Educational Technology Research & Development

Volume 68 • Number 4 • August 2020
ISSN 1042-1629

Special Issue: Systematic Reviews of Research on Learning Environments and Technologies
Guest Editors: Florence Martin, Vanessa P. Dennen, and Curtis J. Bonk

A bi-monthly publication of the Association for Educational Communications & Technology

Springer

Educational Technology Research & Development

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Volume 68 ☐ Number 4 ☐ August 2020

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continued on next page

Abstracted/Indexed in *Social Science Citation Index, Journal Citation Reports/Social Sciences Edition, Social SciSearch, SCOPUS, PsycINFO, INSPEC, Google Scholar, EBSCO, Academic OneFile, Academic Search, Communication Abstracts, Current Abstracts, Current Contents/Social & Behavioral Sciences, ERIC System Database, ERIH, FRANCIS, Gale, JSTOR, MathEDUC, OCLC, OmniFile, PSYCLINE, SCImago, Summon by Serial Solutions*

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Educational Technology Research & Development

A Publication of the Association for Educational Communications & Technology

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www.springer.com/11423
Electronic edition: link.springer.com/journal/11423

Subscription Information

Educational Technology Research & Development is published 6 times a year. Volume 68 (6 issues) will be published in 2020.

ISSN: 1042-1629 print
ISSN: 1556-6501 electronic

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Office of Publication

Springer Science+Business Media LLC,
1 New York Plaza, Suite 4600, New York,
NY 10004, USA. Periodicals postage paid at New York, NY and additional mailing offices.

Postmaster: Send address changes to Educational Technology Research & Development,
Springer Nature, 233 Spring Street, New York,
NY 10013-1578, USA

Education Tech Research Dev (2020) 68:1595–1612
https://doi.org/10.1007/s11423-020-09809-x

Preface: Reflections on the waves of emerging learning technologies

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Published online: 27 July 2020

Abstract
There have been many waves of emerging learning technologies over the past few decades. Some of these waves are extended, some waves are connected, and other waves are repeated. The authors discuss the special journal issue from the standpoint of their personal involvement in many such waves during their careers. They also detail the evolution of this special issue and the potential audiences and stakeholders for it. In the end, they pose several questions and points to ponder in looking toward the future.

Introduction

This preface was written as a means of lending an historical context and some humanization to the systematic research reviews found in this particular journal issue. By including personal reflections, accounts, and anecdotes of our own participation in the field of emerging learning technologies over the past few decades, it was hoped that the research revealed in this special issue could be better understood and appreciated. Consequently, at times, our reflections and stories will be based in the places in which each of us worked; in particular, West Virginia University and Indiana University for Curt Bonk and Utah State University, Brigham Young University, and Lumen Learning for David Wiley.

We feel most fortunate to have worked in such special places where so much was happening at significant moments in society in terms of emerging technologies for learning. Over the years, both of us have been involved in personally developing, funding, beta testing, researching, evaluating, and reporting on various software tools and learning-related portals (Curt Bonk since the 1980s, David Wiley since the 1990s). Our experiences hopefully equip us with useful insights and a base from which to offer a macro lens to this special issue.

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Some stories to be told

There is admittedly a lack of humanness when reading the seemingly endless rows and columns of data in the charts, tables, and figures of a journal issue that is focused on summarizing masses of research. Therefore, it is vital to keep in mind the personal investments that were made in different technologies as they emerged in assorted learning environments and situations. Stated another way, each of the thousands of research reports that were considered and then selected and analyzed for the manuscripts in this special issue has countless underlying stories. We start this preface with two stories of our own.

Story #1: Are you covering learning objects?

It is 8:00 am on Friday morning September 3, 1999. Professor Curt Bonk (hereafter "Curt"), enters Room 1210 of the School of Education at Indiana University (IU) and finds it filled with many of the top master's and doctoral students of his program as well as visiting scholars from Australia, Finland, Korea, and the United States. In fact, 14 of 20 students who are enrolled would move on to professorial positions of their own after graduation.

Course syllabi are soon passed out for his course on "Interactive Tools for Learning and Collaboration" (Bonk 1999). Steve, a new doctoral student who had worked in instructional design and consulting in Silicon Valley until earlier that month was sitting in the middle of the room toward the front (i.e., within a few feet of the instructor). He raises his hand and asks if the course would cover a fast-emerging topic called "learning objects." He then comments about the outdated design of instructor's homepage; in effect, implying that the instructor may not be qualified to teach this class. Light chuckles are heard within the room.

A few seconds later, an international student from Korea, JY, seated three rows behind Steve also wants to know if learning objects will be addressed because they have suddenly become popular in Korea. She notes that free resources on learning objects had recently been made available from a guy named Wiley (1999a, b). Steve concurs with JY since he has just attended a conference on the topic in the San Francisco Bay area. Soon, several other students in that class join in to voice their concerns that the topic of learning objects is not listed in the syllabus causing the instructor to admit to not knowing much about the topic.

Having spent a good portion of the previous summer of 1999 working on the course syllabus, Curt was somewhat taken aback. During the following weeks, however, he would modify his syllabus and become attuned to the fast-evolving field of learning objects. In fact, during the next 2 decades, Curt would update his syllabus with all sorts of related trends into the field of open education including open source software, open universities, OpenCourseWare (OCW), open textbooks, and open educational resources (Bonk 2009a; Mishra 2017; Wiley and Hilton 2009).

When he finally had a chance encounter with David Wiley at a conference a few years later, he understood why his students were interested in his work. David had a pulse on an inexhaustible amount of information related to the world of open education and he was quite willing to share it. He had formed a team at Utah State University and a Center for Open and Sustainable Learning (COSL) that seemed situated at Ground Zero of the open

education movement in the United States. In addition to talented and committed people, COSL had grants and projects for open courseware research and development.

When Curt met several members of the COSL team at the E-Learn conference in Vancouver in late October 2005, he learned that they had designed "superhero" role cards for team member identity in the openness movement and to help market their message (Bonk 2009b). Of course, David would be "The Opener" while others were designated the "Persuader, " the "Maverick," and "Captain Connections." Perhaps more important than these savvy marketing skills, the COSL team was helping develop standards for OCW with a tool called eduCommons. Additionally, COSL was coordinating conferences, summits, institutes, and online discussions on OCW and open education. With those initiatives in place, they were actively recruiting other colleges and universities to participate in these efforts.

A couple of years later, David would help found the Open High School of Utah and also play a pivotal role at a company related to open education, Flat World Knowledge. That string of innovative educational projects and ideas soon landed "David Wiley" in Fast Company's 100 Most Creative People in Business in 2009 (Fast Company 2009); he was, in fact, the only person in the list from the field of instructional design and educational technology. Such notoriety signaled that emerging technologies for learning were starting to attract immense attention, not just from educators, but from the media, venture capitalists, politicians, and society in general.

During this time, one thing was becoming increasingly clear, learning technologies were emerging and evolving at a much faster pace at the start of the twenty-first century than had ever been witnessed in the previous one. It was almost as if a magic switch went off toward the end of the 1990s to bid adieu to educational technology as we knew it and to signal the start of an era where such technology would not simply be used to enhance, augment, or extend human learning and intelligence, but potentially transform it in revolutionary ways not seen before (Bonk 2009a).

Despite all the exuberance for learning with technology at the start of this millennium, the world of educational technology in the twenty-first century is one that remains filled with caveats, concerns, and an assortment of unknowns. Some raise cautionary flags over the cost justifiability of different technologies tools and applications. Others sound alarms over their practical implications. Still others ask whose needs are being served and for what purposes we adopt or integrate a particular technology tool or application into our instruction.

So, as we started with a personal story about the topic of learning objects from 1999, it is perhaps appropriate that we start to close this section with a quote from Prince, who is famous for a song referencing that particular year. Prince stated, "Technology is cool, but you've got to use it as opposed to letting it use you" (Lauer 2004). For the past 2 decades, the field of learning objects, now open educational resources (OER), has continued to evolve and find new uses and applications (Bonk 2009a, b; Clinton and Khan 2019; Mishra 2017; Wiley and Hilton 2009, 2018). There has been an explosion of reports about the significant cost savings and flexible uses of OER (Baraniuk 2008; Hilton 2016) as well as many others about the shortcomings and difficulties of finding high quality and locally appropriate open education content (Conole and Brown 2018; Lee et al. 2007; Rolfe 2017; Weller 2014). As these reports come out, students will likely continue to demand that this topic be included in course syllabi related to emerging learning technology and trends in instructional technology.

Fast forward a little over 2 decades to mid-June 2020, and Bonk has recently finished teaching a 30th anniversary edition of that same course, which ironically is now titled "Emerging Learning Technologies," thereby matching this special issue theme. It is also

affectionately known as "the monster syllabus" course due to its 100-page syllabus of open educational resources and open access materials (Bonk 2020). In the spring of 2020, Bonk was teaching the course both online and face-to-face (FTF); however, in Week 9, the FTF section had to suddenly shift online due to COVID-19. Since nearly all the course materials were open access, Bonk and his students found the transition seamless. In reflection, he is fortunate to have listened intently to David and the COSL team about open education long ago. We now, in fact, turn to a story from David himself who documents a groundbreaking moment in the history of learning with technology and open educational contents.

Story #2: Open certificates in preMOOC days

It is the summer of 2007, and David Wiley (an open education leader; hereafter "David") is pondering how to make his fall course more open. For several terms now he has been putting his course syllabus in a public wiki and encouraging students to edit it. He has been selecting readings for his courses that are available on the public Internet and that anyone can read without purchasing a textbook or logging into the campus library. In addition, he has been encouraging students to submit their homework assignments for his classes by publishing them on a public blog where the whole world can read and engage with them.

But that is prior course history. David is always tinkering with his course and attempting to find ways to enhance and perhaps even transform student learning. As such, he is now pondering how he can step it up this term. What might be a powerful pedagogical idea in line with his course goals?

Some additional reflection soon prompts a realization: When you teach a class where the syllabus and readings are all on the public Internet, and where students publish their homework on blogs, it could be possible for anyone to participate in that class. Anyone. They would not need to apply to the university, get accepted, or pay tuition in order to participate—they would just browse the syllabus on the public wiki, read the publicly accessible readings found on the Internet, come back to the public syllabus to see what the week's writing assignment was, and then publish it on their blog. Anyone with an Internet connection could "learn along from home."

A person could not earn university credit for taking a course this way, but they likely would not care. David would be teaching "Introduction to Open Education" in the fall—the first time such a course had ever been offered—and he figured that there would be enough interest that people would come and participate without formal recognition from his institution (i.e., Utah State University). Still, people might want to have something to show for the effort that they made in taking the class. So, when David announced the new course and its open design that would allow anyone in the world to participate, he promised to give completers a signed certificate showing that they had participated in the course. It would not have the university's name on it or come with credits, but it would be something.

People were interested. More than fifty people from around the world formally signed up for this obscure graduate seminar by adding their names and blog addresses to the wiki-based syllabus. Many others followed along less formally. The open course design inspired many related efforts, including a spring 2008 course by Siemens and Downes on connectivism that had many more participants and was the first course to be called a "massive open online course" or MOOC (Bonk et al. 2015; de Freitas et al. 2015; Downes 2008; Fournier and Kop 2015; Zhu et al. 2018, 2020). The open course design also prompted the Chronicle of Higher Education to publish an article titled, "When

Professors Print Their Own Diplomas, Who Needs Universities?" (Young 2008), which "inspired" "interesting" conversations about the design of that particular course with university administration.

The work of opening this course happened in the context of broader efforts in the Center for Open and Sustainable Learning (COSL) at Utah State University. As alluded to in the first story above, COSL was the home of eduCommons, an open source software platform for sharing open educational resources that powered one-third of the open courseware initiatives at universities around the world. COSL organized the annual Open Education Conference from 2005 to 2007 and published Yochai Benkler's *Common Wisdom: Peer Production of Educational Materials* (Benkler 2005). In addition, COSL staff wrote commissioned analyses on open education topics for organizations like the OECD. With such books, conferences, and reports, COSL was a clear leader in the movement toward open education.

In the midst of all that, David and other COSL staff members founded the Open High School of Utah, a public, statewide, online charter high school. Importantly, the school's charter documents require it to use open educational resources throughout its curriculum (Note: the school was renamed "Mountain Heights Academy" in 2013). Suffice it to say, there was extensive energy and momentum in the air around using "open" as a lever to improve student learning.

Like all other supposedly novel designs, the Fall 2007 Introduction to Open Education course was not a whole cloth reimagining unlike any course or experience that preceded it. Rather, it was the result of the slow accumulation of incremental design innovations over many semesters that, like the pile of grain in the sorites paradox, eventually became recognizable as a distinct thing. And perhaps this is why the pace of change in learning technologies seems to be accelerating so rapidly—there is a lot more on the ed tech pile today than there was 20 years ago.

The waves

Anyone teaching about or researching emerging learning technologies for the past few decades realizes that the topics of interest change like the wind. Multimedia, hypermedia (e.g., HyperCard and SuperCard), idea processors, CD ROM, interactive laserdiscs, geometry and algebra tutors, microworlds and artificial realities, Logo and then Lego Logo programming, and asynchronous collaboration of many stripes, were popular in the technology waves of the 1980s and 1990s. However, as Reeves and Lin (2020) remind us in their concluding manuscript of this special journal issue, we often talk about these technologies in a decontextualized manner, instead of detailing their thoughtful use in educational settings, the learning theories which they represent, or the specific education-related problems and issues that they can help address.

As constructivist theories were embraced in the 1980s and 1990s, knowledge building and sharing tools arose to exemplify key concepts and principles. Interest in these topics soon gave way to experimentations with podcasts, wikis, blogging tools, and other forms of social media in the 2000s. These were termed Web 2.0 because the user could now create and add content to the Web, not just locate and passively consume it. In the second half of that decade, attention shifted to the use of shared online video for learning as well as flipped classrooms, virtual worlds like Second Life, open textbooks, and various forms of mobile learning.

And the waves of learning technologies show no sign of letting up here in 2020. In fact, it is becoming extremely difficult for educators and researchers to keep up with all the advances. This special issue is, in part, a response to this dilemma.

As indicated in the introduction, during the past few decades, each of us has been highly active in developing and attempting to understand the impact of particular emerging learning technologies. As would be expected, our personal involvement in some of these waves of learning technology are much wider and deeper than others. Each wave is built upon different circumstances and unique flavors of opportunities. What seems clear to us is that some waves are extended over time whereas some are connected to other waves and still others are repeated in cycles as they go in and out of favor.

Extended waves

Some waves are extended. As an example, in 1990, Curt and his colleague Padma Medury at West Virginia University (WVU) conducted a national survey of collaborative writing technologies and similar tools. What they discovered was a more diverse and robust field than they had expected. Collaborative Writer, DIScourse, Realtime Writer, Conference Writer, Aspects, Group Writer, Prep Editor, and the Knowledge Builder were just a few of the tools for collaborative writing from a distance that existed some 3 decades ago (Bonk et al. 1994). Such tools provided a shared space for knowledge generation, document editing, project collaboration, idea exploration, and resource exchange (Schrage 1990). With the emergence of these tools, society now had virtual napkins for brainstorming, discussing, cataloging, and sharing ideas that were available to learners whenever they were connected to the Internet.

In the midst of this revolution in collaborative and interactive learning technologies that appeared at the dawn of the Web in the late 1980s and early 1990s, the School of Education at Indiana University (IU) in Bloomington opened for classes on August 31, 1992. That grand opening happened to be the day after Curt arrived on the IU campus after spending 3 years on the faculty at West Virginia University (WVU). He soon discovered the handsome new School of Education building was purposefully funded to be a demonstration, research, and development site for innovative learning technologies (see Bonk 1998; Bonk and King 1998). During the ensuing decade, Curt and his various research teams conducted extensive research on online collaborative writing and computer conferencing tools that expanded upon his earlier work at WVU. This extended work resulted in an edited volume of their research titled, "*Electronic collaborators: Learner-centered technologies for literacy, apprenticeship, and discourse*" (Bonk and King 1998).

It is important to point out that none of the first wave of collaboration tools that are mentioned above still exist today. However, they indirectly or directly led to such software tools as Slack (Kim 2019), Google Meet (Verbrugghe 2020), Microsoft Teams (Carter 2019), Flipgrid (Gronseth and Hutchins 2020; Mahmoudi and Gronseth 2019; Vander Ark 2019), Google Docs, and other remote document and screen sharing systems today. Unlike such first-generation software which supported collaborative writing, contemporary collaborative technologies of 2020 are more focused on work team production, communication, and efficiency; collaborative writing being one aspect of such work team production and communication and document exchange.

Perhaps the technology trend most directly related to early collaborative forms of writing is wikibooks. The Wikibooks website was launched in 2003 as a sister site to Wikipedia. Like many other online collaborative writing tools such as Google Docs, documents

created on the Wikibooks website rely primarily on asynchronous collaboration. In the late 2000s, Bonk and his colleagues conducted a series of studies on the experiences, challenges, and motivations of Wikibookians and what they viewed as success and failure for their various online collaborative book writing efforts (Lin et al. 2011; Sajjapanroj et al. 2008). They also explored the opportunities and barriers of cross-institutional wikibooks (Bonk et al. 2009, 2010).

Fast-forward a decade or so later to 2020 where interest in collaborative writing technology remains (Abrams 2019; Li and Zhu 2017), including in language learning environments (Yim and Warschauer 2017), but also in the tools for work team production and efficiencies, detailed above. Such rapid changes in society and shifts in focus make useful research on emerging learning technologies difficult since the utility may be short-lived.

Connected waves

Some waves are connected to other waves. When Curt arrived at IU in 1992, it was not just collaborative writing technology that was being explored and tested. As a federally funded technology demonstration site, the IU School of Education was beaming with many types of learning technology experiments. For instance, the Vision Athena project from Ameritech (Lee 2004; Lee and Hutton 2007) had IU faculty members and staff experimenting with videoconferencing via PictureTel throughout all eight IU campuses as well as with many school districts across the state of Indiana. Curt was part of an innovative project to combine two videoconferencing systems, PictureTel and CU-SeeMe. With the success of that initiative, he could bring guests whose articles his students were reading into his classes as a means to foster a cognitive apprenticeship with enhanced perspective taking (Bonk et al. 1996).

Similarly, other inroads were made at IU in employing synchronous videoconferencing in the 1990s and 2000s to connect people in isolated, educationally impoverished, or rural parts of the world. The goal was not only to provide educational services but to offer opportunities for shared understandings, multicultural awareness, and mutual respect. One such project founded in 1995 in the Center for Excellence in Education (CEE) within the School of Education at IU, the International Studies In Schools (ISIS) project, did just that (Lee 2004, 2006, 2007, 2010; Lee and Bonk 2013; Lee and Hutton 2007).

As described by Lee and Hutton (2007), ISIS helped students in previously isolated and rural Indiana farm communities interact with experts on Egyptian, Malaysian, Chinese, Korean, Kenyan, Iraqi, and Australian culture and the cultural norms of many other countries made possible through the use of videoconferencing technology. The goal of these intercultural educational events was enhanced perspective taking, shared understanding, dignity, respect, and the exchange of highly current information as well as enhanced interpersonal skills (Lee 2007, 2010). Through such synchronous technology mixed with thoughtful and appropriate pedagogy, the local world becomes global and the global becomes local, if only for 50 min.

ISIS was unique but it was far from the only example of such cross-cultural educational initiatives. Many similar projects and entities, with names like ePals, iEARN (Gragert 2012), Seeds of Empowerment (Buckner and Kim 2012; Kim 2009), the World Forum (Bonk and Sugar 1998), World Savvy, Taking It Global, RoundSquare, Adventure Learning (Miller et al. 2008; Veletsianos and Eliadou 2009), Learning Circles (Riel 1993) and Soliya, have been developed since the 1980s. Millions of learners around the world have participated in them and continue to do so. As indicated, these programs were designed

to foster a range of skills and experiences including cross cultural collaboration and intercultural awareness. They also were intended to enhance or elevate empathy, world peace (Schrum 1991; Veletsianos and Eliadou 2009), interpersonal understanding, mutual knowledge, social cognition (Selman 1980), and a wide range of other vital twenty-first century skills (Maguth 2012). Given current events taking place across the world in 2020, this is the type of learning technology initiative that could have immense positive consequences.

There is even more power to impact the world community with such technology since this is a connected wave. During the past decade, global collaboration and interaction technology has been increasingly used for online language learning (Bonk 2009a; Xu 2019). For example, programs like VIPKid are focused on Chinese youth learning English with the synchronous videoconferencing support of North American teachers (McCorvey 2018; Zhang 2019). Of course, VIPKid and all other such global programs mentioned above require some instructor training for success. Accordingly, there have been an array of research initiatives and projects devoted to preparing teachers for a global education age filled with cross-cultural collaboration in fully online and blended classes (Hardman 2019; Kumi-Yeboah 2018; Longview 2008; Merryfield 2007, 2008; Merryfield and Kasai 2009; Oliver et al. 2019).

What is clear is that we have entered a new age of education; one that no longer takes place with the kids down the block or even those in one's own city or local region. In addition, one's teachers can come from any corner of the planet at any moment of the day. These opportunities for global interaction and sharing will only increase in the coming decades. Not surprisingly, the ability to collaborate with others electronically around the globe has brought an unparalleled amount of pedagogical possibilities and excitement to the educational world along with a whole host of unanswered research questions and technological problems (Bonk and King 1998).

And the waves keep coming. Today, when much of the world is dealing with a global pandemic, an assortment of popular tools for real-time connections like Zoom (Flaherty 2020; Hogan and Sathy 2020; Snider 2020), Adobe Connect, Cisco WebEx, BlueJeans, Skype, Google Hangouts, and Facebook Messenger Rooms (Guynn 2020; Hughes 2020) have brought renewed attention to the instructional capabilities of synchronous technology. Such synchronous forms of communication and interaction offer unique opportunities for contacting special guests and experts (Janning 2019; Kumi-Yeboah 2018); especially as K-12 schools and higher education institutions struggle with this new era of online instruction brought about by COVID-19 (Kamenetz 2020; Page 2020). Again, we see connected waves.

There seems to be a renewed interest in contacting experts as a means to potentially transform the conventional instructional situation by extending one's classroom to the greater world community (Hardman 2019; Kumi-Yeboah 2018; Lee and Bonk 2013). As Lee and Bonk (2013, p. 133) point out, "There has never been a time in the history of formal education when a classroom space could so swiftly be altered or transformed by online expertise." Small wonder that research and experimentation pertaining to synchronous conferencing has flourished during the past quarter century (Martin et al. 2017).

Repeated waves

Some waves are repeated. As Web-based instruction met with some resistance in the late 1990s and early 2000s, the term blended learning surfaced and soon became widely used (Bonk and Graham 2006; Bonk et al. 2002). This term reemerged a decade later as

educators became both familiar and comfortable with it (Cleveland-Innes and Wilton 2018; Shen et al. 2013). Today, blended learning is one of the most researched areas of the field of instructional design and educational technology.

This wave is a repeater. In fact, ideas and activities regarding blended learning are front and center yet again today with the emergence of COVID-19 (COL 2020; Hodges et al. 2020). Yet, despite more than 2 decades of blended learning use, educators are still unclear about what the term actually means. In a recent *EDUCAUSE Review* article, Dziuban et al. (2020) ask whether blended learning is best defined as a treatment effect that can potentially lead the way to prescriptive instructional practices. They also suggest that it might be a broad description for an evolving local practice. In the end, they acknowledge that for many educators blended learning is best suited as a flexible and responsive term that can accommodate a wide range of educational practices (Dziuban et al. 2020).

Another repeating wave relates to open content in education. This wave goes by many names, including open content (Wiley 1998), open courseware (MIT 2001), open educational resources (UNESCO 2002), and open textbooks (e.g., Benkler 2005). In all these manifestations, learning materials are made available to the public under an open copyright license that provides everyone with permission to copy, edit, and share the learning materials freely and legally (Wiley 2015; Wiley and Hilton 2009). For those seeking additional information on this particular wave, Hilton (2016) provided the first systematic review of the research on open educational resources and Clinton and Khan (2019) published the first meta-analysis pertaining to this topic.

The emergence of this special issue

Suffice to say, we have seen countless educational technologies over the past 3–4 decades. This special issue of *Educational Technology Research and Development* (ETR&D) on "Systematic Reviews of Research on Learning Environments and Technologies" documents the extraordinary amount of relevant research that has been conducted in this area recently. There is no grand masterplan when it comes to technologies for learning. The waves keep coming. Repeatedly! Clearly, there will be no moratorium placed on new ones.

With these incessant waves, aspects of human learning are changing; learning is becoming more open, online, blended, massive, immersive, mobile, gamified, video-based, collaborative, social, flipped, and personal, to name a few (Bonk 2016). It is as though the gigantic advances in communication and transportation devices seen in the last century are being matched in this century by myriad developments in learning technologies. Stated another way, this is quickly becoming the "Learning Century" and the thoughtful use of emerging technology to learn can help humankind find success within it. However, as we explain below, myriad challenges and issues remain.

Given all this momentum, it was deemed vital to create a space to discuss the research on emerging learning technology. Accordingly, a Presidential session at the Association for Educational Communications and Technology (AECT) conference on October 24, 2018 was created titled, "*Systematic Reviews of the Research on Emerging Online Technologies: What's Been Done; What's To Come*" (AECT 2018). It was in that session where many of the contributors to this special issue presented earlier versions of their research, including the two of us.

The event offered opportunities to lay out the spectrum of research on learning technologies. Participants shared their research directions and insightful overviews of the research literature in one of the four following areas: (1) social media, (2) open educational resources, (3)

massive open online course (MOOCs), or (4) synchronous learning. These teams of researchers detailed some of the major findings emanating from their research in these four strands and some of the common research methods undertaken to date. The participants also pointed to untapped areas of research in these areas that await further exploration.

Based on the success of that Presidential session, Florence Martin, Vanessa Dennen, and Curt Bonk were invited to edit this special issue of ETR&D. A call for proposals went out and 48 proposals were received. Of these, 13 made it into this issue.

With the plethora of online learning technologies emerging during the past 2 decades, there has been a persistent and mounting need for scholars—both young and those more seasoned—to better understand what research has been conducted, what it says, and what research gaps remain. Suddenly, there has been a tidal wave of systematic reviews of different online learning technologies published during the past couple of years. Regrettably, as stated earlier, many of those reports address learning technologies as "things" without the context of specific problems that they can help solve.

Simply put, the affair with new technology pervades society. As H. R. McMaster aptly put it, "We're so enamored of technological advancements that we fail to think about how to best apply those technologies to what we're trying to achieve" (Erdmann 2013). Today, in this era of COVID-19, now is the exact time to begin focusing on problems that technology might address rather than studying technology for technology's sake. However, such solutions should not be just for "emergency remote teaching" in dire times (Hodges et al. 2020).

Writing in their daily blog column for Inside Higher Ed, Maloney and Kim (2020) recently argued, now is the time to look ahead a few decades and ponder, "Where might we be in 2050?" Maloney and Kim see many upcoming changes in how we use technology to engage students in both curricular and co-curricular activities as we adopt learner-centered pedagogical approaches that de-emphasize instructional strategies for content delivery, and, in turn, promote experiential and community-based learning and overall learning innovation (Kim and Maloney 2020).

In part, the purpose of this particular journal issue is to bring together a group of innovative researchers who have completed systematic reviews of the research on emerging learning technology from different angles. As such, this special issue should have massive appeal to graduate students and those early in their post-graduate careers looking for research topics to explore during their graduate studies and beyond. It should simultaneously appeal to more senior researchers and scholars who are seeking to understand how these fields have evolved in terms of the research as well as where the open gaps in the research remain.

The articles in this issue, written by dozens of prominent leaders in the field of instructional design and educational technology, provide insights on what the research to date says on social media, MOOCs, wearable technology, mobile language learning, mobile game-based learning, mobile literacy tools, technology for special education, adaptive learning, and other crucial topics. In addition, they detail some of the common research methods undertaken to date and offer pointed guidance and suggestions on untapped areas or issues that await further exploration.

Audience and stakeholders

As indicated, for the past few decades, scholars in the field of instructional design and educational technology have been scrambling to keep up with the pace of technological advances and associated pedagogical change. For one, they have had to learn about each technology trend or invention well enough to answer questions from students curious

about the current state of the research as well as the theoretical implications. At the same time, they would need to know the instructional possibilities and other practical implications when serving on strategic planning committees of different institutions and organizations. Third, technology trends foster media inquiries requiring the ability to condense the research down to a couple of pointed sound bites. Fourth, colleagues, friends, and family members might directly or indirectly encounter different technologies for learning—be it in the form of a popular virtual world or videogame—and inquire about the particular cognitive, behavioral, and social benefits and detriments of playing for extended periods. Alternatively, they might ask specific questions about the virtual world or game itself. Fifth, to be an expert in one or more emerging technology trends, one needs to conduct research that pushes the field ahead. Most importantly, such research should target important local or more global issues and problems.

All of these audiences and stakeholders have different interests and inquiries. But what is common among them is that they want answers. They desire anything and anyone that can help them make sense of recently emerging or popular educational technology innovations for their particular situation and perspective. But what are the problems to be addressed or solved? That is where meta-analyses and systematic reviews of the research can play an increasingly larger role in society. And special issues on such meta-analyses and reviews, like this one, are pivotal to the decision making of organizations and institutions across educational sectors.

They are not, however, intended to be a one-stop shop to find answers for everything in the field. Given the acceleration of learning technologies since the dawn of this millennium, that would require global contributions and collaborations on a massive scale. This is just one journal issue with a finite number of research topics thereby guaranteeing that it will be useful for a fleeting moment in historical time. Nevertheless, it can find use in college classes on learning technologies, research methods, and trends and issues in the field. It should also help policy makers with their technical reports, briefs, and proposals intended to provide targeted funding and support.

Finally, these meta-analyses and systematic reviews of the research can serve as starter fuel for those currently conducting research in any of the areas addressed in this issue as well as those who do so in the coming decade. For scholars who arise in this latter camp, we urge you to first clarify and appropriately detail and define the problem or issue that you are attempting to solve. Reflect on who might benefit from the technology and how. Think about the learning environments that such technologies work in. Just who are the stakeholders that potentially will benefit from this research? What are the means by which learners most effectively learn? How does engagement, collaboration, interaction, and feedback occur in this system? And how does all this come together to solve an important problem? In other words, do not just focus on a type of technology without addressing the broader context.

As Geoff Mulgan from University College London observed, “The emphasis is too often on shiny hardware rather than how it is used…A tablet replacing an exercise book is not innovation, it’s just a different way to make notes” (Burns 2012). At the same time, Mulgan points to the potential for digital technology to rethink and reorganize how learning takes place both inside and outside of school structures, including powerful global peer collaboration possibilities. However, as he astutely argues, such transformations too often take a backseat to standardized exam systems, preset curricula, and educational norms. Ironically, in the closing piece of this special journal issue, *Reeves and Lin* start with a quote from Mulgan offering a similar tone and challenge.

Again, during this pandemic and far beyond, we should be rethinking educational structures and norms and the role of various learning technologies within them (Dede 2020; Maloney and Kim 2020; Mishra 2020). We urge researchers to not simply look at the systematic review averages and totals, but to ponder the educational implications that stem from all the stacks of research papers that they spent months reading and analyzing. And, as we highlighted at the start, take time to reflect on the fact that there are innumerable interesting people, important stories, and unique contexts that underly each of those studies that never found their way into the printed report. Without such reflections, why bother at all?

In closing this opening: The standing wave

We recommend those reading this special journal issue keep some of the stories and experiences detailed in this preface in mind. You may be part of an extended, connected, or repeated technology wave and not yet realize it. As indicated, it is perhaps impossible to expect a single special journal issue to adequately cover the range of instructional design and educational technology research issues, trends, and topics salient at this moment in time, let alone attempt to address the myriad new ones which will emerge during the coming months, years, and decades ahead.

Instead, the pieces in this issue give a snapshot of the research data on select technology advancements and how they are currently impacting education across sectors and age groups. Without a doubt, there will be edited volumes like this one that appear in the future which will report on vastly different technology trends, opportunities, and points of interest. Experimentations that are taking place in the current era of COVID-19 will only accelerate the explosion of technological and pedagogical innovations and models of education.

When you turn the pages, you will quickly see that each article is quite informative. You will also notice that a wide range of emerging learning technology trends, concerns, and opportunities are outlined and summarized in the various articles. Naturally, we recommend you start with the introduction to this issue from Martin et al. (2020). It will be a means for you to grasp significant points, issues, challenges, and gaps in the research before diving in further. Careful reading should provide you with a fresh set of research questions and possible initiatives to personally pursue or suggest to those that you are mentoring and advising. Clearly, as shown by the momentous research reflected in the articles in this special issue, there are many insightful suggestions for future research and exploration.

Perhaps the most frustrating thing about the field of learning technologies is the way it obsesses over technologies while devaluing or even ignoring problems faced by learners around the world. For decades, learning technologies like those discussed in this special volume have been elevated to objects of study in and of themselves. All too frequently, those working in our field respond to questions about their research agenda with answers like “I study iPads,” “I study augmented reality,” or “I study open educational resources.” We question whether this fetishization of learning technologies will help us make sustained, meaningful improvements to the world in the future. As long as we are focused on the tools themselves, the ongoing march of learning technologies will resemble an endless series of waves eternally breaking on the shore only to draw out and come crashing in again without making a visible difference in the surrounding landscape.

We encourage learning technologists to follow the old advice, ‘fall in love with the problem, not the solution.’ The world is full of so very many problems that desperately need solving—racism, poverty, crime, climate change, war, Internet access, educating

refugees… the list goes on and on and range from the local to the global. At the very least, we encourage the reader to consider adding a problem to their answer to the question above. For example, "I study how to help young women maintain their interest in science and math into their high school years. iPads show real promise for mitigating this problem." Or "I study how to make higher education more effective and affordable to students who are most at-risk. Open educational resources have an important role to play in making that happen."

Fall in love with a problem—let it be your "standing wave." Then as the inevitable extended, connected, and repeated waves of learning technologies roll past over the years, you will have a steady foundation from which to evaluate and use them instrumentally to make the world a better place.

Funding Funding information is not applicable/no funding was received.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Education Tech Research Dev (2020) 68:1613–1633
https://doi.org/10.1007/s11423-020-09812-2

A synthesis of systematic review research on emerging learning environments and technologies

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Published online: 23 July 2020

Abstract
In this introduction to the special issue on systematic reviews on emerging learning environments and technologies, we introduce best practices for conducting systematic reviews and meta-analysis and discuss the need for a systematic review on emerging learning environments and technologies. We synthesize research on seven primary areas of emerging learning environments and technologies that include: (1) social media, (2) massive open online courses, (3) special education technology, (4) mobile learning, (5) game-based learning and gamification, (6) adaptive learning, and (7) learning analytics and introduce the thirteen articles that were included in this special issue. This article also provides implications for the readers on using and conducting systematic reviews.

Keywords Emerging technologies · Emerging learning environments · Systematic reviews · Meta-analysis · Research synthesis

Introduction

In recent years, there has been an increase in the number of systematic reviews and meta-analyses employed to synthesize research from primary studies. Systematic reviews aim to examine secondary data by retrieving, synthesizing, and assessing existing knowledge on a subject in a logical, transparent, and analytical manner. Systematic reviews are not literature reviews or narrative reviews but follow a specific methodology to locate, select, evaluate, analyze, synthesize, and report evidence that helps to draw conclusions (Denyer and Tranfield 2009).

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There are guidelines on how to conduct systematic reviews. The U.S. Department of Education, Institute of Education Sciences, What Works Clearinghouse Procedures and Standards Handbook, Version 4.0 (2017). The What Works Clearinghouse (WWC) reviews and profiles high quality research in education to assist educators to make evidence-based decisions. The WWC team recommends a five-step systematic review process that includes: (a) developing the review protocol, (b) identifying relevant literature, (c) screening studies, (d) reviewing articles, and (e) reporting findings. Alexander (2020) offers methodological guidance for framing a systematic review (e.g., situating the review theoretically, establishing what is already known and still needs to be known, articulating an answerable question, etc.), procedural steps and challenges (e.g., setting one's search parameters, specifying search terms and time frames, appropriately delimiting the search, etc.), consolidating and summarizing challenges (e.g., recording the basic details, charting other appropriate characteristics, beginning to consider other ways of grouping the data that are potentially relevant, etc.), and interpreting and communicating findings (e.g., recognizing outcomes that are meaningful and relevant, finding ways to capture significant patterns and trends, clearly communicating the outcomes of the systematic review, etc.). All these components of the systematic review are intended to assist researchers to explore educational research more deeply, critically, rigorously, clearly, openly, and meaningfully.

Within the context of systematic reviews, a meta-analysis is "a set of statistical techniques for synthesizing the results of multiple studies. Such techniques are used when the guiding research question focuses on a quantitative summary of study results" (Pigott and Polanin 2020, p. 24). Pigott and Polanin (2020) recommend the following best practices while conducting a meta-analysis, (a) developing a research question for a meta-analysis; (b) searching all eligible studies; (c) unbiased screening of abstracts and full-text; (d) coding important moderators of effect size variability; and (e) computing and reporting all effect sizes. Some meta-analyses focus on estimating a treatment effect in a set of experimental studies, whereas others focus on estimating the magnitude and direction of an association between two variables. Though time-consuming, meta-analyses add value for future researchers, practitioners, and policymakers. Figure 1 shows a visual of reviews. As is clear from that figure, while all meta-analyses are systematic reviews, not all systematic reviews are meta-analyses.

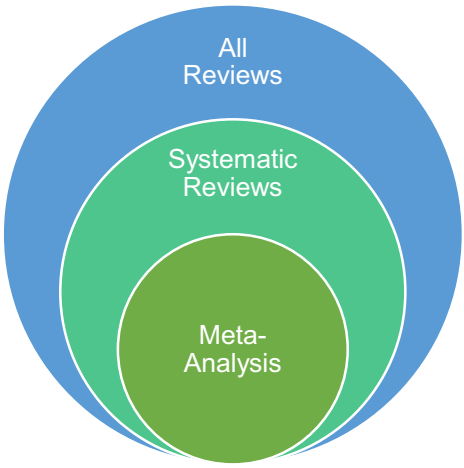

Fig. 1 Visual depiction of research reviews

Systematic reviews and meta-analysis have benefits such as answering critical questions, formulating appropriate search parameters, and using explicit methods of data extraction and synthesis. They also employ sources that otherwise might be considered inconclusive and small. And they provide an opportunity to address topics of mixed-findings (Ioannidis and Lau 1999).

Some of the limitations of systematic review and meta-analyses include that they can be prone to bias due to analyzing only published data as well as the bias that results from screening and coding of those available studies. Another prominent limitation is that such reviews and analyses only provide information pertaining to what is already published and available, and, therefore, such analyses cannot improve the quality of primary research. Additionally, systematic reviews suffer from questions about their inherent validity. To begin addressing validity, researchers might attempt to include detailed inclusion and exclusion criteria, incorporate unpublished studies in addition to published studies, be transparent in screening and coding process using a protocol, and discuss the quality of studies included (Schlosser 2007; Thompson et al. 2012). Finally, researchers might seek to make comparisons that are appropriate and relevant so as not to compare apples and oranges.

Need for systematic reviews on emerging learning environments and technologies

There has been an increase in the use of learning technologies such as MOOCs, social media, virtual and augmented reality, collaborative technologies, open educational resources, synchronous online technologies, adaptive technologies, and mobile technologies (including wearables), to name a few (Bonk 2009, 2016). These technologies are referred to as emerging technologies, a term that indicates that their status and use in educational contexts is still fairly fluid (Veletsianos 2010). Early research in an area typically focuses on what Borko (2004) refers to as "existence proofs," or one-off studies of individual implementations.

It takes time for a more systematic, mature body of research to emerge and for noticeable research gaps to start to be filled in. This special issue brings together a collection of systematic review articles, each focusing on a different aspect of emerging learning technologies. As is apparent, there is a need for a strategic approach to review research on the use of these emerging learning environments and technologies. In this special issue, seven primary focus areas of emerging learning environments and technologies are included: (1) social media, (2) massive open online courses, (3) special education technology, (4) mobile learning, (5) game-based learning and gamification, (6) adaptive learning, and (7) learning analytics. While there are several other emerging learning environments and technologies, only these topics were included as these were based on author submissions to this special issue. We summarize the reviews of research based on these key areas below.

Social media

While the origins of social media can be traced back to the late 1990s (Boyd and Ellison 2007), it took a decade until the popular social networking sites that we use today to emerge. According to a couple of recent Pew Internet surveys (Anderson and Jiang 2018; Perrin and Anderson 2019; Smith and Anderson 2018), these social networking

sites included Facebook, Twitter, Instagram, Pinterest, Whatsapp, LinkedIn, and Snapchat, which serve a broad range of social and communication functions. Among educational researchers, the reception to social media has been mixed.

While these popular social networking sites have been hailed for their educational promise (Greenhow and Askari 2017, Greenhow et al. 2019a, b; Paskevicius et al. 2018), they have been critiqued for the potential discomfort (Dennen and Burner 2017) and disruption (Flanigan and Babchuk 2015) that they may cause in educational settings. In short, the value of taking these more generally used tools and coopting them for academic purposes is uncertain, although both formal and informal learning clearly have been facilitated through social media use (Greenhow and Lewin 2016).

Existing reviews of social media research in the education context explore an array of applications. First, there are reviews that focus on educators and leaders, along with how they use social media. Ranieri (2019) directly examined social media's role in teacher professional development, finding that knowledge exchange and network development are key uses. In contrast, Macià and García (2016) took an indirect approach, conducting a review on professional development communities and networks which are frequently situated in or facilitated through social media platforms. Leonardi and Vaast's (2017) review does not focus specifically on educators but touches on the affordances of the social media.

Next are reviews that focus on the student experience. In moving the field of social media forward, Greenhow and Askari (2017) assessed the state of social media research in education by using Roblyer's (2005) framework of studies in educational technology. They found that while implementation-focused studies along with studies exploring uses of social media by teachers and students were common, the major gap is studies that connect social media to concrete measures of learning. This finding resonates with an earlier review study that noted enthusiasm for social media use, but insufficient empirical support for claims that such technology can be an effective learning tool (Tess 2013). Reflecting on these findings, Greenhow et al. (2019a, b) recommend research that focuses on practices, outcomes, and learning across contexts.

Finally, reviews of research on social media conducted outside of education are valuable to consider as well, given the broad-reaching impact of social media across an individual's life. For example, Bolton et al. (2013) reviewed the research on the millennial generation's use of social media and PrakashYadav and Rai (2017) reviewed the research on GenZ. Both consider how different generations may have unique approaches to social networking and how to use tools in different ways. In contrast, Leonardi and Vaast's (2017) review did not focus specifically on educators or students but touches on the affordances of the social media. Most recently, Orben's (2020) review targeted teenage digital media use and overall wellbeing. This particular study revealed that many review articles on social media aggregate and discuss all platforms together, which is a shortcoming because such an approach overlooks the nuanced differences among the tools.

As the research progresses and evolves over time, more generally focused review studies can help education researchers more thoroughly consider the role of tools or platforms in addition to purpose. To that end, reviews like Chugh and Ruhi (2018) explored Facebook research and Tang and Hew (2017) summarized Twitter research. The former found that Facebook brings both advantages such as increased engagement and disadvantages such as privacy concerns to the classroom, whereas the latter found that Twitter was most frequently used as a means of broadcasting messages to a class.

In this special issue, two articles provide systematic reviews of social media research from different angles. First, *Dennen, Choi, and Word* look broadly at research on social media, education, and teens, including studies from related fields. They find points of

overlap between the research in and out of education, with little interdisciplinary work being conducted between education and other fields. This review highlights opportunities for future researchers to collaborate widely to understand how social media not only fits narrowly within the scope of academic learning, but more holistically across the school setting. *Luo, Freeman, and Stefaniak* take a different perspective, investigating studies of social media use for professional development among higher education faculty. Their findings show promise for this use of social media, but also pose various challenges to overcome before social media-based professional development becomes a widespread, successful practice among this population.

Massive open online courses (MOOCs)

People around the globe were aware of the dire situation in education brought about by the COVID-19 pandemic. What many failed to ascertain is that a form of online education that had been widely criticized during the past decade, massive open online courses (MOOCs), was finding increased traction during the COVID-19 outbreak. The MOOC enrollment numbers in the early months of the pandemic were staggering. An article in the *New York Times* in late May 2020 by Steven Lohr (2020), "Remember the MOOCs?: After Near-Death, They're Booming," noted that the top MOOC provider, Coursera, added more than 10 million learners from mid-March to mid-May 2020. A report from MOOC provider, Udemy, found a similar pattern and attributed the surge in MOOC enrollments to people remotely working and not traveling to events for training. As a result, countless millions were needing to learn online (Udemy 2020).

Perhaps such numbers should not be surprising given that online degrees and MOOCs were flourishing prior to the pandemic (Schroeder 2019b); it was becoming increasingly possible to earn academic degrees and certificates through MOOCs, including master's degrees and other credentials (Hollands and Kazi 2019; Pickard 2019; Shah 2019a, b). As that was occurring, there was a distinctive shift in MOOC offerings toward adult learners in the workplace (Rayome 2017; Schaffhauser 2018). For instance, online programs were becoming modular (IBL News 2018) and stackable where learners could go from taking a few free online courses via a MOOC to enrolling in certificate programs that can later count toward a master's degree (DeVaney and Rascoff 2019).

Although MOOCs are a relatively new phenomenon, many research studies have been carried out since inception in 2008 (Downes 2008). In addition, numerous systematic reviews of MOOC research have been conducted (e.g., Kennedy 2014; Liyanagunawardena et al. 2013). The MOOC research reviews to date span a range of issues such as MOOC success factors, quality, MOOC research in different countries, and MOOC pedagogical approaches. Some MOOC research reviews relate to MOOC scholarship (Ebben and Murphy 2014) such as methodological approaches employed and the publication outlets (Deng and Benckendorff 2017; Veletsianos and Sheperdson 2016; Zhu et al. 2018), whereas other reviews focus on general trends, topics, and themes (Bozkurt et al. 2017; Liyanagunawardena et al. 2013; Zhu et al. 2018). Still other reviews have investigated the geographic distribution of MOOC publications (Veletsianos and Sheperdson 2016; Zhu et al. 2018), most cited articles (Veletsianos and Sheperdson 2015), or MOOC researcher disciplinary affiliations (Veletsianos and Sheperdson 2015). A couple of recent MOOC research reviews have explored self-regulation (Lee et al. 2019) and MOOC engagement and dropouts (Joksimović et al. 2018).

Early MOOC advocates argued that this technology offered greater democratization of education. Recently, there have been concerns made that MOOCs have done little to help the disadvantaged or less educated. In response, there are now systematic reviews of MOOC research related to problems and issues in the Global South (King et al. 2018; Zhang et al. 2020), social mobility among the underprivileged (van de Oudeweetering and Agirdag 2018), and the accessibility of MOOCs (Sanchez-Gordon and Luján-Mora 2018).

Zhu, Sari, and Lee, in this issue, provide a comprehensive look at the extant MOOC research. In the present study, they significantly build on their earlier research of 146 empirical studies published between October 2014 to November 2016 (Zhu et al. 2018). In fact, of the many systematic literature reviews of MOOCs to date, this study is the most comprehensive thus far in terms of both the number of years of research in the analyses and the number of studies. Previously, the largest undertaking of MOOC research was by Bozkurt et al. (2017) who captured and analyzed 362 studies that met their criterion spanning 2008 to 2015. More impressively, Zhu et al. (this issue) included 541 empirical published journal articles from 2009 to 2019. As a result, this study is rich with data and figures, both current and historical.

Zhu and her team appropriately divide their data into two phases: Phase 1 from 2009 to 2016 and Phase II from 2017 to 2019. What distinguishes the two phases is that, after 2016, MOOCs increasingly became attached to a degree program or college credit or led to a certificate (Pickard 2019; Shah 2018, 2019b). In effect, starting in 2017, MOOCs became monetized. With this framework for dividing MOOC research, Zhu, Sari, and Lee provide a better sense of MOOC research trends, topics of interest and focus, data collection and analysis methods, and extent of collaboration within the MOOC research field.

Special education technology

Increasingly society is concerned with meeting the needs of diverse learners across educational settings and sectors. Over the past few decades, the field of special education has developed and researched technologies to support those with learning disabilities across the various content areas including reading, writing, math, and science (Hasselbring and Bausch 2017). As the field of learning technology expanded, naturally, there was increasing attention into learning with technology in the field of special education. This has resulted in systematic reviews focusing on studying the use of various learning technologies including online technologies with learners with cognitive disabilities (Cinquin et al. 2019), support tools for those with autism spectrum disorders (Aresti-Bartolome and Garcia-Zapirain 2014), and mobile technologies to assist individuals with developmental disabilities (Kagohara et al. 2013).

Like with other learning contexts, more common technologies are often repurposed in special education settings. This repurposing has become increasingly common with the widespread use and social acceptability of smartphones and tablets (Campigotto et al. 2013). Part of the motivation behind this repurposing of existing technologies and the use of mobile applications (app) to support learners in special education contexts comes from their affordability (McEwen 2014). It also is derived, in part, from the lessened risk associated with trying an app that often costs less than five dollars in comparison to the many dedicated cognitive support tools that have abandonment rates that exceed 35% (Dawe 2006). The most recent explorations into the uses of new technology for special needs

children have considered how to support socio-collaborative learning approaches (Baykal et al. 2020) and the creation of robots who can support inclusive play (Metatla et al. 2020).

This exploration of the use of robots is unsurprising given the current general focus on artificial intelligence (AI) within society. While the use of AI to support learning dates back to the 1970s and 1980s, its adoption in schools has been less pronounced and its use for supporting special education contexts is less established. However, the types of AI-based approaches that are used to support learners in other contexts have been shown to differentially benefit students with disabilities (Woolf et al. 2010).

In a review of the research on special education in this special issue, *Olakanmi, Olakanmi, Akcayir, Ishola, and Demmans Epp* reviewed 126 publications from 2014 to 2018 focused on various cognitive and developmental disabilities; across these works, there were some 283 different disabilities represented across the studies in this review, making generalities especially difficult. Most addressed the K-12 student population and targeted gaming. The primary goal across the studies that they reviewed was enhancing cognitive outcomes. Most studies took place in academic disciplines such as the natural sciences, reading, and writing prompting the Olakanmi et al. to suggest that more attention should be paid to special education technology in work and social settings as well as life in general.

Mobile technologies

Mobile phones have found their way into the hands of the vast majority of adults in the United States (96%; Pew Research Center 2019) and around the world, though not equally across regions and countries (Taylor and Silver 2019). With one million new mobile learners being added each day, the exact number of worldwide mobile users is difficult to pin down; however, as of late January 2019, there were 5.11 billion unique mobile users out of 7.676 billion people on the planet or about 67% (Kemp 2019). This rapid growth has paved the way for exploring mobile learning as a meaningful way of supporting both formal and informal learning experiences. The existing research on mobile learning is extensive and broad, much like mobile phone ownership; nevertheless, mobile learning is not yet a widespread global phenomenon. A review of research conducted in Africa shows that issues like infrastructure, age of technology, pedagogical ability, and attitudes can make mobile learning prohibitive (Kaliisa and Picard 2017). Although sub-Saharan Africa is the region with the greatest disparity, the shift to remote learning during the COVID-19 pandemic demonstrated that inequality of access for mobile learning extends throughout the world community (United Nations 2020; Vogels et al. 2020).

Although mobile learning—which includes learning with tablets and wearables, in addition to phones—may not yet be a viable solution for all learners, prior reviews have shown that the research in this area has matured over time in terms of research design and focus (Krull and Duart 2017; Lai 2019). For PK-12 learners, most research has looked at mobile learning in science-related disciplines with elementary school learners using behaviorist approaches (Crompton et al. 2017). The mobile learning literature base in science has, in turn, been reviewed, with recommendations made for expanding research into areas such as mobile collaborative learning (Zydney and Warner 2016) and exploring the affordances of mobile learning in the science classroom; specifically, the ability to learn across spaces and contexts (Bano et al. 2018). In higher education settings, mobile learning research shifts to focus more heavily on language instruction and student achievement (Crompton and Burke 2018).

Similar to Crompton et al.'s (2017) PK-12 review, Pimmer et al. (2016) found that behaviorist approaches are also common in higher education.

In this special issue, we have four reviews that address mobile learning, each extending and reinforcing earlier reviews. First, *Eutsler, Mitchell, Stamm, and Kogut* examine 13 years of research on mobile technology use with early learners to develop literacy skills. From the 61 studies that Eutsler et al. reviewed, they found that tablets were the most common devices used with young learners, with a diverse array of mobile learning implementation. Additionally, their results revealed mixed results in terms of effectiveness, especially where reading comprehension is concerned.

Also in this issue, *Chen, Chen, Jia, and An* focus on mobile-assisted language learning (MALL) research, conducting a meta-analysis across 11 years of research to examine effectiveness when compared to other language learning methods. Their findings support MALL as an effective approach to language learning, especially when it takes advantage of the situated and collaborative affordances of mobile devices. This study echoes the suggestions and pleas from earlier reviews of mobile learning (Crompton et al. 2017; Pimmer et al. 2016) that call for researchers to increase their focus on collaborative and constructivist uses of mobile technologies to support learning. It also demonstrates that the skills that collectively support language learning are not all equally taught via mobile learning, which is akin to the mixed results found by Eutsler et al.

The third review of mobile learning in this special issue, by *Gao, Li, and Sun*, examines game-based learning in the mobile context. By looking at 30 studies of STEM-oriented game-based learning, they were able to identify trends in this field. The majority of the studies that they examined were conducted with younger children, reinforcing Crompton et al.'s (2017) findings. They identified a major limitation in the existing studies; notably, the brevity of mobile game-based learning interventions. Like other reviews in this area, Gao et al. noted a dearth of studies focused on collaboration.

Whereas the other three reviews in this special issue focus on mobile learning through smartphones or tablets, the final mobile learning review investigates the research on wearable technology. *Havard and Podsiad* included 12 studies in their meta-analysis. They discussed the challenge of defining the scope of this area given the diverse nature of wearable technologies that are proliferating (e.g., smartwatches, head-mounted devices, fitness trackers, eyewear, wrist bands, and smart garments). Their findings showed generally positive results for learners who use wearable technologies, especially for cognitive outcomes. Although there were relatively few studies in this area, this area seems ripe for growth as wearable technologies show up in both formal and informal educational settings.

Collectively these reviews of mobile technology for learning show how mobile learning remains an emerging and fast-changing technology that has potential for broad use across populations, disciplines, and contexts. Although the research base is maturing, the technology that supports mobile learning continues to develop at an even faster pace. Similarly, the field's understanding of when and how mobile learning applications might best be designed and implemented remains a topic of investigation (Krull and Duart 2017; Lai 2019).

Game-based learning and gamification

While game-based learning existed even in the 1970s (Coleman 1971), the development of the Internet and personal computing resulted in increased interest and instructional practices based on game-based learning. Importantly, de Freitas (2006) defines games

for learning as "applications using the characteristics of video and computer games to create engaging and immersive learning experiences for delivering specified learning goals, outcomes and experiences" (p. 9). Using games for learning has several advantages including, to motivate and engage learners, for skill rehearsal and practice, for role-playing different jobs or professions, problem-solving, communication, collaboration, and critical thinking. Researchers have differentiated game-based learning from gamification, which is defined as the use of "use of game design elements in non-game contexts" (Deterding et al. 2011, p. 9).

Meta-analyses have been conducted in the last two decades to study the effectiveness of digital game-based learning. In an early meta-analysis on games and simulations, Vogel et al. (2006) found that using games and simulations resulted in higher cognitive outcomes and attitudinal outcomes compared to traditional face to face instruction. More recently, Clark et al. (2016) conducted a meta-analysis on digital games and learning for K-16 students and found among 57 studies that were included in that particular meta-analysis, digital games significantly enhanced student learning.

Lamb et al. (2018) conducted a meta-analysis on examining serious educational games, serious games, and simulations. They defined serious games as games "to train a broad series of tasks using real-life examples" (p. 158), and that serious educational games are similar to serious games but "incorporate specific a priori pedagogical approaches to not only train tasks but teach content as well" (p. 158). Among the 46 studies they examined, Lamb et al. (2018) found higher cognitive gains and positive affects toward learning when participants used serious educational games, serious games, and simulations. However, when comparing traditional instruction to instruction using serious educational games, serious games, and simulations, they did not find any statistically significant differences.

Some researchers in this field have focused on learning theory foundations of game-based learning (Wu et al. 2012). Others have examined digital game-based learning in a specific subject such as English as a foreign language (Kao 2014), mathematics (Byun and Joung 2018; Tokac et al. 2019), and vocabulary learning (Chen et al. 2018).

Included in this special issue is a meta-analysis by *Chen, Shih, and Law,* who analyzed 25 digital-game based learning (DGBL) studies. Their meta-analysis found that competition in DGBL studies had a significant positive effect on learning. Interestingly, they found that competition in DGBL had a significant positive effect in the domain subjects of language, math, and science, but not in the subject of social science or other subjects. Their study also discovered a significant effect on all educational levels—elementary, secondary, and college—though the effect of competition in college students was weaker than with K-12 students. In addition, their study revealed that competition in DGBL was effective in role-playing games, puzzles, simulations, and strategy types of games but not in action games. Individual and peer games had both significant effects, and overall the findings were significant for both cognitive and non-cognitive outcomes. Their findings add to the research synthesis on DGBL to inform how DGBL elements have an effect on student learning.

In addition to game-based learning, there has also been an increased interest in gamification. Alomari et al. (2019) systematically reviewed 40 studies to examine the relationship between gamification techniques (e.g., points, badges, leaderboards, levels, rewards, progress bar, challenges, feedback, and avatars) and student learning. From their review, points and badges were the most commonly used gamification techniques. One of their recommendations was to inform the students about the gamification techniques before they participate in gamified learning.

In another review, Antonaci et al. (2019) studied the effects of gamification in MOOC-based online learning environments. Their review included 61 studies focusing on six areas, performance, motivation, engagement, attitude towards gamification, collaboration, and social awareness. They categorized 24 game elements and described the effects of the various game elements in the different focus areas. Badges, leaderboards, and points were the most used game elements in the studies that they reviewed.

In a systematic mapping study, Dicheva et al. (2015) examined gamification in education. Among the 34 studies that Dicheva et al. reviewed, they discovered that visible status and social engagement were the gamification design principles that were highlighted in most studies. Similar to the Antonaci study, badges, leaderboard, and points were used in most studies. They also found that most gamification occurred in blended learning courses.

In an investigation into gamification in higher education, Subhas and Cudney (2018) conducted a review of 19 studies focusing on gamification elements. In terms of discipline, the largest percent of studies were conducted in the computing discipline, whereas in terms of location, the largest percentage of studies occurred in Spain. Their findings were consistent with previous studies that badges, leaderboards, and points were the game elements that were most studied. Subhas and Cudney (2018) also explored student performance, engagement, attitudes, and motivation.

A few meta-analyses have also been conducted on gamification. Sailer and Homner (2019) conducted a meta-analysis to study the effects of gamification on cognitive, motivational, and behavioral outcomes. They discovered a significant but small effect of gamification for the three outcomes. That same year, Baptista and Oliveria (2019) conducted a meta-analysis to take a look at gamification and serious games in which they analyzed 54 studies and found that attitude, enjoyment, and usefulness commonly predict intent to using gamification.

The present special issue of ETR&D includes a meta-analysis by Huang et al. focusing on gamification. Their meta-analysis included 30 independent studies where they compared gamification to non-gamification conditions on student learning outcomes. Huang et al. discovered that the gamification condition had a small to medium effect in comparison to the non-gamification condition. This finding is similar to the meta-analysis findings from Sailer and Homner (2019) noted above. Huang et al. also examined a number of gamification elements. Ironically, they discovered that studies not using leaderboards had a higher statistically significant effect than the ones using it. They concluded that while using leaderboards is considered a form of motivation, it also might have adverse influences on students progressing towards their educational outcomes. The other gamification elements such as badges/awards, points/experience, and advancement/levels had a similar effect and resulted in increased effect size with or without those features. However, responsive feedback, collaboration, use of quests/missions, or modules were found to have a larger effect size in their meta-analysis. While the authors recommend the use of gamification in well-designed instructional content, they caution that it cannot replace poor instructional design and inadequate learning materials.

Overall, the studies on DGBL and gamification show that DGBL and gamification elements have effects on student educational outcomes. At the same time, these studies also reveal that it is critical for the instructional content to be well-designed.

Adaptive learning and technologies

Adaptive Learning is defined as a process that "dynamically adjusts the way the instructional content is presented to students based on their comprehension of the material as revealed in their responses to embedded assessments or learner preferences such as visual presentation of materials" (Lowendahl et al. 2016, p. 7). In effect, it provides a learning experience that adjusts for individual differences. As such, it is linked to popular trends to personalize or customize learning (Schroeder 2019a).

There have been several systematic reviews on adaptive learning since 2008. One of the earliest studies was by Verdú et al. (2008). Verdú et al. (2008) conducted a meta-analysis of adaptive learning research to address the question, can students improve their knowledge when the system adapts to their profile and performance? Though they did not calculate an overall effect size for the 15 studies they analyzed, they tabulated individual effect sizes which were mostly positive in terms of improvement in academic achievement when comparing adaptive learning with a control group.

Three years later, Vandewaetere et al. (2011) examined learner characteristics in computer-based adaptive learning environments. Vandewaetere et al. (2011) concentrated their efforts on how instruction will be adapted. They examined both theoretical and empirical studies and categorized 42 studies based on the source of adaptation focusing on learner and learner-environment interaction. Through the lens of what is adapted, they analyzed 29 studies and categorized the source of adaptation as content, presentation, and instruction. Finally, in their review, they also identified pathways of adaptation and categorized 25 studies as rule-based, probability-based, or other adaptive pathways.

The following year, Akbulut and Cardak (2012) conducted a content analysis with 70 studies that addressed learning styles in Web-based adaptive educational hypermedia (AEH) systems. The findings of their review indicated that the learning style-based AEH system had positive impacts on students' performance, learning process, and satisfaction levels. However, most of the studies emphasized the adaptive framework or model of AEH as a system; scant studies evaluated the effectiveness of AEH on learning outcomes. Akbulut and Cardak suggested that future studies should focus on the adaptivity of the learning system as well as the adaptability from the learners' perspective.

To determine what type of characteristics should be considered for a learner model, in 2015, Nakic et al. (2015) used an evidence-based approach and reviewed 98 journal papers and conference proceedings that specifically focused on the evaluated adaptive learning systems. Nakic et al. identified 17 individual differences as sources of adaptation for adaptive learning, including age, gender, processing speed, cognitive abilities, personality, experiences, learning styles, motivations, and preferences. The findings of this study contribute to the improvement of user interaction and learning performance in an adaptive learning environment.

Next, Kumar et al. (2017) conducted a document analysis with 78 studies and reviews focused on learning style in adaptive intelligent tutoring systems (AITS). The findings of this study further confirmed that most of studies addressed a framework or architecture of AITS (e.g., Felder-Silverman learning style model). Studies also centered on the learning outcome or learner satisfaction of using AITS. Applications of learning styles in AITS covered the learning materials, learner characteristics, learner knowledge, learning media content and resource format, recommended tutoring materials or pedagogy, intelligent games, learner evaluation and practice, or other mixed characteristics. Rule-based and Bayesian network algorithms were the two most adopted learning style classification

techniques. Kumar et al. suggested that future studies should focus on the implementation of mixed learning style models in AITS as well as the application of algorithms to detect these mixed learning styles to improve the adaptivity of the system.

In the most recent review, Normadhi et al. (2019) reviewed 78 studies to explore the most commonly used learners' personal traits (e.g., learning styles, cognitive styles, knowledge level, etc.), dimensions of personal traits (e.g., visual, aural, and kinesthetic), identification techniques (e.g., questionnaire, computer-based detection, etc.) for these attributes in an adaptive learning environment. The findings revealed four categories of personal traits: cognitive, affective, behavioral, or psychomotor which were appropriately mixed with the six levels of remembering, understanding, applying, analyzing, evaluating, and creating. The personal trait identification techniques included computer-based detection using algorithms or programs (such as machine learning), traditional questionnaires, and both. Normadhi et al. also pointed out emerging issues related to the identification of personal traits in adaptive learning environments. Such traits include as the lack of validation of the obtained data, the concern of learning motivation and cognitive load, and the limitations of existing adaptive technology in this regard. Normadhi et al. suggested that future studies should focus on the empirical evaluation related to the effectiveness of the personal traits and its identification techniques as wells as the strengths and weaknesses of personal traits being integrated into the learning object and materials in adaptive learning environments.

Several of the systematic reviews of adaptive learning above concentrated on the learner characteristics aspect of adaptive learning and not on the instructional aspects. This special issue includes a study by *Martin, Chen, Moore, and Westine* who conducted a systematic review on adaptive learning focusing on both a learner model and an instructional model that builds on the previous review studies described above. They analyzed 61 empirical studies from the years 2009 to 2018 and studied adaptive strategies and technologies. The authors examined adaptive sources based on learner models and adaptive targets based on content and instructional models. Learning style was the most observed learner characteristic, while adaptive feedback and adaptive navigation were the most investigated adaptive targets. Though there are several meta-analyses focusing on intelligent tutoring systems (ITS), there is a need for meta-analysis in the area of adaptive learning which is considered as the next generation of ITS (Essa 2016).

Also included in this special issue a bibliometric analysis and a meta-analysis review by *Liu, Moon, Kim, and Dai* who reviewed educational games with adaptivity. They analyzed 62 studies for the qualitative thematic analysis and a subset of 12 studies that used experimental designs for the meta-analysis to study the effects of adaptivity in educational games. Their meta-analysis found that adaptive learning condition did not result in a substantial overall effect compared to a non-adaptive condition. However, the target effect size was positive when focusing on learning but not for game performance.

Learning analytics

The Society for Learning Analytics for Research (SOLAR) defines learning analytics as "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (2011, p.1). More recently, Ifenthaler (2015) elaborates and defines learning analytics as "the use, assessment, elicitation and analysis of static and dynamic information about learners and learning environments, for the near real-time

modelling, prediction and optimization of learning processes, and learning environments, as well as for educational decision-making" (p. 447).

Identified as an emerging trend due to the availability of data, a number of research studies have focused on learning analytics. As a result, systematic reviews have been conducted using primary research studies on learning analytics. We found at least seven systematic reviews on learning analytics. One of the earliest systematic reviews was by Papamitsiou and Economides (2014) who reviewed learning analytics and educational data mining from 40 empirical studies. Their focus was to identify research objectives and methods researchers use to achieve these objectives. Two years later, Avella et al. (2016) reviewed 44 studies to study learning analytics methods, benefits, and challenges in higher education.

More recently, Mangaroska and Giannakos (2019) conducted a systematic review on learning analytics for learning design by examining 43 articles. They reviewed these studies for their research design, topic of study, educational context, learning scenario, pedagogical practices, learning platform, technology tools, and methodological techniques. Around that same time, Vieria et al. (2018) reviewed 52 papers in the field of learning analytics by systematically focusing on visual learning analytics of educational data to identify approaches, audiences, purposes, contexts, and data sources. They also examined how the existing literature integrates educational theories and visualization principles into visual learning analytics strategies.

In addition, there have been a couple of important reviews specifically focusing on learning analytics dashboards. For instance, Bodily et al. (2018) systematically reviewed learning analytics dashboards and open learner models (OLM) attempting to bridge these two areas. They sought to study the types of data collected in OLM systems and different modeling methods used, research themes, the nature of OLSM system evaluations, and the similarities and differences between OLM and learning analytics dashboards. Matcha et al. (2020) also reviewed learning analytics dashboards from a self-regulated learning perspective. Their focus was to review the support of learning analytics dashboards in self-regulated learning, the types of information that was offered as feedback, and the quality of study designs that reports empirical evaluations.

Another recent systematic review of 11 publications related to learning analytics focused on the efficacy of learning analytics interventions in higher education in terms of student retention and/or academic success (Larrabee Sønderlund et al. 2019). Most of the studies they examined showed a post-intervention increase in grades or activities. Building on this particular systematic review, is the final systematic review in this special issue from *Ifenthaler and Yau*. These researchers inspected 46 empirical articles to address whether and to what extent learning analytics is successful in facilitating study success in higher education. Importantly, they conceptualized positive factors of study success as course completion and student retention, whereas they identified negative factors as student-at risk of dropping out, loss of academic success, attrition, and other more abstract factors. They categorized the factors contributing to study success broadly as predictors and visualization. Predictive algorithms and visualizations were used in a number of studies that they reviewed. In their review, Ifenthaler and Yau confirmed that a combination of learners' background information, behavior data from digital platforms, formative and summative assessment data, and information collected through surveys could be applied in the field of learning analytics.

Conclusion

We hope that this introduction has excited potential readers about the contents of this issue. Our goal was to bring together systematic reviews in one issue, so that together the reviews could show both breadth and depth in the range of research being conducted on emerging learning environments and technologies. As *Reeves and Lin* point out in the closing article of this special issue, systematic reviews have a relatively recent history and have become increasingly popular with the explosion of research reports related to educational and instructional technology since the dawn of this new millennium. With waves of technological progress occurring during the past few decades, as detailed by *Bonk and Wiley* in the preface to this issue, such reviews of research are increasingly necessary.

It is nearly impossible to stay abreast of research and development on any learning technology trend, let alone the assorted dozens of such trends at this time (Bonk 2016, 2020). Fortunately, the 44 authors who contributed to the systematic review articles found in this special issue have spent painstaking months searching, mining, filtering, accumulating, analyzing, cataloging, documenting, and summarizing what they found. They should be commended for their efforts.

Perhaps you are already sensing a potential role that you can play in one or more emerging learning technologies in the form of a research gap that is apparent or a possible project that you might commence with a research partner. Or perhaps you have simply found someone to add to your network. It is conceivable that one or more research projects will spring to life from reading and discussing the findings of the next 13 articles of this issue.

As *Bonk and Wiley* highlight at the end of the preface and *Reeves and Lin* caution several times in the conclusion of this particular journal issue, it is vital to study complex and pervasive educational problems instead of the latest technology system or device. Accordingly, we intend for this issue to be valuable to graduate students and those new to the field of instructional design and educational technology who simply want to know the state of the research in areas that are attracting much professional interest. At the same time, instructors might find timely research findings to add to a graduate class or to reference in a technical report or book chapter. Administrators might find data for an upcoming strategic plan or campus technology committee.

As is stated in the preface, this special issue only serves up a portion of the emerging learning technologies research scene in 2020. In effect, this issue offers but a glimpse of the state of research in field; albeit, we hope, an eye-opening glimpse.

To be fair, technically speaking, emerging learning technologies is not a field; it is a reflection of conditions in society and life itself. As such, there is immediate intrigue in researching aspects of it. Where else is one able to spend a morning reading about the use of social media in school-based learning, the afternoon focusing on wearable technology, and the evening learning about the use of mobile technology to learn a language? Importantly, the articles you are about to read contain key insights into what we know in terms of the existing research in these fields and more, so as to help form policy guidelines and other practical implications. These articles will also tell us what we do not know, thereby perhaps provoking much contemplation and a few trial studies.

Enjoy your journey through this volume. It is only through systematically reviewing and synthesizing the literature on emerging technologies for learning that we can truly make informed decisions as practitioners and know what needs to be seriously studied next as researchers. Whatever you do, whether researcher, student, educator, trainer, policymaker, instructional designer, educational technologist, technology vendor, consultant, or parent,

find your niche within the wide spectrum of learning environments and technologies that permeate each our lives. Think about what problems or issues you are addressing and potentially solving. For only then will the learners of the world have a chance to benefit in truly transformative ways.

Articles in the systematic review special issue

1. Bonk, C.J., & Wiley, D. A. (2020). Preface: Reflections on the waves of emerging learning technologies. *Educational Technology Research and Development.*
2. Martin, F., Dennen, V. P., & Bonk, C. J. (2020). A synthesis of systematic review research on emerging learning environments and technologies. *Educational Technology Research and Development.*
3. Dennen, V., Choi, H., & Word. (2020). Social media and the school context: A scoping review of research in education and related fields. *Educational Technology Research and Development.*
4. Luo, T., Freeman, C., & Stefaniak, J. (2020). "Like, comment, and share": Professional development through social media in higher education: A systematic review. *Educational Technology Research and Development.*
5. Zhu, M., Sari, A.R., & Lee, M. M. (2020). A comprehensive systematic review of MOOC research: Research techniques, topics, and trends from 2009 to 2019. *Educational Technology Research and Development.*
6. Oluvabunmi, O., Akcayir, G., Oluvabukola, M.I., & Demmens Epp, C. (2020). Using technology in special education: Current practices and trends. *Educational Technology Research and Development.*
7. Eutsler, L., Chrystine, M., Stamm, B., & Kogut, A. (2020). The impact of mobile technologies on preschool and elementary children's literacy achievement: A systematic review spanning 2007–2019. *Educational Technology Research and Development.*
8. Chen, Z., Chen, W., Jia, J., & An, H. (2020). The effects of using mobile devices on language learning: A meta-analysis. *Educational Technology Research and Development.*
9. Gao, F., Li, L., & Sun, Y.Y. (2020). A systematic review of mobile game-based learning in STEM education. *Educational Technology Research and Development.*
10. Havard, B., & Podsiad, M. (2020). A meta-analysis of wearables research in educational Settings published 2016–2019. *Educational Technology Research and Development.*
11. Chen, C-H., Shih, C.-C., & Law, V. (2020). The effects of competition in digital game-based learning (DGBL): A meta-analysis. *Educational Technology Research and Development.*
12. Huang, R., Ritzhaupt, A. D., Sommer, M., Zhu, J., Stephen, A., Valle, N., Hampton, J., & Li, J. (2020). The impact of gamification in educational settings on student learning outcomes: A meta-analysis. *Educational Technology Research and Development.*
13. Martin, F., Chen, Y., Moore, R.L., & Westine, C. D. (2020). Systematic review of adaptive learning research designs, context, strategies, and technologies from 2009 to 2018. *Educational Technology Research and Development.*
14. Liu, Z., Moon, J., Kim, B., & Dai, C.-P. (2020). Integrating adaptivity integrating adaptivity in educational games: A combined bibliometric analysis and meta-analysis review. *Educational Technology Research and Development.*

15. Ifenthaler, D., & Yau, J.Y-K. (2020). Utilising learning analytics for study success in higher education: A systematic review. *Educational Technology Research and Development.*
16. Reeves, T., & Lin, L. (2020). The research we have is not the research we need. *Educational Technology Research and Development.*

Funding Funding information is not applicable/No funding was received.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Education Tech Research Dev (2020) 68:1991–2001
https://doi.org/10.1007/s11423-020-09811-3

The research we have is not the research we need

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Published online: 26 July 2020

Abstract
The special issue "A Synthesis of Systematic Review Research on Emerging Learning Environments and Technologies" edited by Drs. Florence Martin, Vanessa Dennen, and Curtis Bonk has assembled a noteworthy collection of systematic review articles, each focusing on a different aspect of emerging learning technologies. In this conclusion, we focus on these evidence-based reviews and their practical implications for practitioners as well as future researchers. While recognizing the merits of these reviews, we conclude our analysis by encouraging readers to consider conducting educational design research to address serious problems related to teaching, learning, and performance, collaborating more closely with teachers, administrators, and other practitioners in tackling these problems, and always striving to make a difference in the lives of learners around the world.

> There is incredible potential for digital technology in and beyond the classroom, but it is vital to rethink how learning is organized if we are to reap the rewards.
>
> - Geoff Mulgan quoted in Burns (2012)

A story in the *USA Today* newspaper (García Mathewson and Butrymowicz 2020) was titled "Online programs used for coronavirus-era school promise results. The claims are misleading." The article highlighted the fact that many online education providers who market their products to K-12 educators claim that their online programs are "proven" to be effective by scientific research, but that the evidence for such claims is typically very weak or even nonexistent. The article went on to state that this problem has been exacerbated by a virtual stampede to provide online learning opportunities in the wake of the coronavirus pandemic. School district administrators and other decision-makers have had to rush to find resources to support teaching and learning activities that have suddenly been forced online, and in this scramble they are likely to have been susceptible to false advertising. The authors pointed out that whereas the Food and Drug Administration in the USA

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restricts what pharmaceutical manufacturers can claim about their drugs and supplements, merchandizers of digital educational technologies have no such restraints.

The authors of the *USA Today* article are staff writers from *The Hechinger Report*, an independent nonprofit, nonpartisan organization focused on educating the public about education and how it can be improved. Perhaps there would be little need for *The Hechinger Report* if the What Works Clearinghouse that was established nearly twenty years ago by the U.S. Department of Education actually functioned as a reliable source of information about the quality of research on education products and programs. However, García Mathewson and Butrymowicz (2020) noted that "out of 10,654 studies included in the What Works Clearinghouse in mid-April, only 188—less than 2 percent—concluded that a product had strong or moderate evidence of effectiveness."

So where are educational administrators, practitioners, and others to go to find the information that they need to make informed decisions about which educational programs to adopt if commercial advertising is untrustworthy and the What Works Clearinghouse can't tell them what actually works? Hopefully they can find guidance in the types of systematic reviews found in this special edition of *Educational Technology Research and Development*. In this concluding paper, we examine the reviews published in this special issue, with special attention to the advice for practitioners that might be found in them. A caveat is warranted given that the systematic reviews in this special issue were not conducted specifically to provide practical implications, but nonetheless they all do to some extent as delineated below.

Countering bogus claims with evidence-based guidance

Exaggerated claims about education technology innovations are hardly new nor are literature reviews. In describing programmed instruction more than 50 years ago, Slack (1968) wrote:

> Thanks to the genius of a few men who have devoted their efforts to new ways to write self-instructional materials — men such as B. F. Skinner, Thomas F. Gilbert, Lloyd Homme, Donald Tosti, Frederick Keller and others — the lowly workbook has undergone marvelous improvement in the last decade. The workbook has become so good that it works all by itself without a teacher to help fill in the answers. The new workbooks are **guaranteed** to teach all by themselves, without a teacher. They must be passed out, however, filled in by the student and collected by someone capable of **managing** the class. But this person does not have to do the **teaching**. That is done by the workbook, which, by the way, works just as well with drop-outs and delinquents as it does with nice little boys and girls. All in all, a marvelous thing. (Bold in original.)

The over one-hundred-year history of educational technology is replete with such outlandish claims starting perhaps with Edison's prediction in 1913 that films would soon replace textbooks in classrooms (Reiser 2001). Literature reviews have also been around for decades. For example, more than a half century ago, Chu and Schramm (1967) synthesized the research on instructional television. As comprehensive as their seminal literature review was, the distinguished authors provided at best ambiguous guidance to practitioners:

> Assuming a degree of caution in applying results, what kinds of guidelines can we extract from this body of research? For one thing, it has become clear that there is no

> longer any reason to raise the question whether instructional television can serve as an efficient tool of learning. This is not to say that it always does. But the evidence is now overwhelming that it can, and, under favorable circumstances, does. (Underlined words were italicized in original.) p. 98

The editors of this special edition of ETRD point out that the papers herein are not literature reviews in the traditional sense, but systematic reviews that utilize "a specific methodology to locate, select, evaluate, analyze, synthesize, and report evidence that helps to draw conclusions." Meta-analysis is utilized in five of these systematic reviews whereas the other eight employ different cutting-edge review approaches such as scoping reviews (Arksey and O'Malley 2005).

Meta-analysis was largely unknown in educational technology research until Glass (1976) promoted its value for the educational research community at large. Since then, it has flourished with such high-profile educational researchers as Robert E. Slavin (cf. Cheung and Slavin 2012), John Hattie (cf. Hattie 2009), and James A. Kulik (cf. Kulik et al. 1985) conducting these types of analyses over the years. Unfortunately, educational technologies per se generally have not fared well in these analyses. For example, Cheung and Slavin (2013) conducted a meta-analysis to answer the question: "Do education technology applications improve mathematics achievement in K-12 classrooms as compared to traditional teaching methods without education technology?" They reported "the findings suggest that educational technology applications generally produced a positive, though modest, effect (ES = +0.15)" (p. 88).

The modest effect size reported by Cheung and Slavin (2013) does not come close to the 0.4 effect size that Hattie (2009) argued is necessary for any educational treatment to be taken seriously. Hattie's (2009) comprehensive review of meta-analyses examining the effectiveness of 135 educational variables showed that only instructional design processes (e.g. feedback to students and mastery learning) rather than technologies per se (e.g. computer-based instruction or games) have demonstrated worthwhile impact on learning.

What guidance do systematic reviews provide practitioners?

In this section of the paper, we have attempted to tease out kernels of practical advice for practitioners that can be found in the 13 systematic reviews of the learning technologies and environments. Of course, we recognize that these systematic reviews were not written for practitioners but were primarily oriented toward other researchers and/or developers. We also acknowledge that the evidence that educational decision makers and practitioners actually avail themselves of educational research findings of any kind is lacking (Ion and Iucu 2014; Vanderlinde and van Braak 2010). Table 1 (below) summarizes the recommendations for other researchers proffered by the authors in their assorted reviews as well as the implications for practitioners that we have gleamed from the reviews.

The reviews published in this special issue of *Educational Technology Research and Development* have all been conducted rigorously according to the guidelines of the specific review processes used and reported skillfully with the guidance of the editors. As such, the papers provide an up-to-date portrayal of educational technology research across a wide variety of contexts. These reviews are especially useful in providing departure points for other researchers who seek to advance educational technology research in these contexts. Although clearly not intended to do so, each review also offers useful implications for practitioners.

Table 1 Summary of advice for researchers and practitioners based on the 13 systematic reviews

Topics	Authors	Recommendations for researchers	Implications for practitioners
Social media and school context	Dennen, Choi, and Word	The systemic nature of social media use by individuals should be considered; studies bridging disciplines and contexts need to be conducted	There does not yet exist a robust set of design principles for incorporating social media into teaching and learning at any level. Hence, efforts to utilize social media to support teaching and learning should be approached carefully and best implemented and tested using action research with clear pedagogical needs in mind
Social media and professional development in higher education	Luo, Freeman, and Stefaniak	Further systematic research is needed using different research methods to investigate specific components and claims of social media-based professional learning	Social media-supported professional learning networks and communities of practices can potentially contribute to faculty learning; yet, challenges exist in sustaining faculty participation, engagement, and effective navigation of the social media space
MOOC research	Zhu, Sari, and Lee	Most MOOC research to date has focused on learner issues. MOOC researchers should design comprehensive studies of various MOOC stakeholders including instructors, designers, or program administrators	MOOCs are researched around the world and research is becoming cross-institutionally and internationally collaborative. MOOC instructors and instructional designers should communicate and collaborate globally to share design approaches and pedagogical practices to improve the quality of MOOCs and meet diverse learner needs and expectations
Using technology in special education	Oluvabunmi, Akcayir, Ishola, and Demmans Epp	More research is needed into learning technologies for life, job skills and training, and social skills; further studies in everyday settings could help students to contextualize their learning	We need to keep improving the design and deployment of educational technologies for supporting those with developmental and cognitive disorders to contribute towards creating a future that offers equitable educational opportunities to every student

Table 1 (continued)

Topics	Authors	Recommendations for researchers	Implications for practitioners
Mobile technologies on preschool and elementary children's literacy achievement	Eutsler, Mitchell, Stamm, and Kogut	Transparency is needed in reporting participant characteristics so that the studies are applicable to other contexts; standardized achievement measures are needed to address reliability and replicability of the studies	To use mobile apps effectively, practitioners must ensure alignment between the app characteristics and the learning goals (e.g. literacy domain). It is unrealistic to expect too much impact from a single app, and thus multiple interventions and/or apps may be needed to improve students' literacy over time
Mobile devices on language learning	Chen, Chen, Jia, and An	MALL (mobile-assisted language learning) studies employing the situated and collaborative features of mobile learning produce a high effect. These features of mobile technologies are transforming the way we live, work, and learn. Future research should explore the role of mobile devices in shaping the relationship between people, technologies, and learning contexts	Language learning through mobile devices can be more effective than some traditional instructional approaches. Effective language learning can be enhanced through situated and collaborative features in MALL
Mobile game-based learning in STEM education	Gao, Li, and Sun	The following studies are needed: studies that move beyond simple comparison of traditional approach and mobile game-based approach; studies that base the design of mobile games on learning and motivational theories; studies that adopt a theoretical framework to categorize learning outcomes; and studies that utilize innovative research techniques	Mobile game-based learning has a potential to motivate students to learn STEM and improve their learning. It is important for instructional designers and educators to make sure that the game design is aligned with learning principles. Other factors including learner characteristics, learning contexts, learning content, learning goals, learning activities, and game features should be taken into consideration throughout the design and implementation process

Table 1 (continued)

Topics	Authors	Recommendations for researchers	Implications for practitioners
Wearables research in educational settings	Havard and Podsiad	Researchers need to explore wearable technology and conduct rigorous quantitative studies that can evolve the current literature	When using wearables in educational settings, instructors should focus on aligning objectives, pedagogical strategies, specific affordances of the wearables, and assessment strategies in their lesson planning and implementation
Competition in digital game-based learning	Chen, Shih, and Law	More empirical research is needed in this area, particularly, the examinations of different game elements to enhance cognitive and non-cognitive learning outcomes	Competitions worked better in math education than in language learning and science education. Education practitioners are encouraged to include competition in game-based learning environments
Gamification in educational settings on student learning outcomes	Huang, Ritzhaupt, Sommer, Zhu, Stephen, Valle, Hampton, and Li	Researchers should move past this current era of "pointification" (points, badges, and leaderboards) and evolve into something with more potential in facilitating learning	The integration of gamification along with other innovations (e.g. flipped classroom or learning analytics) in educational settings has the potential to advance educational outcomes
Adaptive learning research	Martin, Chen, Moore, and Westine	Adaptive learning researchers need to consider the broader scope of the adaptive learning model to include both the source and target. Future studies should focus on the increasing availability and capacities of adaptive learning as a learning technology to assist individual learning and personalized growth	For designers, developers, and instructors, it might be beneficial to know that learning can be adapted based on a variety of learner characteristics such as knowledge and metacognitive knowledge, preference, behavior, profile, ability, and interest. In addition, content (including presentation, assessment, feedback, and navigation) can be adapted in several ways, such as topic and question difficulty, learning sequence, path, pacing, and material format

Table 1 (continued)

Topics	Authors	Recommendations for researchers	Implications for practitioners
Adaptivity in educational games	Liu, Moon, Kim, and Dai	Adaptive learning condition did not result in a substantial overall effect compared to a non-adaptive condition. Future research should encourage more rigorous experimental design to validate the added value of adaptivity	Researchers and practitioners should seek sound theories from learning sciences and instructional design that explain: (a) how learning happens through in-game interactions, and (b) how to support game-based learning experiences
Utilizing learning analytics for study success	Ifenthaler and Yau	A wider adoption of learning analytics systems is needed. Standardized measures, visualizations, and interventions are needed to be integrated into any digital learning environments so as to reliably predict at-risk students and to provide personalized prevention and intervention strategies	Teachers should be encouraged to further their educational data literacy, especially with respect to the ethically responsible collection, management, analysis, comprehension, interpretation, and application of data from educational contexts

In the light of the research we have, what is research we need?

Despite the high quality of the systematic reviews found in this special issue, they are only as good as the research studies that were incorporated into them. A major contributor to the paucity of practical guidance in these and other types of systematic reviews is that they are primarily focused on the "things" of our field such as wearable technologies and mobile devices rather than on the "problems" faced by teachers and students such as the lack of engagement of students in online learning (Stott 2016) or the failure to develop higher order learning in STEM education (Sadler and Zeidler 2009). Bonk and Wiley (2020) also note this tendency to focus on things rather than problems in the Preface to this special issue.

Improving educational opportunities is essential to addressing the major problems that the world confronts today such as poverty, climate change, racism, and the current global pandemic (Desai et al. 2018). Unfortunately, educational technology research does not have a distinguished record in dealing with local educational problems, much less global ones (Reich, in press). Arguably, a major contributor to this poor record is the focus on the things of educational technology rather than the problems of practitioners (Reeves and Reeves 2015a).

Fortunately, there are other ways to conduct educational technology research than the quasi-experimental methods employed in most of the studies included in the systematic reviews found in this special issue. One viable option is educational design research (EDR) (McKenney and Reeves 2019). EDR a genre of educational research in which the iterative development of solutions to complex educational problems through empirical investigations are pursued in tandem with efforts to reveal and enhance theoretical understanding. Such efforts can serve to guide educational practitioners as well as other researchers. As a genre of educational inquiry rather than a discrete methodology, EDR encompasses a family of approaches that endeavor to accomplish the twofold goal of designing and implementing interventions that solve serious educational problems while at the same time developing enhanced theoretical understanding to inform further practice. This family of approaches includes design-based research (Design-Based Research Collective 2003), design-based implementation research (Fishman et al. 2013), development research (van den Akker 1999), design experiments (Middleton et al. 2008), and formative research (Newman 1990), among others.

For most of its decades long history as a distinct field (Reiser 2001), educational technology researchers have focused primarily on the question "What works?" with respect to teaching and learning with technology leading to findings that are often so weak as to be practically inconsequential. Educational design research fundamentally changes the focus of research from the often fruitless "what works?" question to the more socially responsible questions "what is the problem, how can we solve it, and what new knowledge can derived from the solution?"

It should be clear we can no longer afford to have research agendas exclusively focused on things (e.g. digital games) rather than problems (e.g. the under-representation of women and minorities in STEM fields). Fortunately, the situation is improving. Notably, the new 5th edition of the *Handbook of Research on Educational Communications and Technology* (Bishop et al. 2020) has a very different focus from the previous four Handbooks that included many chapters focused on specific technologies as things. Whereas the fourth edition of the Handbook (Spector et al. 2014) has a dozen chapters on 'emerging technologies' such as e-books and open educational resources (OER),

most chapters in the 5th edition are focused on complex problems and review the extent that these problems can be addressed using innovative learning designs and appropriate applications of technology. In the new Handbook, researchers and practitioners will find an excellent set of contributions that target serious educational problems such as increasing the accessibility of online learning environments and motivating and engaging students using emerging technologies. As a bonus, the 2020 Handbook includes thirteen design cases that are uniquely indexed with the research chapters focused on specific problems.

What else can be done to move from the research we have to the research we need? Reeves and Reeves (2015b) considered this question and responded by stating that our field is at a critical fork in the road:

> Educational technology researchers may continue as we have for decades, conducting isolated studies focused on new things rather than significant problems, publishing our research in refereed journals just enough to ensure that our careers are advanced, working as recognized "scholars" but having virtually no impact on practice, and being largely unresponsive to the enormous challenges the world confronts around issues related to teaching and learning. Or we could take a new direction whereby we develop robust, multi-year research agendas focused on important problems and innovative solutions, judge our worthiness for promotion and tenure on evidence of impact rather than simple article counts, closely collaborate with practitioners, and establish our field as preeminent in meeting global problems related to education.

Of course, we are not suggesting that research focused on the things of educational technology has no merit, and we are fully cognizant that such studies will continue to be conducted every time an educational technology innovation appears. However, we encourage readers of this noteworthy special issue of ETR&D to focus on serious problems related to teaching, learning, and performance, collaborate closely with teachers, administrators, and other practitioners, and seek to make a difference in the lives of learners around the world. Instead of expecting the next "killer app" or technical innovation to transform education, perhaps we can better transform education by fostering incremental changes through collaborative research and development with practitioners (Reich, in press).

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval No human participants were involved in this writing because this is a concluding piece for a special issue.

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EDUCATIONAL TECHNOLOGY RESEARCH & DEVELOPMENT

Volume 68 • Number 4 • August 2020