E-Learning:

The opportunities and challenges of online instruction

Jonathan G. Tullis

University of Arizona

Author Note

Jonathan G. Tullis, Department of Educational Psychology, University of Arizona;

Correspondence concerning this article should be addressed to Jonathan Tullis, Department of Educational Psychology, 1430 E. Second St., Tucson, Az, 85721. Email: jonathantullis@gmail.com

Abstract

Learners are increasingly using digital and networked technologies to access instruction. This revolution in how education is delivered carries important affordances and serious limitations that must be considered when designing online instruction. Online instruction allows learners greater flexibility and control over their learning, can include engaging and helpful multimedia representations of knowledge, can provide social interactions, and can be scaled to reach broader audiences of students. However, significant costs come with these advantages. Online environments typically demand greater self-regulation skills, impose larger cognitive loads, challenge students' motivation, and limit social learning. Possibilities for overcoming these challenges, including various forms of scaffolding, are discussed.

The internet is quickly revolutionizing how education is delivered, with important consequences for student learning. Large numbers of learners utilize digital and networked technologies, including internet searches, online class management systems blended with face-to-face classes, courses hosted entirely online with no synchronous face-to-face time, and Massive Open Online Courses (MOOCs) that can host tens of thousands of learners simultaneously, to seek out information, fulfill school requirements, learn new job skills, and satisfy curiosities (Jordan, 2014). For example, more than a quarter of university and college students took a course online, totaling over 5.8 million students, in the fall of 2014 (Allen, Seamn, Poulin, & Straut, 2016). Similarly, one in seven higher education students reported taking *all* of their courses online (Allen et al., 2016). Online courses are even gaining popularity in middle and high schools, particularly to deliver remedial math classes (Brants & Struyven, 2009). The expansion of online education shows little signs of slowing: the majority of academic leaders report that online courses are critical to their long-term institutional strategic plans, as they view online courses as a solution to a lack of physical classroom space, increased costs, and student demand for flexibility (Allen et al., 2016; Hart, Friedman, & Hill, 2015).

E-learning (i.e. learning through course activities and material delivered through computer networked technology [Welsh, Wanberg, Brown, & Simmering, 2003]) is the newest form of education delivery in a long history of technologies that were supposed to revolutionize education. As early as the 1800s, paper-and-pencil correspondence courses provided students opportunities to learn on their own and submit their assignments to instructors through the mail (Bourne, 1998). Correspondence courses faded as educational radio and television programs grew in popularity during the first half of the 20th century; education through radio and television rapidly abated by the mid-1960s (Gagne, 1987). By the early 1980s, enthusiasm grew for using personal computers for instructional purposes. Each of these innovations prompted great expectations of educational transformations; yet, expectations of revolutions were met with modest outcomes. New mediums of education had little to no lasting impact on practice, causing enthusiasm and interest in the innovations to fade (Cuban, 1986). Several reasons are hypothesized for the relatively quick demise of each of these educational innovations, including the slow rate of interaction between teacher and student in correspondence courses, the unidirectional and static delivery mode from teacher to pupil in television and radio (Fleming & Hiple, 2004), and often mediocre instruction quality of programs produced (Anderson & Ronnkvist, 1999; Gordon, 1970).

E-learning presents immense technological affordances beyond those of prior technologies that, if utilized well, could revolutionize education. Online instruction typically allows asynchronistic interactions within a virtual environment, which allows students to participate regardless of their physical location or time constraints. Online content (especially content with non-linear hyperlinks to other content) provides alternative paths through the material, which permits students flexibility in how they explore and engage with the content (Moos & Marroquin, 2010). E-learning can support multi-way and instantaneous communication between teacher and student and between students and personalized instruction based upon an individual's prior experience and knowledge. Finally, online courses offer the possibility of easy scaling, such that greater numbers of students can be reached at a reduced cost (Littlejohn, Hood, Milligan, & Mustain, 2016). The affordances of online learning, however, pose significant challenges to learners' self-regulation, cognition, motivation, and social interactions. After outlining academic outcomes associated with e-learning, each specific opportunity and challenge will be examined in detail.

Academic Outcomes in E-Learning

Online instruction produces mixed academic outcomes. No consensus exists on the effect of online instruction on academic grades and conceptual learning. As compared to traditional face-to-face instruction, online environments may benefit learning (e.g., Hughes, 2007), hamper learning (e.g. Hart, Friedmann, & Hill, 2015), or make no difference for learning (e.g., Nguyen, 2015). How learning is structured and supported in each setting is more important than delivery format, as there is huge variability in the effectiveness of both face-to-face and online instruction (Allen, Bourhis, Burrell, & Mabry, 2002). Perhaps the biggest challenge with online learning is high drop-out rates. The drop-out rates of online courses are consistently 10-20% higher than traditional courses (Angelino, Williams, & Natvig, 2007). MOOC drop-out rates are even higher: among students who intend to complete a MOOC, only 22% do so (Reich, 2014). Drop out rates may be especially problematic in e-learning environments because students often lack self-regulatory, cognitive, motivational, and social supports, as discussed below.

Self-regulation in E-Learning

Given that online environments tend to be open-ended, non-linear, information rich, and removed from the direct supervision of an instructor, the very nature of online learning requires greater self-regulation than traditional in-person classes (Kizilcec, Perez-Sanagustin, & Maldonado, 2017; Milligan & Littlejohn, 2014). In online learning environments, students make many choices about when they will learn, what content they will cover, what activities they will complete, and in what order they will complete them. For example, learners in MOOCs skip about a quarter of the course content and most employ non-linear navigation through course materials by jumping over some and revisiting other material (Guo & Reinecke, 2014). The increased flexibility afforded by e-learning can allow learners to tailor their instruction to their specific needs and can ultimately contribute to learners' success. For a description and example of self-regulation, see Table 1. Students with control over their learning can learn more than those with less control over their learning. In simplistic learning situations, average college students typically make effective and efficient choices about what they should study (Tullis & Benjamin, 2012), how they should study (Tullis, Fiechter, & Benjamin, 2018), and how long they should study (Mayer, 2003; Tullis & Benjamin, 2011). Yet, far from all students may be able to effectively monitor and control their learning in complex online environments.

The increased freedom of online learning imposes significant challenges to self-regulation. Online environments afford greater vulnerability to external and internal distractions that may jeopardize successful learning (Serdyukova & Serdykov, 2006). Further, complex web-based hypertext environments can require that students divide attention between navigating through the environment and acquiring new schema. Hypertext environments (i.e. text and media that have click-able links to other content) consist of discrete pieces of information (i.e., nodes) linked to one or more other nodes, resulting in a non-linear organization of content. In complex, non-linear environments, learners must remember the nodes they have already visited (along with the content displayed on those nodes), determine each node's relevancy (Chen, Fan, & Macredie, 2006), and decide which nodes to visit next (Müller-Kalthoff & Möller, 2006). Regulating one's learning through this non-linear environment with little or no guidance can place high demands on limited cognitive resources and impede learning (Moos, 2009; Shapiro & Niederhauser, 2004). Creating well-organized structures of informational nodes (or presenting a graphical overview of the environment) may mitigate the cognitive load on learners (Müller-Kalthoff & Möller, 2003).

While the importance of many self-regulation abilities (e.g. metacognition and critical thinking) is similar across in-person and online settings (Broadbent & Poon, 2015), some specific self-regulation skills, including time management and effort regulation, are particularly important in online learning environments. Because students have wide flexibility in when they complete activities, time management (i.e., the ability to plan and carve out time to complete activities) is especially crucial for success in online classes (Broadbent & Poon, 2015; Broadbent, 2017). In fact, most students who fail to complete MOOCs report that they did not complete the MOOC due to time management problems (Kizilcec & Halawa, 2015). Effort regulation (i.e. the ability to persist in the face of challenges) may also be especially important in online settings (Broadbent & Poon, 2015; Broadbent, 2017), as online learners have reduced social support when facing setbacks. Building in co-regulation (like interactions with an instructor and specific deadlines) may reduce the self-regulation burden placed on online students and support their success (see Table 1: Tichavsky, Hunt, Driscoll, & Jicha, 2015).

Online learning environments may exacerbate the consequences of individual differences in self-regulation because they afford flexible control over one's own learning. Learners with strong self-regulation skills may thrive in this controllable environment, while learners with under-developed self-regulation abilities may struggle. For example, learners with strong self-regulatory skills show a non-linear approach to their learning in online environments, often skipping material that they already know and focusing on more challenging material; however, learners with poor self-regulatory skills follow the course in a linear way (Littlejohn et al., 2016). Similarly, learners with low domain knowledge struggle to successfully manage high levels of control over course navigation and can become disoriented (Salmerón, Cañas, Kintsch, & Fajardo, 2005). Research suggests that giving 7th grade students who lack the skills to self-regulate the responsibility to guide their own learning and pick their own path through hypertext environments can be detrimental to their learning (Young, 1996). Learners in online classes who struggle to regulate their learning process effectively tend to experience frustration, become less engaged, and ultimately are less successful than learners with strong self-regulation behaviors (Sun & Rueda, 2012). The increased flexibility of online learning provides learners opportunities to tailor their instruction to their own specific needs, but in doing so, requires learners to exercise greater self-regulation over their learning.

Cognition in E-Learning

Web-based instruction provides cognitive affordances as it extends human cognition, allows learners to tailor instruction to their own abilities, and can support multiple cognitive representations of the to-be-learned information. The World Wide Web allows learners to access almost any information efficiently and on-demand, which greatly extends learners' limited memory abilities (Tullis & Finley, 2018). However, the nature of the internet has reshaped how learners interact with digital text. Learners have little incentive to process digital text deeply or remember it because they can efficiently find the information they need whenever they want it (Sparrow, Liu, & Wegner, 2011). When engaging with digital text, learners often show shallow information processing, increased scanning behavior, reduced contemplation, rapid and nonlinear attention shifts, selective reading, and decreased information retention (Carr, 2011; Delgado, Vargas, Ackerman, & Salmeron, 2018; Nicholas et al., 2009). In this way, learners struggle to effectively self-regulate, monitor, and control their learning when reading digital text compared to printed hardcopy (Ackerman & Goldsmith, 2011). Interspersing questions throughout digital text may help students better monitor and control their learning from digital text (e.g., Anderson & Biddle, 1975).

Hyperlinks embedded throughout digital text may impose additional cognitive demands on learners, including increasing visual processing demands (as hyperlinks stand out from normal text), decision costs (as learners need to decide whether and when to click them), and effort needed to integrate across multiple nodes of information (DeStefano & LevFevre, 2007). The extra cognitive demands of hypertext can reduce the mental resources available for deeper processing (as discussed in the self-regulation section above).

Computer mediated environments can easily include multiple representations of information, including text, videos, diagrams, computer simulations, and more. Multi-media modes of representation can support students' schema acquisition, as they can engender richer and more varied encoding (Clark & Paivio, 1991). For example, computer simulations can provide both textual and concrete visual representations of phenomenon and how they evolve over time (Jacobson & Wilensky, 2006). Students can interact with the simulations to understand the impact of different factors on the emerging phenomenon. Interactive simulations prompt deeper encoding and create more thorough understanding of natural phenomenon than text descriptions (Tullis & Goldstone, 2017). However, poorly implemented multimedia representation may impose a significant extraneous cognitive load on students and impair learning (Kester, Kirschner, & van Merrienboer, 2005). For example, when information is redundant across graphics, narration, and printed text, students must integrate across the three representations; integrating across representations may require extra cognitive resources and overload students (Moreno & Mayer, 2007). While e-learning provides great opportunities for harnessing different representations of knowledge to support student learning, implementing multiple and interactive representations must be done in ways that minimize extraneous cognitive load (see Mayer, 2003).

Motivation in E-learning

As e-learning reaches new and diverse populations of students, online students show greater variation in motivations, expectations, and goals than students in face-to-face classes (Kizilcec, Piech, & Schnedier, 2013; Matuga, 2009). E-learners report a variety of different reasons for taking e-courses, including professional advancement, the need to better serve others, escape or stimulation, and pure interest in the subject (Howell, Williams, & Lindsay, 2003). Some e-learners report extrinsic motivations, such as earning certificates, job skills, or course credit, while others profess intrinsic goals related to personal growth and satisfaction (Matuga, 2009; Milligan & Littlejohn, 2016). In fact, specifically in MOOCs, far from all student report aspiring to complete the course (Reich, 2014). Students' goals make a big difference; of those intending to complete the MOOC, 22% did so, while only 6% completed it who only intended to browse. The learners' goals in MOOCs more strongly predicted completion than any demographic variable!

Web-based environments provide some opportunities and great challenges for supporting students' motivation. The autonomy that students have in web-based courses over what they study, when they study, and how they study may foster motivation (Deci & Ryan, 2000). Ceding control over instruction to learners can bolster their interest in the material (Kinzie, 1990), the amount of mental effort they invest (Salomon, 1983), their attitude toward the instruction (Hintze, Mohr, & Wenzel, 1988), and their motivation to pursue similar topics later (Kinzie & Sullivan, 1989).

Online instructors can further utilize engaging multimedia, graphics, and videos to support student interest (Mayer & Estrella, 2014; Moos & Azevedo, 2008). More specifically, e-learning modules with multimedia formats increased positive affect for college students in a computer programming course (Moneta & Kekkonen-Moneta, 2007), 3D animations boosted student interest in science for 8th grade students (Korakakis, Pavlatou, Palyvos, & Spyrellis, 2009), and multimedia presentations supported high school students' interest in biology (Koroghlanian & Klein, 2004). Web-based learning can even incorporate interactive games that users find entertaining and motivating (Gee, 2004).

A major unique contributor to students' motivation in online environments is their internet self-efficacy. Internet self-efficacy (ISE) is students' self-assessments of their ability to execute internet-related activities to achieve their desired results (Eastin & LaRose, 2000). High ISE predicts greater student engagement (Pellas, 2014; Shi, Chen, & Tian, 2011), motivation (Liang & Wu, 2010), and satisfaction (Kuo, Walker, Schroder, & Belland, 2014) in online courses. Learners with high ISE show greater self-regulation, as they are more likely to engage with the material (Livingston & Helsper, 2010) and seek out needed information online (Rains, 2008). High ISE correlates with high academic performance (Tsai, Chuang, Liang, & Tsia, 2011 [but see Puzziferro, 2008]) and an intention to continue in online learning (Livingstone & Helsper, 2010). Providing explicit and step-by-step guidance about how to use specific technologies could potentially increase learners' ISE.

Motivation and academic emotions are reciprocally related in online learning environments. Negative emotions, especially boredom and frustration, jeopardize students' success in online courses (Kim & Hodges, 2012). In contrast, online students' positive emotions (like satisfaction) correlate with persistence (Ali & Ahmad, 2011), completion rates (Yukselturk & Yildirim, 2008), and grades (Puzziferro, 2008). Several contributors to e-learners' positive affect have been identified through surveys of online students: these include perceived instructional quality (Artino, 2008), task value (Artino, 2008; Lee, 2002), the ability to control learning for students with the goal of mastering difficult content (Cho & Heron, 2015), and student-instructor interaction (Bolliger & Martindale, 2004), which will be discussed more in the next section.

Social Interactions in E-learning

Social interactions play a vital role in online learning settings even though instruction is mediated through computer interfaces. Social interactions can provide opportunities for modeling, guided practice, instrumental feedback, and feelings of community (Zimmerman, 2002), which can support student self-efficacy (Shea & Bidjerano, 2010) and achievement (Lou, Abrami, & Spence, 2000). In online courses, both learner-learner and learner-instructor interactions correlate with students' perceived learning (Marks, Sibley, & Arbaugh, 2005), actual learning (Jung, Choi, Lim, & Leem, 2002), and course satisfaction (Bolliger & Martindale, 2004). Social interactions in online courses can enhance students' self-regulation (Broadbent & Poon, 2015), boost motivation (Borup, Graham, & Davies, 2012), and increase student retention (Gregori, Zhang, Glavan-Fernandez, & Fernandez-Navarro, 2018).

Social interactions are important for student success in online environments, but providing structure for effective interactions remains problematic (Kim, Park, & Cozart, 2014). Online education offerings have broadly prioritized easily-scalable content (which typically involves video lectures and automated assessment) over opportunities for social interactions (Margaryan, Bianco, & Littlejohn, 2015). The mediated virtual learning environment often does not support the organized bonding that occurs during face-to-face classroom activities. The lack of social bonding can dampen feelings of respect among peers and instructors, social support, the sense of accountability, and feelings of belonging (Erichsen & Bolliger, 2010; Kruger-Ross & Waters, 2013). Limited interactions with others can decrease students' course satisfaction and contribute to the student drop-out rate (Bernard et al., 2014). Requiring student discussions and interactions in online forums may provide some of the missing social interactions in online courses, but cannot not replace in-person social interactions (Johnson, Guetal, & Falbe, 2009).

Providing Support to E-Learners

Given the widespread nature of e-learning and its growing enrollment, web-based learning environments should be designed to robustly support student learning. Scaffolding may be the most effective means of supporting student success. Scaffolding is support or guidance provided to learners that allows them to accomplish a task that would otherwise be too difficult. Scaffolding can take various forms, including innate course structure, extra hints, specific prompts, and feedback (Collins, Brown, & Newman, 1989). Research has indicated four important attributes of effective scaffolding including diagnosis (i.e. determining a learner's current ability), calibrated support (i.e. providing support to extend the learners' current ability), fading (i.e. slowing removing the support), and individualization (i.e. providing unique support and schedules of assistance to each individual; Azevedo & Cromley, 2004). Each of these characteristics of scaffolding are crucial to its effectiveness. For example, if scaffolds are not faded during training, students fail to learn how to accomplish the task without the support (Tullis, Goldstone, & Hanson, 2015). Scaffolding in online environments can take the shape of a digital pedagogical agent or tutor that automatically assesses students' abilities, provides pre-programmed support for the ability level of that student, and adapts the support as the student progresses (e.g. Ritter, Anderson, Koedinger, & Corbett, 2007).

Scaffolding has been developed and tested in online environments across many areas, including self-regulation, cognition, and motivation. Given the immense personal responsibility and flexibility involved with online learning, self-regulation scaffolds may be the most important kind of scaffolding for e-learners. Research shows that providing self-regulation hints from prior students at the beginning of an online course (e.g., "What helped me the most was to devote a specific time of the day to work on the course") do not impact long-term student behavior (Kizilcec, et al., 2016); however, embedding systematic self-regulatory scaffolds throughout the course shows promise to support students. For example, requiring students to consistently keep journals of their activities, record their study time, summarize their learning, and reflect on their learning processes can support and teach self-regulation skills in online courses (Barnard-Brak, Paton, Lan, 2010; Chang, 2005). Restricting learners' paths through the material can also ameliorate the self-regulatory burden and facilitate learning of online students (Graesser & McNamara, 2010). Additionally, online platforms can guide students through metacognitive monitoring so they can better assess their own learning and choose effective study tactics for the specific tasks at hand (Hadwin, Oshige, Gress, & Winne, 2010). Self-regulatory scaffolds in e-learning may be a specific instantiation of co-regulated learning (McCaslin, 2009), as described in Table 1. Online platforms can gradually withdraw scaffolds so that students transition from co-regulation to self-regulation.

E-learning provides great opportunities for scaffolding cognitive activity for individual students. An example of a simple conceptual scaffold is a graphical overview of the structural organization of information in a hypertext environment. Navigation aids can reduce the cognitive demands associated with hypertext by helping learners create a mental map of the hypertext environment (Muller-Kalthoff & Moller, 2003). Cognitive scaffolds are most effective if they can optimize cognitive load to the level of learners' expertise. Providing too little cognitive support can leave novice students confused, while providing too much support can counter-productively increase the cognitive load for experts (Kalyuga, 2007). For example, in a situation in which no cognitive guidance is provided, novice learners must apply general search strategies to navigate through the task, and these general search strategies consume the novices' limited cognitive resources. Alternatively, for experts who already have routines for navigating a task, external guidance may interfere with their established routines; experts may have to reconcile their established routine with the external guidance, which can induce an extraneous cognitive load during problem solving. A simple, rapid automated test of learners' knowledge can help scaffold cognition at appropriate levels for individual students in order to yield efficient and effective learning (Kalyuga, 2006).

Cognitive scaffolds can also be embedded throughout computer-based instruction. Intelligent tutoring systems, for example, can adjust the rate and progression through content based upon their assessment of a student's ability (Ritter et al., 2007). More specifically, Cognitive Tutors can trace students' actions and knowledge relative to a cognitive model and tailor the curriculum, progression through material, and feedback to individual students' needs. They can provide step-by-step feedback, specific messages for common errors, and instructional hints when needed (Koedinger & Aleven, 2007). Cognitive Tutors have shown great promise in supporting student learning. Students who learn Algebra I from Cognitive Tutors outscore their peers on standardized tests by about 0.3 standard deviations (and even more on tests of problem solving: Koedinger, Anderson, Haldey, & Mark, 1997) and their effectiveness approaches that of a good one-on-one human tutor (Koedinger & Corbett, 2006). For Cognitive Tutors to be effective, however, complex tasks must be decomposed into individual, measurable knowledge components. Defining, ordering, and measuring individual components of complex ideas requires significant effort and may be impossible for ill-defined tasks and concepts. Further, Cognitive Tutors have only been used in conjunction with traditional face-to-face classes; whether the benefits would translate to fully online courses remains untested.

Finally, scaffolds can be embedded within e-learning to help student control their motivation and affect. Automated tutors can accumulate records of individual student's past activities and current performance in order to provide personalized emotional support for individual students (Baylor, 2011). Affect-aware tutors can respond to student's academic emotions and motivation by encouraging students to implement emotion and motivation regulation strategies (Kim & Hodges, 2012). For example, AutoTutor is an automated intelligent tutoring system that detects and helps learners regulate their negative affect (e.g., frustration, boredom, and confusion) in order to increase task persistence, engagement, and learning (D'Mello, Chauncey-Strain, Olney, & Graesser, 2013). Tutoring systems that support emotion and motivation may be especially important for struggling students, like those in online remedial math courses (Kim, 2012).

Future Research Directions

As technology advances, e-learning is likely to continue expanding. Novel technologies will afford new opportunities to address the self-regulation, cognitive, motivational, and social challenges posed by e-learning environments. Yet, combining self-regulation, cognition, and motivation scaffolds may overload students' cognitive resources and result in learners selectively attending to a subset of the possible information (Roll, Aleven, McLaren, & Koedinger, 2007). Overloading students' cognitive resources may be especially problematic for novice students. Knowing *which* scaffolds to provide and *when* to provide them is paramount to ensuring successful learning.

Structuring online environments to afford for students to control their own learning, without overburdening them with choice, must be a central concern of instructors. E-learning provides increased options for students, including which hyperlinks to click, when to complete activities, and in what sequence. Increased freedom can boost student learning if students actively self-regulate their own learning and adapt their choices to their own needs. Alternatively, navigating through increased choices may divert cognitive resources away from encoding and impair student learning. As Schwartz (2000) argues, "freedom, autonomy, and self-determination can become excessive, and when that happens, freedom can be experienced as a kind of tyranny" (p. 70). Students in e-learning environments may become overwhelmed with choices, with negative impacts on student learning and satisfaction.

Interestingly, allowing students more control over their own learning may impair social connectedness among students (Schwartz, 2000). As students personalize their instruction to meet their needs, students may not share experiences with peers, which can inhibit social interactions in a class. The lack of meaningful social connectedness remains one of the biggest and under-researched hurdles to e-learning. Technologies that reduce learners' feelings of isolation and loss of community in web environments have not been well-developed nor tested. Social media technologies could be incorporated into online courses to bolster community (Mazman & Usluel, 2010), but whether this effectively improves social learning remains an open question. Similarly, the impact of other technologies that allow learners to contribute to online classes by creating videos of themselves talking (e.g. VoiceThread) on feelings of community (and subsequent motivation and self-regulation) has not been examined.

While e-learning can expand access to education to diverse populations and non-traditional students (Kearsley, 2000), the structure of online courses may not be setting up all learners to succeed. E-learning environments may particularly disadvantage low performing students (Cuneo & Harnish, 2002). For example, the increased need for self-regulatory abilities in online courses may prove a tremendous hurdle for students with poor self-regulation (Loomis, 2000; Young, 1996). For example, students with ADHD may struggle with the extra freedom associated with e-learning (Ben-Yehudah & Brann, 2019). Difficulty adjusting to a self-directed approach notably contributes to the higher attrition rate in online courses than traditional face-to-face courses (Bocchi, Eastman, & Swift, 2004; Morris & Finnegan, 2008). Further, given that access to the Internet and technology is not equitably available to learners (i.e. the digital divide: Tate & Warshauer, 2017), some students may lack important ISE needed to thrive in an online environment. Learners develop ISE through previous experience with computers; reduced experiences with Internet technology may impede under-resourced students, particularly minority and rural populations (Johnson & Galy, 2013). If implemented without providing appropriate scaffolds for these students, e-learning may prove to be another instance of the "rich getting richer" (e.g., Merton, 1968).

Much research remains to be done on the structure and effectiveness of e-learning. For example, how online instruction should best be tailored to different domains is unexplored. E-learning has been examined broadly across domains (Holder, 2007; Kizilcec, Perez-Sanagustin, & Maldonado, 2017) and in a range of specific courses, including business (Marks et al., 2005), computing (Moneta & Kekkonen-Moneta, 2007; Yukselturk & Bulut, 2007), education (Kuo et al., 2014; Tsai et al., 2018), engineering (Sun & Rueda, 2012), math (Cho & Heron, 2015; Kim et al., 2014). Yet, no research has examined how to differentiate online instruction based upon the domain. Domains may be able to take advantage of different aspects of e-learning; for example, science domains may be able to incorporate web-based scientific simulations into courses to bolster learning, while government courses can incorporate online videos of important political speeches. Similarly, little research exists about optimizing online instruction to address different kinds of learning. For example, given the ability of online instruction to provide simple cognitive scaffolding, individualized and immediate feedback, and endless practice, e-courses may be particularly well-suited to teach specific skills and facts; devising online courses to teach complex conceptual knowledge and creativity may be more difficult.

Finally, online courses typically involve conventional pedagogies of video lectures and automated quizzes (Margaryan et al., 2015). How effectively other pedagogical designs meld with e-learning is unknown. For example, whether hypermedia and web-based instruction can effectively support problem-based learning should be examined in more detail (see Jacobson & Archodidou, 2000 for a design framework). More research is also needed to test how online learning can move beyond online videos and text to incorporate varied technologies like web-based gaming, virtual reality, animations, and simulations.

While the internet has already changed *how* instruction is delivered, advanced technologies have huge potential to re-imagine *what* instructional activities are delivered to e-learners in the future. These changes pose great opportunities for personalizing instruction to individuals, granting students greater flexibility and control over their learning while still encouraging social connectedness, and reaching broader audiences of students. The greater opportunities for student flexibility and personalization in e-learning environments renews a persistent dilemma facing instructors: balancing the autonomy and structure provided to students (e.g. Deci, Schwartz, Sheinman, & Ryan, 1981). Embedding personalized and adaptive self-regulatory, cognitive, motivational, and social scaffolds throughout instruction might be able to provide support to students who need structure without interfering with those who do not.

Ultimately, the lasting impact of e-learning environments on education will depend upon how effectively we harness its unique capabilities to support students' self-regulation, cognition, social interactions, and motivation.

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Table 1.
Descriptions and e-learning examples of self-regulation, co-regulation, and socially shared regulation (see Hadwin & Oshige, 2011).

	Self-Regulated Learning	Co-Regulated Learning	Socially Shared Regulated Learning
Definition	An individual strategically plans, monitors, and controls cognition, behavior, emotion, and motivation.	Strategic planning and control emerge from the interaction between people or systems, each with different regulatory expertise.	Groups of people mutually regulate their collective activity by creating group goals and standards, monitoring group progress, and controlling group behavior.
Goal	Adaptation and advancement towards individual goals	Advancement towards personal goals and gradual internalization of individual self-regulatory processes	Collective regulation of collaborative processes and socially shared cognition
E-learning Examples	A student believes they already know a topic, so they take an online quiz without reading the corresponding text.	An e-learning module requests that students judge how well they have learned material before they can advance to the next topic.	Groups of students post public messages on an online forum to work through a difficult concept and to create shared understanding of a topic.