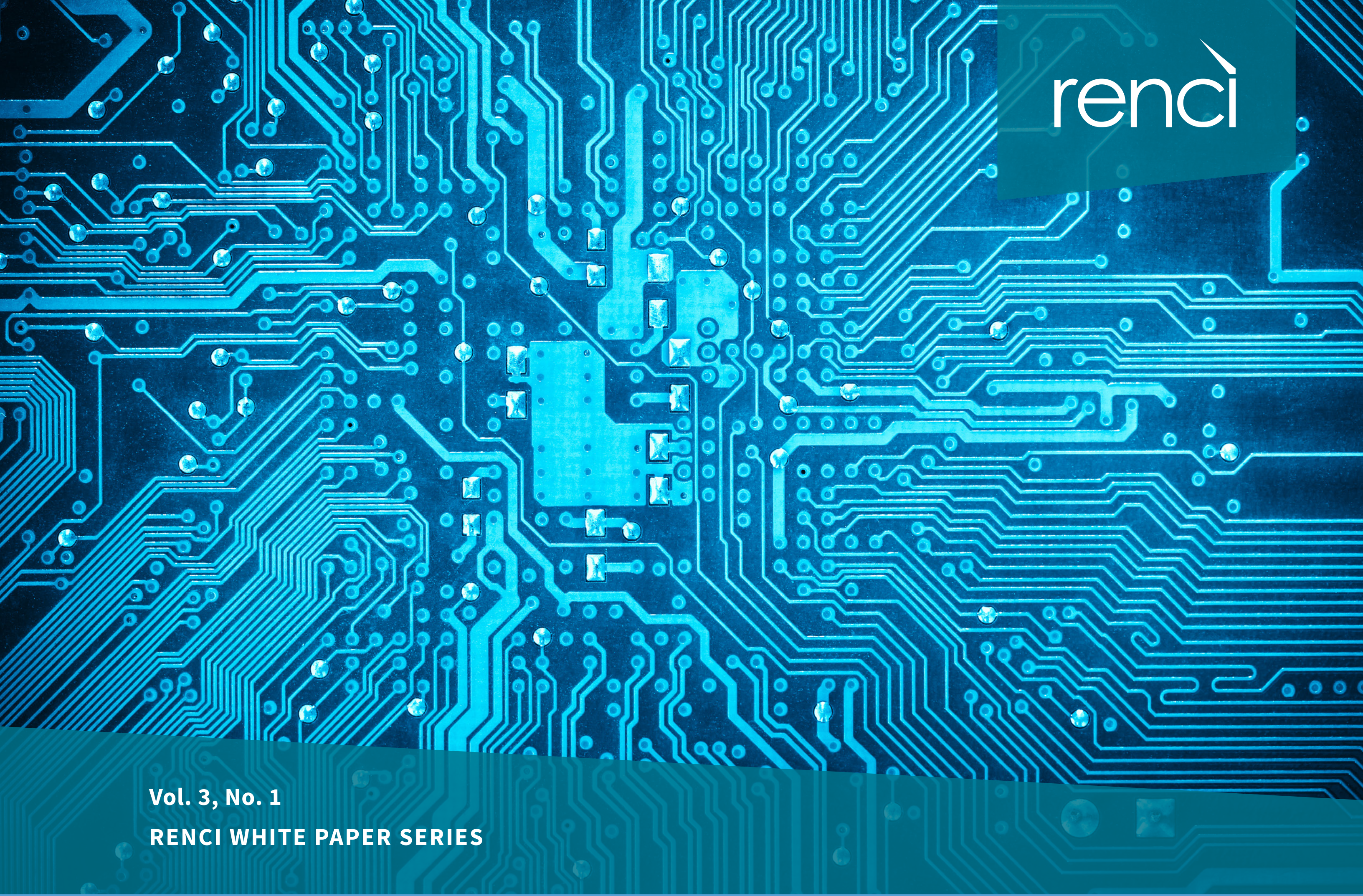

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# Ten Emerging Technologies for Higher Education


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# Summary

Today's colleges and universities face numerous challenges, with rising tuition costs and pressures for educational reform. Numerous technologies are emerging that aim, in part, to address these challenges. Herein, we provide an overview of 10 technologies and approaches that have the potential to improve higher education and enhance student learning and achievement; these include, Computerized Grading, Electronic Textbooks, Simulation Technology, Gamification, Flipped Classrooms, Active Learning Classrooms, Massive Open Online Courses, Collaborative Distance Learning Environments, the Active Learning Forum™ platform, and Learning Management Systems.

# The Challenges

Much has been written over the past decade about the failure of the American educational system, from pre-K through postsecondary education. At the college and university level, current challenges include rapidly rising tuition costs and pressures for educational reform (Lederman 2008; Atkinson 2010; Lynch 2013; Nisen 2013). Proponents for educational reform argue that students are disengaged from the learning process and that traditional lecture-based courses do not encourage student immersion, interaction, or critical thinking (Atkinson 2010). They argue that teachers are equally disengaged from the learning process, with insufficient value placed on teaching, pressures to assign overinflated grades, and incentives to teach content only, not critical thinking skills. College students themselves appear to support the push for educational reform. Indeed, a recent McKinsey/Chegg survey indicates that recent graduates feel unprepared for the "real world" and ill-equipped with the skills required to be competitive in today's job market (McKinsey 2013). Even supporters of today's higher education system recognize the need to better engage both teachers and students in classroom learning (Gutting 2011; Shulevitz 2014). Others argue that the American higher education system has become nothing more than a "failure factory," with graduation rates even lower than those of high schools and largely disproportionate to the amount of national gross domestic product that is spent on higher education (Schneider 2008).

# Emerging Technologies to Address the Challenges

Technology has the potential to help alleviate many of the challenges facing today's higher education system, including the issues raised above. In this white paper, we provide a brief overview of 10 emerging technologies that hold promise to enrich and revitalize today's higher education system and better prepare students for the 21st century. These technologies include: Computerized Grading; Electronic Textbooks (E-textbooks); Simulation Technology; Gamification; Flipped Classrooms; Active Learning Classrooms; Massive Open Online Courses (MOOCs); Collaborative Distance Learning Environments; the Active Learning Forum™ platform; and Learning Management Systems (LMSs).

## AT A GLANCE

- The U.S. higher education system is facing increasing pressures to reduce costs and improve student achievement.
- New technologies are being developed that aim, in part, to address these challenges.
- Ten emerging technologies that have the potential to improve higher education are: Computerized Grading; Electronic Textbooks; Simulation Technology; Gamification; Flipped Classrooms; Active Learning Classrooms; Massive Open Online Courses; Collaborative Distance Learning Environments; the Active Learning Forum™ platform; and Learning Management Systems.
- While these technologies hold great promise as tools to reform and revitalize higher education, most have not yet been fully evaluated in "real-world" settings and likely will need to be refined as weaknesses are identified and new challenges arise; nonetheless, these technologies have the potential to positively impact today's higher education system.

# Computerized Grading

Computerized grading is not new; indeed, educators have relied on computerized grading for years, beginning with the Scantron "bubble sheet" solution for multiple choice questions (Markoff 2013; Strauss 2013). Computerized grading of written, free-form short answers or essays has not yet been fully realized but is rapidly gaining attention as a new technology for education (Markoff 2013; Strauss 2013).

Computerized grading applies the techniques of machine learning and artificial intelligence to determine statistically the probability that a human grader would give a particular grade to an essay (Markoff 2013; Strauss 2013; Winterhalter 2013; Cody 2014). A software program does this by searching for aspects of writing such as the number of words, spelling, sentence structure, use of punctuation, average length of a word, average length of a sentence, accuracy of quotes against source material, etc. (Strauss 2013; Winterhalter 2013).

A number of companies are developing software for computer grading. Several companies already have marketable products, such as the ETS eRater (http://www.ets.org/erater/about) and the Vantage Learning IntelliMetric system (http://www.vantagelearning.com/products/intellimetric/). Open source software products are also emerging. edX (http://code.edx.org/discern/), for example, released an open source product in 2013. Other proprietary and open source products are likely to emerge.

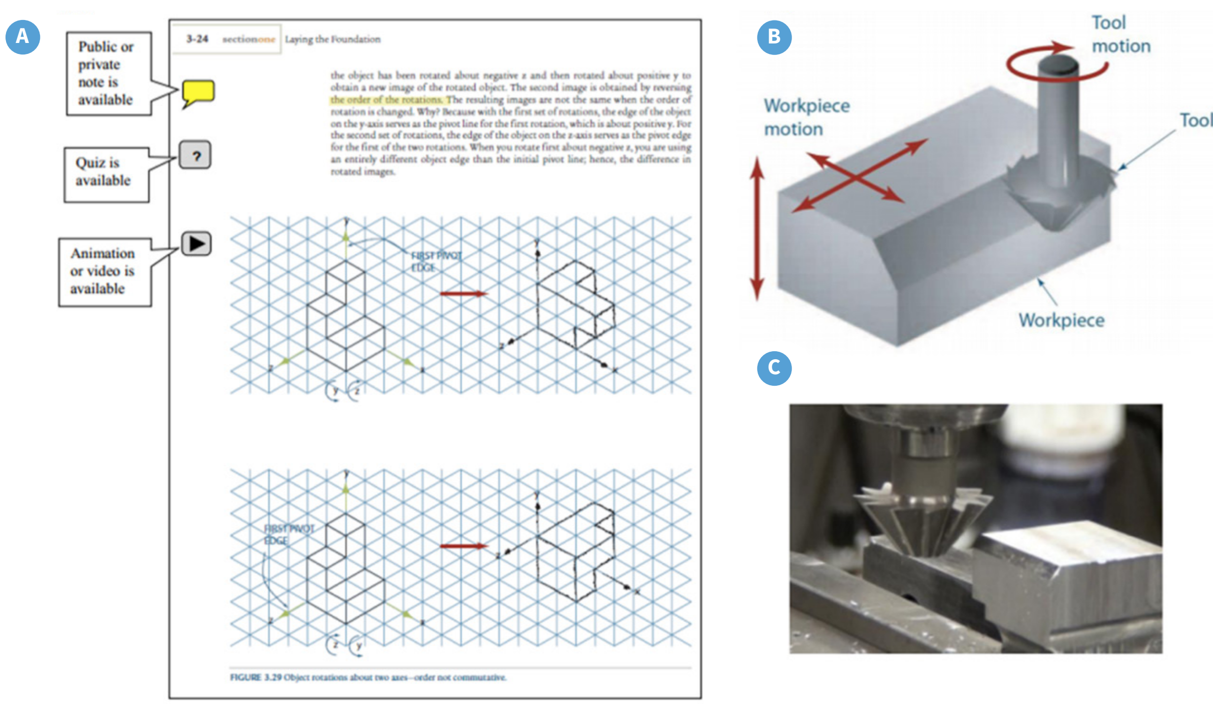
Computerized grading has received mixed reviews among educators, with headlines claiming that "Computer grading will destroy our schools" (Winterhalter 2013). The National Council of Teachers of English (NCTE) has released a position statement in strong opposition to computerized grading (NCTE 2013). An MIT researcher has even developed a software program, titled "Basic Automatic BS Essay Language Generator (BABEL)," that generates "babel" essays designed to intentionally "trick" grading programs (Cody 2014). Proponents, however, argue that computerized grading will cut costs, provide faster student feedback, and standardize the grading process (Markoff 2013; Strauss 2013; Winterhalter 2013; Cody 2014).

# E-Textbooks

E-textbooks offer the opportunity to enhance written text with hyperlinks to additional resources, including other textbooks or readings, videos, audio feeds, and slide presentations (Murray and Pérez 2011; Talancon and Lieu 2012; Greenfield 2013; PR Newswire 2014). Theoretically, e-textbooks could link students to real-world data sets or streaming sensor data and thereby empower students with data to explore graphical software packages, statistical tests, and other forms of data analysis. The goal of e-textbooks is to create a truly dynamic, interactive learning experience, in which students and teachers can simultaneously immerse themselves in the learning experience (Murray and Pérez 2011; Talancon and Lieu 2012; Greenfield 2013; PR Newswire 2014). An example of

**FIGURE 1.**

**A.** An example pdf page from an engineering e-textbook, showing links to additional resources. **B.** An image showing a machine shop process, available as a linked resource from a pdf page. **C.** A screenshot from a streaming video, available as a linked resource from a pdf page. *(The figure is reprinted with permission from Talancon & Lieu 2012).*



an engineering e-textbook is shown in Figure 1. This example e-textbook was designed for a tablet, but a variety of digital devices can be used to access e-textbooks, including laptops, e-readers, and other mobile devices.

E-textbooks provide greater portability at a reduced cost when compared to traditional paper textbooks, and their popularity has been growing, albeit somewhat slowly (Murray and Pérez 2011; Greenfield 2013; Jabr 2013). In fact, students continue to prefer traditional paper textbooks over e-textbooks, even though they have adopted other forms of digital learning, such as online course materials and discussion forums (Greenfield 2013; Jabr 2013).

A number of companies specialize in the development and marketing of e-textbooks and other digital course materials, including Apple (https://www.apple.com/education/ipad/ibooks-textbooks), CourseSmart (http://www.coursesmart.com), and Google (https://play.google.com/store/books/category/coll_1673?hl=en).

A significant drawback regarding e-textbooks is that publishers have not adopted a common platform or standardized approaches to the creation of e-textbook material (Murray and Pérez 2011). However, IBM is working with a Polish company, Wydawnictwa Cyfrowe LLC, to create a cloud-based solution to this challenge (PR Newswire 2014), and other solutions are likely to emerge. In terms of effectiveness, early research found that paper textbooks are associated with significant learning advantages over e-textbooks, but recent research suggests that there is less of a difference in learning outcomes between the two types of textbooks (Murray and Pérez 2011; Talancon and Lieu 2012; Jabr 2013). Clearly, additional research is required to fully compare electronic versus paper textbooks.

# Simulation Technology

The use of simulation technology as a learning tool traces its roots to the urgent need to improve safety in the aviation industry (Sexton, et al. 2000; Moore 2014). The premise underlying flight simulation is to create a realistic (but simulated) flying environment in order to safely train pilots. The idea dates back to the origins of modern airplanes, when pilots would be trained by sitting in the glider of a plane while facing strong winds, thus allowing the pilot to get a feel for the plane in a realistic setting. Modern flight simulation typically incorporates advanced technologies such as sensors and virtual reality displays to better simulate the “real” experience of flying, including any emergency situations that may arise. Simulation technology has since been adopted as an established training tool by the military and certain high-risk industries such as nuclear energy (Passiment, et al. 2011).

While traditional simulation has been widely used in higher education, through activities such as role-playing, technology-based simulation has been less widely adopted, with the exception of medical education. Indeed, technology-based simulation is largely considered one of the most significant technical innovations in medical education over the past two decades, and a fairly large body of research supports its benefits in the training of medical students and resident physicians (Sexton, et al. 2000; Kunkler 2006; Passiment, et al. 2011). Medical simulations often involve a combination of traditional simulation techniques, such as team-based role-playing (e.g., an operating room team of anesthesiologists, surgeons, and nurses), and technology-based simulation techniques, such as software programs that mimic real-world medical emergencies (e.g., a mannequin "patient" hooked up to an anesthesia machine and various other hospital monitors that are programmed to signal cardiac arrest or another medical emergency), (Begg, et al. 2005; Kunkler 2006; Passiment, et al. 2011, see example image in Figure 2.) Screen-based computer simulators and virtual reality devices are also used in medical simulations.

Simulation technology is now routinely incorporated into the curriculum of most major medical schools, and federal agencies such as the Agency for Healthcare Research and Quality (http://www.psnet.ahrq.gov) increasingly emphasize the importance of technology-based simulation among the broader health care system in an effort to improve patient safety (Kunkler 2006; Passiment, et al. 2011).

Simulation technology is becoming more widely recognized as an important learning tool for several reasons (Damassa & Stiko 2010):

- It actively engages students in the learning processes and allows students to practice skills and apply knowledge;
- It provides flexibility in learning, with the option of slowing down (or speeding up) the learning process and/or repeating lessons;
- It provides a "safe" environment for making mistakes, and:
- It allows students to engage in virtual situations that would otherwise be difficult, dangerous, or impossible to engage with.

**FIGURE 2.**
An image from an operating room simulation at the Walter Reed Medical Simulation Center.
(The image is freely available at http://wrnmmc.devhub.com/.)

Examples include: single-user software programs such as Change Management Simulation: Power and Influence (http://cb.hbsp. harvard.edu/cb/product/4345-HTM-ENG); dynamic visualization tools such as QuinET (http://dspace.mit.edu/handle/1721.1/85743); virtual laboratories such as The Virtual Chemistry Laboratory (http://csusap.csu.edu.au/~bdalgarn/vclab/); and multiplatform technologies such as The Virtual Law Office (http://www.uwe.ac.uk/elearning/she/simita.shtml).

The major downside to the use of simulation technology in higher education is the high upfront development costs; however, the costs associated with commercial simulation technologies have been decreasing, thus encouraging their widespread adoption (Damassa & Stiko 2010; Passiment, et al. 2011). Moreover, for medical simulation, the initial investment costs have been shown to lead to significant downstream savings, in terms of training time and reduction in medical errors (Kunkler 2006).

# Gamification

Game-based learning is not a new concept, and many educators routinely incorporate games into their lesson plans, particularly at the preschool and early elementary school levels. "Gamification" is a relatively new concept that was coined in the early 2000s by British IT expert Nick Pelling, but only recently has it become widely used (Smith 2014; Kunkel [undated]). Gamification can be considered as a very specific type of simulation technology; it refers to the use of game theory and practices in the development of digital simulations for e-learning (i.e., game-*informed* learning) (Begg, et al. 2005; McClarty, et al. 2012; Buck 2013; Smith 2014; Kunkel [undated]). Gamification is based on the theory that students will be more engaged with the learning process and will ultimately achieve greater academic success if learning is based on gaming concepts such as competition, incentives, and goal attainment. Many e-learning games are available today; some of these are targeted for individual learners, but many are intended for teams, and some have options for either individuals or teams.

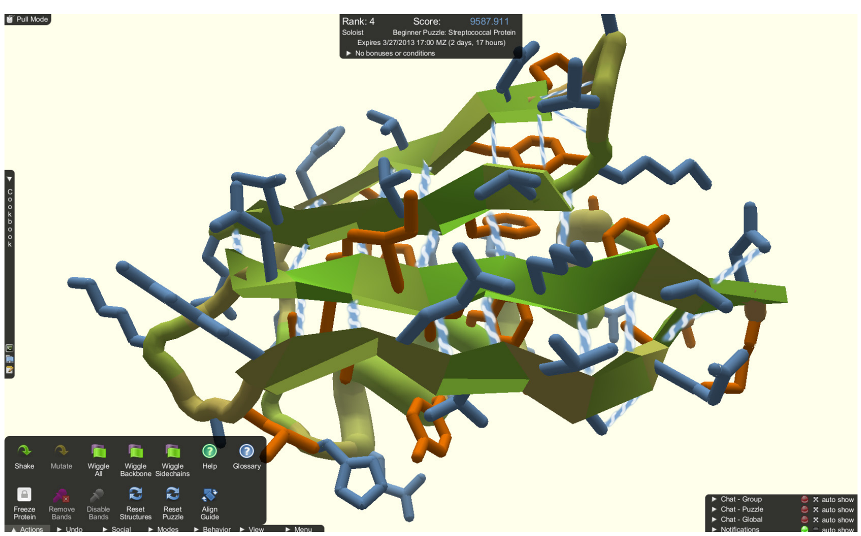



**FIGURE 3.**
The foldit gaming interface, showing the structure of a streptococcal protein. (The image is freely available at http://fold.it/portal/info/about.)

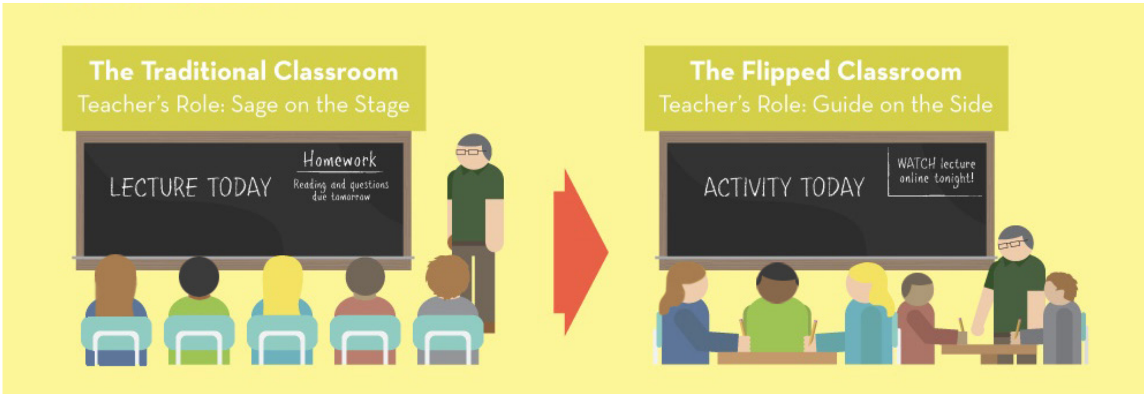
Examples of popular e-learning games include Bridge Constructor (https://itunes.apple.com/us/app/bridge-constructor-free/id507125352?mt=8). This is an iPad/iPhone app, with free and for fee versions available. The learner's job is to build stable bridges using only the provided materials, and the goal is to build, under a fixed budget, a bridge that can carry a given weight (i.e., certain number of vehicles) without collapsing. Another example is foldit (http://fold.it/portal/). Foldit was developed by investigators at the University of Washington as a game that enables learners to participate in actual scientific research by exploring virtual protein-folding designs. (See example image in Figure 3.) Duolingo (https://www.duolingo.com/) is receiving praise as a highly effective way to learn a foreign language. A number of languages are available. Learners earn points for correct answers, race against the clock, and climb levels until they reach mastery of a language. There is research supporting the effectiveness of duolingo, which is available free of charge and has been developed using a crowdsourcing business model. Codecademy (http://www.codecademy.com), while not strictly a game-based learning tool, offers free software coding classes, developed through crowdsourcing and available for several programming languages, including Python, JavaScript, jQuery, HTML, CSS, Ruby, Learn, and PHP. Gaming principles are incorporated through the use of interactive feedback, badges for completion of exercises, and scorekeeping. Youth Digital Studio (http://www.youthdigitalstudio.com/) is a for-profit company that offers both in-person courses and online courses on a variety of topics, including app design, game design, game development, animation, 3D printing, and others. Though not strictly game-based, the courses incorporate gaming principles through the use of badges, scorekeeping, and incentives in the form of a final functional product. Courses were developed initially for students ages 8-14 but have since reached a broader audience.

While widely popular, the effectiveness of digital games in promoting student learning is unclear; indeed, the few studies that have been conducted have demonstrated mixed effects (Begg, et al. 2005; McClarty, et al. 2012).

# Flipped Classrooms

The concepts of "flipped learning" and "Flipped Classrooms" arose circa 2007, when two high school teachers in Colorado, Jonathan Bergmann and Aaron Sams, realized that, for a very small investment in software ($50), they could record their classroom Microsoft® PowerPoint lectures and post them online for students who were absent the day they were taught (Tucker 2012; Knewton 2014). Much to their surprise, the online, freely available lectures became popular among both students who missed the lectures and those who wanted to refresh and reinforce the lesson plan. Thus was born the concept of the Flipped Classroom, in which educators prepare online lectures and interactive lessons that students are required to review *before* coming to class, and class time is spent engaging in hands-on "homework," discussion, and other classroom activities (see Figure 4). The model is such that the educator moves from "on-stage" lecturer to "on-the-side" tutor, thereby providing more personalized instruction; in this regard, flipped learning embraces several of the principles of "active learning" (see section on "Active Learning Classrooms") and the design of the MOOCs (see section on MOOCs).

**FIGURE 4.**
A schematic distinguishing the Traditional versus Flipped Classroom.
(The schematic is freely available at http://www.knewton.com/flipped-classroom/.)




Educators, including those in higher education, are embracing the Flipped Classroom (Bogost 2013; Educause 2014; Yarbro 2014). This approach has even been implemented for large courses of more than 1,000 students (Educause 2014; Yarbro 2014). Kahn Academy (http://www.khanacademy.org), for example, is believed to have been conceptualized using the flipped learning model (Tucker 2012). Formal research, albeit limited and mostly in the form of surveys, also supports the success of Flipped Classrooms (Yarbro 2014).

The Flipped Classroom faces several challenges, however. One such challenge is the development of short, but high-quality, online video content that is simultaneously engaging and informative—a challenge that, admittedly, is not new to educators but may be harder for them to achieve without sufficient training and time (Tucker 2012; Educause 2014; Yarbro 2014). Another challenge is that educators need training in how to best integrate the online and in-class instruction into their course curriculum (Tucker 2012; Educause 2014). Critics argue that Flipped Classrooms are simply "condensed classrooms," which compress learning material into short pieces of summarized information that can be understood with little or no synthesis or critical thinking on the part of the student (Bogost 2013). Ironically, students also may rely strictly on the online preparatory lecture and skip the in-class activities (Educause 2014).

# Active Learning Classrooms

Active Learning Classrooms are designed to promote the concept of "active learning" into in-person classroom environments of any size, for virtually any type of course (Prince 2004; Whiteside, et al. 2009; Cotner, et al. 2013). Active learning involves the engagement of students and educators in the learning process through collaborative classroom activities and reflection (Prince 2004). Active Learning Classrooms are engineered and designed to promote these behaviors. They feature round, computer- and network-equipped tables to accommodate small student teams, a central teaching station to promote teacher circulation around the classroom (as opposed to traditional podium lectures), and multiple computer screens placed strategically

**FIGURE 5.**
A screenshot from a demonstration video of an Active Learning Classroom at the University of Minnesota. (The demonstration video is freely available at http://www.classroom.umn.edu/projects/alc.html.)

around the classroom to enhance visual learning and create a dynamic learning environment (Whiteside, et al. 2009; Cotner, et al. 2013; Beichner 2014). The design of Active Learning Classrooms is intended to promote team-oriented, highly collaborative, student-driven but teacher-facilitated, hands-on interactive learning, with the goal of better preparing students for the "real world." An example of an Active Learning Classroom is shown in Figure 5.

While the concept of the Active Learning Classroom is not new, there is now strong evidence for the success of this type of learning environment in fostering student achievement (Walker, et al. 2008; Whiteside, et al. 2009; Beichner 2014). Evidence suggests that these classrooms: are effective in promoting student learning in both small classes and larger ones; can be used for courses originally designed as traditional lecture-based courses; and are particularly effective in improving the performance of low-performing students.

Examples of successful Active Learning Classrooms include the University of Minnesota's Active Learning Classrooms (http://www.classroom.umn.edu/projects/alc.html) and the Student-Centered Active Learning Environment for Undergraduate Programs (SCALE-UP) project at North Carolina State University (http://www.ncsu.edu/per/scaleup.html).

The major drawback to Active Learning Classrooms is the high upfront investment, with classroom renovations costing hundreds of thousands of dollars (Whiteside, et al. 2009; Cotner, et al. 2013). Another challenge is resistance among educators to implementing active learning techniques within Active Learning Classrooms. Indeed, the effective use of these classrooms and techniques requires considerable educator training and experience (Walker, et al. 2008).

# MOOCs

The Massive Open Online Course (MOOC) teaching format has its roots in the philosophical approach of the Open University and the technological platform of traditional online courses (Marques 2013; Marques & McGiles 2013). Canadian educators Stephen Downes and George Siemens, both of the University of Manitoba, are credited for introducing the first predecessor to today's MOOC, with their 2008 open online course titled "Connectivism and Connective Knowledge/2008 (CCK08)" (Marques 2013; Marques & McGiles 2013). The course was offered free of charge and with open admission, and it adopted a wide variety of digital platforms, including forums, blogs, wiki pages, and other forms of social media, with the goal of creating an online community of engaged and connected students.

While CCK08 enrolled more than 2,000 students, the first truly massive MOOC was introduced in 2012 by Stanford educators Sebastian Thrun and Peter Norvig, whose "Introduction to Artificial Intelligence" course attracted more than 160,000 students, thus launching the term Massive Open Online Course or MOOC (Marques 2013).

**TABLE 1.**
Comparison of the features provided by different MOOC platforms.
(The table is reprinted with permission from Yuan & Powell 2013).

| Initiatives | For profit | Free to access | Certification fee | Institutional credits |
|---|---|---|---|---|
| eDX | x | ✔ | ✔ | x |
| Courses | ✔ | ✔ | ✔ | x ✔ |
| Udacity | ✔ | ✔ | ✔ | x ✔ |
| Udemy | ✔ | x ✔ | ✔ | x ✔ |
| P2PU | x | ✔ | x | x |

Today, thousands of MOOCs are available through a variety of academic and commercial providers, with some offered free and others available for a fee (http://www.moocs.co) (During 2013; Marques & McGiles 2013). While the MOOCs vary in accessibility, content, approach, size, and teacher credentials, they are all true courses in the sense that they have requirements (e.g., assignments and evaluations) and are time-limited (e.g., a traditional semester) (Marques & McGiles 2013). This differentiates MOOCs from other forms of distance learning such as the online lectures of Khan Academy (http://www.khanacademy.org), iTunesU (http://www.apple.com/education/itunes-u), or Technology, Entertainment, and Design (TED) Talks (https://www.ted.com/about/our-organization).

Numerous MOOC platforms are available, and several popular ones are compared in Table 1: Udacity (http://www.udacity.com); Coursera (http://www.coursera.org); edX (http://www.edx.org); P2PU (Peer-2-Peer University; https://p2pu.org); and Udemy (http://www.udemy.com).

MOOCs have become extremely popular; indeed, *The New York Times* named 2012 “The Year of the MOOC” (Pappano 2012). Yet, their effectiveness, in terms of both student learning and economic soundness, is debatable (During 2013; Cusumano 2014). For example, critics argue that by offering free MOOCs, academic institutions are devaluing the value of a college education and undermining existing academic business models. Most organizations that offer MOOCs have yet to establish a sustainable business model, although some are subsidizing free MOOCs by charging for grading or certification credentials. Another criticism is based on student achievement. Few formal evaluations have been conducted on the effectiveness of MOOCs in promoting student achievement, and the few that have been conducted show little evidence of success, when compared to traditional in-person courses. Furthermore, MOOCs have very low retention rates, with a study from the University of Pennsylvania finding that only about 4% of student enrollees actually complete the course.

# Collaborative Distance Learning Environments

Collaborative Distance Learning Environments are similar to the Active Learning Classrooms and MOOCs described above, but they aim to take those concepts one step further through active learning among distant, distributed networks of students (Berg 1995; Miller & Padgett 1998; Filigree Consulting 2012).

Most courses that aim to achieve collaborative distance learning rely on a combination of technologies, such as online lectures, interactive whiteboards, personal devices, cameras, sound amplification, multimedia (e.g., video, audio, Web), collaborative learning software (e.g., Google docs, Yammer, Red Pen, etc.), instructional games, and conferencing tools (Skype, Google+ Hangout, Blackboard Collaborate, WhatsApp, etc.) (Berg 1995; Miller & Padgett 1998; Filigree Consulting 2012; Morrison 2014). Social media plays a critical role in collaborative distance learning by promoting the integration of technologies, humanization of virtual interactions, and personalization of learning (Berg 1995; Brindley, et al. 2009; Morrison 2014). The combination of high-quality, richly-integrated technologies and best practices in their use is believed to be associated with positive collaborative distance learning outcomes, and a limited amount of research supports that notion (Berg 1995; Brindley, et al. 2009; Filigree Consulting 2012).

An example of a new Collaborative Distance Learning Environment is Maker Camp (http://makercamp.com), which is a free, “live,” interactive summer camp that was developed by Make in collaboration with Google. Maker Camp is designed for children ages 13-18, although it has attracted an older audience. It enables learners to take virtual “field trips” to meet inspiring “makers” from around the world and embark on “maker” projects of their own. Counselors and junior counselors facilitate the camps, and campers (whether individual or in groups) can interact with other campers and their “maker” expert through audio/video streams.

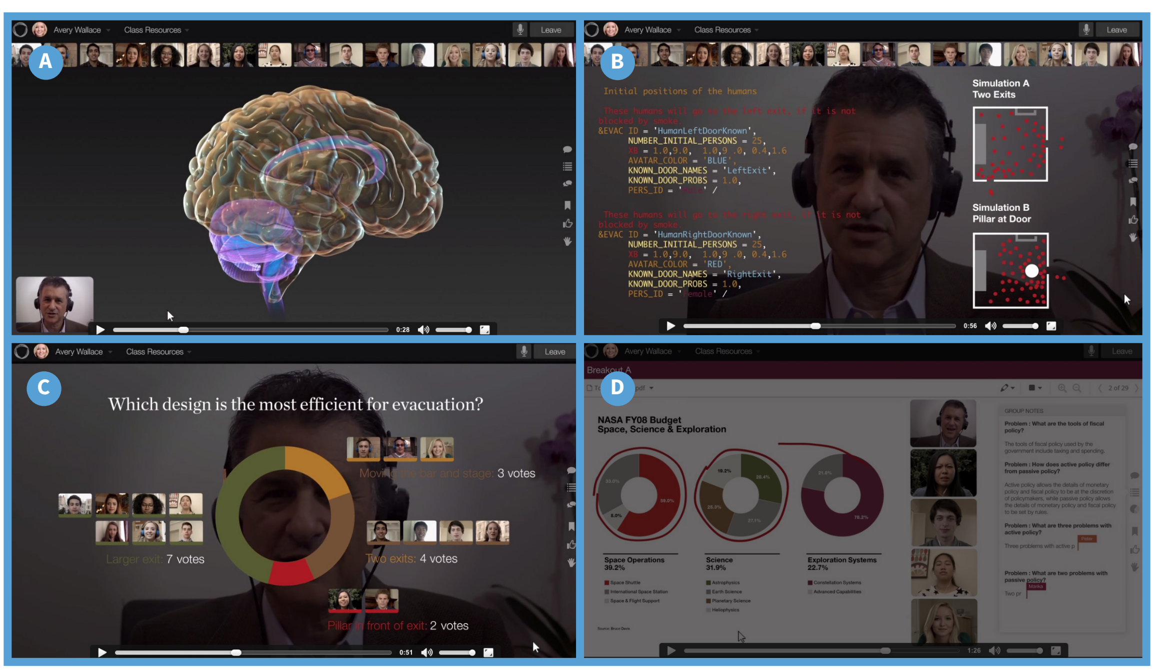
Major drawbacks to Collaborative Distance Learning Environments are their high upfront development costs and the lag-time between video and audio feeds, which can be disruptive to the learning experience and can also add time to any given lesson plan (Brindley, et al. 2009; Morrison 2014). Careful selection of technologies and adequate educator training also are essential (Miller & Padgett 1998; Filigree Consulting 2012). An additional, significant challenge is the wide variety of student needs and learning styles and differences in time zones, which greatly hinders attempts to simultaneously engage students from disparate geographical locations (Miller & Padgett 1998; Brindley, et al. 2009).

# Active Learning Forum

The proprietary Active Learning Forum is a collaborative distance learning platform that fuels the online curriculum at the Minerva® Schools at Keck Graduate Institute. Minerva is an accredited, for-profit, four-year undergraduate institution that aims to revolutionize higher education through its combination of international "real-world" fieldwork and entirely online, distance coursework (https://minerva.kgi.edu/; Wood 2014). Unlike MOOCs, Minerva's online courses are restricted to small groups of students ( fewer than 20 per course) in order to facilitate dynamic interactions between teachers and students in a manner similar to the Active Learning Classroom but with all interactions occurring remotely.

**FIGURE 6.**

Screenshots from Minerva's demonstration video on its Active Learning Forum platform. **A.** Responsive gesture control is used to manipulate a 3-D model of the human brain. **B.** Real-time simulation is used to compare two different simulation scenarios. **C.** Dynamic polling is used to tally student responses to a question. **D.** Professor-facilitated breakout sessions enable students to "meet" in small groups. *(The demonstration video is freely available at https://minerva.kgi.edu/academics/seminar-experience.)*



The Active Learning Forum platform provides several key capabilities: interactive discussions; real-time debate options; responsive gesture control to enable 3-D manipulation of digital objects; real-time simulations to demonstrate complex analyses; dynamic, collaborative document creation; dynamic polls and quizzes; live breakout sessions involving small groups of students and facilitated by the professor; and enhanced office hours designed to provide individual students with up-to-date feedback on course performance and to track progress. Figure 6 presents several screenshots that highlight key features of the technology. (A full demonstration video can be found at https://minerva.kgi.edu/academics/seminar-experience.)

The Active Learning Forum platform incorporates several emerging technologies and approaches that have potential to enhance student learning and achievement, including a virtual Active Learning Classroom, Collaborative Distance Learning Environment, simulation technology, and gamification. However, the technology is new and has not been evaluated in actual practice (Minerva's first class of students enrolled in August 2014). Minerva's educational model and its Active Learning Forum technology are already drawing both praise (Wood 2014) and criticism (Shulevitz 2014). Proponents claim that the innovation of the Minerva model is responsive to the challenges facing higher education and will transform higher education (Wood 2014), whereas detractors question the sustainability of the Minerva model and the quality of the education it provides (Shulevitz 2014).

# LMSs

A variety of open source and commercial LMSs are available and designed to support all aspects of e-learning and the needs of all stakeholders, including students, educators/employers, administrators, and IT staff (Docebo 2014; mindflash 2014; TrainingForce 2014; skill spark [undated]). A typical LMS provides automated administration (including integration with human resource systems), calendar support, course design, document and curriculum management, student registration support, tracking of student and organization progress, basic assessment and testing tools, synchronous collaboration tools such as webcasts, and a variety of other features, including training.

Many LMSs are based on the Software-as-a-Service (SaaS) "cloud" model (Docebo 2014; Pappas 2014; skill spark [undated]). The popularity of the SaaS LMS model is driven by three factors that have proven to be critical to educators and employers:

1. speed to implementation;
2. direct cost and resource savings; and
3. outsourced technical expertise.

While more popular among industry learners than academics, SaaS LMSs currently account for more than 60% of the e-learning total market revenue (skill spark [undated]).

According to a recent Capterra report (http://www.capterra.com/learning-management-system-software/), the 20 most popular LMS programs are: Moodle; Edmodo; ConnectEDU; Blackboard; SumTotal Systems; Schoology; Collaborize Classroom; Docebo; Desire2Learn; Interactyx; Litmos; DigitalChalk; Meridian Knowledge

Solutions; Latitude Learning; Educadium; and Rcampus. Open source LMS programs also are available, and several popular ones are reviewed by Chaudhari (2012): Moodle; LRN; eFront; Dokeos; Sakai; and ATutor.

A major drawback to LMSs is their high upfront costs, although those costs are decreasing (Docebo 2014; TrainingForce 2014). In addition, the LMS model tends to cater to industry and continuing education in the workplace rather than traditional higher education (Docebo 2014; mindflash 2014).

# The Upshot

New technologies continue to emerge and bring with them the promise to reform and revitalize today's higher education system. In this white paper, we discuss 10 such technologies: Computerized Grading; E-Textbooks; Simulation Technology; Gamification; Flipped Classrooms; Active Learning Classrooms; MOOCs; Collaborative Distance Learning Environments; the Active Learning Forum platform; and LMSs. While research supports the effectiveness of several of these technologies in improving student learning and achievement (e.g., Active Learning Classrooms, Simulation Technology), we note that most of them have not been fully evaluated and likely will need to be refined iteratively as weaknesses are identified and new challenges arise. Furthermore, we recognize that educators must be fully trained and incentivized to use new technologies (Shuvelitz 2014). Nonetheless, these technologies and/or others not yet conceptualized will surely be incorporated into higher education as it evolves to meet the many challenges of 21$^{st}$-century learning.

# The Big Picture

Education and technology have historically evolved together and will continue to do so. The technologies discussed herein have the potential to improve higher education; however, technology alone is insufficient to address the many challenges students and educators face today. New technology is but a part of the broader solution that should include new business models, reform of the tenure system, greater incentives for teaching, and a variety of other critical changes to the U.S. higher education system. Only with such a comprehensive approach will we be able to educate and train today's students to become tomorrow's leaders.

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