Competency-Based Education in STEM–Course Design and Delivery for an Online Engineering Technology Program

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Abstract

Competency-based education (CBE) has received significant attention in the last several years from the federal government, Ohio Department of Higher Education (ODHE), educators, and accreditation bodies. CBE is an innovative approach to improving and enhancing student learning in a STEM program. While the main characteristics of a CBE course and program are generally agreed upon, the final course design is generally unique to individual programs and the institution. The purpose of this paper is to present the design and development of a trial CBE course at Bowling Green State University that will ultimately lead to enhanced student learning. Additionally, this pilot was intended to validate three aspects of CBE, these are (a) allow students to work at their own pace, (b) move through the course by demonstrating competency vs. traditional time-bound learning, and (c) utilize the students industry knowledge in lean manufacturing. At this time, no other program at BGSU offers CBE-based courses. A successful pilot course(s) could be the foundation for a full CBE program at BGSU and potentially serve as a model for other engineering technology courses and programs.

This paper (a) highlights the best practices in CBE used at BGSU as they relate to design and delivery of a course in lean manufacturing, (b) presents the rationale behind the design and delivery of a trial CBE course, (c) establishes the methods to measure student-learning outcomes, and (d) documents the results from the pilot course. Furthermore, this paper presents the pilot course results demonstrating that the goals of the CBE pilot have been achieved.

Introduction to Competency Based Education—The Intuitive Philosophy

Competency-based education (CBE) is being explored and actively pursued by many universities, colleges, and even high schools. Recent data presented by McIntyre, citing Fain, (2016) suggest that approximately 600 universities are actively pursuing competency-based programs in an attempt to align academic outcomes with the needs of industry. While there are many factors for pursuing CBE (political, monetary, etc.), the main crux for the movement is recognizing that a shift is needed from the traditional format where coursework is completed in a time-based fashion (i.e., discreet semesters) and credits accumulate towards a degree or certificate. The CBE philosophy is opposite; students move through a course at their own pace and only move to the next course topic when they have demonstrated mastery of the current topic(s). Re-evaluation and further study of the material is required to master the topic and only then can the student progress to the next topic in sequence. The learning model assures mastery of the topic when required competencies are properly identified.

If one examines this CBE learning model, it is quite intuitive and makes sense especially when paralleled with other activities in society. Sal Khan, founder of Khan Academy, summarizes the philosophy of CBE best as he presents analogies and examples in a TED Talk (2016). Kahn describes the process used in the martial arts: students do not move up the ranks without demonstrating competency. Imagine the result if a young yellow belt prospect was allowed to progress into the black belt class/status without fully mastering yellow and green belt competencies.

Kahn's simple analogy suggests the implications of CBE in higher education. In STEM courses, fundamental concepts build on each other, forming a solid foundation for the next concept. Without mastery of concepts, progressing to the subsequent topic occurs under the traditional, time-based model but often with consequences. An organic chemistry student may achieve a C or 70% on the topic of molecular bonding, but with this level of achievement, 30% competency is not achieved, and the student may not have mastered some key aspects of bonding. When a subsequent topic requires full knowledge of these competencies as a prerequisite, student performance and mastery of the concept are weakened. However, since the student "passed" the topic at 70%, s/he was permitted to move on because, based on the semester format, time and completion of assignments dictates progression. Apply this analogy to the construction industry (building a second story when the first story is 70% complete) or to the teaching of mathematics or physics. Clearly, the potential shortcomings and the need for a new learning model, especially in STEM curricula, are evident.

Although the historical aspect of CBE is relevant and important, it is not within the scope of this paper. Other researchers, such as Gallagher (2014) and Irvine and Kevan (2016), have documented the evolution and history of CBE. Similarly, definitions or models for CBE are numerous. For purposes of this research, the Competency Based Education Network (C-BEN) description provides the framework:

> CBE is a flexible way for students to get credit for what they know, build on their knowledge and skills by learning more at their own pace, and earn high-quality degrees, certificates, and other credentials that help them in their lives and careers. CBE focuses on what students must know and be able to do to earn degrees and other credentials. It combines an intentional and transparent approach to curricular design with an academic model in which the time it takes to demonstrate competencies varies and the expectations about learning are held constant. Students acquire and demonstrate their knowledge and skills by engaging in learning exercises, activities and experiences that align with clearly defined programmatic outcomes. Students receive proactive guidance and support from faculty and staff. Learners earn credentials by demonstrating mastery through multiple forms of assessment, often at a personalized pace. (Definition, n.d.)

While variations in the approach to CBE exist, this description highlights important characteristics incorporated into the pilot CBE course at BGSU, including (a) the ability for students to move through the course at an individual pace, (b) exploitation of student knowledge from industrial experience, (c) various pathways to master concepts and complete the course, (d) intimate engagement by faculty, and (e) online delivery targeted at current Ohio

learners, 75% who are either 25 or older attending part time (Ohio, Competency, 2016). The design and delivery of BGSU's experimental CBE course followed these core principles.

CBE at BGSU—The Philosophy for CBE & the Need for CBE

BGSU first encountered the need for CBE when asked to complete a survey from the ODHE regarding the institution's intentions for implementing a CBE-based program. In its report (Ohio, Case, 2016), the ODHE published several resources and best practices for universities and colleges in Ohio interested in developing CBE programs. This was in reaction to many Ohio colleges and universities that felt "they did not have enough information about CBE and its potential costs and benefits in order to take the next steps" (Ohio, Case, 2016, p. 6). This report outlined the rationale for an increased need and interest in CBE programs at its universities and colleges. The executive summary noted that Ohio has a large gap between working age adults (aged 25-64) holding postsecondary credentials and the number of working adults needed for current and future Ohio jobs. It is estimated that 43% of Ohioans have postsecondary credentials; however, fulfilling expected job demand must increase from 43% to 64% of working adults. Thus, a statewide goal was established: 65% of Ohio working adults will obtain some type of post-secondary "credential of value" (related to a specific industry or job need) by 2025 (Ohio, Competency, 2016, p. 9).

Further details are outlined in *The Case for Ohio Attainment Goal 2025* (2016). Ohio believes this goal cannot be realized with the current model in higher education, emphasizing the need for a new paradigm to help achieve the goal. Additionally, CBE seemed particularly well suited to support key strategies identified by ODHE to help achieve the goal: (1) directly aligning educational credentials to Ohio jobs, (2) increasing the number of educated Ohio adults, and (3) reassessing the higher education model if it promotes positive outcomes for Ohio students.

CBE in STEM—Quality Systems Program

As a result of the Ohio Attainment Goal 2025 and the ODHE's increased interest and participation encouragement, BGSU selected the undergraduate Quality Systems degree to pilot a CBE-based course. This degree is offered via BGSU's eCampus where all degrees are delivered 100% online in an 8-week course format. Two 8-week sessions are offered in each traditional 16-week semester. eCampus is an exclusive online degree granting campus at BGSU where learners can enter a degree program in any of the six sessions offered throughout the academic year. The Bachelor of Technology in Quality Systems is a particularly good fit for CBE and is well aligned with the CBE model. Currently, the program has an active enrollment of approximately 140 students.

The average age for an undergraduate student in this program is 36, with a range of 22-57 years. Since this is a degree completion program, each student brings prior college credit and/or an associate degree, and the majority of the students have industry experience in quality. Student backgrounds are diverse and include various manufacturing (automotive, aerospace, medical equipment), service operations, healthcare, education, government, military, food processing, and chemical processing industries. These students are attentive learners and are

generally highly motivated to complete the degree in hopes of promotion, pay increase, or pursuing a better opportunity. For these students, traditional face-to-face instruction is not an option due to work and life constraints. Furthermore, most are employed full time; therefore, the need for flexibility in scheduling and completing course activities is essential.

The deciding characteristic that makes this program an ideal fit for CBE is the direct correlation of course outcomes to the needs of industry, specifically in the field of quality assurance. Courses include "Lean Manufacturing," "Six Sigma," and the "Core Tools of Quality," all of which are competencies required by almost any industry that has a quality department or initiative. After examining the characteristics of students in the program and the fundamentals of a CBE course and/or program, BGSU decided to pilot "Lean Manufacturing for Manufacturing & Service Operations" (QS 3550) in the CBE format. This class was selected for three reasons: it represents a current industry need within the immediate BGSU radius, it is a STEM course in the engineering technologies, Quality Systems program, and students are non-traditional adult learners with years of industry experience. These reasons support the Ohio attainment goal. This author, a current professor and program coordinator in the program, was designated as the individual to develop and offer the course in Summer 2018.

Best Practices from CBE Research and Collaboration with Existing CBE Practitioners

While there is a vast amount of published material regarding all aspects of competency-based education, the author narrowed the search to the *Handbook of Research on Competency-Based Education in University Settings* (2016), a compilation of research surrounding all relevant CBE topics. In particular, two chapters, by Mott, Nyland, Williams, Atkinson, & Ceglia, 2016, and Boyer, Roe, Ross, Jones, Bucklew, & Conliffe, 2016, were useful while developing the pilot course. In addition, the author is a member of the State of Ohio CBE Network Steering Committee. As a result, some of the theory behind the course design and delivery originated from meetings, collaboration, and discussion with other committee members, most notably conversation with personnel from Sinclair Community College in Dayton, Ohio (2018).

Regarding CBE pilot course design, Mott et al. outlined a CBE learning infrastructure and a backwards design model developed by Wiggins and McTighe (1998). Many of the concepts were used in developing this pilot course. The CBE learning infrastructure suggested the following "pedagogical capabilities" (Mott et al., 2016, p. 140):

- Support for backward design at all levels
- Authentic, effective assessments aligned with course outcomes or competencies
- Support for learners in a variety of methods/pathways to complete the course and demonstrate competencies
- Flexibility for course personalization, i.e., self-pace to completion, learner prior knowledge, and route to course completion
- Performance measure for the course

These capabilities are modified slightly to fit align with the needs and goal of this CBE pilot course. Further in this paper, the use of these capabilities is clarified as they relate to the pilot course.

Mott et el. (2016, p. 142) identified a backward approach to design. Phases in this process are

- Identify the desired result
- Determine acceptable evidence
- Plan learning experiences and instruction

The importance of the backward model in CBE course design cannot be overstated. By defining upfront measurable learning outcomes that align with the needs of the customer (industry), the student not only masters the desired competencies but also has the opportunity to exploit prior, course-specific knowledge gained from industrial experience. Accomplishing the desired competencies (outcomes) requires establishing evidence criteria and carefully designing varied assessments that students can fulfill. Lastly, the course design and learning instruction should allow for attainment of competencies documented by effective assessments. The backward design as it relates to this course development is outlined later in the paper.

The Polk State case study detailed by Boyer, Roe, Ross, Jones, Bucklew, & Conliffe (2016) provided valuable information regarding critical elements of a CBE program. Since BGSU decided to only pilot a course and not yet delve into a full CBE program, elements of a full program had to be considered in the pilot offering. Items considered in the pilot development in the Polk case include

- Course scheduling format: When would the pilot be offered?
- Student registration: How would student be recruited, made aware and registrar for the pilot course?
- Payment and fees: Special fees or same tuition structure?
- Course delivery: 100% online, face-to-face, or hybrid?
- Defined student progression: How do students move through the course with flexibility
- Instructor role: What additional tasks are necessary for the instructor?
- Advising: Will advising be available for the pilot offering?
- Consideration of student scenarios: Can a student drop from the pilot and return to the traditional course? What is the process for students who fail to demonstrate competency after completing assessments?

Each of the above represents elements presented in the Polk case along with the corresponding BGSU consideration. Decisions based on these considerations shaped the CBE pilot course.

The final piece of research that assisted in development of this course was collaboration with fellow CBE practitioners at Sinclair Community College (SCC) in Dayton. including examination of SCC CBE course syllabi, discussion with a CBE academic coach/program coordinator & CBE program project manager, participation as member of the Ohio CBE Steering Committee, and a detailed review of the SSC CBE orientation model and college eLearning website.

Elements of the CBE Pilot Course at BGSU

The pilot course consisted of multiple elements: the CBE orientation module, student selection, course learning competencies (outcomes), course structure and student progression, assessment methods, grade criteria, and administrative constraints.

CBE Orientation Module

Since most students are not familiar with or aware of CBE, an orientation module was developed to inform students of the methodology, assess their potential to succeed in a CBE course, communicate course criteria, define the course-grading scheme, outline course administrative rules, and define expectations such as timing and communication. Additionally, a summary of preliminary student questions was posted to a discussion board within the orientation module that allowed students to post questions about the course. Both the professor and CBE coordinator monitored the discussion board. Figure 1 shows the main contents within the CBE orientation module.

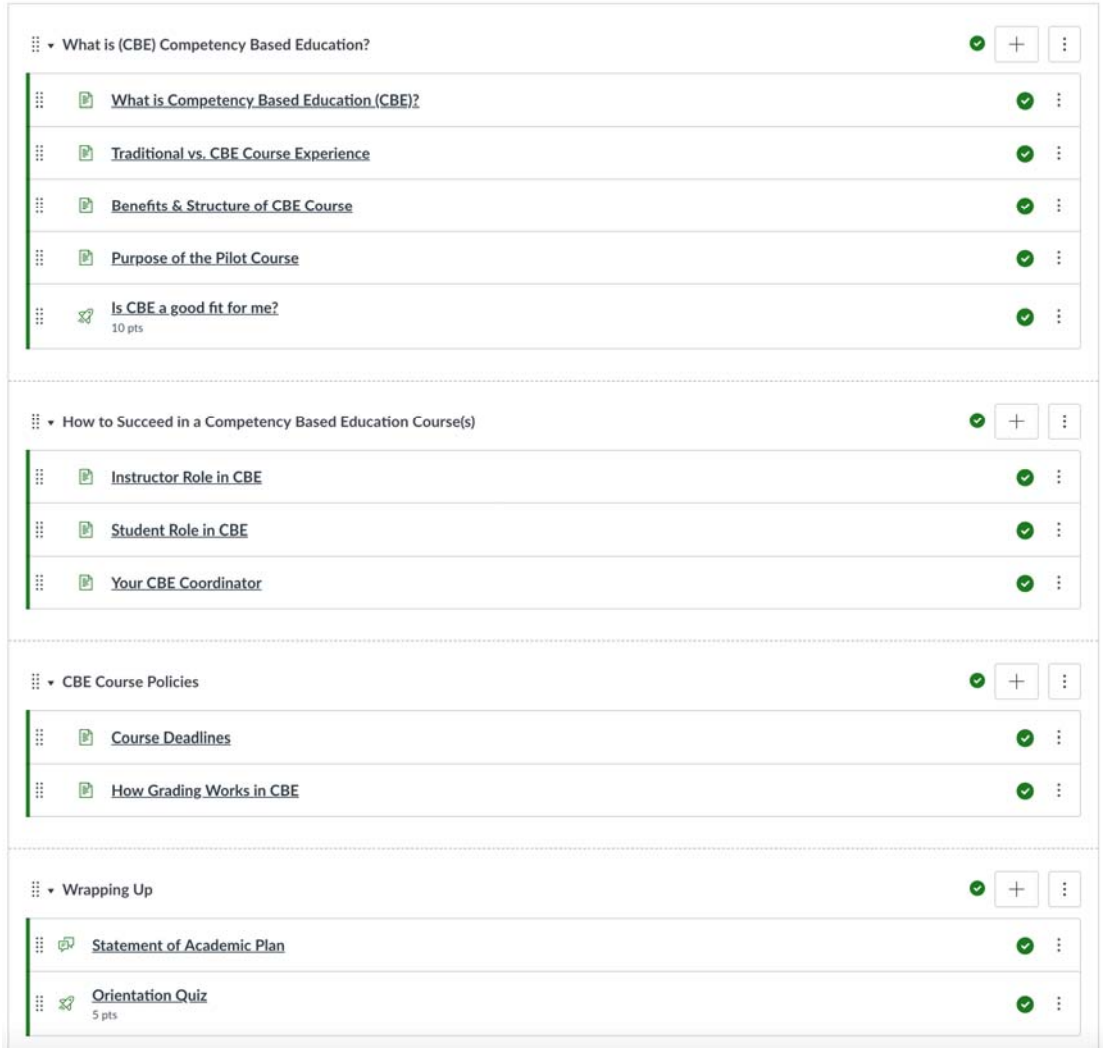

Figure 1. CBE orientation module contents.

Student Selection & Demographics

The pilot offering, "Lean Systems for Manufacturing & Service Operations," was planned for the 2018 summer session. The course is fully delivered online using Canvas. Since the course is regularly offered in the summer session, the professor and the CBE coordinator examined the list of students registered for the traditional course and contacted selected students describing the pilot project and requesting their voluntary participation. Interested students were enrolled in the CBE orientation module. Initially, the professor decided to enroll approximately 5 to 10 students for the pilot course; 8 students were contacted and expressed interest. After completing the orientation module, all 8 committed to participation in the pilot course. The pilot course student characteristics are as follows:

- Six have industry experience in lean systems and have previously taken online, traditional coursework at BGSU.

- One had industry experience in lean but none at BGSU; this was the first course since acceptance into the quality systems program.
- One had industry experience in an unrelated field. The student is enrolled in the Management & Technology eCampus program at BGSU.
- None had ever taken a CBE course prior to this offering.
- All are classified as nontraditional or adult learners.

The sampling of students from the population of all registered students for the QS 3550 traditional course offering was both convenient and purposeful. The majority in the program have industry experience, are classified as nontraditional, and are degree completion, having transferred previous college credit or holding an associate degree students. A "new to BGSU" student and a student from outside the quality systems program were selected to serve as the control for the pilot offering.

Course Learning Outcomes

The course learning outcomes are as follows:

- Compare and contrast the benefits and shortcomings of mass production, craftsmanship and lean manufacturing
- Apply the principle concepts of lean systems in a manufacturing or service environment
- Demonstrate how to develop and apply standardized work in lean systems
- Apply the concepts of stability to Lean systems in a manufacturing or service environment
- Define and apply the principles of JIT, kanban and production leveling
- Explain the concept of Jidoka and its importance in lean manufacturing
- Explain why involvement of people is critical to success in lean systems
- Define and outline the steps of Hoshin planning

Each of the learning outcomes is associated with a specific learning module dedicated to establishing and demonstrating competency.

Course Structure & Student Flexible Progression

The CBE course shell consists of 8 learning modules, each of which has core competencies. Students must demonstrate comprehension to successfully "pass" the module and progress to the next. The coursework can be done at the students' desired pace; once a module is open, it does not close until the student completes the module by either passing the pre-module competency evaluation or the post-module competency evaluation with a minimum score of 80%. After successfully completing the fourth module in sequence, students must complete a course midterm competency evaluation with a minimum score of 80%. This process is then repeated for the remaining modules, culminating with the final course competency evaluation, also completed with a minimum score of 80%. Figure 2 is a sample of a course module.

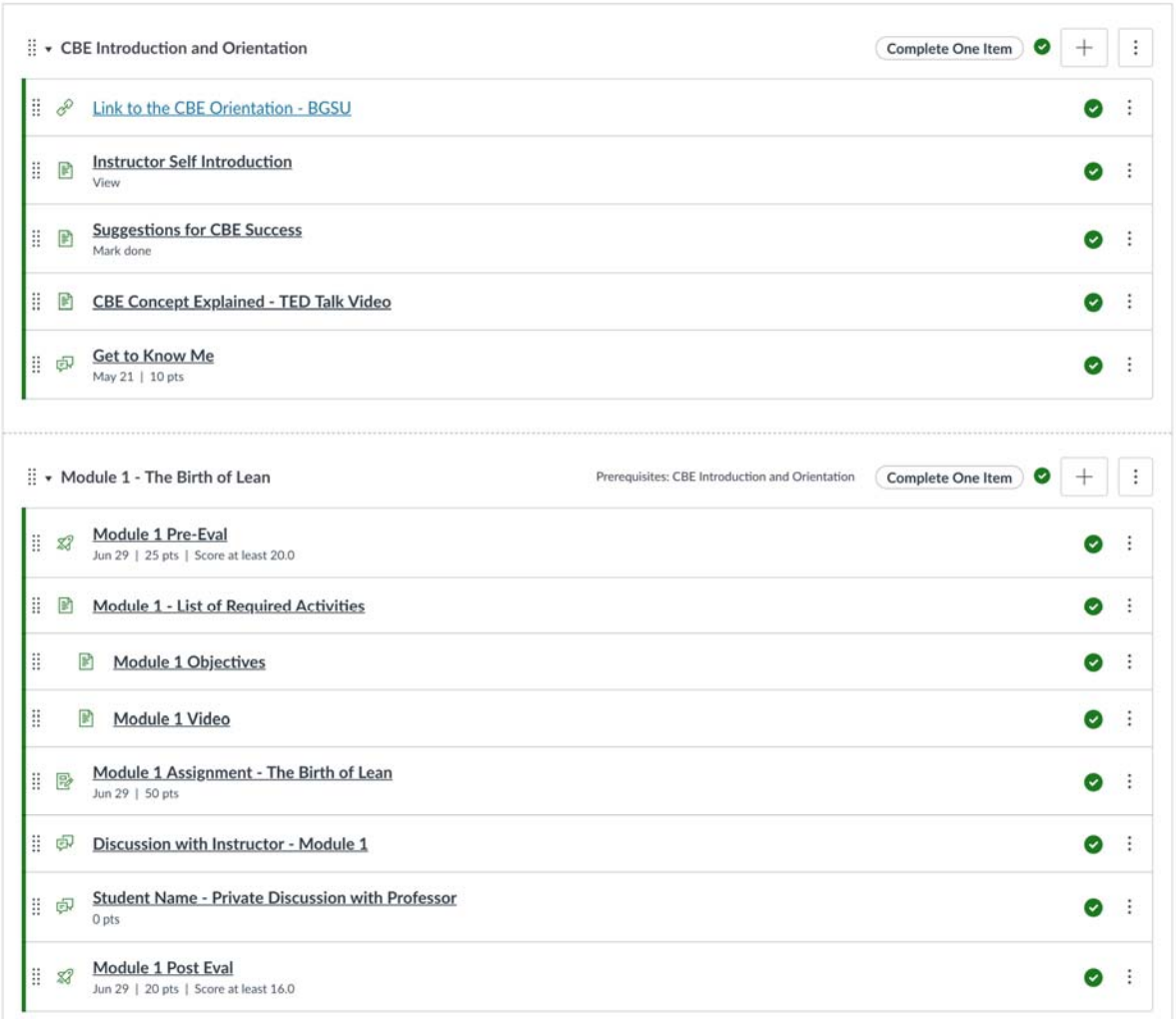

Figure 2. Example of a CBE module & contents.

Each learning module contains a pre-module competency evaluation. Completing this evaluation is optional; however, by successfully completing it, the student demonstrates that s/he already possesses the necessary competencies. Thus, if a student takes the pre-module competency evaluation and obtains a minimum score of 80%, the next module is automatically unlocked. If the student does not pass, s/he must complete the module learning activities and then pass the post-module competency evaluation. This process repeats, at the student's desired pace, until s/he has completed all 8 learning modules, the midterm competency (after Module 4), and final course competency evaluation (after Module 8) with a minimum score of 80%.

To incorporate social interaction, each module includes discussion boards, providing two options for student-student and instructor-student interaction. Moore (1989) states that student interactions transpire "between one learner and another learner, alone or in group settings, with or without the real-time presence of an instructor" (p. 4). Furthermore, Colson and Hirumi (2016) describe student-student interaction: "Learner-learner interactions help

groups and individuals construct knowledge and apply targeted skills. Typically, learner-learner interactions ask students to discuss important topics by using online discussion forums to share information opinions, and insights." Standard #5.4 of the *Quality Matters Rubric* (2018) requires that "The requirements for learner interaction are clearly stated." Thus it is required component of an online and/or CBE formatted course.

A module-specific discussion is open for students to post questions, concerns, or general comments and feedback regarding the module content. Both students and the professor are active in these discussions. Additionally, a private student-instructor discussion allows each student to privately communicate directly with the instructor.

A student may also elect to attempt an accelerated course completion option by bypassing Modules 1-4 and proceeding directly to the midterm competency evaluation. By completing this evaluation with a minimum score of 80%, the student may proceed to the final course competency evaluation. However, a score below 80% indicates that the student must begin the course at Module 1. Obtaining a minimum score of 80% on the final course competency evaluation indicates course completion. A score below 80% indicates that the student must begin the course at Module 5.

In this pilot course, a nontraditional syllabus was created. Since all of the course policies, grade criteria, and information are contained in the mandatory orientation module, the syllabus was streamlined to only include course topics and suggested completion timing. Table 1 is the syllabus/course schedule.

Table 1. Pilot course syllabus.

Competency Based Education - QS 3550 Pilot Course					
Module	Topic	Reading Assignment	Start Date	Suggested Completion	Week
CBE Orientation	CBE Guidelines	Module Content	Prior to Course Enrollment	Prior to Course Enrollment	1
Module 1	The Birth of Lean	Chapter 1	May 14, 2018	May 21, 2018	1
Module 2	Lean Production Systems	Chapter 2	May 21, 2018	May 28, 2018	2
Module 3	Stability	Chapter 3	May 28, 2018	June 4, 2018	2
Module 4	Standardized Work	Chapter 4	May 28, 2018	June 4, 2018	3
Mid Course Competency Evaluation Module 1 - 4					
Module 5	Just in Time	Chapter 5	June 4, 2018	June 11, 2018	4
Module 6	Jidoka	Chapter 6	June 4, 2018	June 11, 2018	4
Module 7	Involvement/Culture	Chapter 7 & 9	June 11, 2018	June 18, 2018	5
Module 8	Hoshin Planning	Chapter 8	June 18, 2018	June 22, 2018	6
Final Course Competency Evaluation Module 1 - 4					

Defining the Competency Model—Method of Assessment and Grade Criteria

All competency evaluations are graded on a competency scale; 80% is the minimum score a student must achieve in order to demonstrate mastery. Schaef (2016) states, "If you scan the

field, you'll notice that mastery means many different things to different folks. Some define mastery as '80%!' Some define mastery as 'Advanced!' Others use the term mastery, but have not yet defined it. It is important to be clear, thoughtful, and I would argue, quantitative, when you define mastery. You'll want a consistent set of tools (rubrics, a rating system, scoring rules, and calibration protocols) for measuring it fairly and consistently, too". Therefore, it is important to define the competency model used in this pilot course and to note that 80% mastery differs from obtaining a grade of 70 or 80% in a traditional offered course.

According to Colson & Hirumi (2016), "There is often a misconception that 'competency' implies a very high level of performance such as 90-100%. In fact 'competency' has a range of scores associated with it just like the term 'passing.' A student may pass a course with a grade range of 60-100%. Likewise, students may be considered competent within a range of scores, usually from about 75%-100%." In this pilot course, students are considered competent when they (a) complete the module assessment with a score of 80% and (b) complete the formative essay questions with a score of 80%. Each of the competencies must be demonstrated to advance to the next module. 80% is not arbitrary and represents the level of competency typical of industry certifications offered in lean manufacturing.

Demonstration of mastery was done through learning activities, module evaluations and module specific summative essay questions. The student has two attempts at any graded learning activity assignments/post module evaluation. However, this does not apply to pre-module evaluations nor the midterm and final course evaluations if the student proceeds directly to the midterm evaluation. If the student does not obtain 80% on any of these evaluations after the second attempt, the professor/instructor determines how or if the student will progress to course completion. Because, like many online courses, it is not always feasible to incorporate lab activity, evaluations focused on application-based (an industry scenario) assessments in lieu of a lab activity.

While not utilized in this pilot course, future CBE courses will require the use of Respondus to validate student identification. Additionally, Lockdown Browser is appropriate for all module evaluations. Both programs are LTIs available in Canvas. This will help ensure the integrity of a CBE program.

Delimitations—Administrative Constraints

Many options can exist in a CBE program/model. Fees structures may vary from a traditional pay for credit model to a subscription-based model. Student flexible pace can be open ended or course completion may be in line with a traditional semester. A program could be modeled as a direct assessment CBE or as a course-based equivalency CBE model. Therefore, a need to define pilot course delimitations was important for administration. The delimitations of this pilot course are

- The student must complete the course within the traditional semester timeframe.
- The student may start the course at any time within the semester but must complete it by semester's end.
- Tuition is traditional, credit-based fee.

- The student may opt out of the pilot within the first two weeks of the session and be placed into the traditional course.
- Students who complete the course early do not have the ability to enroll in another course (as in a subscription-based CBE program) until the next available semester.
- If a student does not finish the course within the traditional semester, an incomplete will be entered without requiring rationale from the student. The incomplete is granted outside the traditional university policy, which typically allows an incomplete only if documented extraordinary circumstances exist.

The pilot course will be used to determine if CBE is a good fit for BGSU. As the CBE program develops, delimitations may change based on feedback from the pilot course.

Results

Student Grades and Completion Rate

All students completed the course within the semester (6-week summer session) while three students completed it by the end of week 3 of the semester. Table 2 summarizes the grades and completion rates.

Table 2. Student grades & completion rate.

Student Final Grades	Final Grade	Time (weeks) to Complete Course
Student #1	B	6
Student #2	B	6
Student #3	B	6
Student #4	A	6
Student #5	A	6
Student #6	B	3
Student #7	A	3
Student #8	A	3

All students obtained the minimum competency 80% (B) in the course. A breakdown of each learning outcome with the number of students achieving competencies levels is depicted in Table 3.

Table 3. Learning outcome competency, entire class.

% Students Obtaining Level of Competency			
Learning Outcome	Exceeds > 90	Meets >79.9 and < 90	Does Not Meet < 80%
CO1	38	63	0
CO2	13	88	0
CO3	38	63	0
CO4	50	50	0
CO5	38	63	0
CO6	13	88	0
CO7	13	88	0
CO8	50	50	0

Course Assessment—Student Interview Feedback

As students completed the course, qualitative data was collected from a post-course completion interview, conducted via phone by the CBE coordinator at BGSU and the professor (see the appendix for interview questions). Each interview was recorded and transcribed with consent of the interviewee. Table 4 presents the main themes from coded qualitative data and summaries of each student's experience.

Table 4. Student qualitative course assessment.

Main Interview Themes	Student #1	Student #2	Student #3
Independent course pace is a benefit compared to traditional approach	A	A	A
Student has taken at least one (1) online course	A	A	A
Student preferes the CBE approach preferred over traditional	D	A	A
Time spent on this CBE pilot is less than time spent on a traditional course	A	A	A
Assessments are true demonstrations of competency	N	A	NA
This was the first/only CBE format course taken by the student	A	A	A
Student believed industry experience was beneficial and was exploited in this course	A	A	A
BGSU should offer more courses in this format	A	A	A
Student believes course rigor is equal or above traditional course rigor	A	NA	A
Specific ares of improvement expressed by student	Had particular difficulty with assessments	None	None
Other specific positive(s) expressed by student	None	None	Instructor prompt feedback promoted rapid course completion

Main Interview Themes	Student #4	Student #5	Student #6
Independent course pace is a benefit compared to traditional approach	A	A	A
Student has taken at least one (1) online course	A	A	A
Student preferes the CBE approach preferred over traditional	A	A	A
Time spent on this CBE pilot is less than time spent on a traditional course	A	A	A
Assessments are true demonstrations of competency	A	NA	A
This was the first/only CBE format course taken by the student	A	A	A
Student believed industry experience was beneficial and was exploited in this course	A	A	A
BGSU should offer more courses in this format	A	A	A
Student believes course rigor is equal or above traditional course rigor	N	A	A
Specific ares of improvement expressed by student	Ambiguous wording of some questions	Allow a bit more time for essay questions	Allow a bit more time for essay questions
Other specific positive(s) expressed by student	None	None	Feedback from Instructor

Main Interview Themes	Student #7	Student #8
Independent course pace is a benefit compared to traditional approach	A	A
Student has taken at least one (1) online course	A	A
Student preferes the CBE approach preferred over traditional	A	A
Time spent on this CBE pilot is less than time spent on a traditional course	A	A
Assessments are true demonstrations of competency	A	A
This was the first/only CBE format course taken by the student	A	A
Student believed industry experience was beneficial and was exploited in this course	A	A
BGSU should offer more courses in this format	NA	A
Student believes course rigor is equal or above traditional course rigor	A	A
Specific ares of improvement expressed by student	Some questions seemed tricky	None
Other specific positive(s) expressed by student	Excellent Text to Support Learning	Direct & frequent interaction with instructor

Key	
A	Student Agrees
D	Student Disagrees
N	Neutral/Undecided
NA	Did not obtain answer

Examining the achievement of learning outcomes, student completion rates, course grades, and the qualitative data gathered from the post-course interviews, the main benefits (as expressed in the literature) and goals of this CBE course have been obtained. Students achieved the

course competencies working in a self-paced atmosphere while being able to utilize/build upon industry knowledge and experience in lean manufacturing.

35.7% of the class completed the course in less than the allotted semester, and the remainder of the students, while taking the entire 6 weeks, expressed the significant benefit of having the flexible course pace and no set "schedule" of learning activity due dates. Additionally, all students believed the independent pace was beneficial compared to a traditional offering and all students stated that less time was spent achieving the course outcomes vs. the traditional, time-bound course format. Most students, with the exception of Student #1, preferred the CBE format to a traditional course format. Student #1 felt that in a traditional course format, concepts that are difficult to understand may be better explained or understood if student groups could discuss course material; this student further explained that the option of open discussion was available yet did not take advantage of the discussion area. In brief, the CBE format did not fit the student's preferred learning style; however, the student very much supported the flexible pace aspect.

Furthermore, most students believed the rigor of the course was not compromised in this format, and most felt it was equal to the rigor experienced in a traditional course in the same program. Several students cited both the text selection and prompt instructor feedback as a significant characteristic that made for a positive experience and helped promote competency-based learning exploiting a flexible pace.

Below are selected student quotes from the interviews that are aligned with the data analysis and goals of the pilot course:

Q: *What do you like about the course?*
A: "There was of course being a non-traditional student with outside responsibilities beyond academia meaning family, work requirements. This setup in terms of the CBE was wonderful. In addition to it being online it allowed me to go at my own pace whether it be expedited or I'd say not slower attached to a rigid schedule, something must be submitted by such and such date, so I found that wonderfully helpful in terms of being able to working it into my work and family schedules. Then the other thing that was a benefit was the number of years of professional experience, specifically in this course, being able to go ahead and take the testing through the modules was a great help also." (Student #6)

Q: *How did you feel this style of course accounted for your professional experience?*
A: "Oh yeah, when it came to the book and the specific questions and applications that the modules covered absolutely was very indicative of what I experienced in my professional life, absolutely." (Student #6)

Q: *Are there pros and cons of CBE course format?*
A: "Yeah so I think one of the good things about this class is you didn't waste a lot of unnecessary time going through assignments where you pretty much already knew the material. So I think that was probably the biggest benefit for me was you weren't kind of wasting time relearning that information." (Student #8)

Q: *How did you feel this style of course accounted for your professional experience?*
A: "Uh absolutely, it really good for the people who have been in the industry for a while that have gained that basic understanding of the material. I think that's the people who benefit from this the most. So I'd definitely, I'd love to see other classes follow the same suit." (Student #8)

Q: *When you did not achieve the minimum competency score, did subsequent assignments help?*
A: "Yeah. Yeah it was like every time I failed a module it was like I was so close; but then after I would study the questions that I had missed the first time and I would just go over the chapter again and do that homework. So by the time I got to that last test then it wasn't difficult." (Student #2)

Q: *How did the CBE experience compare with a traditional QS course?*
A: "The class really let me kind of show off what I already had, which was really great. So…there's value in both. The self-paced really does add a lot of value to the being able to work at my own pace. If I had known that we had the option I might have signed up for another class this semester. As far as a business education you can double your ROI potentially or triple it. To a certain extent I'm actually using a company reimbursed tuition, so a little of an eliminating factor of them trying to not do too much without pay so my company is able to pay it more." (Student #7)

Faculty Role, Workload and Involvement

Prior to offering the course, the traditional course had to be modified to the CBE format. This included creating competency based assessments, modifying course curriculum, and building a new course shell in Canvas. Overall, this author spent approximately a total of 23 hours within Canvas developing/converting to the new CBE format for QS 3550, "Lean Manufacturing." Another 20 hours was dedicated to developing the course assessment outside of the Canvas course shell and then loading the assessment into it. Thus course conversion required about 53 development hours.

Since each student had a dedicated personal discussion board to interact with the instructor, this author responded directly and individually to student questions, concerns and comments. Ultimately, 59 hours of total instruction time were spent in the class for the 6-week session; the interaction time spent with students in Canvas was approximately 7.4 hours per student or 1.4 hours per day. This did not include answering daily e-mails from students (who were asked to keep all correspondence in Canvas, but some did not), and, on average, replied to 7 e-mails per week outside of Canvas from CBE students. It should be markedly noted that *daily* correspondence and checking of student progress was required. It is feasible that this daily interaction can be reduced when the CBE format is mature; however, the attention was needed to ensure students had a positive experience. Within the 6-week period, there was not any single day where some student-instructor interaction was not required.

Daily interaction and feedback were critical to course success. Compared with the standard section of QS 3550 that was run concurrently with the CBE version, this author spent a total

time of 71 hours with a course enrollment of 43 students, approximately 1.6 hours per student. In the traditional course, some of the time spent is outside Canvas (off line grading, e-mails, etc.); thus the 1.7 hours per student may be on the low end of the true value. It should also be noted that this author has taught the traditional QS 3550 course several times. In either case, it is important to note the increased amount of time from a faculty member in a CBE course. Future iterations of the course would probably require less time due to a decrease in curriculum development and experience with executing a mature CBE format.

Future CBE Considerations and Conclusions

Based on student experiences and results from the course, the CBE pilot course has fulfilled its preliminary goals to (a) allow students to work at their own pace, (b) move through the course by demonstrating competency vs. traditional time-bound learning, and (c) utilize the students industry knowledge in lean manufacturing. The pilot course provided an initial foundation demonstrating that the CBE concept can work well, especially with nontraditional and/or working students.

While there are many considerations before launching a full program in a CBE format, this initial step has answered some important questions. Further research and exploration into competency-based education within the Quality Systems program will be ongoing. A second pilot course is planned for QS 3710, "Six Sigma," where the sample size of students will be increased, and they will be able to register for the CBE version, thus students will not be selected as in this pilot course. After completion of the second pilot course, pending outcomes, the focus will be on potentially taking the Master's Certificate in Quality Systems to a full CBE offering. It is important to note that the student demographic (working students who possess quality-related experience) seems well aligned with the CBE framework, and other programs may not realize the same positive results as Quality Systems. Furthermore, what this pilot course and paper did not present or consider are other important challenges when implementing CBE such as faculty buy-in, financial aid, accreditation, program model, (subscription based or pay per credit) and faculty role alteration.

The CBE pilot course was developed from the need identified by the State of Ohio Department of Higher Education. Many of the principles used in the course design and development were drawn from existing research and represent current best practices for a CBE course. It is important to note that many models for CBE course design and development exist; this pilot course follows best practices and has been designed to specifically fit the needs of BGSU Quality System students. Readers are encouraged to explore CBE resources such as C-BEN, The Competency Based Education Network (www.cbenetwork.org), *The Journal of Competency Based Education,* and *The Handbook of Research on Competency Based Education in University Settings*.

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References

Boyer, N., Roe, E., Ross, K., Jones, P., Bucklew, K., & Conliffe, M. (2016). Building competence: Polk State College's Engineering Technology OEEE associate's degree. In K. Rasmussen, P. Northrup, & R. Colson (Eds.). *Handbook of research on competency-based education in university settings* (pp. 308-339). Hershey, PA: IGI Global.

Colson, R., & Hirumi, A. (2016). A framework for the design of online competency-based education to promote student engagement. In K. Rasmussen, P. Northrup, & R. Colson (Eds.). *Handbook of research on competency-based education in university settings* (pp. 168-187). Hershey, PA: IGI Global. doi: 10.4018/978-1-5225-0932-5.ch009

The definition of CBE. (n.d.). Retrieved from http://www.cbenetwork.org/about/about-the-network

Gallagher, C. (2014). Disrupting the game-changer: Remembering the history of competency-based education. *Change: The Magazine of Higher Learning*, *46*(6), 16-23.

Irvine**,** C. K., & Kevan, C. M. (2016). In K. Rasmussen, P. Northrup, & R. Colson (Eds.), *Handbook of research on competency-based education in university settings* (pp. 1-27). Hershey, PA: IGI Global.

Jones, K., & Olswang, S. (2016). Building competence: A historical perspective of competency-based education. *Handbook of research on competency-based education in university settings* (pp. 28-40). Hershey, PA: IGI Global.

Khan, S. (2016, September 26). Let's teach for mastery – Not test scores? [Video File]. *YouTube*. Retrieved from https://www.youtube.com/watch?time_continue=7&v=-MTRxRO5SRA

McIntyre-Hite, L. (2016). A delphi study of effective practices for developing competency-based learning models in higher education. *The Journal of Competency Based Education*, *1*(4), 157-166.

Moore, M. G. (1989). Editorial: Three types of interaction. *American Journal of Distance Education*, *3*(2), 1-7. doi: 10.1080/08923648909526659.

Mott, J., Nyland, R., Williams, G., Atkinson, M., & Ceglia, A. (2016). the next generation CBE architecture: A learning-centric standards-based approach. In K. Rasmussen, P. Northrup, & R. Colson (Eds.), *Handbook of research on competency-based education in university settings* (pp. 143-156). Hershey, PA: IGI Global.

Ohio Department of Higher Education. (2016). *Competency based education, The 9th report on the condition of higher education in Ohio.* Columbus, OH: Ohio Department of Higher Education.

Ohio Department of Higher Education. (2016). *The case for Ohio attainment goal 2025.* Columbus, OH: Ohio Department of Higher Education.

Schaef, S. (2016). *Five key lessons for mastery learning startup*. Retrieved from https://www.competencyworks.org/understanding-competency-education/five-key-lessons-for-mastery-learning-startup/
Sinclair Community College. (2018). *Sinclair Flex Pace: Your path to flexible completion*. Retrieved from https://www.sinclair.edu/locations/online/flexpace/
Standards from the quality matters higher education rubric. (6th ed). (2018). Retrieved from https://www.qualitymatters.org/sites/default/files/PDFs/StandardsfromtheQMHigherEducationRubric.pdf
Wiggins, G. P., & McTighe, J. (1998). *Understanding by design*. Alexandria, VA: Association for Supervision and Curriculum Development.

Appendix

Post-Course Completion Interview Questions:

1. What did you like about the course?
2. What didn't you like about the course?
3. What could be improved in the course and in the course delivery?
4. How did the course flexibility of pace benefit you?
5. How did the CBE experience compare with a traditional QS course?
6. How did you feel this style of course accounted for your professional experience?
7. Did you feel that the learning activities prepared you for the module assessments?
8. What was your amount of time and energy spent on content before attempting and ultimately passing assessments?
9. If you could complete the traditional course in a self-paced paced format vs. the CBE format, what would you prefer and why?
10. Did you feel that you were able to utilize your industry & life experience to move through the course efficiently?
11. Was the professor interaction and feedback timely and useful?

Suggestions for CBE Pilot Success Posted for Students in the Introduction Module

Suggestions for Success & Course Background:

I want to again thank everyone for offering to participate in the pilot course. I truly believe Competency Based Education is a great model especially for working students with experience in the field. This approach to education is gaining popularity, however my interest is from a more personal standpoint. In brief, from my associate degree that I obtained from a community college to my PhD, I was 100% a working student. I would have loved to be given the opportunity to self pace my work and also utilize some of the knowledge I had gained while working in industry. Thus, my hope is that this course can offer both of these aspects; (1) the ability to move through the course at you own pace and (2) exploit the knowledge you already have gained from real life experience.
Please watch the video (if you have not already done so) regarding the concept of CBE. It really explains the concept quite well!

Items of Note:

- I am not using a traditional syllabus in this course. The grade policy and all other important items are contained in the CBE orientation module. Refer to this Canvas Course for any questions about CBE course policy. You can always reach out to me using your private discussion or module discussion board.
- You have 2 methods to communicate with the instructor. Each module has a "public" discussion board and each student in the course has a private discussion board. I will monitor these daily as respond generally within about 4 - 6 hours. If I don't answer, send me a reminder or a text message.
- If you DO NOT hit 80% on a given evaluation, please notify me. Since this is the first time I am using these questions and evaluation methods, I want to evaluate each case by case, I don't want you to get discouraged if you score 79% and can't move on. I will evaluate and act. Also when you take a Module Pre Evaluation, keep in mind there are essay questions which are **not auto-graded.** Thus, I need to review and assign the grade to these questions. So do not panic or get discouraged when you finish a pre evaluation and you see a score of say 56% which indicates 14/15 correct on the multiple choice questions and 0/10 for the essay questions. The evaluation grade is not final until I grade the essay questions. I will get this done within 24 hours, most times it will be much quicker.
- Be patient and work with me. This is new to me also, and I am highly confident it can be beneficial in the long run. But like any problem solving exercise, or continual improvement initiative, obstacles or issues arise. When/if they do, alert me and we will address promptly. Since you are all from the Quality Assurance discipline, you are not new to this type of process; trying a new strategy to improve the overall product.
- Constraints: Unfortunately I have to work under some administrative constraints. In a perfect scenario, you would not have the 6 week session constraint, you'd be able to start the course anytime within a semester and complete the course under you own plan within an entire semester. Don't worry about the timing. Ideally I'd love to see everyone move through quickly and finish well before 6 weeks. Keep in mind if you DON'T finish in 6 weeks, I will grant an INC grade and you can complete the course regardless.
- Feel free at any time to offer suggestions, complaints, etc. But please use one of the discussion boards. I do not mind getting and responding to e-mails, but my goal is to capture all issues, etc. within the course shell. If you feel you need to communicate via e-mail vs. discussion board, please do so!

You can now proceed to Module 1. I suggest reading the chapter in the text first, then attempting the pre-evaluation. I suggest this strategy for the entire course. If you want to be aggressive and proceed directly to the Mid Course evaluation, by all means do so! - However I'd recommend reading Chapter 1 - 4 first.
Best of Luck, Enjoy and communicate with me often!

Biography

CHRISTOPHER KLUSE is an assistant professor of Engineering Technology & Quality Systems at Bowling Green State University. He is also the quality systems program coordinator. Christopher holds a PhD in Technology Management with a specialization in

quality systems from Eastern Michigan University. Christopher is a former quality & manufacturing professional, with the majority of his 25 years experience spent in the automotive industry. Additionally, Christopher is an ASQ certified manager of quality/organizational excellence and formerly served as a part time lecturer (while employed in industry) of quality management at Eastern Michigan University and as a subject matter expert in quantitative studies and operations management at Southern New Hampshire University. Dr. Kluse can be contacted at ckluse@bgsu.edu.