How Competency-Based Education Can Fulfill the Promise of Educational Technology

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Abstract. Even with today's sophisticated technologies, we usually are still exporting the classroom as if that is the ideal learning environment. Learning science has advanced a great deal in the past several centuries since the lecture became the most common form of 'teaching' at colleges and universities. There is a lot we know about how people learn, yet very few faculty members are learning experts. There is good evidence that adaptive or personalized learning environments help more students be successful, but these are hard to implement in traditional settings. The use of a competency-based education model can facilitate the use of these new learning environments to benefit students.

Keywords: Competency-based education · CBE · Personalized learning · Adaptive learning · Student success · WGU

1 Introduction

In the late 1980's Johnstone and her team designed the first distance learning system to enable students in very rural communities of Maryland to take college classes in real-time with faculty teaching in College Park. The system required two telephone lines into each location. One was for voice, the other for a modem connected to computers. While the instructor lectured he/she could share slides, pictures, diagrams, text, and illustrations with the students in the rural areas. To make it more personal, the faculty member shared a picture of the local classroom-based students, and the remote students shared their pictures with all participants. The remote students could ask and answer questions during class and the instructor could hold virtual office hours using this rather low cost technology. A wide variety of classes were taught via this method. The students (and their employers) were grateful to be able to participate in college classes without driving five or six hours to a campus [1].

Today, we have much more sophisticated technologies. Students can watch a lecture in real-time regardless of where they are in the world. Even though the time zones may be inconvenient, the quality of the visuals and audio over the internet are quite good. The costs of the transmission are also much better than it was when paying for long distance phone calls. However, in most cases we are still just exporting a classroom as if that is the ideal learning environment.

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Learning science has advanced a great deal in the past several centuries since the lecture became the most common form of 'teaching' at colleges and universities. There is a lot we know about how people learn, yet very few faculty members are learning experts. By and large we still hold up the lecture (designed and delivered by a subject matter expert in their field to a group of students who as individuals are likely to be at varying levels of expertise) to be the pinnacle of best practices to which we will compare other types of learning environments. The federal financial requirements specify that for students to be eligible for grants or loans, there must be 'regular and substantive interaction between faculty and students' or the experience is considered a correspondence course [2].

What do we know about how people learn – processing, active engagement, and motivation? As Richard Clark, a cognitive psychologist at the University of Southern California puts it, 'mental architecture' has limits on how much we can think about at a time. For most people it is about four ideas (± 2) [3]. If we overload it with too much information, the system 'crashes.' This crashing actually protects us, so it is pleasurable. However it drives students to tune out completely or just shift over to checking Facebook to see what their friends are doing while they sit in the lecture hall.

To put this into perspective, consider a typical large lecture section of an introductory statistics class. The instructor is an expert in the field and has created a lecture based on his/her perspective. To the instructor the notion of 'central tendency' is a single idea that may be expressed as a mean, median, or mode and can be used to describe aspects of a group of scores. Some of the students will remember that from high school classes. For these students when the faculty member mentions these, it is one idea. Other students listening to the lecture do not recall any of this and they are trying to think about three different ideas plus the notion of a distribution of scores. They are overloading their cognitive architecture or coming close to doing so. When we add to this the reality that individuals process new information at different rates, we get to the impossible dilemma inherent to a lecture-based classed. The lecturer cannot individualize the information for each student based on his/her prior knowledge of pace of learning.

As the next section will make clear, the advances in personalized learning technologies enable students to work within learning environments that meet an individual student where he/she actually is regarding their knowledge of the field of study, his/her learning style and the speed with which he/she is able to learn. As will become clear, in personalized learning systems the role of the faculty member is not to lecture, but rather to design the learning environment and the methods for determining how students can demonstrate what they have learned, as well as guiding/coaching students in the appropriate application of their new knowledge.

2 Personalized or Adapted Learning

Adaptive Learning technology at its core combines competencies to be learned, assessments of those competencies, and instructional content into a system of learning that adapts or personalizes learning by repeatedly assessing the current state of learning of an individual learner against the desired competencies, and uses scaffolding of

knowledge to determine what learning activities to present next to help the learner best progress to full competency. In more elaborate systems, individual learners may be presented with formative feedback and given prioritized options for study, and may be presented with reinforcement on learned competencies based on learning and forgetting curves. Faculty can be presented with dashboards on the progress of all students and presented with a prioritized list of the most troublesome concepts.

The New Media Consortium [4] identifies Adaptive Learning Technologies as an important development in educational technology for higher education with an implementation horizon of four to five years. In a recent report for the Bill and Melinda Gates Foundation, Adam Newman and his colleagues argue for the accelerated adoption of adaptive learning in higher education "…promises to make a significant contribution to improving retention, measuring student learning, aiding the achievement of better outcomes, and improving pedagogy" [5]. Decades ago we had promising intelligent tutoring systems research that was never seemed to be fully implemented. What is causing this optimism for adaptive learning technology?

A growing body of evidence for adaptive learning shows benefits in learning, completion time, completion rate, and better use of instructional time. The settings for these studies vary from hybrid courses to fully online courses, at both public and private universities as well as community colleges. The level of the learning in the studies is primarily college-level general education, but also includes graduate preparatory concepts. The subject matter to be learned in these studies included pre-algebra, algebra, statistics, logic & proof, business, and anatomy & physiology. The types of studies were implemented on a variety of platforms, and ranged from case studies to rigorous formal evaluation. The platforms involved in the studies and sharing the features described above are supported by the following organizations (selected from a wide field of systems):

- Open Learning Initiative (oli.cmu.edu) and its commercial descendant Acrobatiq (acrobatiq.com)
- ALEKS (aleks.com) is supported by McGraw-Hill Higher Education
- Knewton (knewton.com)
- RealizeIt (realizeitlearning.com)

The OLI platform is an outgrowth of research conducted at Carnegie Mellon University that began in 2002 and has grown to support over twenty open courses in foreign language, math, and science [6] The approach has evolved into a commercial initiative of called Acrobatiq that is associated with Carnegie Melon University. The original OLI research project remains at Carnegie Melon University and has now spread to Stanford University.

An overview article using OLI research [7] summarized a number of studies that variously showed reduced learning time by less than half the time of equivalent concepts with no significant difference in learning retention after one semester. These effects are not restricted to university-level students. In a proof and logic OLI course offers at a community college, there was 33 % more learning in the equivalent time of the lecture session. The same review reported completion rate improvement from 41 % to 99 % in a 300 student study at a large public university [8]. A separate effort involving six public

institutions, documented a randomized study of an OLI statistics course that showed students using adaptive learning learned equivalent concepts a statistically significant 25 % faster over the control group that participated in the traditional lecture section [9].

These impressive results do not happen without faculty involvement. The importance of faculty experience, preparation, and use of the OLI system features, such as grade book to help trigger interventions, for successful learning by students is critical [10].

In a study encompassing 37 faculty members at 24 community colleges teaching primarily the OLI anatomy and physiology, biology, psychology, and statistics courses to over 1600 students, the learning results in OLI versus traditional courses were not significantly different overall. However deeper analysis showed that the more faculty used the grade book and the more experience they had in general, and with OLI in particular, the better their students performed in OLI versions of the course [11]. These findings on OLI, coupled with earlier results show the promise of adaptive learning, and the importance of training, experience, and commitment on the part of faculty.

ALEKS, which stands for "Assessment and Learning in Knowledge Spaces" grew out of a research project on Knowledge Space Theory with support from the National Science Foundation [12]. The ALEKS platform includes all the elements of adaptive learning technology and has been used most prominently for mathematics and also to support math, business, science, and behavioral science courses [13]. In a federally funded accelerated learning preparation program using ALEKS for minority students in New Mexico called Accelerate New Mexico across six college campuses. Fifty-five students of all backgrounds and ages participated in the study. Math instruction supplemented robotics instruction. Average scores on the pre-test for content mastery examinations were 22 % while average scores on the post-test were 42 points higher at 64 %, and were statistically extremely significant [14].

Other results on the efficacy of various platforms come directly from the vendors. Knewton is a well-known adaptive learning technology platform used by Pearson, Cengage, Elsevier, Wiley, and other publishers. Knewton reports on case studies from Arizona State University, the University of Alabama, and the University of Nevada Las Vegas [15]. The Arizona State University case study [16] is the most extensive and reports on a two semester study of over 2000 students in developmental mathematics. They report withdrawal rates drop from 16 % to 7 % and pass rates increase from 64 % to 75 % with an accelerated completion of four weeks for 50 % of the students. Case studies provided by Knewton showed improvement in remedial math by 17 points in pass rates at the University of Alabama and 19 point improvements at UNLV [17].

The adaptive learning platform created by RealizIt is used by University of Central Florida, Indiana University, the University of Texas System, Colorado Technical University, and others. The platform contains all the key elements defined above [18]. RealizeIt (operating under its old name, CCKF) has been used to implement 300 sections serving 11,000 general education students at Colorado Technical University and American Intercontinental University, which it's parent, Career Education Corporation refers to as Intellipath(™). The results for American Intercontinental University saw a 13.6 percent decline in withdrawals in a pilot group taking English composition and mathematics courses and slightly better final course improvements of 6.8 % [19]. The application of RealizeIt's adaptive learning platform to the MBA preparatory program at

Colorado Technical University, demonstrated a usage of the technology to content above the remedial and general education levels and won a WCET Outstanding Work, [20] though no score improvement is noted, the system ensures students have mastered prerequisite competencies [21].

These results shed some light on why higher education analysts are so optimistic for the adaptive/personalized learning approach to make contributions to student achievement for a wide array of students. While the studies are not completely uniform in their findings, they do point to very promising approaches for advancing the promises of technology to improve and open up learning.

3 Competency-Based Education

It is tough to incorporate personalized learning resources into current practices in higher education. Professors are comfortable lecturing. It is how they learned. They were the ones for whom it worked. If it worked for all their students just as well, there would be fewer poor grades in courses. Different students may need different amounts of time to master course content. If we try to allow students to progress through learning materials at their own rates, we get trapped by our semester or quarter requirements. In addition the technological systems we have in place to track students and their grades operate with strict start and ends dates. To complicate things further, the grade itself is just a means of differentiating the level of mastery among students within the fixed time period defined by the term. At most colleges and universities individual faculty members design and administer their assessments. So two students taking different sections of a course with the same name/course number are likely to be assessed quite differently by their instructors, which renders a grade fairly worthless in any absolute sense as a measure of what each individual mastered.

This brings us to competency-based education (CBE) as a means to allow the integration of what we know about how people learn and how to help them master a body of knowledge. As has been noted previously, we know different people learn at different rates. Some people can master the vocabulary of a new language very quickly, while others may have to practice for a much longer time to achieve mastery of the same material. In addition the same individual may take more time to understand an algebraic formula and apply it, than to learn a new tune on a familiar instrument. People bring different skills, background, and ability to each new learning opportunity, yet as mentioned above, our gold-standard of teaching, the lecture, delivers the same material to everyone in a class at the same pace. All students start their term at the same time and are expected to master a sufficient amount of the material by the end of a fixed period at which all will be graded. If a student demonstrates he/she has mastered 60 % to 100 % of the course material, he/she passes the course. If the student only masters 50 % of the course material, he/she fails and is left with two options: repeat the whole course again or just give up. If he/she chooses to repeat the course, it means paying another fee and sitting through a course half of which he/she knows and then trying to master the parts he/she does not know at the same pace at which it was covered the first time. Many students do just give up.

In the CBE model, the relationship between time and mastery is flipped. Students can learn at their own paces and get personalized support as they progress. They can accelerate based what they already know and slow down with novel material. Well-designed learning resources can easily be incorporated into a student's program of study and each student must demonstrate mastery in order to progress. The faculty still control the curriculum but it is now defined as 'what a student needs to know' and 'how we will determine if he/she knows it.'

The more traditional roles of faculty are typically disaggregated in CBE models so qualified experts can serve in appropriate roles, such as, defining learning objectives, creating or identifying appropriate learning resources, evaluating student learning demonstrations, and working directly with students on their learning plans. That means we are not asking faculty to adapt personalized learning tools to their usual practices. Instead we are creating learning environments into which we can plug tools like OLI, Knewton, ALEKS, or RealizIt as the learning resources. The faculty members are not creating lectures and delivering them to large groups of students in lock step each term nor grading tests or papers, but rather are freed to act as designers of the curriculum and able to offer individualized support to students as they need it. The personalized learning resources can be readily shifted as new, superior products emerge thus enabling students to get the benefit of the latest developments in learning science.

The best proof of concept for CBE is Western Governors University, a private, not-for-profit university. At this writing, it has over 53,000 students, is fully recognized by regional and specialized accreditors, and produces the largest number of secondary STEM teachers in the country [22]. WGU is among the top five producers of bachelor's degrees in nursing for minorities. In addition to Health Professions and the Teachers College, WGU offers degrees in Business and Information Technology that all include general education courses. Employers think highly of WGU graduates and it continues to change the learning resources it offers to students as learning science develops. In addition students pay less than $6,000 a year for tuition for as many courses as they are chose to take.

At WGU faculty members offer direct and personal support to students. Faculty members are called *mentors* and all are full-time employees who may be located anywhere throughout the United States. When a student enrolls at WGU, he/she is assigned a *student mentor* who stays in weekly or bi-weekly electronic contact with that student throughout his/her matriculation with the university. If a student needs tutorial support in a particular course, a *course mentor*, works with that student either one-on-one or in small group webinars. Students' work products are 'graded' by part-time evaluators who have been trained on grading rubrics created by faculty, instructional designers and psychometricians. Students are scored as either 'pass' or 'not pass' on an assignment and get feedback on their skill and knowledge deficits. This allows them to work with their faculty to learn what they did not know. By separating the evaluation component of a course and the direct support to the students, the nature of the relationship between the student and his/her faculty is different than in a traditional course where the role of the faculty member is both to instruct and evaluate.

Even though WGU's students and *mentors* do not meet face-to-face until commencement, students report high levels of engagement. In 2014, the National Survey of Student

Engagement (NSSE) polled more than 350,000 students from more than 600 institutions. Students gave WGU the highest scores possible at significantly higher levels than the national average in the follow key areas [23]:

- Quality of interactions with faculty – 20 % higher
- Quality of academic support – 23 % higher
- Would attend same institution again – 25 % higher
- Rating of entire educational experience – 16 % higher
- Time spent per week on studies – 13 % higher
- Acquisition of job-related knowledge and skills – 13 % higher

4 Design Principles of CBE [24]

There are quite a few higher education institutions now developing CBE programs. A January 2015 article in the Atlantic Magazine reported at least 50 [25]. Western Governors University is working with almost a dozen community colleges across the United States as they each develop their own CBE programs. To make the realities of CBE programs less mysterious, we created a set of design principles that our partner colleges are using. These five principles are guiding the development of high quality CBE programs.

1. Degree Reflects Robust and Valid Competencies. Competencies are core to the CBE curriculum. In professional programs, they should align with both industry and academic standards. The process by which they are developed should be explicit and transparent. Program-level competencies should reflect the skills and knowledge that students will need at the next stages of their development, whether it is for further education or employment.

2. Students are able to Learn at a Variable Pace and are Supported in Their Learning. A CBE program should allow students to attain mastery by progressing through the curriculum at an individualized pace. Student success when progressing at differential rates requires a strong support system to keep them motivated and on track. Just-in-time academic assistance must be provided to students as well.

3. Effective Learning Resources are Available Anytime and are Reusable. In order for students to accelerate in a CBE program, they need to be able to work through the learning resources at their own pace. The materials (e.g., e-texts, recorded lectures, simulations) need to be available anytime the student is ready to study and paced to the student's requirements, not the institution's schedule. This suggests asynchronous learning resources coupled with academic assistance available in a just-in-time manner.

4. The Process for Mapping Competencies to Courses/Learning Outcomes/Assessments is Explicit. Once the competencies are established at the program-level, academic teams need to translate them into topics that can then be formulated into courses of appropriate length and complexity. The courses are then broken into learning objectives, which will drive the selection of learning resources and the assessments.

5. Assessments are Secure and Reliable. Assessments are built using the expertise of academic subject matter experts and employers (for professional programs), thus ensuring content validity. Scoring rubrics can provide a shared understanding for students and evaluators and also contribute to the reliability of the assessments.

5 Different Types of CBE Implementations

As the whole arena of competency-based education develops, there are a number of different implementation strategies that stick to the principles noted above, but result in different looking programs. The institutions creating CBE programs are doing so in a variety of ways to fit with the structure and practices they have in place. WGU was created as a stand-alone institution and has over the last 18 years created policies and practices that allow students to be successful in self-paced but highly supported CBE programs.

Our partner community colleges are integrating the CBE programs into their already existing campus structures and practices. As they do so, they have chosen approaches that fit within their own cultures. For example, at Sinclair Community College (Ohio) they are using a centrally managed approached with their distance learning personnel supporting faculty and other units across the whole college as they develop CBE programs. At Austin Community College District (TX) they developed all the CBE support functions within a single academic department. As other academic areas are considering their own CBE programs, the support unit will need to shift. In the state of Washington, four colleges developed their own CBE programs (Bellevue College, Columbia Basin College, Edmonds Community College, and the Community Colleges of Spokane's Spokane Falls campus). As these programs have successfully launched, other colleges in the state created a consortium to develop and offer a transferable business management CBE degree that will share academic and support services [26]. Other partner colleges, Broward College (FL), Ivy Tech (IN), Lone Star College District (TX), and Valencia College (FL) are all using different strategies for integrating CBE programs into their existing institutions. The lessons they are learning are being shared publically (www.CBEinfo.org), but generally students are flocking to these programs that offer them flexible learning options with consistent, high quality learning outcomes.

6 Conclusion

In conclusion, competency-based education is a different but effective means of awarding credentials that is enabled by 21st century learning technologies. In a CBE program, students progress based on demonstrations of skills and knowledge unrelated to time. Time is only an administrative variable that can be used to measure the length of a term for financial aid disbursement but is not a proxy for learning. Qualified faculty and subject matter experts define the learning objectives, and qualified faculty and psychometricians determine how learning is measured. In a CBE model, the more traditional roles of faculty are typically disaggregated so qualified experts can serve in appropriate roles, such as, defining learning objectives, creating or

identifying appropriate learning resources, evaluating student learning demonstrations, and working directly with students on their learning plans. Graduates of these programs will have demonstrated consistent learning outcomes with the skills and knowledge they need to be successful in either the workplace or further education. CBE can help us fulfill the promise of educational technology.

As researchers at Carnie Melon University were beginning the work that developed into the Open Learning Initiative, one of those researchers and a Nobel Laureate, Herbert Simon, put it, "Improvement in post-secondary education will require converting teaching from a 'solo sport' to a community-based research activity" [27].

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