CHAPTER 1

Maximizing the Affordances of Contemporary Technologies in Education: Promises and Possibilities

Olusola O. Adesope and A. G. Rud

For several decades, extensive instructional research comparing the effects of different media on learning has been conducted, albeit with mixed results (Broadbent 1956; Clark 1983; Kinchla 1974; Kozma 1991; Mayer 2009; McLuhan 1964; Severin 1967). Researchers have debated whether educational technology (media) use is actually effective for improving student learning (Clark 1983; Kozma 1994; Tamin et al. 2011). Research in educational technology has moved past the classic debates that pervaded the educational literature between the 1980s and 90s. Rather than continuing the debates on media versus pedagogy, researchers have called for efforts to maximize the affordances of new technologies based on sound pedagogical principles (Kozma 1994). Hence, a plethora of studies have been published over the last two decades on multimedia learning and the use of learning technologies (Clark et al. 2016; Guri-Rosenblit and Gore 2011; Mayer 2009, 2014). However, development of new technologies continues to outpace research efforts on best practices for effectively using

O. O. Adesope (✉) • A. G. Rud
College of Education, Washington State University, Pullman, WA, USA
e-mail: olusola.adesope@wsu.edu; ag.rud@wsu.edu

O. O. Adesope, A. G. Rud (eds.), *Contemporary Technologies in Education*, https://doi.org/10.1007/978-3-319-89680-9_1

such technologies for learning. For example, the last few years have witnessed the emergence and extensive use of contemporary technologies such as the Flipped Classroom (FC), Massive Open Online Course (MOOC), Social Media, Serious Educational Games (SEG) and Mobile Learning (ML). While some of these new learning environments have been touted as panaceas, researchers and developers have been faced with enormous challenges in enhancing the use of these technologies to arouse student attention and improve persistent motivation, engagement, and learning (Annetta 2008; Hamlen 2011; Waks 2013; Yarbro et al. 2014). Broadly speaking, educational technologies have brought about developments and challenges in theory, methods, and practice. In the next section, we discuss theoretical, methodological, and practical developments and challenges with educational technologies. We caution that our review of these developments and challenges is not exhaustive, as such endeavor is beyond the scope of this chapter.

Theoretical Developments and Challenges with Educational Technologies

Because human learning, motivation, and engagement are highly complex, researchers have constructed several theories of human learning and instruction to explain these constructs (e.g., Jonassen and Land 2012; Mayer 2014; Reigeluth 2012). Among the more important recent theoretical advances relevant to emerging educational technologies are theories on multimedia learning, cognitive load, machine learning, data mining, learning analytics, and knowledge representation, and how they can be used to model human learning (Bottou 2014; Kirschner 2002; Markauskaite 2010; Martin and Sherin 2013; Mayer 2014; Plass et al. 2010). More recently, Michelle Chi and her team developed the ICAP framework (Chi and Wylie 2014). This framework provides theoretical underpinnings for the effects of educational technologies on different forms of cognitive engagement and the resulting learning outcomes. Other theoretical advances in the field of educational technologies are refinements or applications of long-standing psychological theories, including the social cognitive theory (Bandura 1989), its concomitant model of self-regulation (Zimmerman and Schunk 2001), and situated learning theory (Dawley and Dede 2013), especially legitimate peripheral participation and communities of practice (Lave and Wenger 1991) to explain student learning and engagement. For example, some contemporary educational technologies have incorporated online collaborative learning environments that facilitate learning with the help of others. Today's students increasingly use social, intelligent, and online learning environments to share ideas, get feedback, refine ideas, and publish information (e.g., Carter et al. 2017; Hundhausen et al. 2015; Kaufer et al. 2011; Ma et al. 2014; Maloney et al. 2010; Myneniet al. 2013). Hence, these long-standing psychological theories of learning have advanced the design of contemporary educational technologies and provided theoretical explanations for their benefits and challenges.

Although theoretical developments in educational technologies are advancing, new technologies are being developed at a rapid pace. This gives rise to the need for new theories to help researchers understand learning processes and outcomes. Some argue that existing theories of learning cannot sufficiently explain the fundamentally changed contextual conditions for learning brought about by advances in the technological landscape (Siemens 2005). More than ever before, new learning technologies help track and log learners' traces of their learning activity across different contexts—in school, at home, indoors, and outdoors (Martin and Sherin 2013). This generates rich, *big data* and a new wave of research questions (Greenhow et al. 2009; Reich et al. 2012).

Today's educational technologies provide fine-grained, process-oriented data at every click of the mouse. Tracking time spent online reading or working on a unit, notes taken, common errors, and other details can open up new pathways for understanding how people learn (Feng et al. 2009; Kramer and Benson 2013). SEG, intelligent tutors that provide formative feedback, MOOC courses or FCs, and posting reflections on electronic boards and blogs is part of daily life for many students. Such affordances of contemporary educational technologies require development of new learning theories and reconceptualization of research (DeBoer et al. 2014). The chapters in this book showcase affordances of contemporary and emerging educational technologies thus presenting a rich space for robust discussions on the role of existing theories and development of new theories to conceptualize and understand anticipated findings related to contemporary and emerging educational technologies.

Methodological Developments and Challenges with Educational Technologies

The field of educational technology has made great methodological strides. Methodological advances through the development of machine learning, data mining, and learning analytics have significantly expanded the research that can be carried out with contemporary educational technologies (Bottou 2014; Markauskaite 2010; Martin and Sherin 2013). More than ever, the use of technologies allows teachers, researchers, and instructional designers to track students' interaction with learning resources and offer more real-time support for students. The nature of these technologies and the ability to ask rich research questions provide new opportunities to collect, analyze, and synthesize data in ways that were previously considered impractical. Based on this influx of data from rich research questions on both the process and outcomes of learning, educational researchers now harness statistical techniques such as hierarchical linear modeling, growth curve analysis, and latent profile analysis (Lee 2010) to advance our knowledge of human learning, engagement, and motivation.

Despite these methodological advances, several methodological challenges require immediate attention. For example DeBoer et al. (2014) argued for a reconceptualization by way of creating new educational variables or providing different interpretations of existing variables to more accurately understand the nature of MOOC data. They demonstrated the inadequacy of conventional interpretations of four variables for quantitative analysis (enrollment, participation, curriculum, and achievement). Although their research exclusively focused on MOOCs, similar issues may be found with some educational technologies that generate big data (e.g., logs of class interaction with SEG, instructional materials in a FC, etc.). There is a need to reconcile the changing nature of variables generated or afforded by several new technologies with entrenched practices, particularly curriculum-based learning with fixed learning objectives evaluated by standardized exams. Although methods for analyzing big data to understand student learning are evolving, this evolution is slow. The need to keep pace by developing effective methods at a brisker pace is vital.

Another area of educational technology requiring methodological consideration is the use of conversational agents and interactive technologies (Graesser et al. 2008; Rus et al. 2013; Spector 2010). Conversational agents and interactive technologies on the internet can collect detailed information from students in log files that track learning, emotions, and achievement with a fine-grained focus. The agents can precisely manipulate what is said and how it is said. However, using agents is often challenging, particularly where online delivery is necessary. There is a need for researchers to discuss and explore viable scalable approaches for delivering agents over the web.

Perhaps one of the great methodological challenges in educational technology is a dearth of rigorous experimental research that will examine the effects of different features of contemporary technologies. There is clearly a need for more robust research efforts supported by a national agenda to rigorously examine the effects of technology-rich environments through experimental work. There is clearly a need to engage in robust discussions around these methodological challenges, as well as others, posed by advances in educational technologies.

Practical Developments and Challenges with Educational Technologies

One practical example of educational technology is the use of Khan Academy videos and problem sets as learning resources both in the classroom and at home. Indeed, the Khan Academy video library is associated with the FC model, where teachers assign videos on concepts to be learned for students to watch at home and then use the class time to engage students in discussion and interactive activities (Murphy et al. 2014). The evaluation report by Murphy et al. (2014) suggests that the use of Khan Academy and similar resources and models may facilitate both cognitive and noncognitive outcomes, including student learning, engagement, perseverance, motivation, and self-regulation. However, current implementation of such resources precludes researchers from making causal claims about their effectiveness. The promise of FCs, immersive environments, and machine learning are not yet fully realized (Calders and Pechenizkiy 2012; Bienkowski et al. 2012; Yarbro et al. 2014). For example, although classroom lectures are problematic for today's students in terms of engagement, MOOCs and FCs have not yet leveraged the affordances of immersion and motivation offered by the technologies people use in daily life. Practical applications of educational technologies must move beyond the classroom and static experience to incorporate innovative approaches.

One of the educational technologies of the future will be intelligent systems that incorporate sophisticated learner and teacher models (Ma et al. 2014). They will monitor and model the emotional, metacognitive, and cognitive states of learners and will interact with them through avatars that function as pedagogical agents. The systems will support collaborative learning and simulate peer agents with whom the learner can practice to improve cooperative learning skills. Applying adaptive models of assessment to each learning activity allows for continuous assessment and increases accuracy, although challenges abound in embedding those diagnostic, dynamic assessments in multimedia learning environments (Dede 2013).

Summaries of Each Chapter

This section focuses on the road ahead that each chapter delineated. More specifically, we summarize where current trends lie to predict affordances of the technologies and how the technologies might be able to advance student engagement, motivation, and learning in the future.

Annetta, Lamb, Vallett, and Shapiro-Eney
Annetta, Shapiro, Luh, and Berkeley focus on learning progressions and project-based learning in STEM fields, and how these become a powerful learning technology when used in the construction of SEG. The authors state that learning progressions and project-based learning have had increased attention in the past decade, as educators endeavor to improve STEM learning. These activity-based modes of learning show higher results than other, older, and more passive means used in science education. The emphasis on agency and activity by the student learner is taken a further step if she engages in the construction of a serious educational game. The authors show how the construction and playing of a serious educational game develops the understanding of science required by current science assessments, specifically the Next Generation Science Standards (NGSS). The joining of learning progressions and project-based learning provides a powerful tool for learning within the inviting format of a serious educational game, as the authors explain:

> The use of project-based learning, as discussed above, fosters the development of science and engineering practices including making observations, making determinations regarding data, and the construction of explanations and arguments. Likewise, well-identified learning progressions would prove

useful not only in creating the deeper conceptual understandings that the NGSS purports to target but in vertical planning for the spiraling aspects of the content in the standards.

Reich

Wikis are characterized as collaborative websites where users comment, amend, and further develop content. Wikis seem like ideal environments to further goals of progressive education, and to realize a democratic form of learning advocated by John Dewey 100 years ago. Reich wants to know if this is the case: "Is the wiki-inspired 'revolution in education' underway or do these thousands of new learning environments show little sign of nurturing Dewey-inspired forms of collaborative learning?" After studying the behavior of participants in a large sample of wikis, Reich concludes that students engage in sparse collaborative behavior when contributing to a wiki. Such collaborative activity is present only 11% of the time on wikis. Wikis are more accurately characterized as venues where individual accomplishment is evident. Reich discusses the optimistic view of wikis as a technology of furthering progressive, Deweyan education discussed by Glassman and Kang:

> My reading of Glassman and Kang, however, is that they argue that knowledge-building, content co-creation, and communities of investigation are not merely made theoretically possible by wikis, but that educators should understand wikis as places where these advanced learning behaviors can emerge with some regularity, indeed, enough regularity to inspire a revolution. The evidence presented here suggests that these particular arguments should be tempered with the caveat that, in practice, most wikis are individually-produced platforms for content delivery, more often created by teachers than by students.

Nesbit, Niu, and Liu

Cogently advancing a position is an important skill for all students. Traditionally this skill is learned in presenting reasons orally for a position or writing a paper, and, importantly, getting feedback from others and a teacher. John Nesbit, Hui Niu, and Qing Liu focus on the goal of learners to argue as well as the instructional strategy of "argue to learn" by utilizing the developing technology of cognitive tools. Argument is notoriously difficult to teach but of vital importance to a democracy. The future of argumentation in education for these authors is instructional software that utilizes tools such as cognitive schemas, cognitive tools, argument tagging, and argument maps, and how these may be refined and further developed. Of even greater importance to future development in this area is how to spread and deepen this practice in all subject matter. The authors see that the technology of cognitive tools aid this endeavor:

> If arguing about subject knowledge has the dual effect of developing students' subject knowledge and developing their argumentation abilities, we propose that using appropriately designed cognitive tools in such learning activities can boost that effect.

The authors present evidence from studies of how they have accomplished an increase of argumentation and subject knowledge through the use of cognitive tools. These tools are highly interactive and take advantage of visualization of evidence, reasons, and argument paths to further enhance a student's ability. Though the authors do not discuss the need for cooperation among instructors to enable cross over, this is certainly assumed here.

Winne

It is well-known that computers permit analysis of much larger data sets than was previously feasible with pen and paper. If we study large data sets on learner behavior, we can begin to see how we can enhance learning. Philip Winne uses nStudy software to gather big data in both ipsative (within an individual over time) and normative (comparing an individual to a group) means, all in an effort to support learning analytics that will enhance self-regulated learning and problem-solving. Recording each action by a learner provides a powerful ipsative feedback loop to the learner, while comparing individual learners across the collected data points gives a picture of how effective a learning task is, how engaged the learners are with the task, and what gaps in learning may be addressed. nStudy permits fine-grained analysis of trace data. One gets a sense from Winne's chapter that we are at the very beginning of this kind of robust learning analytics that allows researchers, teachers, and learners to drill down, to compare, and to draw up plans for further learning that was not possible even a few decades ago. Big data allow these kinds of comparisons that both provide ipsative and normative feedback useful to designers of learning activities.

Kessler

Certainly one aspect of the innovative environment for learning today are the many opportunities for the collaborative construction of a learning environment. Elsewhere in this volume, Justin Reich examines critically claims that wikis promote collaboration among learners. In his chapter, Greg Kessler reviews a wide range of social learning experiences enhanced by technological development. He sees that these practices are still nascent, but promising. Kessler acknowledges that schooling is for the most part still conducted as it was a century ago, when John Dewey tried to alter the instructor-centric model of content delivery to a learner-centric, participative model where the instructor facilitated student-driven learning. Kessler believes that the new social learning experiences being developed now in such arenas as augmented reality and virtual reality draw students in to be agents of their own learning, and in the case of big data coupled with artificial intelligence and bots, come to conclusions that would be impossible for humans to do unaided. Kessler mentions the IBM artificial intelligence agent Watson, which is able to examine the 8000 medical papers published each day to sort out salient information, and asks how education might be transformed if we utilized such a process. A particular strength of Kessler's chapter is his focus on the future of teacher preparation in light of rapid development and implementation of learning technologies. He believes teachers should not be apprehensive about these technologies, such as the widespread fear that robots will replace teachers, but should embrace opportunities to enhance social learning through technologies.

Virk and Clark

It is important to acknowledge the limitations of new learning technologies, and endeavor to overcome them, as that will help optimize what helps learners best. This is a lesson that helps learning technologies progress, and will be central to their adoption in the future. Virk and Clark's chapter discusses the use of signaling in a Disciplinarily Integrated Game (DIG). Signaling is a well-known procedure where cues direct learners toward particular features or content. A DIG uses game technology to support the development of scientific modeling in K-12 classrooms. The DIG examined in this chapter, SURGE Symbolic, is on Newtonian physics concepts, and signals were embedded with one group and not another in the authors' study. While signaling should improve the efficacy of learning by coaxing and encouraging learners toward relevant parts of the game, Virk and Clark found that learners who did not have signaling performed better than those who had signaling embedded in the game. Signaling, as a proven cognitive tool, provides the leverage to improve and refine the SURGE Symbolic DIG. This process of iterative and dialectical testing and improvement must remain robust as development and assessment practices as games, a burgeoning area of learning technologies, are developed in the future.

Glazewski

Krista Glazewski advocates for skepticism about the claims of technologies for educational transformation. Her chapter goes back to the early proponents and skeptics of how transformative technology would be to teaching and learning, and states many of us are still allured by the promises of such. She cites how Second Life was widely adopted and then abandoned, and proposes using it as a cautionary "yardstick" example of what she calls the "enthusiasm-interest-investment-expiration-desertion cycle." Her chapter sets out policy direction for the future of educational technology as "innovative and pedagogically coherent."

> In short, I am arguing that educational technology should not be cast as both the *goal* of the learning environment and the *actor* for catalyzing change in higher education. However, if we decouple technology from the revolutionary role to place emphasis on understanding robust pedagogical uses, we can inform practices and potential in higher education. In this context, educational technology can be broadly defined as the ways in which we make pedagogical decisions to support a wide range of teaching or learning actions in our classes.

Here the emphasis is first upon pedagogy, and she gives three examples in university instruction, in history, biology, and medical education, where pedagogy guided the choice and use of technology, and where technology afforded transformative teaching and learning.

Ketelhut

The science educator Diane Ketelhut builds upon Lee Shulman's concept of "pedagogical content knowledge" by considering how technology can become an added layer of pedagogy in how content is tailored for learning. Students are already steeped in computer and especially now smart phone technology—she notes that high school seniors were in second grade when the iPhone was released—but schools and especially teacher education programs have not kept up with these innovations. In teacher education students, there are wide variations in knowledge of science and the integration of technology into pedagogy is inchoate. Ketelhut, like Glazewski, stresses that technology is not an end in itself, but a means to focus on strong pedagogical uses of technology. Teachers should acquire "technological pedagogical content knowledge" (TPACK) and having such "means knowing what tools to use for what purposes to achieve what learning." Thus the road ahead for the uses of technology is all about integration and choice of appropriate means to tailor content for learning. There is much to achieve here in preservice and inservice teacher education; science content must be mastered and technologies must be appropriately integrated for the particular purpose of the learning.

Waks

Leonard Waks recounts the quick rise and early maturity of an innovation in the delivery of online education. Starting ten years ago and developed at a rapid pace in the last five years, MOOCs "promised to bring free university courses by global super-star professors at top-ranked universities to any student with Internet access, anywhere in the world."

Here rather simple information technology helped to facilitate a leveling of the educational playing field and a greater degree of participation, much as the earlier technology of the printing press did centuries ago. Waks sees MOOCs as an early development in what he calls Education 2.0, where learners will take more fully charge of their learning by customizing their education to fit their needs, taking short courses to gain a skill for employment or learn about a topic for pleasure. Waks predicts that such education, uncoupled from degrees and credit hours, will enable workers to move around nimbly in the "gig" economy, retooling qualifications as needed:

> As firms shift from full time 'professional workers' to short-term, low obligation contract workers, they search for those who can perform specific tasks at high competence levels without further training. In the process, university degrees and transcripts become less important, searchable credentials of capabilities essential. This has created pressure to break apart or rearrange the elements of college education.

Wise

Alyssa Wise discusses how advances in digital technologies allow the collection and analysis of large numbers of various and finely grained data provided by learning activities. This endeavor, called learning analytics, is still nascent, but its practices should help us improve teaching and learning:

> Learning Analytics is the development and application of data science methods to the distinct characteristics, needs, and concerns of educational contexts and the data streams they generate. The goal is to better understanding and supporting learning processes and outcomes through both short-cycles improvements to educational practice and long-cycle improvements to the underlying knowledge base.

There are technical and policy issues that need to be addressed before such practices can become effective. Wise notes that infrastructure enhancement is crucial for learning analytics to be robust and widespread, but just as important is attending to the policy and ethical issues surrounding such data uses. It is crucial that stakeholders understand why certain data are gathered and analyzed. It is up to researchers and practitioners to make plainly clear how the collection and analysis of certain data are linked to enhanced learning in ways that would not have been possible otherwise. Collecting large amounts of data could also be used in surveillance and control, so the ethics of learning analytics promises to be a burgeoning subfield.

Advances in learning science are highly dependent on technological developments. This book will create a unique opportunity for robust discussions among expert researchers in the fields of educational technology, educational psychology, learning sciences, computer science, instructional design, educational game development, social media for learning, and other relevant areas to inspire new thinking and lay out bold research ideas that will significantly advance the field theoretically, methodologically, and practically.

References

Annetta, L. (2008). *Serious educational games: From theory to practice*. Rotterdam: Sense Publishers.

Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist, 44*, 1175–1184.

Bienkowski, M., Feng, M., & Means, B. (2012). Enhancing teaching and learning through educational data mining and learning analytics: An issue brief. U.S. Department of Education Report. Retrieved from http://www.ed.gov/edblogs/technology/files/2012/03/edm-la-brief.pdf

Bottou, L. (2014). From machine learning to machine reasoning: An essay. *Machine Learning, 94*, 133–149.

Broadbent, D. E. (1956). Successive responses to simultaneous stimuli. *Quarterly Journal of Experimental Psychology, 8*, 145–152.

Calders, T., & Pechenizkiy, M. (2012). Introduction to the special section on educational data mining. *ACM SIGKDD Explorations, 13*(2), 3–6.

Carter, A. S., Hundhausen, C. D., & Adesope, O. O. (2017). Blending measures of programming and social behavior into predictive models of student achievement in early computing courses. *ACM Transactions in Computing Education, 17*(3). Article 12, 1.

Chi, M. T. H., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist, 49*(4), 219–243.

Clark, R. E. (1983). Reconsidering research on learning from media. *Review of Educational Research, 53*, 445–459.

Clark, D. B., Tanner-Smith, E., & Killingsworth, S. (2016). Digital games, design, and learning: A systematic review and meta-analysis. *Review of Educational Research, 86*(1), 79–122.

Dawley, L., & Dede, C. (2013). Situated learning in virtual worlds and immersive simulations. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), *The handbook of research on educational communications and technology* (4th ed., pp. 723–734). New York: Springer.

DeBoer, J., Ho, A. D., Stump, G. S., & Breslow, L. (2014). Changing "course": Reconceptualizing educational variables for massive open online courses. *Educational Researcher, 43*(2), 74–84.

Dede, C. (2013). Opportunities and challenges in embedding diagnostic assessments into immersive interfaces. *Educational Designer, 2*(6), 1–22.

Feng, M., Heffernan, N. T., & Koedinger, K. R. (2009). User modeling and user-adapted interaction: Addressing the assessment challenge in an online system that tutors as it assesses. *The Journal of Personalization Research, 19*(3), 243–266.

Graesser, A. C., Rus, V., D'Mello, S. K., & Jackson, G. T. (2008). AutoTutor: Learning through natural language dialogue that adapts to the cognitive and affective states of the learner. In D. H. Robinson & G. Schraw (Eds.), *Recent innovations in educational technology that facilitate student learning* (pp. 95–125). Information Age Publishing.

Greenhow, C., Robelia, E., & Hughes, J. (2009). Web 2.0 and classroom research: What path should we take *now*? *Educational Researcher, 38*(4), 246–259.

Guri-Rosenblit, S., & Gros, B. (2011). E-learning: Confusing terminology, research gaps and inherent challenges. *Journal of Distance Education, 25*, 1–17.
Hamlen, K. R. (2011). Children's choices and strategies in video games. *Computers in Human Behavior, 27*(1), 532–539.
Hundhausen, C. D., & Carter, A., & Adesope, O. O. (2015). Does social interaction predict learning outcomes? An empirical study in an early computing course. *Association for Computing Machinery's Special Interest Group on Computer Science Education (SIGCSE)* Conference Proceedings. Kansas City, MO.
Jonassen, D. H., & Land, S. M. (Eds.). (2012). *Theoretical foundations of learning environments: Theory into practice* (2nd ed.). New York: Routledge.
Kaufer, D., Gunawardena, A., Tan, A., & Cheek, A. (2011). Bringing social media to the writing classroom: Classroom Salon. *Journal of Business and Technical Communication, 25*(3), 299–321.
Kinchla, R. A. (1974). Detecting target elements in multi-element arrays: A confusability model. *Perception and Psychophysics, 15*, 149–158.
Kirschner, P. A. (2002). Cognitive load theory: Implications of cognitive load theory on the design of learning. *Learning and Instruction, 12*, 1–10.
Kozma, R. (1991). Learning with media. *Review of Educational Research, 61*, 179–212.
Kozma, R. (1994). Will media influence learning: *Reframing the debate. Educational Technology Research and Development, 42*, 7–19.
Kramer, S. R., & Benson, S. A. (2013). Changing faculty use of technology—One cohort at a time. *Journal of Applied Research in Higher Education, 5*(2), 5–5.
Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.
Lee, C. D. (2010). 2010 presidential address: Soaring above the clouds, delving the ocean's depths: Understanding the ecologies of human learning and the challenge for education science. *Educational Researcher, 39*(9), 643–655.
Ma, W., Adesope, O. O., Nesbit, J. C., & Liu, Q. (2014). Intelligent tutoring systems and learning outcomes: A meta-analytic survey. *Journal of Educational Psychology, 106*, 901–918.
Maloney, J., Resnick, M., Rusk, N., Silverman, B., & Eastmond, E. (2010). The scratch programming language and environment. *ACM Transactions on Computing Education, 10*(4), 1–15.
Markauskaite, L. (2010). Digital media, technologies and scholarship: Some shapes of eResearch in educational inquiry. *The Australian Educational Researcher, 37*(4), 79–101.
Martin, T., & Sherin, B. (2013). Learning analytics and computational techniques for detecting and evaluating patterns in learning: An introduction to the special issue. *Journal of the Learning Sciences, 22*(4), 511–520.
Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). New York: Cambridge University Press.

Mayer, R. E. (Ed.). (2014). *The Cambridge Handbook of multimedia learning* (2nd ed.). Cambridge, UK: Cambridge University Press.
McLuhan, M. (1964). *Understanding media: The extensions of man*. New York: McGraw-Hill.
Murphy, R., Gallagher, L., Krumm, A., Mislevy, J., & Hafter, A. (2014). *Research on the use of Khan Academy in schools*. Menlo Park: SRI Education.
Myneni, S., Narayanan, N. H., Ruinfar, A., Rebello, S., & Puntambekar, S. (2013). An interactive and intelligent learning system for physics education. *IEEE Transactions on Learning Technologies Special Issue on Learning Systems for Science & Technology, 6*(3), 228–239.
Plass, J., Moreno, R., & Brunken, R. (Eds.). (2010). *Cognitive load theory*. New York: Cambridge University Press.
Reich, J., Murnane, R., & Willett, J. (2012). The state of Wiki usage in U.S. K-12 schools: Leveraging web 2.0 data warehouses to assess quality and equity in online learning environments. *Educational Researcher, 41*, 7–15.
Reigeluth, C. M. (2012). Instructional theory and technology for a post-industrial world. In R. A. Reiser & J. V. Dempsey (Eds.), *Trends and issues in instructional design and technology* (3rd ed., pp. 75–83). Boston: Pearson Education.
Rus, V., D'Mello, S. K., Hu, X., & Graesser, A. C. (2013). Recent advances in intelligent tutoring systems with conversational dialogue. *AI Magazine, 34*, 42–54.
Severin, W. J. (1967). Another look at cue summation. *Audio Visual Communication Review*.
Siemens, G. (2005). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology & Distance Learning, 2*(1). Retrieved from http://www.itdl.org/Journal/Jan_05/article01.htm
Spector, J. M. (2010). An overview of progress and problems in educational technology. *Digital Education Review, 3*, 27–37.
Tamim, R. M., Bernard, R. M., Borokhovski, E., Abrami, P. C., & Schmid, R. F. (2011). What forty years of research says about the impact of technology on learning: A second-order meta-analysis and validation study. *Review of Educational Research, 81*, 4–28.
Waks, L. J. (2013). *Education 2.0: The LearningWeb revolution and the transformation of the school*. Boulder: Paradigm Publishers.
Yarbro, J., Arfstrom, K. M. McKnight, K., & McKnight, P. (2014). *Extension of a review of flipped learning*. Retrieved September 28, 2017, from https://flippedlearning.org/wp-content/uploads/2016/07/Extension-of-FLipped-Learning-LIt-Review-June-2014.pdf
Zimmerman, B., & Schunk, D. (Eds.). (2001). *Self-regulated learning and academic achievement: Theoretical perspectives* (2nd ed.). Mahwah: Erlbaum.