Ten Challenges in CAD Cyber Education

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Abstract

The advancement of technology and its application to the field of education has caused many to re-examine the merits and pitfalls of cyberlearning environments. Though there is a wealth of research both for and against its mainstream use, there is a consensus that much work remains to be done in key areas such as collaboration, course content, personal learning environments, and engagement. CAD and cyberlearning share a common goal: to communicate information effectively. Unfortunately, many aspects well understood in CAD have been overlooked in online education. In this paper, ten key challenges and their implications for CAD cyber education are discussed. The purpose of this paper is not to provide a dismal outlook for cyberlearning, but to incite discussion, research, and development into these areas with the anticipation of a viable and attractive alternative to traditional classroom education.

Keywords: Cyberlearning, CAD, Crowdsourcing, Peer review, Self-directed learning

1 INTRODUCTION

Both engineering and education have much in common, not the least of which is building meticulously upon the foundations of others, as Sir Isaac Newton famously alluded to in his letter to Robert Hooke in 1675. Today, through emerging technology, both fields seem inextricably linked: we have tools produced by software engineering that augment education and extend its reach in previously unimagined ways. With the progression of technology, we are faced with the significant task of determining how to fully utilize online learning in the current educational paradigm. Franklin identifies a critical need for cyberlearning systems, but notes that often engineering best practices are not applied in hasty development, and students suffer [16]. In the coming age of cyberlearning, there are a number of challenges that must be addressed before effective solutions are offered. Many of these challenges closely relate to principles of CAD education (e.g. 1, 4, and 7) and many are also open non-cyber educational problems (e.g. 1, 3, and 8).

2 THE CHALLENGES

2.1 Student Engagement

The National Survey of Student Engagement (NSEE) notes that student engagement increases learning and can be measured in two ways: the time and effort students invest in their courses and the utilization of campus resources that foster learning [46]. This challenge will focus on the first aspect of engagement. It is assumed that each student is at least somewhat intrinsically motivated and has a passion for the subject which can be augmented or diminished by course content and presentation. A survey of current research in this area indicates a clear understanding that this problem affects both physical and online courses [54] [1], but few truly novel solutions are suggested, and even fewer proposals are implemented. Currently, there are three key ways authors propose to increase engagement: appropriate content difficulty, collaborative environments, and extrinsic motivation.

Many papers regarding engagement begin with the assumption that students must find a zone where content is just challenging enough to prevent boredom, but not so difficult as to produce anxiety [7]. To find this area, students must receive frequent feedback. Krause et al. propose gathering feedback in three ways: beginning and end of semester material-comprehension quizzes, in class clicker questions, and post-class reflections [32]. Once each student receives appropriate feedback, they may utilize the resources provided to match their skill to course difficulty. Above average students must have access to more challenging problems, and below average students require extra tools to build their understanding. If a student utilizes these resources, the course will be of appropriate difficulty, increasing engagement.

Arnone et al. suggest that media-rich (e.g. zyBooks, Teaching Textbooks, etc.) and social networking (e.g. Facebook, Twitter, etc.) technologies promote engagement through an environment of collaboration in which students can learn from one another, support and correct mistakes, and provoke participation from their peers [5]. This is especially important in large, online environments where instructors cannot have a personal presence. Games, with elements of competition, randomness, and rewards, present another attractive solution [19]. Gamification can be used to integrate other desirable qualities such as student-produced material, personalized learning environments, and peer feedback. All of these elements can foster engagement in online learning environments [18].

Ideally, intrinsic motivation would be enough to motivate today's students, but sadly that is not always the case (if it were, this challenge would be inconsequential). Thus, some supplement of extrinsic motivation, beyond simply receiving a passing grade, can incentivize engagement. Three key areas are: appropriate stakes (reward), purpose (applicability to future career), and importance (present value). These three traits correspond to the relevance and satisfaction characteristics of Keller's ARCS model of motivational design [29]. Without these factors to tie course content to future value, a student may see no particular reason to invest appropriate effort [32]. Towards this end, course content should be developed that allows a student to solve real-world problems or to develop reusable tools they can apply to their personal life or career.

Providing appropriate course difficulty has always been the goal of an instructor. Unfortunately, it is virtually impossible to predict course difficulty quantitatively and to adjust content to an individual, especially in a large online course. The NSEE found in 2015 that 46% of first-year and 39% of seniors report feeling insufficiently challenged to do their best work [2]. Although it may be possible to skip introductory material, it would almost never be beneficial to lower overall level, as this produces a chain reaction for later courses. With the possibility of leaving an increasing number of students behind, along with the preparation time required, it is unlikely that a professor will significantly change a course based on student feedback. Finally, there are a number of incorrect assumptions from this proposal: the student does not already know how well they understand course content without frequent feedback, the student will always utilize feedback appropriately, the student will understand the content clearly immediately after class (otherwise there is a flaw in the lecture), and the professor is already providing an engaging, interesting, and prepared lecture. Ultimately, frequent feedback can measure difficulty of content, but it fails to solve our problem of engagement.

Although social and game-like environments have the potential to increase student interaction, a game can become monotonous or boring if overused. Additionally, many games are closed – that is, they do not allow for creativity outside of the game's constraints. Thus, solely replacing traditional learning with another fixed model is not an ideal solution. Social networking technologies and games may also inadvertently increase distractions, as well as introduce an element of pettiness if not well-implemented. Finally, although strides are being taken to improve behavior in the online gaming environment [37], there is a stigma of 'toxic behavior' that should be addressed before it is allowed prominence in the educational arena.

Due to the relatively recent emergence of massively open online courses (MOOCs) by companies like Coursera, Udacity, and edX, it is not yet known how well meaningful coursework will be incorporated. Though corporations have incentives to provide real-life problems to students (i.e. offload their work or produce workers skilled in solving their specific problems), the professor has almost no incentive to do so. Not only does it require extra time, communication, and coordination for assignments, but it places a burden of selecting corporations and determining how much influence to allow them. The aim, after all, is for a university to produce students skilled at solving a wide variety of problems, not a select subset important to a specific company.

2.2 Risk Taking

Students must be allowed to take risks, make mistakes, and learn from failure. Incorporating the CAD principle of developing robust systems that easily accommodate trial and error is key. There are two primary reasons this is currently lacking in education: firstly, the concept that all participation should be rewarded equally, coupled with parents praising ability rather than effort, leads students to falsely believe in their own innate excellence. This belief is threatened by the possibility of mistakes, thus risk is avoided [42]. This problem can be compounded if an instructor does not create a psychologically safe environment [14] in which learning from mistakes can easily occur. Secondly, because of increasing focus on grades for admission, scholarships, and jobs, enormous pressure to perform is placed on both students and educators [15]. Though continuously increasing standards are desired, it can easily degrade into a vicious cycle: higher peer grades force students to achieve yet higher grades to stand out. Ironically, this may shift the focus from learning for learning's sake to learning for a grade, which produces risk aversion. Failure will be a part of every student's life and must be included in the educational arena, with the end goal being, of course, that the student will overcome and learn from it [21].

Invention activities [21], problem-based learning [22], inquiry learning [26], and discovery learning [3] — these are a few of the many ideologies that attempt to implement failure in the classroom. Although united in their goal (a concept Plass, Homer, and Kinzer refer to as "graceful failure", where students realize there are less severe penalties for making mistakes [51]) each ideology differs on how much and when to lend support to a student. These theories have not yet reached the mainstream academic environment, in which traditional instruction dominates. Unfortunately, this traditional approach along with standardized testing continues to produce risk-averse students focused on regurgitating taught examples to avoid suffering potentially severe consequences (i.e. assignment and course failure).

Perhaps the newest, most extensive, and most importantly, quantitative research encouraging risk taking is Kapur's model of "productive failure." Productive failure, in contrast to the traditional style of "direct instruction" (lecturing), allows groups of students to attempt problems for which they have not yet received all of the tools to solve. It is not expected that they will succeed, only that they will 1) develop a context of prior knowledge in which to view the solution and 2) better understand common pitfalls and the purpose and structure behind the correct solution [27]. Only after this initial process of discovery are the students given the solution through direct instruction.

Though evidence suggesting the positive results of productive failure has been offered [27], the educational community is by no means united in its validity [31], and productive failure is rarely utilized in the classroom (online or otherwise) [28]. Reasons for this include: it may discourage students with low self-efficacy, it may overwhelm a student (cognitive overload), it requires greater knowledge from the instructor in order to clearly explain incorrect attempts, and it requires more class time to allow adequate attempts before presenting the solution. Most importantly, productive failure only allows students to draw from a limited body of knowledge for their attempts (i.e. the collective mind of a novice group). The proponents of this type of failure realize the limits of the students' knowledge, and attempt to remedy it with the very thing they were trying to avoid: adding direct instruction. In fact, when and how much support to add is the direction of debate, which completely misses the mark of organic learning. This is more or less "artificial failure", that is, having a set amount of time to think about the answer before it is provided. Ultimately, the various methods of productive failure still rely on the instructor to deliver content, and thus they present no novel solutions to the problem of learning from mistakes.

2.3 Collaboration

The third major challenge facing the emergence of cyberlearning as a valid alternative method of education is promoting the social aspect of education through collaboration and teamwork. Pelton mentions that students often lack collaboration in the classroom due to pressures of competition [47]. It is important that students learning online do not complete their studies in just such a vacuum, but learn extra-educational qualities such as delegation, conflict resolution, and social intelligence.

As mentioned in the section on promoting engagement in cyberlearning, media-rich technologies, social networking, and games can all promote student collaboration. But engagement in cyberlearning must go beyond simply increasing student engagement with the material, it must also include expanding students' engagement with each other.

Arnone et al. explore the concepts of 'participatory cultures' (an environment of collaboration and community involvement) and 'affinity spaces' (groups formed around a common interest), both of which they claim "inform and define what we understand as 'social skills' and 'cultural competencies'" [5]. Thus, not only will students learn important social skills through their online interactions with others, but they will also change social norms. They do this through peer-to-peer teaching and sharing content and expertise with one another [25]. Jenkins et al. note that there is a strong participatory culture flourishing in media content on the web, with students beginning to contribute content from an ever-decreasing age [25]. However, this does not yet occur often in learning environments even though modern technology allows teamwork and collaboration in previously impossible ways through video conferencing, instant messaging, repositories, and project management software [36]. Thus, even though students are learning valuable, marketable skills from each other, they are learning them not through standard educational paths, but through their own initiatives outside of school [25] [60].

An absence of collaboration in cyberlearning environments bleeds over to an absence of social interaction. Since children develop socially by interacting with other children, replacing traditional education with an online education that includes no socialization could have disastrous results. Current solutions to this problem include incorporating existing social media into academic environments (e.g. Cloudworks) or developing new social platforms for educational use (e.g. the Nest) [36].

Unfortunately, neither solution is particularly useful. Since the student is already in an online educational environment, any social media site is already at their disposal, so it is not necessary to create something new. Those students who already use a specific social media integrated into their academic environment may find no benefit, and those prefer other social media sites may resent another information source being forced onto them. Perhaps most importantly, this tends to be a boring and archaic solution for the students.

Although it may be tempting to develop the next new piece of software to solve the world's problems, creating a new social platform for educational use is no easy solution in today's educational environment. In particular, current attempts seem to be focused on everything other than collaboration: defining and accomplishing learning outcomes, meeting standards, etc. With either proposed solution, it seems the focus is on students interacting with the software rather than each other. Finally, it seems almost impossible to find the perfect blend of educational content and social interaction to provide a stimulating experience for every user. Rather than try to artificially produce collaboration, it is useful to note that people organically communicate with others who enjoy learning the same things.

2.4 Government and Industry Participation

In order for cyberlearning to thrive, it must integrate government and industry participation. Although the leading cyberlearning companies do have partnerships, they are typically confined to other universities, with industry participation limited to using cyberlearning resources for training and with virtually no government involvement. While it is clearly inappropriate for government and industry to overstep their bounds by forcing unnecessary requirements onto students, it is desirable for them to have an appropriate role in the crowd of educators as they both have a stake in the quality of education.

Little is mentioned in the existing literature on the integration of industry and cyberlearning. Udacity seems to be the one exception to this trend. They currently offer eleven courses in their nanodegree program which are developed in partnership with large tech companies (Google, GitHub, AT&T, Lyft, Facebook, etc.) which are designed to connect graduates with employers. Aside from being severely limited in variety and number of courses, the Udacity nanodegree program is only offered in English and students must be United States citizens to be guaranteed job placement in the nanodegree plus program. Coursera is itself in the early stages of promoting the industry-cyberlearning relationship by offering capstone projects in technology by a handful of industry leaders (Instagram, 500 Startups, Snapdeal, Google, Swiftkey, and Shazam). Although it is a step in the right direction, the scale and diversity of companies is lacking. Current problems facing employer-university partnerships also lend a challenge to cyberlearning-employer relationships: employers do not always desire the relationships, there are different workplace cultures, and the quality assurance agenda in higher education is restrictive [55]. Piegl notes these differing requirements between educators and industry in CAD education [50]. Since a smooth transition from education to workforce is desirable, agreement between requirements in cyberlearning and industry must be codified and publicized.

In their sixty-four page report on the opportunities and challenges facing cyberlearning, the National Science Foundation Task Force on Cyberlearning briefly mentions the role of government in developing cyberlearning platforms and views their contribution in two distinct areas [9]. The first is as primary financial supporters to ensure development and sustainability. Secondly, the task force views government, particularly the NSF, as the primary generators of content and motivation. They propose funding research, forming competitions, soliciting company involvement, sponsoring learning initiatives, and creating committees to explore questions, issues, and solutions related to cyberlearning [9].

Because cyberlearning can be extremely cost-effective (thus incentivizing research and development), and because it is inherently easy in cyberlearning to adopt emerging technologies, financial support from government and industry is not a key requirement. In fact, there are good reasons for government and industry to take a hands-off approach in the financial realm. Though financial sustainability is essential to success, money means control, and distributed, not centralized, control is the goal of a successful crowdsourced cyberlearning system. If financial support comes with strings attached it may inhibit the natural, dynamic growth desired in a cyberlearning system. Thus, government and industry financial support should be relegated to one player among many.

The notion that government, through the NSF, can successfully develop, organize, and implement a cyberlearning environment, identify and recruit specific organization and company involvement (a particularly difficult task [63] [55]), and determine what content students should learn and how they should learn it is far from ideal. Cyberlearning is an opportunity to solve the problems facing education today, many of which stem from educational paradigms the government has implemented, and entrusting them to solve the problems will not result in sweeping change. Laurillard notes that this sort of top down change has not and will not keep pace with emerging technology [23]. For example, in 2012 the state of Minnesota banned Coursera (or rather, banned its citizens from using Coursera) because the company had not received permission to offer courses in the state. More recently, since Coursera's content is considered a service subjected to export regulations, the U.S. government forced the company to ban access to IP addresses in four nations in 2014. These examples demonstrate the danger of thinking of cyberlearning as a business, government entity, or even a single institution. Instead, it should be unaffiliated and universal, education by the people, for the people. Ultimately, the key to success in the online educational environment is the distributed, open-sourced work of the crowd, which is more intelligent, more diverse, and more effective than the work of the few.

2.5 Instructor's New Role

"Our understanding of learning has expanded at a rate that has far outpaced our conceptions of teaching. A growing appreciation for the porous boundaries between the classroom and life experience, along with the power of social learning, authentic audiences, and integrative contexts, has created not only promising changes in learning but also disruptive moments in teaching" [8]. Another challenge facing the emergence of cyberlearning in the educational arena is determining the new role of the instructor. Obviously, extra effort will be required to learn and master ever-changing cyberlearning technology and to keep coursework current

[43]. Because cyberlearning transcends the traditional concepts of space and time in the classroom, the instructor will also need to adapt his or her teaching style and methods. Additionally, Massy and Zemsky point out that cyberlearning technologies "[challenge] the faculty's definitions of autonomy, which dictate that a professor can individually decide what, when, and where he or she teaches" [39]. Students increasingly gain that control and have the ability to learn from a variety of resources – the instructor is just one option among many. This is consistent with the concept of "learner autonomy" – courses becoming based on self-directed learning rather than instructor-centric [34]. In such a cyberlearning environment, the role of the instructor may appear to lose significance, moving from one of complete control to one of a learning facilitator. Undoubtedly, this will not be received well by all instructors.

Especially in large classes, communication between instructor and student becomes asynchronous and one-to-many. The instructor will be unable to offer individual, personal, and face-to-face time to all students. This interaction has long been thought supportive to learning, and thus the "depersonalization of the learning process" cyberlearning engenders has earned critics [44]. In fact, even though eighty-eight percent of cyberlearners felt they had adequate opportunity to ask questions of the TAs (Teaching Assistants) and professor in Navarro and Shoemaker's 1998 cyberlearning case study, the number one cited disadvantage was a lack of interaction between professor and students [44]. Thus, something beyond simply the opportunity to communicate must be present in order for the students to utilize their resources.

As Amir, Iqbal, and Yasin point out, this divide between instructor and student makes it more difficult for the instructor to understand the characteristics and needs of the class, which may in turn allow for less affective teaching strategies [4]. The larger the class size and the less interaction, the easier it is for a student to become just another number, and the more difficult it is to evaluate student understanding and adjust resources accordingly. This is especially important in the area of engagement. It will be extremely difficult for the instructor to attempt to engage every student, instead they must provide engaging course content and trust the students take to advantage of it.

2.6 Attractive Alternative to Traditional Learning

Almost every empirical study on the effectiveness of cyberlearning concludes that cyberlearning is at least as effective as traditional classroom learning at the university level [44] [40]. Rarely, however, do the studies proceed to claim cyberlearning is more effective. Typically, it is insinuated that different learning paths are better for different types of students, and much research has been devoted to discovering the ideal student for cyberlearning. For example, self-discipline and motivation [38], time, study, and effort management [53] [64], self-efficacy [61], and even age [40] are all claimed to have an effect upon how well a cyberlearning student learns. Unfortunately, as Phipps and Merisotis point out, 1) the reliability of the tools used to measure student success is questionable and 2) it is intrinsically hard to control for extraneous variables in these studies, especially since students typically self-select distance learning [48].

There are currently, however, at least two crucial benefits of cyberlearning for every student: convenience and cost. Universities are motivated to expand their client base, which they can do cheaply and effectively through cyberlearning as they distribute the cost among many students. Indeed, it is a growing thought that universities must incorporate online learning to remain relevant and survive. Secondly, all students, but especially non-traditional learners, have the opportunity to take courses at their own pace without compromising their lifestyle [43]. Piegl recommends a "CAD Depot", or comprehensive solution [50]. Properly implemented, this concept could allow students to easily manage all aspects of their education from the comfort and convenience of their location of choice. As cyberlearning develops, there may be additional benefits such as a highly personal learning environment, greater digital presence, and increased collaboration. It is important that these elements are commonly known and accepted for cyberlearning to excel.

Finally, there are also some negative aspects of or stereotypes against cyberlearning that, if widely held, will do much to damage the field. First, some critics of cyberlearning claim that it may leave out the poor and disadvantaged because they will not have access to the required technology to participate [43] [13]. Secondly, since cyberlearning is still in its infancy, there is a perception that industry is not yet fully committed, and thus students with degrees or certifications from online environments may have difficulties finding a job.

Finally, there is the risk of reluctant instructors, with little motivation to produce dynamic content, leading to a generic or boring learning environment [43]. Finally, if cyberlearning is implemented merely as a mirror of the physical classroom, as is too often the case, it will lose its ability to offer its full potential. There is no reason to only keep the classic, yet often ineffective structure of semester, course, class, and lesson [41]. Lifelong and self-directed learners need the flexibility of how and when they learn. Ultimately, all of these risks must be eliminated before cyberlearning can thrive.

2.7 Dynamic Course Content

As in the physical classroom, the cyberlearning classroom may struggle with staying current. It is tempting once online content has been created (a much more expensive and time-consuming process than just preparing lecture notes and slides [43]) to never re-invest effort, especially since cyberlearning is more depersonalized than standing before students in a lecture hall. This problem has been approached from different angles but typically includes incentivizing instructors to continually revise and update course content. Some online education sites attempt this by paying instructors indirectly for the quality of their lectures by basing it off of number of views.

Kian observes this movement of instructors into a new role of multimedia developers, and that it is a positive direction for education, but does not mention the copyright issues that arise [43], the ingrained educational paradigms and opinions working against them [23], nor the additional time and thus, money, involved [45]. This is often a price instructors and universities are not willing to pay. There is no guarantee that new content (not just old information with a cyber face-lift) will be created or that the amount and quality of content generated will exceed what is currently being produced in physical classrooms. Finally, it is the opinion of many authors that the ability of the crowd, when results are properly aggregated, is greater than any individual [59], thus the quality of the work should improve if crowdsourced to students.

A different approach, similar to what Gatto and others refer to as “open education” or “open-sourced education,” is encouraging students to access content through all sources available [17]. This is an important step towards crowdsourcing, and can be extended to allow students to share the responsibility of content creation and organization under limited guidance of the instructor. Students can be incentivized to produce quality work by either intrinsic motivation, instructor mandate, or through external benefits like submission to paying educational websites. Student-produced content can take many forms, from research papers to notes to presentation materials or even detailed student reviews. This content can be shared within the class via peer instruction. Studies have also suggested that students experience increased learning in group discussions, even if there is no expert among the group [52] [58]. In all these approaches, students receive information from a wider variety of sources than a single instructor. This idea, adapting to the “global brain”, is the driving factor behind Pelton’s tenth point on educational reform in the 21st century [47].

Finally, to extend the open-sourced learning approach and fully utilize crowdsourcing, student content must not be filed away where it does not aggregate the body of the world’s learning, as is so often the case today. Instead, student-produced material can be aggregated for future learning by adding it to an appropriate digital repository. Over time, and with proper evaluation methods, the best repositories will become the best sources for learning new materials, creating a cycle of aggregated, student-produced material. This idea is partially implemented by Xu and Recker, but their Instructional Architect system is limited to teacher-produced materials [62].

Different sites currently aggregate information in different media forms. StudyBlue uses flash cards for specific courses to allow students to share their notes. Glogster keeps a library of informational posters, organized by topics. Curious.com, Udemy, and even Youtube all contain educational videos designed to instruct. Finally, Scratch is an online programming environment designed for children that allows development, sharing, and extending others’ projects [56]. CAD applications like Google SketchUp’s 3D Warehouse offer promising examples of how student material should not be wasted. Each of these sites allow simultaneous education and instruction — students are able to develop their own content and build on others’ work as they learn from experience. As learning from the crowd continues, so does content generation if the crowd is properly motivated to produce. Unfortunately, the more useful, interesting, and dynamic of the specifically educational sites, those with video instruction, may have restrictions on who can post. Although intended to protect quality, this limits such sites' crowdsourcing capabilities.

Though sites exist for aggregating digital content of all forms, they are rarely utilized in the physical classroom. This is to the detriment not only of the students, who need practice contributing content to the world, but to society as a whole. Though instruction in the physical classroom can be modified to incorporate dynamic, student-produced content, cyberlearning can provide a smoother transition.

2.8 Personal Learning Environments

"Distance learning is rapidly developing new learning environments, which are to be understood on their own merits, rather than by comparison to the familiar campus-based experience" [41]. In an era of increasing online education, much has changed regarding learning environments. Many authors believe that the principles of Web 2.0 (collective classification of information, mass participation and communication, software as a service, and a responsive user experience) are driving online learning environments, but we are still in the beginning stages of figuring out what works and what does not [30]. CAD principles relating to human cognition and psychology, visualization, design, and user experience can all contribute to this discussion [50].

Virtually everyone believes that the more personal a student's learning environment, the better education they will receive. It is important to note that a personal learning environment (PLE) is a concept, facilitated by a framework, rather than an entity in itself. Downes describes it as "one node in a web of content, connected to other nodes and content creation services used by other students. It becomes, not an institutional or corporate application, but a personal learning center, where content is reused and remixed according to the student's own needs and interests. It becomes, indeed, not a single application, but a collection of interoperating applications — an environment rather than a system." In theory, PLEs allow students to control their own learning through setting goals, managing learning content and processes, and communicating with others. Put another way, students should actively collect information, construct and organize it, collaborate with others, and share what they discovered. This is towards the goal of self-directed or self-regulated learning and lies in contrast to a learning management system. Instead the instructor or system offers a framework for learning direction, but does not completely control it [24]. It is worth noting that most authors consider PLEs extra-institutional because too much university involvement can conflict with the goals of personal learning.

Most research in the cyberlearning arena focuses on the aspect of managing learning content. And though the goal of a PLE is to give control to the student, most academic frameworks self-identifying as a PLE instead try to determine a given student's learning style, then provide specific content based on that information. For example, Samah et al. list four different systems, all based on different ideologies of learning styles, to give students "personalized" content [57]. Although there is no clear agreement on how to group student personalities, systems are developed based on those categories, which seems quite ineffective. Kohn notes that such systems miss the mark of true, personal learning: "Personal learning entails working with each child to create projects of intellectual discovery that reflect his or her unique needs and interests… Personalized learning entails adjusting the difficulty level of prefabricated skills-based exercises based on students' test scores. It requires the purchase of software from one of those companies that can afford full-page ads in Education Week."

Some downsides of a PLE that must be addressed by cyberlearning include students who have weak metacognitive skills and do not realize how they learn effectively, immature students who are not responsible enough to self-direct their own learning, and students who are not able to differentiate between good and bad information and sources [24]. To solve the first two problems, systems have been developed that focus on increasing a student's ability to self-monitor a learning process. One such example is Chen's personalized e-learning system with self-regulated learning assisted mechanisms [11]. Though the system allows students to set goals and self-report their progress, the system does not allow students any flexibility in course content control. Truly personal education is highly counter-intuitive in today's academic environment, perhaps because it involves relinquishing control of a knowledgeable source providing the "best" content. Furthermore, it is much harder to provide and manage an open-sourced framework than it is to choose content and deliver it.

2.9 Utilizing Peer Review
Peer review remains an interesting challenge for cyberlearning because it is an important tool utilized by the crowd to segregate information based on its usefulness. Peer review in a basic sense is already incorporated into most online applications (liking or sharing on Facebook, thumbs up or commenting on Youtube, number of stars on Amazon, etc.). However, in the educational arena the prevailing thought has been that a single content expert should review material and assign a grade. There are a few problems with this notion. First, it is quite subjective and could depend on a host of factors (e.g. difficulty of grader, like/dislike of student, current mood, etc.). Secondly, it is not scalable. Large courses, whether online or in person, require an alternative for short answer, essays, or creative work.

Some MOOCs currently use a peer review system. Coursera's Calibrated Peer Review (CPR) has students use a provided rubric to grade one to three essays already scored by the instructor. Each reviewer is assigned a Reviewer Competency Index (RCI) based on how well their score matches the instructor's. The RCI is then used to weight the score they assign to three to four other essays. Finally, students review their own essay and receive a score based on how closely their review matches the weighted reviews their essay received. Figure 1 shows an example of a Courser peer-graded network highlighting the work of one peer reviewer [49]. The six circular nodes represent essays scored by that student (including his or her own essay), and square nodes represent reviewers who scored his or her essay. Node size represents the number of reviewers for a given essay (note the three "super graded" essays which were scored by all the students).

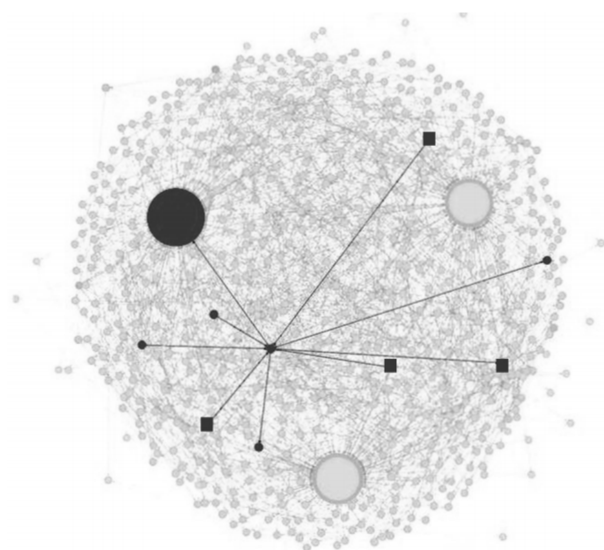

Figure 1: Coursera Peer-grading Network. Courtesy of Chris Piech.

The effectiveness of learning gains using CPR has received mixed results from independent studies [6], however at least one study found that it increased student confidence in evaluating their own work [35]. Some other noted limitations of CPR are that it requires basic HTML experience, a common rubric limits creativity, and grading too many essays presents a burden on students that diminishes their motivation to provide quality assessment [6].

Some Coursera researchers go further to propose intelligently assigning graders to gradees based on a number of criteria: grader bias (to inflate or deflate a score), reliability (past closeness to actual score), and performance in the class [49]. Piech et al. even explore a model of peer review that allows student grades to be influenced by their performance as graders to incentivize quality reviews [49]. Table 1 shows that through a series of simulations using different models over two human computer interaction courses peer grades were found to be within five and ten percentage points of instructor grade 69-74% and 92-97% of the time, respectively [49]. It is worth noting that this research assumes the “true” grade of an assignment comes from the instructor, not the peers.

	HCI 1					HCI 2				
	Baseline	**PG_1-bias**	**PG_1**	**PG_2**	**PG_3**	Baseline	**PG_1-bias**	**PG_1**	**PG_2**	**PG_3**
RMSE	7.95	5.42	5.40	5.40	**5.30**	6.43	4.84	4.81	4.75	**4.73**
% Within 5pp	51	69	69	**71**	70	59	72	73	73	**74**
% Within 10pp	81	92	94	94	**95**	88	96	96	**97**	**97**
Mean Std	7.23	5.00	4.96	4.92	**4.77**	6.19	4.57	**4.52**	4.53	**4.52**
Worst Grade	-43	-34	**-30**	-32	**-30**	-36	-26	-26	**-25**	-26

Table 1: Comparison of models on the two HCI courses. Courtesy of Chris Piech.

Of course, as Ching points out there are problems with peer review itself — some studies found students uncomfortable with reviewing their peers’ work and others found the quality of the reviews lacking depth and insight [12]. Also, in all of these examples, peer review has come from four to five students, which does not seem quite large enough to benefit from the diversity of the crowd.

2.10 Accurately Reflect Learning

The final challenge facing cyberlearning is how to accurately reflect learning. The current grading paradigm results in the student receiving a letter grade, or perhaps a certificate, but often not much else to show for their work. While this grade is a useful filter for many applications, it is especially important for a cyberlearning student — whose means of education is counter-cultural or non-standardized — to have a better descriptor of their educational experience. Additionally, the wealth and persistence of digital information leads to a deluge of learning data per student, which must be compiled into a concise, yet still meaningful summary. The NSF Task Force on Cyberlearning suggest that one opportunity for action is a “Lifelong Digital Learning Portfolio” [9]. Although they do not mention the specific merits of such a portfolio to the student, they offer scenarios in which the portfolio and associated quantitative/qualitative details can be useful for an instructor to offer targeted instruction.

LiveText is one example of a web-based portfolio service that several schools use. Such a system seeks to allow assessment of students and programs, teacher preparation based on student proficiency level, graduation eligibility, student work planning or showcasing, and determination of college admission. Unfortunately, this system requires a paid membership to continue using its services, portfolios are difficult to share with non-members, and organization and evaluation of the portfolio is based on how well students meet explicit program goals rather than showcasing the interests and activities of the student themselves.

Although there is some research in electronic portfolios, the bulk lies in reference to portfolios in specific fields. For example, rehabilitation [20] or counselor education [33]. Others view the portfolio as a summative explanation of a single experience (final project, dissertation, etc.) and not as a living document [10]. Unfortunately, none of the above approaches take advantage of the full capabilities electronic portfolios can offer. Portfolios should go beyond simply allowing assessment by instructors and should cause the student to reflect upon their learning, preserve and organize meaningful historical data, and provide a fuller picture of a student’s lifelong educational process.

3 CONCLUSION

Although by no means an exhaustive list, the ten (naturally subjective) challenges presented in this survey paper provide a starting point for topics that must be addressed for the future of online learning software. The CAD field provides a good starting point for many of the topics. At first glance, the challenges provide a formidable path for cyberlearning to succeed alongside of traditional classroom learning. However, therein lie its strengths. Each challenge successfully accomplished sets a higher standard for the field of education in general and can produce a positive ripple effect for students no matter which method of learning they choose.

Again, the primary purpose of this paper is not to point out unsolvable issues, but to stimulate discussion and research that will ultimately improve education for future generations.

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