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Technology-mediated learning theory

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Abstract
Technology-enhanced learning research, such as that relating to the use of online technologies in formal learning contexts, is sometimes criticised for being under-theorised. This paper draws together areas of research and theory that have previously been somewhat separately treated, to support the integrated analysis and research of situations where technology mediates learning. First, key areas of research and theory relating to technology-mediated learning are introduced, along with their associated conceptual underpinnings and assumptions, in terms of premises. These areas are then explained with relation to one another regarding how they can be used to holistically understand learning in contexts where technology mediates learning. The implications of the theoretical concepts are discussed in terms of the future conduct of technology-mediated learning research, as well as the scope and conditions under which the theorisations apply.

Defn. Mediate [technical, with object]
Bring about (a result such as a physiological effect)
1. Be a means of conveying.
2. Form a link between.

(Oxford Dictionary, 2019)

Introduction

While technology-enhanced learning can appear on the surface to be quite a simplistic phenomenon, in reality, it is deceptively complex, with its various actors, their diverse assumptions, intentions, and background knowledge, the numerous technologies at peoples' disposal and their various attributes, all within the context of attempting to facilitate learning. The use of digital technologies such as wikis, blogs, social media, mobile applications, virtual worlds, learning management systems and so on is becoming increasingly common in formal learning environments, particularly within online learning environments such as massive open online courses (MOOCs), and in many of these instances technology is the means by which interactions between participants (most typically teachers and students) is mediated. A wide variety of theoretical perspectives have been used to examine the use of technology in education, including Activity Theory, Social-Cognitive Theory, affordances, multimodal and multimedia learning,

Practitioner Notes

What is already known about this topic

- The learning technology research field has used a wide variety of theoretical frameworks to conceptualise and analyse technology-enhanced learning.
- Many of these frameworks are either borrowed from other areas of research, or focus on specific aspects of educational technology usage.
- This has led to criticisms that learning technology research is under-theorised and fragmented.

What this paper adds

- An integrated and holistic theorisation of situations where technology mediates learning.
- Clear specification of the assumptions and premises that underpin the theorisation, based on existing theories and research.
- Qualifications and elaborations regarding the bounds of the applicability of technology-mediated learning theory.

Implications for practice and/or policy

- The possibility of using an integrated theoretical referent when analysing situations where technology mediates learning.
- The holistic theorisation encompassing sociopolitical elements and individual differences encourages critical rather than deterministic approaches to learning technology research.
- Research consequently needs to more deeply examine the relationship between goals, beliefs, practices, environments and learning designs on outcomes and experience in technology-mediated settings.

Actor Network Theory, Community of Inquiry and Communities of Practice, to name a few. However, some of these have been borrowed from fields outside technology-enhanced learning so as to lack contextual specificity, while others focus attention on specific aspects of technology-enhanced learning at the expense of additional important influences. In this paper, pertinent theories and perspectives of import are synthesised to derive a holistic view of how learning occurs in situations where technology mediates learning.

The term "mediated" can have several meanings, and in this paper the term "technology-mediated learning" is used to imply that technology is the means by which information is conveyed and people are linked together. For instance, when an educator designs a diagram on a computer and places it online for later interpretation by students on their laptop or smartphone, the communication act is entirely facilitated through digital technologies, and without the mediation of the digital technologies the communication and any associated learning would not occur. Similarly, when a lesson takes place using video-conferencing software, the technologies, both hardware and software, mediate the entire set of interactions. While Carse (1986) points out that in an ideal world the technology would be so transparent that users do not notice it is there, in reality the technologies, their features, and the way in which they are used, do have a substantial influence on activity and learning, and thus is it important the technology-enhanced learning field has a domain-specific and comprehensive means of analysing their educational use.

Consequently, this paper examines from a holistic perspective what it means for learning to be mediated by technology. It does this by integrating findings and theorisations from a broad range of fields and subdomains to inform the way in which we analyse and understand the nature of learning in technology-mediated contexts. In particular, premises are presented, based upon influential and relevant theorisations and findings from the technology-enhanced learning field and beyond. These are accompanied by an explanation of how the corresponding theories and findings justify the premises, and in some cases the limitations of the theorisations when used individually. The large number of theories considered means it is not possible to explain each in-depth—rather the purpose of the paper is to identify how the theorisations and subareas of technology-enhanced learning can be interrelated, to provide an overarching orientation to the domain. The paper also highlights the implications of these integrated theorisations, and qualifies the boundaries of their application.

The fundamental assumption of technology-mediated learning

The examination presented herein is based on the fundamental assumption that, in a technology-enhanced learning context, technologies in and of themselves have no intentions, but rather are featured objects used to convey meaning between participants.

This can be formally expressed as follows.

Fundamental assumption of technology-mediated learning*: In technology-mediated learning contexts, agentic intentions reside with humans, and not with technology*

That is to say, it is people, often educators and learners, who control the content that is represented and shared using technology, with the operations and representations of the technology being a consequence of the actions of humans. In many circumstances this is an uncontroversial assumption, eg, when a person types a message on their screen and it is directly displayed on the screen of a participant in another location, the technology is merely mediating communication and is not exercising any autonomous discretion. Even in situations where it may appear that technology exercises agentic intentions, for example when an online platform selects groups based on student performance, or even randomly, this behaviour has ultimately been programmed by a human.

The use of the term "mediated" in the fundamental assumption above accords with Actor–Network Theory (Latour, 2005) in so far as it leaves open the possibility that technology itself might unexpectedly transform what is communicated in unintended ways, for instance when there is a bug in software, when a screen distorts an image, or network access drops out intermittently (via Latour, 2005, p. 39). However, in most cases for the purposes of educational technology analysis, educators and researchers may choose to consider technology as what Latour calls an "intermediary," ie, that transports meaning across a network without manipulation or transformation.

Where the work presented here departs from Latour (2005) is to emphasise the asymmetry between humans and nonliving objects, by pointing out that it is people who have intentions and make conscious interpretations, whereas technologies and other nonliving objects do not. Technologies can have agency—they may affect change in educational settings—but they are intentionally designed by humans to do so, and do not inherently act with intentions. This is the position adopted elsewhere in the technology-enhanced learning field (Fox, 2002; Goodyear & Carvalho, 2014a). For this reason, the term "intentional agency" is used in the fundamental assumption above, to clarify that the agency we are talking about is purposeful and emerges from participants. This notion that humans have agentic intentions with respect to learning

technology is, for example reflected in the growing design-based research movement, where researchers work with educators to investigate and iteratively refine the use of technology in learning contexts (Wang & Hannafin, 2005).

It is particularly important, at least from an epistemological perspective, to make the fundamental assumption of technology-mediated learning explicit, because it places responsibility for technology-mediated learning decisions entirely with people (most notably, teachers and students). Though the assumption that humans rather than technology have intentionality may be questioned in an age of increasingly powerful artificial intelligence, it is conjectured that it safely applies in the large majority of educational settings where educators are using technology to mediate the learning of their students. The bounds of this assumption, including in our age of rapidly evolving artificial intelligence, are further considered in the Discussion section of this paper.

Having established the fundamental assumption of technology-mediated learning, several other premises are proposed, based on prevailing theory and research that has been applied in technology-enhanced educational settings.

Premises of technology-mediated learning

Premise 1*: Digital technologies can perform a mediating role for participants in their attempts to achieve learning goals*

From the perspective of Activity Theory (Engeström, 1987), subjects (participants) create objects, often using tools (such as technologies), in an attempt to achieve desired outcomes. This occurs within the context of rules and customs held by a community who divides labour amongst themselves. Activity Theory is important in so far as it highlights this important mediating role that digital technologies can play when participants attempt to achieve desired learning outcomes within social learning contexts. However, while Activity Theory has been used as a theoretical referent in many technology-enhanced learning research studies (see for example Carvalho *et al.*, 2015; Lewin, Cranmer, & McNicol, 2018; Zurita & Nussbaum, 2007), it was not specifically designed for educational technology settings, and can in fact be equally applied to any goal-directed collaborative context such as corporate production initiatives. Moreover, according to Activity Theory, "tools" not only refers to technologies, such as digital technologies, but any resources that can be used in transformation processes, such as cognitive resources, like heuristics. Thus, while Activity Theory helps to establish important theoretical aspects of technology-mediated learning—notably the crucial facilitating role that digital technologies can play when participants engage in goal-directed learning pursuits—it does not specifically account for the nature of digital technologies, or learners, or teaching in contemporary educational contexts. Consequently, additional premises, synthesised from pertinent subareas and themes within the technology-enhanced learning literature, are presented to provide a more contextual theorisation of situations where technology mediates learning.

Premise 2*: In technology-mediated learning contexts, participant beliefs, knowledge, practices and the environment all mutually influence one another*

Social Cognitive Theory (Bandura, 1977) highlights how people's beliefs and knowledge, their practices and the environment all reciprocally influence one another, as people learn in social settings. This is reflected in several technology-enhanced learning theories, frameworks and results. Teacher knowledge with respect to technology-enhanced learning has been extensively explored through the Technology, Pedagogy And Content Knowledge TPACK model (Mishra

& Koehler, 2006), for example with relation to knowledge associated with using technology to represent content and apply particular pedagogical practices. From the students' perspective, digital literacies have also been broadly examined in terms of their impact on learning processes (see for instance Littlejohn, Beetham, & McGill, 2012). The importance of underlying teacher beliefs has been highlighted in empirical research (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012), whereby second-order barriers relating to teachers' internal assumptions exercise a substantial impact on how teachers utilise technology to enhance learning. The design of learning environments, such as the spaces (including digital spaces) in which learning occur, can have a considerable influence upon learning outcomes (Goodyear, Carvalho, & Dohn, 2014). From a sociopolitical perspective, environmental factors such as government policy, industry organisations, societal concerns, professional bodies and financial tensions within education sectors influence educational beliefs and practices by prescribing and constraining ways in which technology should be used for learning (Selwyn, 2007; Veletsianos & Moe, 2017). Recently, there has been increasing emphasis upon *how* teachers design technology-enhanced learning, the practices they adopt, and what they emphasise when making their design decisions (Bennett, Agostinho, & Lockyer, 2015; Laurillard, 2012). This is the fundamental basis of the Learning Design field.

Premise 3*: In technology-mediated learning settings, the role of teachers is to help optimise student learning outcomes and experiences through the purposeful deployment of learning technologies*

The Learning Design field aims to help educators create and share great teaching ideas, with a particular focus on the use of technology (Dalziel *et al.*, 2016). The process of creating effective learning tasks, resources and environment, often referred to as "designing for learning" (Beetham & Sharpe, 2013), requires that educators design tasks in a way that helps students achieve the learning outcomes that will be assessed (Biggs & Tang, 2011). There are many technology-enhanced learning design frameworks that have been created to help teachers effectively deploy technologies in educational settings (see Bower & Vachopoulos, 2018 for a collection of more than twenty such models), as well as a range of tools that support this process (for instance see Conole, 2013; Dalziel, 2013; Laurillard, Masterman, Magoulas, Boyle, & Manton, 2017). Critical in the design and implementation process is to account for the wide range of individual differences and contextual factors that can influence learning (Brook & Oliver, 2003). An important recent development is the increasing emphasis upon how feedback from students, including learning analytics data, can and should inform designing for learning in contexts where technology mediates learning (Lockyer, Heathcote, & Dawson, 2013). This accords with a shift from teachers simply being deliverers of static content to teachers as orchestrating a number of complex technology-enhanced design, evaluation and implementation roles (Roschelle, Dimitriadis, & Hoppe, 2013).

功能可见性；自解释性；给养；可供性

Premise 4*: The affordances of technologies, including their recognition and use, influences the sorts of representation, interaction, production and learning that can take place*

If technologies mediate learning, then the action potentials or "affordances" of the technologies being used must influence the learning that can take place. Gibson (1979) defined the affordances of an object as "what it *offers* the animal, what it *provides* or *furnishes*" (p. 127, italics by Gibson). Norman (1998) later extended the concept from pure utility to also incorporate usability, by defining affordances as "the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used" (p. 9). There have been many different attempts to characterise the sorts of affordances availed by learning

technologies (eg, Bower, 2008; Cochrane & Bateman, 2010; Conole & Dyke, 2004; Dalgarno & Lee, 2010; Deng & Yuen, 2011). For instance, affordances have been classified into clusters such as those relating to media, spatial, temporal, navigational, emphasis, synthesis and access control elements, noting that more static affordances facilitate more receptive learning, while more interactive affordances promote more productive learning (Bower, 2008). As well as all of these affordances that provide functional options to users, there are a range of non-functional affordances such as those relating to reliability, aesthetics, usability and technical performance that can influence learning, for example by affecting the fidelity with which interactions between participants are mediated (Bower, 2008). Synchronicity is another important aspect of learning technologies, with asynchronous technologies such as wikis and discussion forums offering more opportunities for reflective contribution compared to synchronous technologies such web conferencing or virtual world environments that enable real-time rich media interactivity.

Given people have agentic intention, not technologies, it is important for educators and often students to select and appropriate technologies that will help to best facilitate the representation, interaction and productive requirements of the intended learning tasks. The value of recognising and appropriately deploying technologies was identified quite early on in the technology-enhanced learning field, with Hannafin and Land (1997) pointing out that "computers can monitor responses, provide individualised feedback about choices, and maintain records of performance [however] design decisions regulate how, or if, technological capabilities will be utilised" (p. 176). While the concept of affordances has been criticised for being ambiguous and perpetuating technologically deterministic views of education (for instance, Oliver, 2013), the capabilities of technologies and their recognition by users can influence how they are utilised and consequently the learning that takes place (Conole & Jones, 2010), and are thus important to consider when theorising technology-mediated learning.

Premise 5*: The way in which modalities are used and combined influences the way in which meaning is processed, interpreted, created and interrelated*

When learning is being mediated using technology, all communication occurs as a combination of one or more modalities. Modalities are the representational (semiotic) resources that are used to make meaning, such as images, sound, text and video (from Jewitt, 2006). The way in which modalities are used and combined is important because of its direct impact on how accurately and efficiently people interpret communications to create and internalise meaning (Kress, Jewitt, Ogborn, & Tsatsarelis, 2001). Notwithstanding that modalities in the multimodality field are conceptualised differently to modes in the field of multimedia, a range of studies from the multimedia learning field have established somewhat reliable effects with respect to how different combinations and arrangements of modalities are interpreted. Prime examples include the multimedia affect, the modality effect, the redundancy effect, the split-attention effect and the signalling effect (for an overview of these, see Mayer, 2014). At the heart of these results is the fact that people have limited information processing capacity, and when combinations of modalities cause them to reach a state of "cognitive overload" they can no longer sufficiently interrelate information for learning to occur (Paas & Sweller, 2014). It is important to note that while traditionally research has focused on how modalities can be effectively arranged to positively influence cognitive aspects of learning, we should also be mindful that the impact of how we combine and use learning technologies may also be affective (D'Mello, 2013), conative (McKenney & Reeves, 2018) or potentially even kinaesthetic (Coles, Meglan, & John, 2011).

Premise 6*: The way in which technology is used to mediate interaction patterns and possibilities between networks of participants influences the learning that takes place*

One of the principle ways that technology can mediate learning is through learning networks, which in a digital context can be defined as collections of people and devices interconnected via technologies that are engaging in and supporting the completion of learning tasks (in accordance with Goodyear & Carvalho, 2014b). Networked learning makes more interactive and productive learning possible by enabling learners to contribute and share their ideas online, the study of which underpins much of the Computer-Supported Collaborative Learning field (see Dillenbourg, Järvelä, & Fischer, 2009 for a discussion of key issues). In Computer-Supported Collaborative Learning, the way in which technology is used plays a substantial role in shaping collaboration, however, the effectiveness of learning is also heavily influenced by the way educators design tasks, support groupwork processes, provide scaffolding and guide the overall learning experience (Goodyear, Jones, & Thompson, 2014). The mutually influential role of the teacher and technologies in mediating different online learning patterns is highlighted by Laurillard's (2002) Conversational Framework, noting that the theorisation presented herein constitutes a generalisation of the types of learning processes that can take place and the technologies that can be used.

Premise 7*: Arrangements of technologies and the way they are used can influence the sense of presence and community that are experienced*

When learning is being mediated using technology, all sense of presence and community must be established through those technologies and the way they are used. According to the Community of Inquiry model, students' sense of presence is related to their sense of connection with the content being studied, the teacher and their peers (Garrison, Anderson, & Archer, 2010). If students do not feel confident with the mediating technologies they are using, and do not feel a strong sense of teacher contribution, cognitive engagement or social connection, it can result in a sense of "transactional distance" (Moore, 2013). On the other hand, when technology is used well, it can result in the development of "Communities of Practice" (Wenger, McDermott, & Snyder, 2002), where learners and teachers mutually engage, jointly enterprise and share their repertoires within and beyond a course.

Essential aspects of the theorisations above are captured in Figure 1. In particular, in technology-mediated learning the technologies are positioned as mediators between participants (Premise 1), beliefs, knowledge and practices feature as explicit influences within the broader environment (Premise 2), the role of the teacher is to optimise design and implementation of learning tasks based on learner feedback (Premise 3), identification and effectively utilisation of technology affordances is critical (Premise 4), the way in which modalities are used and combined will influence information processing of students (Premise 5), interaction and production through technology-mediated networks impacts upon learning processes (Premise 6), and the way in which the mediating technologies are used can influence the sense of presence and community that is experienced within the environment (Premise 7).

Discussion

There are several subtle yet important features encapsulated in Figure 1. Firstly, aligning with Activity Theory, technology is positioned as a tool used by subjects, to create objects (semiotic artefacts) and achieve outcomes (learning). Technology is the means by which all communication is mediated, with no direct links between participants (later in the paper we will discuss ways in which this assumption can be relaxed to include learning situations where direct interaction

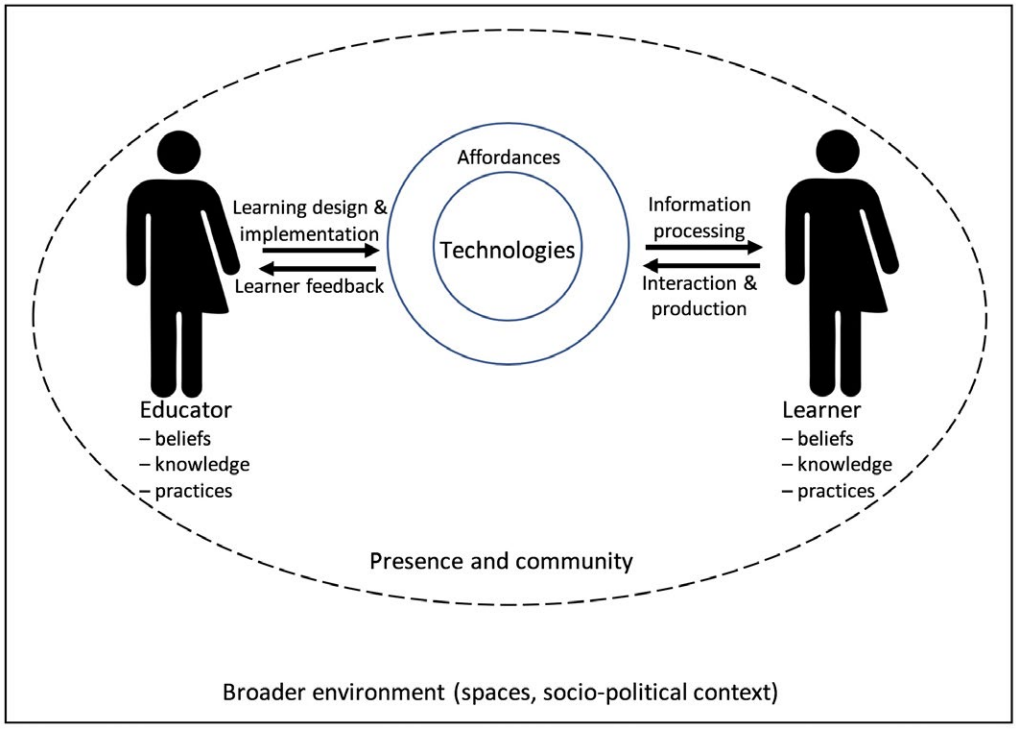

Figure 1: Schematic representation of technology-mediated learning theory [Image of person CC-BY-SA 4.0 Don Clark: https://commons.wikimedia.org/wiki/File:Gender_neutral.svg] [Colour figure can be viewed at wileyonlinelibrary.com]

between participants also occurs). The educator and learner background knowledge and beliefs determine what is communicated—according to technology-mediated learning theory the technology has no ultimate intentional agency. The contributions of students, through their technology-mediated interaction and production, play a critical role in providing feedback to the teacher that can inform subsequent pedagogical actions. The environment, while inextricably interconnected with the beliefs, knowledge and practices of the participants, is positioned as circumscriptive, indicating its overarching contextual role in influencing learning processes, presence and community.

The diagram above is of course a radical abstraction, that reduces much of the complexity surrounding technology-mediated learning. For instance, there can of course be many more than one student, and in fact more than one educator. As well, in classes where students are completing productive tasks, and are provided with more autonomy to be designers, they can start to assume responsibilities more typically associated with teachers, whereby they need to understand the affordances of technologies and how these can be used to communicate meaning between participants. Additionally, while "technologies" have been represented as a singular entity, in reality it is often a suite of technologies that are used in combination across a network, each with their different affordances, in order to mediate learning. According to Gibson (1979) affordances are relational between participants and all objects in the environment, however in Figure 1 only the affordances of technologies are represented because the key point of interest is the way in which technology mediates learning.

Of course, much of the detail of the various theories and research in the preceding section were necessarily omitted from the diagram to support interpretation, so it is critically important that the underlying theorisations are understood, not the figure alone. For instance, as information being interpreted in technology-mediated contexts it can have a cognitive impact, affective impact, conative impact and also a kinaesthetic impact. Both the affordances of technologies and understanding how those affordances can be used have a critical influence on learning (and so on). It is also useful to note that the diagram above can be applied to any duration of learning episode, from instantaneous learning activities to extended programs of study, though different factors may be more or less influential at these various levels of scale.

The extent to which technology-mediated learning theory relates to learning contexts that are blended (eg, in a physical classroom where some of the learning is mediated through online activity and other parts of the learning is face-to-face) is obviously an important question to consider in the current milieu of increasingly flexible and distributed learning. The interplay between those parts of the learning experience that are mediated using technology and those parts that involve direct face-to-face contact adds further complexity to educational analysis where technology is being used. However, for those aspects of a blended learning situation that do involve the use of technology as a mediator, it is proposed that all aspects of technology-mediated learning theory can be applied for the purposes of research and analysis. Researchers may choose to use traditional analytic techniques, or aspects of the theorisations above, when analysing face-to-face aspects of blended learning episodes.

The theorisation has concentrated on formal learning, where teachers intentionally design and facilitate learning activities for their students, so only some aspects may apply for informal and ubiquitous learning contexts. For instance, while technology can still play a mediating role in informal learning (Premise 1), the resources that people learn from may not have been intentionally designed by teachers (contradicting Premise 3). As such researchers and educators are encouraged to reflect upon the applicability of the framework in semi-formal and informal learning contexts.

The technology-mediated learning theorisations above are commensurate with other broader learning theories, eg, behaviourist, cognitivist, constructivist, social-constructivist or connectivist perspectives. All of the assumptions and conceptions that apply for other theories can still be brought to bear when using technology-mediated learning theory, noting that technology-mediated learning theory may provide a useful lens for examining the role of technology in the learning process when these different learning theories are being applied. However, the fact that technology is being used in a learning context does not imply that a technology-mediated learning perspective *need* be applied. For instance, when analysing the cognitive and affective impact of a form of written instructions in class, the fact that the instructions are on a computer screen rather than on paper may not be of any analytical consequence. In such cases, technology-mediated learning theory may not add value, because the way in which technology is being used to facilitate learning and the role that technology plays is not of central importance.

Does technology-mediated learning theory apply to situations where the technology itself is the focus of study in a face-to-face classroom, eg, when a child or adult is learning to program a robot? In these situations, it could be argued that the technology is in fact mediating learning, and is being intentionally used by educators to achieve student outcomes. However, in these instances, the technology is less directly being used as a means of conveying messages and linking people, so technology-mediated learning theory is less likely to be applicable and useful. Alternatively, does technology-mediated learning theory apply in computer-assisted learning situations where a program of instruction or software package has been written for use by a student in isolation at

a stand-alone machine? Even though such learning may not occur in a social context, the digital content has been composed by educators and is mediated using technology, so technology-mediated learning theory may be useful to examine and explain effects.

The fundamental assumption of the technology-mediated learning theory presented above is that technology is the means by which intentions of human participants are mediated, rather than possessing any intentions in and of itself. The claim that humans have agentic intentions, and that technologies do not, has philosophical roots that date back to Searle (1980), who argues that artificial intelligence does not have intentionality unless it has been programmed with causal powers that in sum resemble those of the human mind. However, in an age of rapidly advancing artificial intelligence, this assumption and the bounds of its applicability may be called into question. For instance, if an online learning system marks student assignments and provides them with feedback, or makes decisions about student learning pathways, without any additional human input, is technology still a mediator of learning or has it become an intentioned actor? On the one hand, a human or humans have at some point programmed the system to provide intelligent feedback and make intelligent pedagogical decisions, so in fact, the technology is still executing the will of humans, albeit in a less deterministic fashion. On the other hand, as artificial intelligence technologies become more autonomous, and the relationship between the underlying intentions of the human programmer and the actions of technology becomes less direct, it may be argued that technology is no longer a mediator but exercises independent intentional acts. In such instances, researchers and educators may choose to separate those aspects of the technology that are used for mediation, and those components which are treated as intentioned actors. This point is seen as a possible area for vibrant and ongoing future debate.

It should also be noted that the integrated theorisation presented above in no way provides solutions for *how* technology should be used to successfully mediate learning. Rather it provides a framework for analysis by identifying pertinent influences and relationships. Ongoing and future research is needed in order to more fully understand how technology use influences learning outcomes and experiences. However, viewing technology-mediated learning from the integrated theoretical position presented above has several direct implications for educational technology research. In order to more completely understand learning in situations where technology mediates learning, we need to focus upon:

1. deeply understanding the various underlying goals of educators and students when they use technology to mediate learning;
2. understanding ways in which technological beliefs, knowledge, practices and the environment (including the sociopolitical environment) mutually influence one another with relation to educational technology usage;
3. further understanding how teachers go about learning design and what influences their design decisions;
4. understanding how the affordances of various technologies (both functional and non-functional) along with their recognition by educators and students, impact upon learning;
5. understanding how use and combination of modalities influence learning, on cognitive but also affective, connotative and kinaesthetic levels;
6. understanding how different arrangements of interactions between networks of participants mediated through technology influence learning; and
7. further understanding how presence and community can be enhanced in technology-mediated learning contexts, and the impact this has on students.

Importantly, an integrated view of technology-mediated learning implies that each of these areas should be examined with consideration for the other areas, rather than in isolation. As well, in combination and at an overarching level, the field will benefit from better understanding how we can most effectively cultivate the knowledge, beliefs and practices of all stakeholders, particularly but not limited to educators and students, according to their contexts and environment, so as to optimise learning outcomes, experiences and the success of the education field more generally.

Concluding remarks

The learning technology research field has been criticised for being under-theorised and fragmented (Oliver, 2013), for not adequately clarifying its assumptions (Kirkwood & Price, 2013), as well as often over-relying upon "pre-digital" theories of learning (Castañeda & Selwyn, 2018). Additionally, it has been critiqued as primarily applying theory as part of practically oriented design research, but rarely "speaking back" to theory, eg, by "integrating work from different disciplines in a thoughtful way" (Bennett & Oliver, 2011, p. 186). This paper responds by providing an integrated and holistic theoretical referent with clear assumptions that is specifically designed to help analyse and understand situations where technology mediates learning. Of course, while the various components of technology-mediated learning theory presented here have been separately theorised and often empirically derived, combining them into an integrated conceptualisation, has not. The holistic theorisation of how technology mediates learning may encourage researchers and educators to adopt a more comprehensive and integrated view in their endeavours, and indeed to pressure-test the assumptions that have been proposed herein. In doing so, it encourages critical approaches to educational technology usage and research, which is ultimately seen as healthy for the field.

Framing the use of technology within its sociopolitical context and noting the heterogeneity of individual beliefs and practices, also deliberately aims to encourage critical rather than deterministic approaches to educational research. It leaves entirely open the possibility that the use of technology may influence some learners in one way, other learners quite differently, and yet other learners not at all. The important point in critical approaches to educational technology research (and one that is inherent in the theorisations above) is that technology is seen to occur in a social context, and is thus influenced by the participants and environment, rather than technology being deemed to automatically have fixed effects (Selwyn, 2007). The narrative also aims to honour calls by Oliver (2013) to not assume that technologies are given or neutral, but rather need to be selected, designed and made, thus positioning technology-enhanced learning design as a site of contestation. However, the degree to which the integrated theorisation presented in this paper is used critically depends at least as much on how it is applied by researchers and educators as it does on the framework itself. To that extent, researchers and educators are encouraged to approach the use of the integrated theorisation above with ongoing reflexivity and criticality.

One limitation of this paper is that it has only been able to briefly address areas of learning technology research and theory that are in and of themselves entire fields. It is not possible to comprehensively explain and interrelate all of the theories and areas within the space of one article. Rather, the purpose of this paper has been to provide a narrative that offers a general orientation to and essential integration of these theories as they relate to situations where technology mediates learning. Interested readers are urged to pursue relevant areas using the references provided, so as to develop a comprehensive understanding of the complex issues associated with technology-mediated learning and their interrelations. As Friesen (2009) points out, superficial interpretation of theory in research can result in overly simplistic analysis and findings. Additionally,

it should be noted that the integrated theorisation presented here is only one of many possible interpretations. Other conceptualisations, advancements and ongoing debate are highly valuable, to further the accuracy, relevance and applicability of theory within the field.

Finally, and more broadly, the field of technology-enhanced learning has been predicated on the idea of "enhancing" learning, which is indeed a noble aspiration. But it is also ephemeral one, and does not intrinsically imply a focus on understanding what is happening when technology is being used in education. From a research perspective, it also implies that the use of technology *will* enhance learning, which is by no means the case, and thus constitutes an inherent bias. Actually, what we really mean, and are really interested in investigating, is the way the use of technology mediates learning. It is intended that the theoretical referents provided in this paper will enable researchers and educators to better focus upon, conceptualise and analyse technology-mediated learning from a more holistic and integrated perspective.

Statements on open data, ethics and conflict of interest

All research data referenced is available through scholarly databases held by most university libraries.

As a theoretical paper, ethics approval was not required for this publication.

There are no conflicts of interest to declare.

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