideas* by, for example, posting text to a screen (Mercer, Fernandez, Dawes, Wegerif & Sams, 2003). Learners are then able to easily share and reflect on their own, and other people's, ideas (e.g. Enyedy, 2003). Five studies also identify how technology can be used to *inform teachers*, for instance through monitoring progress (Erkens,

Jaspers, Prangsma, & Kanselaar, 2005). In some cases, teachers can provide instant formative feedback as they can literally 'see' students' misconceptions (Looi, Chen & Ng, 2010). Alternatively, teachers may be able to use students' ideas to elaborate, correct and question students (Rasmussen & Hagen, 2015).

The *multimodal* nature of digital technology, noted by seven studies, allows for greater flexibility in the delivery of resources. For example, the IWB boasts visual, auditory and text-based functions (Mercer, Hennessy & Warwick, 2010). The use of digital technology can also have a positive impact on the *pace* of lessons (e.g. Smith, Hardman & Higgins, 2006). From a teacher's perspective, increased pace enables teachers to display information rapidly and spontaneously (Gillen, Staarman, Littleton, Mercer & Twiner, 2007). From the students' perspective, they can feel that they have greater control over their learning as they may dictate the speed at which they work (Warwick, Mercer, Kershner & Staarman, 2010).

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 five studies. For example, ideas expressed using the IWB may be considered both fluid (Mercer et al., 2010) and transitory (Tanner & Jones, 2007), 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 also reported in 12 studies (e.g. The processes involved in summarising information in a 'tweet' [Singleton, 2016]).

Finally, nine studies identify *'temporal factors'*, for instance, the traceability of students' ideas enabling dialogues to be sustained, and ideas to be built, over time (whether during a single lesson or a series of lessons; Kerawalla, 2015). Using technology can also allow students the ability to move back as well as forwards in some tasks (Kershner et al., 2010), whilst the ability to access all previous and current texts can allow for continuity between lessons (Maher, 2012).

These themes provide a useful high-level framework for considering affordance in the context of classroom dialogue. Presented as synthesised above, however, these themes are largely examples of action possibilities for a range of technology. Yet the learning environment and the specific functionality of particular tools determine the ways in which

action possibilities come to relate to 'enacted affordances'. This highlights one of the original notions of affordance (Gibson, 1977), in that, as individuals derive meaning from the world around them, the relationship between the individual, the context and the tool are what determine both possibilities for action and subsequent enactment of affordances. In our view, therefore, they are inextricably linked.

5. Developing the idea of 'affordances for dialogue'

In this section, we outline how affordance can be considered as comprised of two interrelated elements: 'action possibilities' and 'enactment'. Referring to the idea of 'affordances for dialogue', we suggest this highlights a reinterpretation that may helpfully inform researchers, practitioners and developers interested in the role of digital technology in dialogic contexts. Such an understanding is significant in exemplifying how the affordances associated with technology-mediated dialogue can be specifically - as well as more broadly - analysed by researchers. We demonstrate this idea by reflecting on empirical research involving the implementation of the Talkwall micro-blogging tool.

5.1 Connecting 'Action Possibilities' and 'Enacted Affordances'

Whilst high-level overviews of affordance possibilities can be informative (such as the one reported by the scoping review and elsewhere - e.g. Jeong & Hmelo-Silver, 2016), their broad nature means they can be of limited utility when applied to specific contexts where learning is mediated by technology. Further, when considering something as nuanced as the interactions between a dialogic pedagogy and digital technology, a focus on action possibilities in general terms risks telling only 'part of the story'.

Here, we advocate a view of affordance as acknowledging 'action possibilities', but additionally highlighting the value of recognising the closely related idea of 'enactment'; that is, how affordances are specifically implicated in promoting dialogic interaction for learning. The scoping review considered the affordances of technology in an overarching sense, looking across research focused on a range of technology. In considering the idea of 'affordances for dialogue' in relation to specific technology, we suggest 'action possibilities' (APs) and 'enacted affordances' (EAs) for dialogue are intrinsically interlinked. See Figure 1.

[FIGURE ONE TO GO HERE]

This duality indicates how an understanding of affordance as broad categories pertaining to a range of APs can inform more empirically-based analyses of the enacted affordances of specific technology, and vice versa. These two concepts can also feed into one another during software development and research analysis processes - e.g. APs inform EAs, which similarly inform further development of APs, and so on. In this sense, APs and EAs are not separate observational lenses through which the classroom may be viewed; it is not the case that APs and EAs exist independently. Rather, they are interconnected and interdependent, and operate in a dynamic relationship (see Section 5.2).

Such an understanding resonates with Osborne's (2014) recent analysis of affordance as a design tool for aligning pedagogy and technology. This suggests how affordances can be used to 'explain' learning with educational technology, if the concept is broadened to include the wider ecology of learning. Specifically, Osborne proposes extending the notion of affordance in order to give agency to both learner and technology, thereby recognising the important contribution of the digital environment to the learner experience.

Osborne's approach is compatible with Hetherington and Wegerif's (2018) view of 'material-dialogic intra-actions'. Applied in the context of using digital technology to support teachers' development of dialogic pedagogy (where this is interpreted broadly to include, for instance, a teacher's learning intention and curriculum considerations), this acknowledges how technology is not simply part of the classroom setup nor something simply employed by humans to create meaning (Cook, Warwick, Vrikki, Major & Wegerif, 2019). A material-dialogic perspective does not view digital technology as artificially separate from the activities of the teacher and the learners; rather, it envisages a 'voice' for the technology within intra-actions and focuses on the meaning provided by the environment (Cook et al., 2019). An understanding of APs and EAs, therefore, appears to provide two lenses appropriate for analysing if (and how) digital technology acts as a constructive dialogue partner in enabling and constraining learning in the classroom.

Given the Talkwall example discussed below, we note in particular how the idea of 'affordances for dialogue' appears to be aligned with methodological approaches such as design based research (DBR - Brown, 1992; Barab & Squire, 2004). DBR can be used as an approach to technical as well as pedagogical development (Major, Watson & Kimber, 2015), and aims to develop theories about domain-specific learning as well as the means that are designed to support that learning (Bakker & van Eerde, 2015). Thus, in addition to producing useful products (e.g. educational software), insights into how these can be developed and used are generated (Reeves & McKenney, 2013). An understanding of APs and EAs as interlinked 'design principles' may, therefore, be used to inform external stakeholders, as well as those actively involved in a specific research and development process (relating, for instance, to the development of a particular educational technology). The interconnected nature of APs and EAs resonates with the idea that "... enacted affordances are often quite different from the features imagined by the designers and can only be discovered through analysis of actual usage" (Stahl, 2007); and both will be considered in the iterative phases of design, development and further testing that is a key feature of DBR.

At the heart of 'EAs' is the question of how affordances are implicated in promoting dialogic interaction for learning; that is, in what way are affordances implicated in actual dialogic learning processes and outcomes in a specific technology context? Here we refer explicitly to how enacted affordances mediate the development of the 'strategic knowledge' (Vandergrift et al., 2006) of dialogue use in collaborative interaction, leading to the development of new ideas. This is central to what we mean by 'affordances *for* dialogue'. In the next section, we consider the ideas discussed above by reflecting on empirical research involving the implementation of Talkwall.

5.2 Affordances for dialogue in the classroom use of a micro-blogging tool

Influenced by the material-dialogic framework proposed by Hetherington and Wegerif (2018), in this section we consider empirical research involving the implementation of the Talkwall micro-blogging tool. We do so to exemplify the two interrelated components comprising the idea of 'affordances for dialogue': action possibilities and enactment. This is

significant in exemplifying how the affordances associated with technology-mediated dialogue can be specifically, as well as broadly, analysed by researchers.

Talkwall is one outcome of the Digitalised Dialogues Across the Curriculum project (DiDiAC)[4] undertaken by researchers at the University of Oslo (Norway) and University of Cambridge (UK). Working in collaboration with nine schools, DiDiAC involved the alignment of: theories related to productive talk, a cultural-historical approach to understanding mediating technology, and a situated understanding of limitations and opportunities in the classroom (articulated by teachers during the development process). The overarching context for this work is the development of '21st century' educational practices, with a focus on critical thinking, communication and collaboration. Specifically, DiDiAC investigates how classroom dialogue is supported or modified in relation to the use of Talkwall in the naturalistic setting of the classroom. Aligned to a research-based understanding of dialogic pedagogy (exemplified through 'Thinking Together'; Mercer, Wegerif & Dawes, 1999), the project features collaboration between teachers, researchers and technology experts in both Norway and the UK.

Talkwall is a freely available browser-based tool designed to support classroom dialogue and interaction. Secure and local to each classroom, during a lesson involving Talkwall, a 'main' Talkwall is displayed at the front of the class on a projector or large screen (e.g. interactive whiteboard) and is typically controlled by the teacher; learners have their 'own' individual or group Talkwalls that are accessed and controlled using any device with a web browser. The teacher presents the class with a question or a challenge (also displayed at the top of each wall), before learners engage in dialogue in small groups and contribute ideas in response (using short, microblog-style messages). These contributions appear on a class 'feed', similar to Twitter's Timeline, which is constantly available and shared across all devices. Once posted, contributions on both teacher and student walls can be interactively sorted and arranged in a number of innovative ways[5].

Following an analysis of spoken dialogue where Talkwall was in use in lessons, the development of an 'enacted' affordances framework was required in order to examine the

[4] The time frame for DiDiAC is April 2016 to April 2020. The project is funded by The Research Council of Norway (FINNUT/Project No: 254761).
[5] See Talkwall.net for examples of Talkwall 'in action'.

various ways in which dialogue was mediated (enhanced, modified or replaced) as students used the tool. The research team's initial consideration of the APs related to the tool was informed by: Bower's (2008) work on the action potentials of learning technology; research considering the influence of ICT on the interactivity of teaching and its capacity to support dialogic approaches (Beauchamp & Kennewell, 2008; Warwick et al., 2010); and the nine 'high-level' affordance themes identified by the scoping review. Further, we worked with Talkwall's technical development team to determine their perspectives on various 'built-in' functionality intended to provide APs to support classroom dialogue. With this understanding of the broad APs that the tool might bring to a dialogic classroom environment, we then set out to examine lesson video data to ascertain the EAs evident in the actual use of the tool by students and teachers.

Informed by this background analysis of APs, a *first stage* of affordance analysis involved four researchers independently examining video data and transcripts before collaboratively reviewing, and developing, an initial framework of emerging ideas related to Talkwall's affordances. Following this, through a combination of inductive and deductive processes, a *second stage* of affordance analysis involved specifically coding for Talkwall's 'enacted affordances' (or EAs - i.e. how the tool's affordances were directly implicated in promoting dialogic interaction). Following further discussion and subsequent refinement of themes, a *final framework* of Talkwall's enacted affordances was agreed for application across the dataset.

Talkwall's enacted affordances are repeatedly, and directly, implicated in the dialogic interactions that occurred in classrooms where the tool was used in combination with a dialogic pedagogy[6]. Based on an analysis of 17 secondary school lessons in England during the 2016-17 academic year, involving a total of six teachers (from each of English, science and geography) and 138 students (aged 11-12), seven EAs relating to the use of Talkwall were identified. These affordances are applicable to both learners' and teachers' use of Talkwall and can be seen in Table 2.

[6] Analysis of how affordances have been characterised across the data set not presented here, with a 'high-level overview' provided instead. Further methodological details are available in Cook et al., 2019.

Enacted Affordances (EAs)	Enables	Further exemplification[7]
Browsing	Review of Talkwall contributions (possibly with subsequent action)	The enacted affordance of browsing Talkwall's feed facilitates exposure to other groups' ideas in a way that widens material-dialogic space (Hetherington & Wegerif, 2018). Enactment of browsing may occur over a prolonged period, the effect of which may continue to be felt for longer than the affordance is enacted (e.g. when learners continue to discuss an idea)
Selection	Selection of Talkwall contributions (possibly as a basis for dialogue, where it is often strongly linked to elaboration and reasoning)	For example, when a learner browses the contribution feed and reads another group's post before selecting and potentially 'pinning' this to their own group Talkwall, backing up their selection with a reason
Positioning	Orientation/arranging/prioritisation of contributions in relation to task requirements (e.g. split screen). Use of hashtags (#) to categorise posts	Deepening of material-dialogic space can occur through non-verbal means as the positioning of contributions replaces dialogue. Learners' (re)positioning of contributions with their fingers and their pointing at the screen demonstrates the corporeal nature of material-dialogic space (Wegerif & Major, 2018). Positioning of contributions affords a visual representation of the current state of learners' shared thinking (Hennessy, 2011)
Support/ Challenge	Group member may find support for position, or have position challenged, from contributions posted to Talkwall rather than from within their group	For example, when a contribution posted to the Talkwall feed by another group is used by a learner to support what they are saying
Assistive memory	Less reliance on/externalisation of working memory. Revisiting/ reference back to previous contributions. A potential source of evidence.	For example, a learner revisiting a previous wall or feed to remind them of another group's idea in order to create a new contribution on a second wall of their own. This affordance may enable dialogues to progress over time (Mercer et al., 2017)

[7] In part based on analyses reported in Cook et al., 2019.

Control	Deliberate manipulation by the teacher/Talkwall leader to delimit or manipulate the activity. This includes the choice of wall titles, backgrounds, and the ability to delete other people's posts. Includes focusing, via magnification and filter functions, to create an object of attention (potentially for dialogue to emerge around it). May occur prior to, or after, selection and positioning	For example, during a whole-class activity where the teacher has filtered the Talkwall to focus on a particular group's wall only, followed by the teacher asking the group to explain the positioning of their contributions
Provisionality	Tentative selection or positioning of items indicates possible intention, which may be modified on the basis of challenge/dialogue. The ability to edit posts may also make a post provisional.	The enactment of provisionality can support exploratory talk as contributions may be created and placed without final commitment (Mercer et al. 2017). The intra-action between the provisional nature of positioning and the group's exploratory talk can also enable learners to perform a creative dialogic switch (Phillipson & Wegerif, 2017). Potentially, Talkwall contributions may be viewed as dynamically constructed, easily and infinitely manipulable by teachers and learners – in readily reversible ways that support the temporary exploration of ideas (Twiner, Coffin, Littleton, & Whitelock, 2010). Like utterances (Bakhtin, 1986), they are never final or fixed but exist transiently within the dialogic space (Hennessy, 2011)

Table 2. Talkwall's Seven 'Enacted Affordances' for dialogue.

The strategy for determining the enacted affordances of Talkwall takes into account the wider ecology of learning (Osborne, 2014), including the 'voice' or role of the technology in the interaction (Cook et al., 2019). This is because, in addition to acknowledging the 'action possibilities' of the tool, the meaning provided by the environment is considered through analysing how Talkwall's affordances are specifically implicated in promoting dialogic interaction for learning. In addition to intra-acting with dialogue, the identified EAs are also interconnected and interrelated, with several often 'in play' at the same time in a dialogic classroom environment. For instance, learners' *browsing* and *selecting* from the Talkwall feed may be followed by creative engagement within a 'material-dialogic space' facilitated by the intra-action of *positioning* and *provisionality* with their dialogic co-construction of a particular concept (Cook et al., 2019).

As indicated in Figure 1, we suggest that APs and EAs inform and feed into one another. With the example of Talkwall, classroom-based research informed the iterative design-based development of the tool. Researchers and teachers identified specific EAs relating to how the tool has actually been used in 'dialogic classrooms'. Repeated cycles of testing and development resulted in additional APs and EAs being identified, with these used as a basis for further design and development.

But of course, the majority of educational technology is not created in such a manner. With respect to 'off-the-shelf' technology, APs are realised as EAs in relation to a particular pedagogy. The cyclical interaction (Figure 1) occurs where, as a result of the enactment of some affordances, the teacher reviews the use of the tool to consider what further APs it has to offer in promoting the pedagogy. For example, a teacher may find that the AP of moving image objects on an iPad stimulates group dialogue in science, and may then look to see how the AP of movement in a range of apps might be enacted in tasks to develop dialogue (for example, as rotation of '3D' objects).

We conclude this section by reflecting briefly on an idea closely related to affordance - that of 'constraint' (Greeno, 1994, 1998). Identifying the affordances and the constraints related to the use of an educational technology has been reported to deepen our understanding of the needs teachers naturally have within specific contexts and the types of solutions they deem appropriate to identified problems (Li, 2012). Kennewell (2001) writes:

> Constraints are not the opposite of affordances; they are complementary, and equally necessary for activity to take place. Of course, by virtue of their support for particular actions in a setting, the affordances and constraints may inhibit other actions which are more desirable.

To give an example involving the use of Talkwall, it appears that the enactment of 'browsing', whilst affording access to a range of ideas from around the class, can also serve to inhibit exploratory talk. As detailed in Cook et al. (2019), where browsing was enacted, the size of contribution feed sometimes restricted exploratory talk as the desire to address the contributions posted to Talkwall's feed often curtailed discussions. Therefore, learning itself may be constrained. We refer interested readers to Major et al. (2018) for fuller consideration

of the challenges and constraints that can impact on the use of digital technology in supporting classroom dialogue.

6. Summary

The concept of 'affordance' appears to be significant when considering the interactions between a dialogic pedagogy and digital technology. Here, we have developed the idea of affordances of technology for dialogue to encompass two interrelated components: 'action possibilities' (APs) and 'enacted affordances' (EAs) for dialogue. And we have discussed how an understanding of affordance as broad categories pertaining to a range of APs, as has traditionally often been the case, can inform more empirically-based analyses of the EAs of technology as used in dialogic classrooms.

It is recognised that variables such as the teacher, students, classroom organisation, resources, subject/classroom culture and norms (rules, routines and expectations), task sequence and activity type, and technical arrangements and institutional settings (Seidel, Berente, Debortoli, & Srinivasan, 2016) will always influence what and how students learn (Kennewell, 2001). From this, it will be clear that which APs become evident as enacted affordances in the classroom, and in what form, depends too on the central variable of classroom pedagogy. It is not the technology per se that is important, therefore; it is the technology use in a particular pedagogical context (Mercer, Hennessy and Warwick, 2017). Acknowledging this is central to research that seeks to understand the nature of enacted affordances in a range of settings; and it is central to the teacher, since knowing that the pedagogy is *supposed* to inform technology use frees them to consider not how 'whizzy' the technology may be, but rather how it might become a 'voice' in teaching and learning.

As our exemplification using Talkwall shows (Section 5.2), the overarching idea of 'affordances for dialogue' enables a reinterpretation that may helpfully inform researchers, practitioners and developers interested in the role of digital technology in dialogic contexts. While our approach to the analysis of Talkwall's affordances is of course bounded by its specific context, the lessons learned are applicable more widely. The reported analytical strategy for considering affordance will hopefully prove useful to others interested in the productive use of technology in supporting dialogue and interaction in the classroom.

Meanwhile, the presented framework of Talkwall's 'enacted affordances' can provide a foundation for analyses in other contexts, including the use of other technology.

References

Alexander, R. (2008). *Towards Dialogic Teaching: Rethinking Classroom Talk* (4th ed.). Thirsk: Dialogos.

Alexander, R. (2018). Developing dialogic teaching: genesis, process, trial. Research Papers in Education, 1–38.

Arksey, H., & O'Malley, L. (2005). Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology*, *8*(1), 19–32.

Bakker A., & van Eerde D. (2015). An Introduction to Design-Based Research with an Example From Statistics Education. In Bikner-Ahsbahs A., Knipping C., Presmeg N. (eds). *Approaches to Qualitative Research in Mathematics Educatio*n*. Advances in Mathematics Education.* Springer, Dordrecht.

Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *The Journal of the Learning Sciences*, *13*(1), 1–14.

Barnes, D. R. (1976). *From communication to curriculum.* Harmondsworth:Penguin Education.

Beauchamp, G., & Kennewell, S. (2008). The influence of ICT on the interactivity of teaching. *Education and Information Technologies*, *13*(4), 305–315.

Bouhnik, D., & Deshen, M. (2014). WhatsApp goes to school: Mobile instant messaging between teachers and students. *Journal of Information Technology Education: Research*, *13*(1), 217–231.

Bower, M. (2008). Affordance analysis – matching learning tasks with learning technologies. *Educational Media International*, *45*(1), 3–15.

Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences*, *2*(2), 141–178.

Calcagni, E., & Lago, L. (2018). The Three Domains for Dialogue: A framework for analysing dialogic approaches to teaching and learning. *Learning, Culture and Social Interaction*, *18*, 1–12.

Cook, V., Warwick, P., Vrikki, M., Major, L., & Wegerif, R. 2019. Developing material-dialogic space in geography learning and teaching: Combining a dialogic pedagogy with the use of a microblogging tool. *Thinking Skills and Creativity, 31*, 217-231, https://doi.org/10.1016/j.tsc.2018.12.005.

Davis, K., Drey, N., & Gould, D. (2009). What are scoping studies? A review of the nursing literature. *International Journal of Nursing Studies*, *46*(10), 1386–1400.

Erkens, G., Jaspers, J., Prangsma, M., & Kanselaar, G. (2005). Coordination processes in computer supported collaborative writing. *Computers in Human Behavior*, *21*(3), 463–486.

Fung, D., To, H., & Leung, K. (2016). The influence of collaborative group work on students' development of critical thinking: the teacher's role in facilitating group discussions. *Pedagogies: An International Journal*, *11*(2), 146–166.

Gaver, W. W. (1991). Technology affordances. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, April 28 - June 5, New Orleans, Louisiana, USA, pp. 79–84. ACM.

Gibson, J. J. (1977). The theory of affordances. In R. Shaw & J. Bransford (Eds.), Perceiving, acting and knowing: Toward an ecological psychology (pp. 67–82). Hillsdale: Lawrence Erlbaum Associates.

Gillen, J., Staarman, J. K., Littleton, K., Mercer, N., & Twiner, A. (2007). A 'learning revolution'? Investigating pedagogic practice around interactive whiteboards in British primary classrooms. *Learning, Media and Technology*, *32*(3), 243–256.

Greeno, J. (1994). Gibson's Affordances. *Psychological Review*, *101*(2), 336–342.

Greeno, J. (1998). The Situativity of Knowing, Learning, and Research. *American Psychologist*, *53*(1), 5–26.

Haßler, B., Major, L., Warwick, P., Watson, S., Hennessy, S., & Nicholl, B. Perspectives on Technology, Resources and Learning: Productive Classroom Practices, Effective Teacher Professional Development. Faculty of Education, University of Cambridge.

Hammond, M. (2010). What is an affordance and can it help us understand the use of ICT in education? *Education and Information Technologies*, *15*(3), 205–217.

Hetherington, L., & Wegerif, R. (2018). Developing a material-dialogic approach to pedagogy to guide science teacher education. *Journal of Education for Teaching*, *44*(1), 27–43.

Hoadley, C. M., & Linn, M. C. (2000). Teaching science through online, peer discussions: SpeakEasy in the Knowledge Integration Environment. *International Journal of Science Education*, *22*(8), 839–857.

Howe, C., & Abedin, M. (2013). Classroom Dialogue: A Systematic Review across Four Decades of Research. *Cambridge Journal of Education*, *43*(3), 325–356.

Howe, C., Hennessy, S., Mercer, N., Vrikki, M., & Wheatley, L., 2019. Teacher-Student Dialogue during Classroom Teaching: Does it Really Impact upon Student Outcomes? *Journal of the Learning Sciences*.

Jay, T., Taylor, R., Moore, N., Burnett, C., Merchant, G., Thomas, P., Willis, B., Stevens, A. (2017). Dialogic teaching: evaluation report and executive summary. Education Endowment Foundation and Sheffield Hallam University. EEF. https://educationendowmentfoundation.org.uk/public/files/Projects/Evaluation_Reports/Dialogic_Teaching_Evaluation_Report.pdf

Jeong, H., & Hmelo-Silver, C. E. (2016). Seven Affordances of Computer-Supported Collaborative Learning: How to Support Collaborative Learning? How Can Technologies Help? *Educational Psychologist*, *51*(2), 247–265.

Kaptelinin, V., & Nardi, B. (2012). Affordances in HCI: toward a mediated action perspective. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 5 May - 10 May, Austin, Texas, USA, (pp. 967–976). ACM.

Kennewell, S. (2001). Using affordances and constraints to evaluate the use of information and communications technology in teaching and learning. *Journal of Information Technology for Teacher Education*, *10*(1–2), 101–116.

Kerawalla, L. (2015). Talk Factory Generic: Empowering secondary school pupils to construct and explore dialogic space during pupil-led whole-class discussions. *International Journal of Educational Research*, *70*, 57–67.

Kerawalla, L., Petrou, M., & Scanlon, E. (2013). Talk Factory: supporting 'exploratory talk' around an interactive whiteboard in primary school science plenaries. *Technology, Pedagogy and Education*, *22*(1), 89–102.

Kershner, R., Mercer, N., Warwick, P., & Kleine Staarman, J. (2010). Can the interactive whiteboard support young children's collaborative communication and thinking in classroom science activities? *International Journal of Computer-Supported Collaborative Learning*, *5*(4), 359–383.

Khoo, E. G., Falloon, G., & Nguyen, N. H. (2016). iPad-mediated talk in young children's learning and exploration of interests. In *DEANZ2016 Biennal Conference*, April 17 - April 20, University of Waikato, New Zealand, (pp. 163–167). DEANZ. http://researchcommons.waikato.ac.nz/handle/10289/10280

Kirschner, P. A. (2002). Can we support CCSL? Educational, social and technological affordances. Inaugural address, Open University of the Netherlands, The Netherlands. Retrieved from https://dspace.library.uu.nl/bitstream/handle/1874/25602/kirschner_02_threeworldcscl.pdf?sequence=1

Kitchenham, B. A., Budgen, D., & Brereton, P. (2015). *Evidence-Based Software engineering and systematic reviews.* (Vol. 4). CRC Press.

Kucirkova, N., Messer, D., Sheehy, K., & Fernández Panadero, C. (2014). Children's engagement with educational iPad apps: Insights from a Spanish classroom. *Computers & Education*, *71*, 175–184.

Lemaignan, S., Warnier, M., Sisbot, E. A., Clodic, A., & Alami, R. (2017). Artificial cognition for social human–robot interaction: An implementation. *Artificial Intelligence*, *247*, 45–69.

Levac, D., Colquhoun, H., & O'Brien, K. K. (2010). Scoping studies: advancing the methodology. *Implementation Science*, *5*(1), 69.

Li, Q. (2012). Understanding enactivism: a study of affordances and constraints of engaging practicing teachers as digital game designers. *Educational Technology Research and Development*, *60*(5), 785–806.

Linell, P. (2009). *Rethinking language, mind, and world dialogically*. IAP.

Littleton, K., & Mercer, N. (2013). *Interthinking: putting talk to work.* Abingdon, Oxon : Routledge.

Looi, C.-K., Chen, W., & Ng, F.-K. (2010). Collaborative activities enabled by GroupScribbles (GS): An exploratory study of learning effectiveness. *Computers & Education*, *54*(1), 14–26.

Magnusson, T. (2010). Designing constraints: Composing and performing with digital musical systems. *Computer Music Journal*, *34*(4), 62–73.

Maher, D. (2012). Teaching literacy in primary schools using an interactive whole-class technology: facilitating student-to-student whole-class dialogic interactions. *Technology, Pedagogy and Education*, *21*(1), 137–152.

Major, L., Warwick, P., Rasmussen, I., Ludvigsen, S., & Cook, V. (2018). Classroom dialogue and digital technologies: A scoping review. *Education and Information Technologies*, *23*(5), 1995–2028.

Major L., Haßler B., Hennessy S. (2017). Tablet Use in Schools: Impact, Affordances and Considerations. In: Marcus-Quinn A., Hourigan T. (eds) Handbook on Digital Learning for K-12 Schools. Springer, Cham.

Major, L., & Watson, S. (2018). Using video to support in-service teacher professional development: the state of the field, limitations and possibilities. *Technology, Pedagogy and Education*, *27*(1), 49–68.

Major, L., Watson, S., & Kimber, E. (2015). Developing instructional and pedagogical design for the Cambridge Mathematics Education Project: A Design-based research approach. *Proceedings of British Society for Research into Learning Mathematics (BSRLM)*, 35(2).

Mercer, N. (2013). The Social Brain, Language, and Goal-Directed Collective Thinking: A Social Conception of Cognition and Its Implications for Understanding How We Think, Teach, and Learn. *Educational Psychologist*, *48*(3), 148–168.

Mercer, N., & Dawes, L. (2014). The study of talk between teachers and students, from the 1970s until the 2010s. *Oxford Review of Education*, *40*(4), 430–445.

Mercer, N., Hennessy, S., & Warwick, P. (2010). Using interactive whiteboards to orchestrate classroom dialogue. *Technology, Pedagogy and Education*, *19*(2), 195–209.

Mercer, N, Hennessy, S., & Warwick, P. T. (2017). Dialogue, Thinking Together and Digital Technology in the Classroom: Some Educational Implications of a Continuing Line of Inquiry. https://doi.org/10.1016/j.ijer.2017.08.007

Mercer, N., & Wegerif, R. (1999). Is 'exploratory talk' productive talk? In K. Littleton & P. Light (Eds.), *Learning with Computers: Analysing Productive Interaction*. London: Routledge.

Mercer, Neil, Fernandez, M., Dawes, L., Wegerif, R., & Sams, C. (2003). Talk about texts at the computer: using ICT to develop children's oral and literate abilities. *Reading*, *37*(2), 81–89.

Mercer, Neil, & Howe, C. (2012). Explaining the dialogic processes of teaching and learning: The value and potential of sociocultural theory. *Learning, Culture and Social Interaction*, *1*(1), 12–21.

Merleau-Ponty, M. (1973). *Adventures of the Dialectic*. Northwestern University Press.

Michaels, S., & O'Connor, C. (2012). Talk science primer. *Cambridge, MA: TERC*.

Mortimer, E., & Scott, P. (2003). *Meaning Making in Secondary Science Classrooms*. Buckingham: Open University Press.

Nikolaidou, G. N. (2012). ComPLuS model: A new insight in pupils' collaborative talk, actions and balance during a computer-mediated music task. *Computers & Education*, *58*(2), 740–765.

Norman, D. A. (1998). *The invisible computer: why good products can fail, the personal computer is so complex, and information appliances are the solution*. MIT press.

Nystrand, M., Wu, L. L., Gamoran, A., Zeiser, S., & Long, D. A. (2003). Questions in time: Investigating the structure and dynamics of unfolding classroom discourse. *Discourse Processes*, *35*(2), 135–198.

Oliver, M. (2005). The Problem with Affordance. *E-Learning and Digital Media*, *2*(4), 402–413.

Osborne, D. R. (2014). *An ecological approach to educational technology: affordance as a design tool for aligning pedagogy and technology*. Doctoral Thesis. University of Exeter.

Pifarré, M., & Kleine Staarman, J. (2011). Wiki-supported collaborative learning in primary education: How a dialogic space is created for thinking together. *International Journal of Computer-Supported Collaborative Learning*, *6*(2), 187–205.

Rasmussen, I., & Hagen, Å. (2015). Facilitating students' individual and collective knowledge construction through microblogs. *International Journal of Educational Research*, *72*, 149–161.

Rasmussen, I., & Ludvigsen, S. (2010). Learning with computer tools and environments: A sociocultural perspective. *International Handbook of Psychology in Education*, 399–435.

Reeves, T. C., & McKenney, S. (2013). *Conducting educational design research*. Routledge.

Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge-building communities. *The Journal of the Learning Sciences*, *3*(3), 265–283.

Schwarz, B. B., & Baker, M. J. (2016). *Dialogue, Argumentation and Education*: *History, theory and practice*. Cambridge University Press.

Seidel, S., Berente, N., Debortoli, S., & Srinivasan, N. (2016). Tweeting Like Taylor Swift? Affordances, Status Production, and Online Platforms. In *2016 49th Hawaii International Conference on System Sciences (HICSS)* (pp. 1861–1869). Koloa, HI, USA: IEEE.

Shor, I., & Freire, P. (1987). What is the "dialogical method" of teaching? *Journal of Education*, *169*(3), 11–31.

Singleton, S. (2016). *The effect of microblogging on middle school student engagement and critical thinking.* PhD Thesis. Liberty University.

Smith, F., Hardman, F., & Higgins, S. (2006). The impact of interactive whiteboards on teacher—pupil interaction in the National Literacy and Numeracy Strategies. *British Educational Research Journal*, *32*(3), 443–457.

Stahl, G. (2007). Meaning making in CSCL: Conditions and preconditions for cognitive processes by groups. In *Proceedings of the 8th international conference on Computer supported collaborative learning*, New Brunswick, New Jersey, USA, July 16 - 21 (pp. 652–661). International Society of the Learning Sciences.

Tanner, H., & Jones, S. (2007). Using video-stimulated reflective dialogue to learn from children about their learning with and without ICT. *Technology, Pedagogy and Education*, *16*(3), 321–335.

Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology*, *8*(1), 45.

Turner, P. (2005). Affordance as context. *Interacting with Computers*, *17*(6), 787–800.

Twiner, A., Coffin, C., Littleton, K., & Whitelock, D. (2010). Multimodality, orchestration and participation in the context of classroom use of the interactive whiteboard: a discussion. *Technology, Pedagogy and Education*, *19*(2), 211.

Vandergrift, L., Goh, C., Mareschal, C., & Tafaghodtari, M. (2006). The Metacognitive Awareness Listening Questionnaire: Development and validation. *Language Learning*, 53(3), 431-462.

Virtanen, M. A., Kääriäinen, M., Liikanen, E., & Haavisto, E. (2017). The comparison of students' satisfaction between ubiquitous and web-based learning environments. *Education and Information Technologies*, *22*(5), 2565–2581.

Vyas, D., Chisalita, C. M., & van der Veer, G. C. (2006). Affordance in interaction. Proceedings of 13th European Conference on Cognitive Ergonomics (ECCE-13). ACM Press: NY, 2006, 92-99.

Vygotsky, L. S. (1962). *Thought and Language*. Cambridge MA: MIT.

Vygotsky, L. S. (1980). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Warwick, P., Mercer, N., Kershner, R., & Staarman, J. K. (2010). In the mind and in the technology: The vicarious presence of the teacher in pupil's learning of science in collaborative group activity at the interactive whiteboard. *Computers & Education*, *55*(1), 350–362.

Wegerif, R. (2010). Dialogue and teaching thinking with technology. In K. Littleton & C. Howe (Eds.). *Educational Dialogues: Understanding and Promoting Productive Interaction* (304). Oxford: Routledge.

Wegerif, R., & Major, L. (2018). Buber, educational technology, and the expansion of dialogic space. *AI & Society*. https://doi.org/10.1007/s00146-018-0828-6

Wells, G. (1999). *Dialogic Inquiry: Towards a Socio-cultural Practice and Theory of Education*. Cambridge: Cambridge University Press.

Wittgenstein, L. (2009). *Philosophical investigations*. John Wiley & Sons.

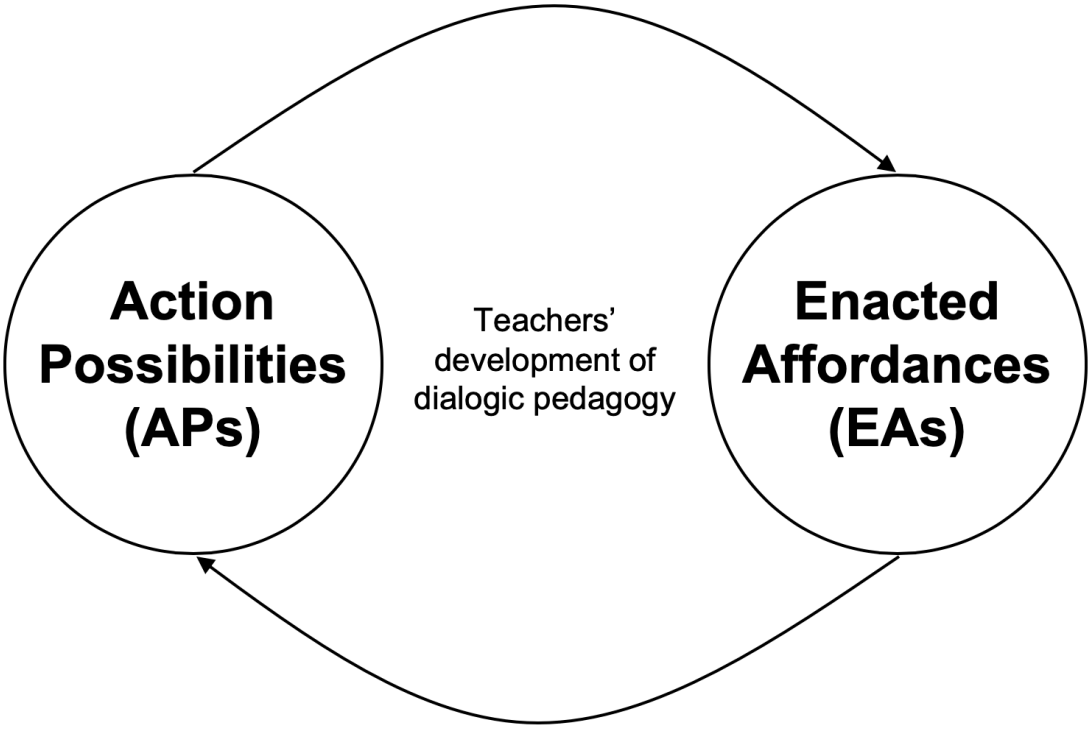

Figure 1. Connecting Action Possibilities (APs) and Enacted Affordances (EAs)