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Applying Backward Design Principles to Online Continuing Education Course Design and Development for Working Professionals

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Abstract -- This paper describes the design and development of professional development courses using backward design principles. Backward design means first identifying desired outcomes and the acceptable evidence for those outcomes before designing the learning experience. Detailed steps of the framework can be applied to any online continuing education course to achieve course outcomes, to ensure efficacy through design and development, and to maximize the impact of the online courses in engineering education.

Paper describes the framework to design and develop of an online continuing education course on Cost Engineering. First, it outlines the analysis of the learners' needs in the field of Cost Engineering. Second, the paper provides details on the steps taken to design the course. It specifically describes (1) how the course outcomes and objectives were written based on the analysis of learners' needs; (2) how course learning activities and assessments were determined to achieve the intended learning outcomes and objectives; and (3) how the course content was constructed to successfully complete the learning activities and assessments in the course. Third, the paper describes the development and implementation of the course in the learning management system. Particularly, it explains (1) how the course activities and assessments were created and implemented; (2) how the course materials were prepared with stakeholders; and (3) how the visual identity of the course was designed with Universal Design Principles.

The paper concludes by providing lessons learned from user feedback and directions for future development of the online continuing education courses using backward design principles.

I. Introduction

Communication and information technologies continue to provide new opportunities for continuing education for working professionals in the field of engineering. As the number of online continuing education courses continues to increase, the need for evaluation of the efficacy of them also increases. Applying backward design principles [1] into the course design and development ensures the efficacy of continuing education courses and programs.

Practices described in this paper could be beneficial to the reader in two specific ways. First, while in many cases the implementation of the professional development courses are decoupled from the design and development team, we argue that designers and developers should work together employing backward design principles to make a successful course. Second, we demonstrate how backward design principles can be a useful framework to achieve course outcomes, to ensure efficacy through design and development, and to maximize the impact of the online courses in engineering education. We argue that filling a gap between the industry standards in professional development and pedagogical standards in higher education can better meet the needs of working professionals. This paper could allow readers to directly apply some

of our strategies to overcome similar problems when redesigning a professional development course.

II. Background

In 1996, a Civil and Construction Engineering Professor from Iowa State University developed a professional development correspondence course called the Fundamental Skills and Knowledge of Cost Engineering. Administered by the university extension office, the course prepares professional cost engineers and project control professionals for the certification exams administered by the Association for the Advancement of Cost Engineering (AACE) International. Because the course is part of the organization's recommended introductory course, it attracts a global audience of professional engineers from six continents.

The original course structure consisted of readings from the recommended textbook and completing 15 assignment sheets. Once a student signed up for the course, the university continuing and extension office mailed the required textbook and assignments. Correspondence between the instructor/Teaching Assistant (TA) and learners was facilitated by mail, fax, or email. Once learners had completed the assignments, they would send their materials to the office to be evaluated by the instructor or TA. While correspondence was a logical course delivery option at that time, correspondence between instructor and learner was minimal and sometimes slow.

In 2008, Iowa State University had restructured the central continuing education office and decided to hand over the course to our department. This is when we took over the administration of the course. By 2008, we were hosting our own learning management system (LMS) to deliver a handful of online professional development courses. When we adopted the course, we decided to convert the course to an asynchronous online course. To avoid disruption to learners already in the course, we decided to convert the paper assignment sheets to digital assignment sheets with the ability to submit and provide feedback using the online course. The online course also integrated electronic grade book and automated notifications. The course continued to have consistent enrollment over the years. However, we started to receive negative feedback about the course, including complaints about outdated content materials, not providing video lessons, and assignments not aligned with the course textbook due to the textbook having been revised a few times since the original course was developed. TA frustration with the course was consistent with student feedback. Since our LMS supports synchronicity and asynchronicity, and since we were not utilizing modern forms of instruction such as lecture videos, it was very clear that we had not taken advantage of LMS and its true potential to make the course beneficial to our learners.

In 2015, we started to review the course materials very closely with what past student feedback provided us. According to the course evaluation survey given at the end of the course revealed that our students believed the course could be improved significantly. When we asked if the course could be improved with online interaction with the instructor, 73% of students agreed. 70% of students also thought providing supplemental resources in addition to the textbook and assignment sheets could improve their learning. 63% of students thought scenario-based training

could improve the course. More than 50% students thought providing videos, online interaction with other learners, and interactive online content could be implemented in the course.

It was eye opening to see how outdated the course had become over time. The original instructor had left the university several years back to pursue a career in the private sector. We had a difficult time reaching out to communicate our concerns, but finally we had a chance to discuss the course with the instructor. In 2016, the instructor and this department agreed to redesign the course.

III. Backward Design - Utilizing Current Technology and Pedagogy

The original Fundamental Skills and Knowledge of Cost Engineering was a produce of its time. As a legacy course, it followed a content delivery model that, while suitable for the technology of the mid '90s, neither utilized the affordances of our current LMS, nor did it align with current scholarship in instructional design. Specifically, the legacy course suffered from what Wiggins and McTighe [1] describes as the "twin sins" of traditional design or purposelessness design. The first sin is activity-oriented design that engages experiences that lead only accidently, if at all, to insight or achievement. Such activity-oriented curricula focus on creating fun and interesting activities; but, oftentimes lack an explicit focus on important ideas and appropriate evidence of learning, especially in the minds of learners. The second sin is "coverage," which is a form of aimless curricula design where learners go through the textbook page by page and/or through lectures/lecture notes in an attempt to transfer all the factual material within a prescribed time. Since the legacy course suffered from the sin of coverage, we knew our course needed to be redesigned as logically derived from the results sought, not inferred from the methods, books, and activities with which we are most comfortable. This way, curriculum lays out the most effective ways of achieving specific results.

We believe that the most effective curricular design is "backward". Backward design arose in tandem with the concept of learning standards, and it is widely viewed as a practical process for using standards to guide the development of a course. As a strategy for designing, planning, and sequencing curriculum and instruction, backward design assists educators create logical teaching progressions that move learners toward achieving specific learning outcomes [2]. Because backward design starts with the end--the desired results, goals, or standards--it drives the curriculum by foregrounding evidence of learning and the teaching needed to equip learners to perform against a standard. We argue that, in addition to a process that involves designers, instructors, and administrators at all levels of course development, the best designs derive backward from the learning sought. The goal of our department is to be more deliberate and focused in our design to create a more meaningful learning environment for professional engineers.

The Stages of Backward Design

The logic of backward design suggests a planning sequence for curriculum. This sequence has three stages: (1) identify desired outcomes, (2) determine acceptable evidence, and (3) plan learning experiences and instruction.

Stage 1: Identify Desired Outcomes

This first stage in the design process calls for clear priorities. In this stage we considered our goals, reviewed curriculum expectations, and examined established content standards by the AACE International. In this stage we had to make choices based on the desired learning outcomes. Learning outcomes are defined as the intended behavioral change that will be observed in learners. In other words, these are the knowledge and skills that educators ideally would like learners to transfer to another context outside of the classroom (e.g., their work environment, other aspects of life). Whereas learning objectives are more specific to the course, outcomes they help learners to achieve learning outcomes by scaffolding through the assessments, activities, and content of a particular course.

We asked the following questions to determine the desired outcomes: What should learners know, understand, and be able to do at the end of this professional development course? What is the ultimate transfer we seek as result of this learning experience? What essential questions will be explored in-depth and provide focus to all learning? Using these questions, our curriculum designers worked with Subject-Matter Expert (SME)/instructor to clearly define the learning outcomes and objectives of the course. Worthy of note is that we had more content than we could reasonably address within time available for the course, so focusing on objectives and outcomes helped us pare the material down to its most important components.

A revised version of Bloom's Taxonomy [3] was used to write learning outcomes and objectives in measurable terms. As a result of an iterative process between SME and curriculum designers, course level learning objectives were aligned with the learning outcomes; likewise, module-level learning objectives were aligned to course-level learning objectives to ensure that each learning module could help learners to achieve intended learning outcomes. To exemplify this point, the table below lists learning outcomes, course-level objectives, and Module 1's objectives and their alignment with each other.

Learning Outcomes	**Course-Level Learning Objectives**	**Module-Level Learning Objectives**
Demonstrate an understanding of and apply the various terminology, technologies, and fundamental principles found within the practice of cost engineering.	1. Demonstrate an understanding of engineering economics fundamental principles and terminology found in the practice of cost engineering. 2. Apply engineering economics	Module 1: Economic Analysis 1. Explain the terms period interest rate, present value, future value, annual payment, number of interest periods and calculate one of them given the other terms. 2. Apply the basic time

	fundamentals to typical decision-making and problems found in the practice of cost engineering. 3. Demonstrate an understanding of contracting fundamental principles and terminology found in the practice of cost engineering; basic management functions and the techniques for successful project management; constructability concepts and the value engineering process; project control techniques; basic quality improvement principles; the basic terminology for computer applications in cost engineering. 4. Analyze project data and productivity. 5. Develop a process for improvement. 6. Demonstrate an understanding of conceptual estimating principles and terminology found in the practice of cost engineering. 7. Use proper terminology related to cost engineering practices.	value formulas to simple story problems. 3. Draw cash flow diagrams to depict basic engineering economics problems to assist with their solutions. 4. Demonstrate and understanding of the various decision-making situations that engineering economics fundamentals are applicable. 5. Apply engineering economics basics to deciding between alternatives, calculating rate of return for investments, incorporating depreciation and taxes into the economic analysis, and performing benefit cost analysis. 6. Calculate the benefit to cost ratio for a project. 7. Identify the best alternatives based on net present value. 8. Identify the rate of return for any investment scenario.

Table 1. An Example of Alignment of course learning outcomes, objectives, and module-level objectives

The legacy course was divided into 15 lessons in order to cover the content of the book. With the guidance of clearly defined and aligned learning outcomes, course-level and module-level objectives, the SME and curriculum designers were able to restructure the course topics under six learning module:

1. Module 1: Economic Analysis
2. Module 2: Cost and Cost Estimate
3. Module 3: Planning and Scheduling
4. Module 4: Cost Control
5. Module 5: Project Management
6. Module 6: Statistics, Probability, and Risk

Stage 2: Determine Acceptable Evidence

The second stage of backward design encourages us to think about the course in terms of assessing collected evidence. This involves which documents are needed to validate how well learners achieved the desired learning outcomes, so that the course is not just content to be covered or an aimless series of learning activities. This backward approach inspired us to first think like an assessor before designing specific learning module content, and thus to consider up front how we would determine whether learners have attained the desired knowledge and skill.

When planning to collect evidence of understanding, we considered a range of assessment methods. We believe, because understanding develops as a result of ongoing inquiry and rethinking, the assessment of knowledge acquisition should be thought of in terms of a collection of evidence over time instead of an event on a single moment. Therefore, instead of using a single test at the end of instruction, as so often happens in many of the current practices, we employed three specific assessment methods. First, periodical checks of understanding called "knowledge checks," second, larger module assignments and third, a midterm examination and a final exam final exam.

First, knowledge checks are comprised of multiple choice and fill-in-the blanks questions, which can be taken by learners up to three times or until they answer over 80% of the questions correctly. Moreover, each question within the knowledge checks provides extensive feedback that would confirm learners' correct answers or, alternatively, lead them to the correct answer if they answered incorrectly. Knowledge checks were assessed, but not graded, making them non-compulsory activities not counted towards the passing grade for the course. This way they provided a stress-free practice environment to learners where they could enjoy learning from their mistakes without penalty.

Second, an end-of-module assignment was built at the end of each learning module. Each module assignment included multiple performance tasks that required higher level of thinking and skills (Anderson & Krathwohl, 2001) to assess learners' progress towards achieving the

course objectives. Contrary to knowledge checks, module assignments were more complex, contextualized, and demanded longer term of retention of knowledge from learners in order to be completed successfully. These assessments were graded by TA to tailor feedback to specific learner's needs. Similar to knowledge checks, learners were given multiple opportunities to submit their assignments to TA, until they score 80% or higher. These assessments were made compulsory -counted towards course grading- in order to pass the course.

Finally, we also created mid-course (after Module 3) and final review assessments. Both of these assessments were counted towards the passing grade for the course. Mid-course review was designed similar to module assignments and included complex and contextualized performance tasks that demanded learners to utilize the gained knowledge and skills from Module 1 to 3. Mid-course review was also graded by the TA and learner specific feedback provided. Final review assessment was designed as a cumulative assessment. This test borrowed 70% of its questions from the knowledge checks, while 30% of the questions were added as new material.

Stage 3: Plan Learning Experiences and Instruction

After clearly identifying desired goals and constructing appropriate evidence of understanding in mind, third stage of backward design assisted us to plan instructional activities as well as the scaffolding in the course. In this stage, SME and curriculum designers came together to determine the learning experiences.
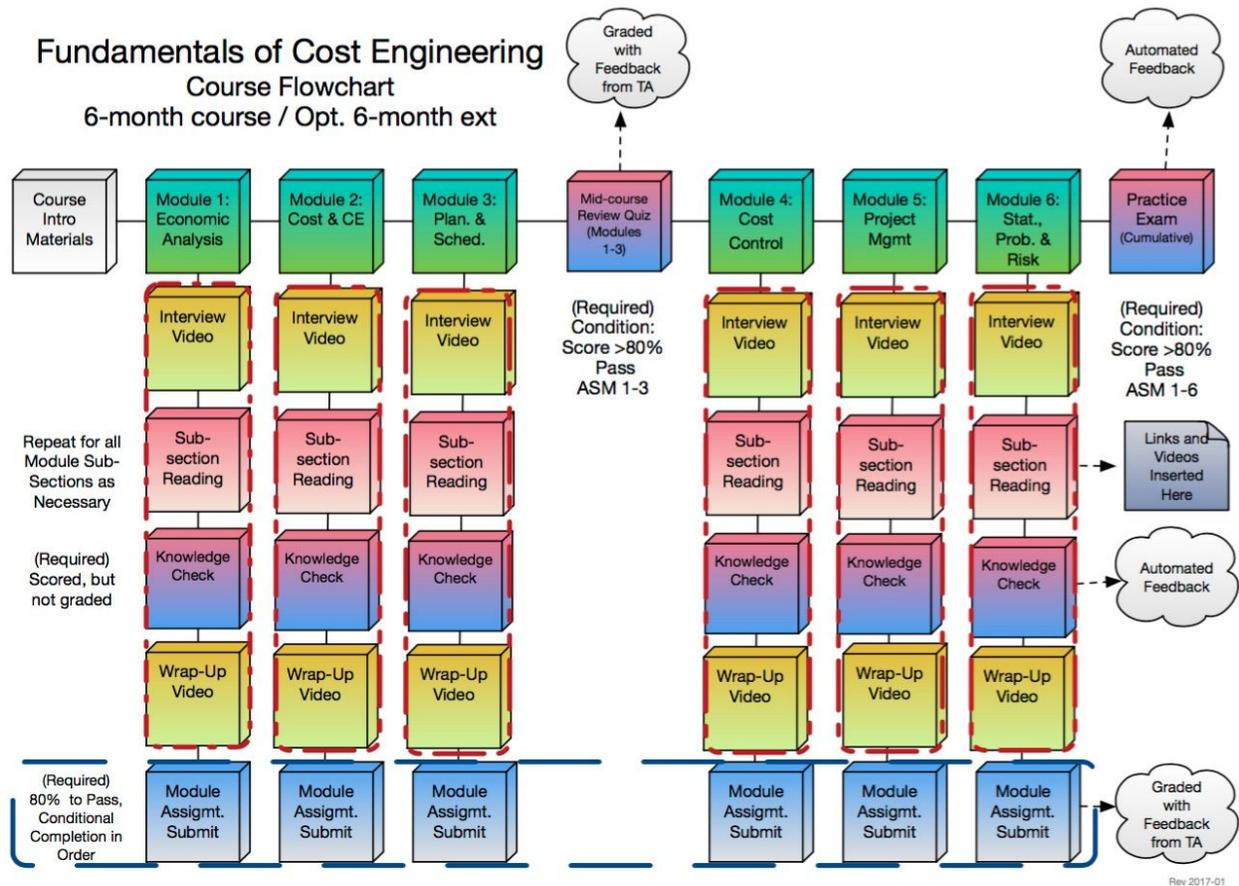
Figure 1. Organization of the course

Regarding organization of the course, each learning module was divided into smaller sub-sections based on the module-level objectives such that each of them could address specific objective. Every sub-section was designed to include knowledge checks for each chapter of the textbook and one major assignment for the module. Two tests were administered, once within the middle of the course and once at the end. These learning activities aimed to check learners' mastery level in particular module-level objective. These activities varied in scope (from simple to complex), time frame (from short-term to long-term), setting (from decontextualized to authentic contexts), and structure (from highly to non structured).

IV. Development and Implementation

Our department uses its own Moodle installation to host its online professional development courses. Moodle is an open-source software that affords great flexibility when designing online courses, as it is a well-supported and powerful learning management system (LMS). Moodle is powerful in the sense that it affords a full range of activities and resources to help learners accomplish learning objectives. It also affords expanded capabilities through an open-source community that develops themes and plugins adapted to a wide range of contexts. This section will discuss these affordances in detail.

The new Fundamental Skills and Knowledge of Cost Engineering is formatted as an asynchronous course where learners can enroll at any time and complete activities at their own pace within a 6-month period. This format made synchronous activities like webinars impossible to implement. Moreover, since it is unlikely that two or more learners are working on the same activity at the same time, certain asynchronous activities like forums would not be useful. Because this is an asynchronous and self-paced course, activities were judiciously selected to fit the format.

One of the most important challenges for asynchronous online courses is to provide learners with feedback about how they are accomplishing the objectives of the course. To this end, we designed the course to provide automated feedback where possible. We used Moodle's quiz tool to design knowledge checks, which provide automated feedback based on questions and answers provided within the Study Guide provided by AACE International. These checks provide consistent, real-time feedback to learners regarding their progress in the course and their mastery of material. Moodle's quiz tool also provides multiple formats for questions such as multiple choice and fill in the blank. Of particular importance is the Cloze Question format, which allowed for a spreadsheet where learners can practice the calculations necessary for solving more complex problems. Consider the following:

Question 1
Not complete
Marked out of 9.00

Instructions: What is the percent complete and earned WH (BCWP) for accounts 03110, 03210, and 03310? What is the percent complete and earned WH (BCWP) for the summary account, Slabs at Grade? Reference questions are provided below.

Code	U/M	Quantity Total	Quantity to date	Budget WH	Earned WH	Percent Complete
03110 Formwork	SF	4,000	3,000	6,000		%
03210 Rebar	Ton	10	6	900		%
03310 Place and Finish	CY	800	640	1,600		%
Subtotal Slabs at grade						%

Reference equations (19.2 and 19.5 in S&K 6, Chapter 19)

Earned value (BCWP) = (actual percent complete) x (budget for the account)

Percent Complete (multiple accounts) = (earned value all accounts) / (budget value all accounts)

Check

Figure 2. An example of cloze question format from Moodle page

The story provided by the Cloze question would contextualize the problem. Then, learners would use the reference equations provided and input their calculations directly into the form. If the learner's answers were incorrect after two attempts, automated feedback would be provided to the student about where the errors occurred and which calculations were desirable. The automated feedback came from the Study Guide, including references to chapters and renderings of fully solved equations. With a strong question and feedback mechanism in place, the knowledge check became an important tool for accomplishing more complex learning objectives,

where learners needed to identify formulas, apply the basic time value formulas to simple story problems, and solve complex equations.

Feedback also came from the instructor and teaching assistant for the course. Moodle's assignment tool facilitates the delivery of assignment sheets that are to be completed in sequence and that challenge learners to apply complex problems common in cost engineering. Once a learner submits the assignment, the grader receives an email notifying them of the submission. The grader then assesses the assignment and provides detailed feedback and a score. The learner then receives an email that the assignment has been assessed and that feedback has been given. Learner's have unlimited attempts to complete an assignment, but all assignments must completed in sequence in order to qualify to take the exam for the course.

While Moodle's built-in activities are useful, learning to utilize Moodle's extended potential is an ongoing process. With the new Cost Engineering course, we used a combination of custom coding and supported plugins to better support Universal Design principles and overcome some of the the "sins" of the original version of the course. A summary of these are as follows:

Plugins

- Herald Theme - chosen because it is a responsive theme that resizes content for different screen sizes and for tablets and mobile devices
- Grid Format - organizes the course like a grid, where each course topic has a title and an icon and where both linear and nonlinear navigation of the course is possible
- Progress Bar - provides a visual indicator of the learners' progress through the course
- Grade Me - provides a visual indicator of which assignments require grading by the teaching assistance
- Enrollment Timer - provides a countdown clock for the completion of the course and emails the learner when their enrollment is close to expiring

Custom styles

- Collapsible lessons - this is a hand coded CSS rule that creates collapsible lessons within each topic
- Visual styling - custom rules to build a more unified visual identity for the course
- HTML scheme - providing visual cues for activities and resources, and all links to course materials within the lesson plan open in a new tab so that learners can easily navigate to and from the course site and the materials they wish to interact with

These plugins and styles were answers to questions asked during the development of the course: How can we adjust to meet professionals' schedules? How can we modify the course for differently abled learners? How can we facilitate asynchronous interactions between instructor and learner? How can we make the course easy to navigate by minimizing the amount of scrolling and clicks? The goal for asking these questions was to create a course site that clearly communicates both linear and nonlinear ways of consuming the content while also encouraging clear paths of interaction between learner and the course materials regardless of which device a

learner has access to. On the whole, these plugins and custom styles made the course more appealing, flexible, intuitive, and perceptible to learners.

For example, Herald is a dynamic theme that automatically resizes site text, video, and interactive elements so that they are viewable at different screen widths. This added flexibility means that learners can easily access the course from a variety of devices: desktops, laptops, tablets, and smartphones. The theme also reorders content so that interactive elements are not rendered unusable by shrinking items to sizes too small for a learner's fingers to operate, a feature that is essential for learners using mobile devices to interact with knowledge checks. The Grid Format plugin allowed us to arrange all the course modules on the page as building blocks of knowledge, or topics that can be navigated linearly by following a numeric path, or non-linearly by moving from topic to topic at the learner's own pace.
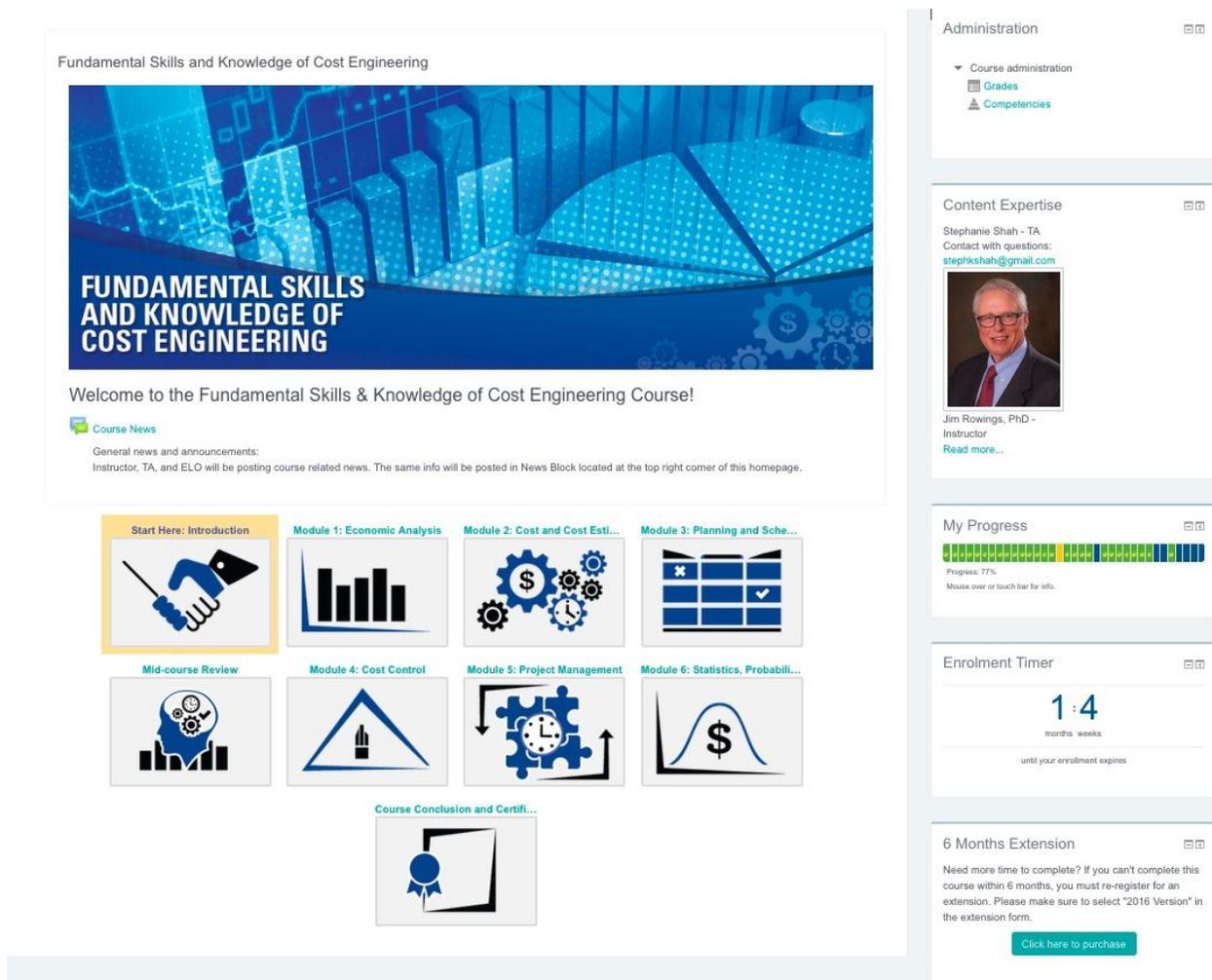

Figure 3. Course home page on Moodle page

To compliment the theme and grid format, the lesson plans are comprised of a combination of hand-coded HTML and CSS that work in tandem to minimize scrolling and provide clear visual

cues for course resources. First, Headings provided a visual hierarchy to communicate the importance of each element on the page; heading 1 was used to highlight the learning objectives for the module, heading 2 was used to denote the collapsible lesson plans, and heading 3 was used to denote each step within the lesson. The lessons were styled to be collapsible so as to minimize scrolling. Within the collapsible lessons, there are book icons used for readings, video icons used for lectures and supplementary materials, test icons used to denote knowledge checks, and handout icons used to denote major assignments.

Figure 4. An example module breakdown on Moodle page

We also added extra resources to help learners navigate asynchronously through the course. The Progress Bar plugin provides a checklist of tasks for learners to complete throughout the course. Second, the Enrollment Timer keeps the learners informed about how long they have until the course must be completed. Third, the grade book allows learners to see real-time reviews of their scores on knowledge checks and assignments.

By combining a well-designed html scheme with a dynamic theme, there was substantial contrast content delivery resources such as readings and videos, or interactive elements such as knowledge checks and assignments. In addition, headings and alt-tags were used to denote both

the kind and arrangement of content, so that information was accessible to audio learners and the blind. This combination of plugins and coding allowed our department to design with Universal Design Principles or flexibility and perceptible information in mind, resulting in more usable experience for learners.

V. Lessons Learned and Future Plans

Lessons Learned

There are lessons that we learned early in the implementation of the new Fundamental Skills and Knowledge of Cost Engineering course. Our previous correspondence course focused primarily on modeling basics skills for knowledge acquisition without extending the lessons to facilitate how learners can either make meaning, or transfer their skills to authentic contexts. This is to say that teaching is not something that can be told; the learner has to actively construct meaning. Thus, our role as educators expands from a knowledge presenter to a facilitator of meaning making and a coach giving feedback and advice about how to use content effectively. This constructivist approach inspired our decisions throughout the re-design and development process. As result, our department decided to make the backward design an integral part of future professional development course design and development.

Second, we consider our collaboration with the SME throughout an iterative design and development process where instructors, designers, and learners worked together to improve the overall design of the course one of our biggest successes. This largely contradicts the general practices in professional development course design and development practices, where the design and development processes are decoupled, the SME is merely seen as the content source, and the course development is done by an instructional designer. Contrary to this general practice, involvement of SME into every stage of the process created an ongoing process for all stakeholders. Although this method is relatively more challenging to accomplish, we also believe that it plays an essential role in our success.

Two significant challenges with the older course were retention and engagement. We knew from our reports that some students would abandon the course before completion, and we inferred from learners' data and survey results that learners may not have been suitably challenged within a year-long time frame. In response, we shortened the time allocated for learners, six months compared to the year, and increased the number of activities and resources that helped learners meet the course objectives. We feel that because there are more activities and resources within a narrowed time frame to complete them that the new course keeps learners considerably more engaged. So far, learners in the course are interacting frequently and consistently.

We have already changed some activities based upon learner's feedback for the new version of the course. For example, we originally called the knowledge checks "quizzes," since this was the Moodle tool that we used to build them. But we found that our adult learner's ideas of "quiz" differed significantly from typical students. Even though these activities were not graded, adult learners wanted to do well on them simply because they expected quizzes to be assessed as part of the grade for the course. Because of this, the experienced undue anxiety over their

performance on these assessments and, in some case, they avoided the "quizzes" all together as a means of avoiding anxieties over their performance. This created an unforeseen obstacle; because, as explained in stage 2 of the design process, quizzes were thought to create a lieu for learners to practice and enjoy learning from their mistakes. Because of this, we changed the titles of these activities to "knowledge checks" in order to foreground they are ungraded assessments that are meant for learning through low-stakes trial and error.

Future Plans

Although we have some data, in the near future, we will compare the learner scores between the assignments and knowledge checks within the new course to that of the assignments of the legacy course.

With the new course, we are aiming to increase the number of learners that complete the course successfully. 269 learners registered the course between 2008 and 2015. Only 96 of them completed the course successfully. An examination of the learners' data showed us that learners dropped the legacy course because it lacked interactive activities and clearly defined objectives for the challenging lessons. Those learners who did not complete the course oftentimes received low scores in such lessons that happened to be the first three lessons of the legacy course. Moreover, qualitative data collected from the surveys as well as anecdotal data from the professional development director of our department highlighted that some of the learners found the content of the legacy course outdated. Thus, moving forward, our plan is to collect and continuously analyze the data from the new course to see whether we have successfully mitigated these challenges.

	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6	Lesson 7	Lesson 8	Lesson 9	Lesson 10	Lesson 11	Lesson 12	Lesson 13	Lesson 14	Lesson 15
Mean	85.57291667	84.8333333	95.1979167	96.4479167	94.5416667	85.3020833	91.15625	89.1875	94.25	93.66666667	94.96875	92.875	93.23958333	96.34375	97.95833333
Standard Error	0.872803608	0.99424514	0.54624311	0.61270714	0.6376211	1.09755708	1.04065686	0.92649979	0.474572753	0.639981268	0.795333584	0.69241663	0.768734548	0.742628707	0.400634548
Median	87	85	96	100	95.5	88	95	92	95	95	100	95	95.5	100	100
Mode	90	100	100	100	100	94	100	100	98	100	100	100	100	100	100
Standard Deviation	8.551693943	9.74157306	5.35206756	6.00327944	6.24738542	10.7538192	10.1963132	9.07780695	4.649844366	6.270510206	7.792645825	6.784269731	7.53202956	7.276245598	3.925400862
Sample Variance	73.1314693	94.8982456	28.6446272	36.039364	39.0298246	115.644627	103.964803	82.4065789	21.62105263	39.31929825	60.72532895	46.02631579	56.7314693	52.94375	15.40877193
Kurtosis	-0.72673135	-1.1714815	2.28681229	3.48516479	2.04901602	5.54123954	-0.1251175	-0.7906307	5.96663602	0.173229061	2.132656459	0.8281458	0.91809061	17.1198804	4.248626336
Skewness	-0.268982216	0.04337648	-1.5126378	-1.9608133	-1.4255775	-1.6233536	-0.9780098	-0.5556309	-1.94080165	-0.90104998	-1.68002535	-1.09143739	-1.24443753	-3.46636531	-2.11697858
Range	32	30	25	27	28	68	40	30	29	25	30	28	29	50	18
Minimum	68	70	75	73	72	32	60	70	71	75	70	72	71	50	82
Maximum	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Sum	8215	8144	9139	9259	9076	8189	8751	8562	9048	8992	9117	8916	8951	9249	9404
Count	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96

Table 2. Descriptive statistics of legacy course data

We have already begun revising the assessments to better meet the needs of learners. For example, the Cloze question format within the knowledge checks poses a significant challenge. The tool requires complex coding to forgive errors in spelling, or if a word is not written exactly as was documented in the Study Guide. Our department could not predict small variations in learner's answers, such as rounding the 10th instead of the 100th (as is documented in the Study Guide does). Despite this challenge, there are opportunities to improve the tool. We worked

between the learners, the TA, and the instructor to determine a range of possible answers beyond what is in the guide. We would then expand the code of the tool to accommodate a greater range answers. Working in complement to the teaching assistant's feedback on major assignments, learners could receive immediate feedback on smaller but suitably complex problems. While it was neither possible, nor desirable to teach to the certification test, questions like these provide a challenge greater than simple multiple choice assessments, while still providing necessary feedback to the learner.

We are planning to revisit the existing surveys and utilize them to collect more insights regarding to learners' experiences with the course. Specifically, we would like to learn more about learners' overall experience in the course and types of changes that they observe and make in their professional practices that are essentially derived by the knowledge and skills that they gained from the course. An important point within backward design framework is to recognize that factual knowledge and skills are not taught for their own sake; but, as a means to larger ends. Acquisition of content is a means to make meaning and knowledge transfer. Ultimately, the goal of any learning environment should equip learners to be able to use or transfer their learning. We believe that to truly measure the efficacy of Fundamental Skills and Knowledge of Cost Engineering course requires a critical self-assessment of our learners' knowledge base development. We think restructuring the surveys will be providing a milieu for them to do so and for us to detect and ameliorate the shortcomings of the course.

References

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