AC 2012-5328: PEDAGOGY FOR PEDAGOGY: USING A WIKI TO PROMOTE THE ADOPTION, DEVELOPMENT, AND IMPLEMENTATION OF CHALLENGE-BASED INSTRUCTION IN STEM EDUCATION

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Pedagogy for Pedagogy: Using a Wiki to promote the adoption, development, and implementation of Challenge Based Instruction in STEM education

Abstract

Finding an effective new pedagogy with a proven record of advances in student efficacy and efficiency while challenging may be easier than establishing widespread adoption of such methods in academia. Challenge Based Instruction (CBI) is an inductive problem based teaching method that carefully encourages student exploration along optimal learning paths. Students are attracted to the learning objectives defined by the instructor using creative and carefully designed challenges presented to the students prior to the delivery of course content. This significant shift in classroom delivery, although proven to be effective, can be a difficult adjustment for faculty who have been neither a student nor teacher in a CBI course. As a part of a three year collaborative Department of Education grant to support the adoption of CBI in STEM fields, a Wiki was developed as a repository and resource of CBI course content using a method of backwards design and the Legacy cycle. Development of the Wiki was supported by over 100 STEM faculty from two institutions who participated in over 20 hours of workshops and workdays. The Wiki is comprised of participating faculty briefs on the development and implementation of a single CBI lecture for a STEM course. Over the course of the three year grant as new groups of 20 cycled through the workshops, the Wiki briefs served as a powerful resource for new faculty and as a useful platform for ongoing development and interaction. The site has recently been adopted for use with a Department of Defense grant to further promote CBI among faculty at four additional institutions. The methods used to develop and promote the site, the significant materials and templates developed, and the challenges faced and successes experienced in widespread adoption of a new pedagogy are presented along with conclusions on the usefulness of a Wiki for faculty development.

Introduction

There is great interest, investment, and involvement in the discovery of new teaching methods and tools that will improve student learning and in turn positively impact student retention, time to graduation, and future success in their respective careers. Fields, especially in the sciences and engineering, are growing and maturing fed by improved tools for communication and research. The ever changing landscape of technology within and outside of the classroom and its impact on student culture makes the challenge of discovery a dynamic one. However, discovery alone may not be the greatest challenge. Finding an effective new pedagogy with a proven record of advances in student efficacy and efficiency while challenging may be easier than establishing widespread adoption of such methods in academia.

The resistance to a change in pedagogy is both institutional and individual. The typical teaching model is a single instructor teaching large groups of students in a classroom setting for fifty minutes three times per week. Although there are deviations from this model (labs, mentoring, independent study, etc.) it is difficult to conceive of a pedagogy that an institution would support and embrace that significantly changes this model. New faculty may be resistant to experiment with teaching methods because of the impact it may have on teaching evaluations and ultimately tenure decisions. Some

pedagogical methods require more time or smaller classes which could lead to greater educational costs. Finally, the pedagogy used by the faculty development team, in the case of an institutional training initiative, will likely impact both the nature and extent of implementation of the pedagogical method being promoted.

Clearly there are a host of factors beyond student learning that to some extent make all pedagogies difficult to disseminate and implement. Every new effective pedagogical method will encounter obstacles in dissemination and implementation that must be effectively addressed before they will see widespread adoption. This paper presents the use of Wiki's for faculty development activities to addresses significant obstacles encountered in training faculty in the use of a proven effective pedagogy called Challenge Based Instruction.

Challenge Based Instruction

To promote student engagement and success in STEM areas, a comprehensive plan for faculty development was implemented at two Hispanic Serving Institutions (HSIs), the University of Texas-Pan American (UTPA) and South Texas College (STC). The faculty development program was designed to support the adoption of Challenge Based Instruction. This program was initiated as part of a large Department of Education College Cost Reduction and Access Act (CCRAA) grant. Detailed information about the different activities and sample results can be found in previous proceedings of ASEE National Conferences[1,2,3]. A series of training workshops and mentoring workdays are part of this faculty development program that presents the latest research in effective pedagogies to college faculty interested in engaging a large number of Hispanic and low-income students in South Texas. Among the goals of the CCRAA grant was to create a lasting positive change in student learning in both institutions by developing a highly trained faculty group able to assume and sustain the training role in Challenge Based Instruction (CBI) after the grant was over. CBI was selected as the primary pedagogical approach because of the evidence of this pedagogy to produce positive results with the college student population. This pedagogy is based on the principles of "How People Learn" and the STAR Legacy cycle. CBI is a form of inductive learning, which has been shown to be a more effective approach to the learning process than the traditional deductive pedagogy[4,5] and incorporates cognitive and affective elements recommended for retaining underrepresented students[6-8]. This teaching method can be explained as teaching backwards since it provides a real life learning environment where the problem/challenge is introduced first and the supporting theory/principles second. It was determined that the most effective way to introduce a new pedagogy to faculty was to use this pedagogy in the faculty development program. Thus, faculty members are able to experience the learning environment from a student's perspective.

The faculty development activities use an implementation of CBI closely related to the STAR Legacy Cycle[9]. As described in the literature, this cycle "is an exemplar of an inductive approach to teaching and learning"[10] and contains a directed sequence of steps that immerses the learner in the four dimensions of the How People Learn (HPL) effective learning environment and provides a framework for CBI and the design of associated learning activities[11]. The suggested cycle is illustrated in figure 1 and it is described below from the perspective of the faculty development program. As described in the literature, the legacy cycle contains steps or activities that appeal to different learning styles[10]. Furthermore, most engineers relate to this

cycle since most of the activities align themselves nicely with key phases of the engineering design process[13].

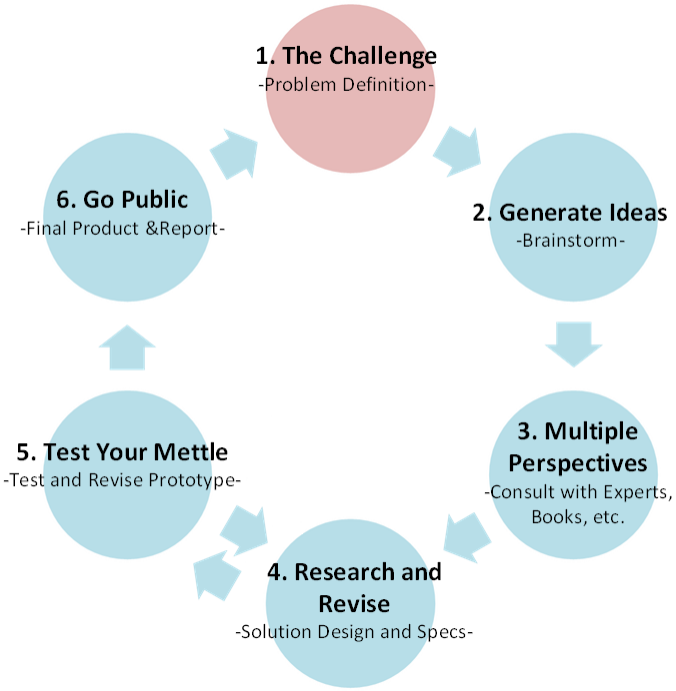

Figure 1. Legacy Cycle and its Mapping with the Engineering Design Process

The Legacy Cycle is used within the faculty development trainings to engage faculty in CBI as they work through the following steps:

- *Look Ahead (Not shown in the Figure)*: The learning task and desired knowledge outcomes are described here. Faculty are given a clear objective that at the end of the faculty development training they will have both the knowledge and course material to develop an effective lecture using CBI that will guide students to a deeper level of understanding than their current teaching methods provide. Faculty are presented with studies that show the measureable positive impact on student learning through CBI giving them a clear expectation of what can be accomplished. This information is conveyed through a short lecture presentation.
- The Challenge: The challenge is a question or task carefully designed to focus the learner on the learning objectives. The primary challenge given to faculty is to develop a 50 minute CBI lesson that covers a lecture topic from one of their courses by the end of the workshop series. Faculty are given time during the workshop and two workdays to complete the task.
- Generate ideas (*Learner and community centered).* Participants are asked to generate a list of issues and answers that they think are relevant to the challenge; to share ideas with fellow participants; and to appreciate which ideas are "new" and to revise their list. *Difficulty*: Faculty work in groups to address their challenge however given the typical diversity of faculty in the workshops they are rarely working on the same lecture topic.

There is a need to connect faculty with other faculty who are teaching similar lecture content and attempting to implement CBI.

- Multiple perspectives *(Community and knowledge centered)*: The participant is asked to elicit ideas and approaches concerning the challenge from "experts." Several examples were presented during the workshop to faculty giving them exposure to how other faculty have implemented CBI in their courses. *Difficulty*: A common complaint arose in the first workshops that while the examples were helpful they needed to see an example in their own content area to fully understand CBI and to be convinced that it will work with their course.
- Research and revise *(Knowledge and learner centered)*: Reference materials to help the learner reach the goals of exploring the challenge and to revise their original ideas. Formative instructional events are useful in this step. A workbook, links to online resources, and a list of reference materials were provided to the faculty.
- Test your mettle *(Knowledge and learner centered)*: Summative instructional events are now presented. A post-workshop survey was taken to assess learning outcomes.
- Go public *(Learner and community centered)*: This is a high stakes motivating component introduced to motivate the participant to do well. *Difficulty*: Faculty are asked to publicly document their CBI course development process and an outline of their CBI lecture and receive feedback from other participants. This step is where faculty provide insights for learning to the next cohorts and is termed "Leaving Legacies" and hence the name of the cycle.
- *Reflect Back (Not shown in the Figure)* The participant is given the opportunity for self-assessment.

In the faculty development implementation of teaching a new pedagogy using the CBI Legacy Cycle three steps (Generate Ideas, Multiple Perspectives, and Go Public) presented significant difficulties as noted above. To address these difficulties within the constraints of the limited resources of the faculty participants and the workshop teams, the use of a dynamic online resource that could be supported by the participants themselves was implemented.

Tool for Collaboration and Motivation

To help promote the adoption, development, and implementation of Challenge Based Instruction in STEM education, a Wiki was developed as a repository and resource of CBI course content using a method of backwards design and the Legacy cycle. Thus, specifically this wiki allows for interaction among a larger population of faculty in the brainstorming of ideas for challenges. Additionally, the wiki provides faculty with the high stakes motivation phase (go public) of CBI leaving numerous accessible and discipline specific examples (legacies) for other STEM faculty.

A wiki is browser-based software tool which enables users to individually or collaboratively write, edit, and link HTML-based documents[14]. There are different platforms or types of Wikis depending on the usage and architecture with different strengths and weaknesses (e.g. Wikiversity, WikEd, etc.). The usefulness of the Wikis as a tool for collaboration is based, among other things, on the fact that documents can be created and edited with the use simple text editing facilities included in the software (i.e. without specialized knowledge or tools). There are different encouraging studies about the use of Wikis in education [15-18] and multiples reports on

diverse uses from undergraduate student learning environments to coordinating curriculum implementation. Important for the authors, literature shows that the visibility of Wikis' shared environment and sense of creativity promotes motivation[14].

Integration of a CBI STEM Wiki website with the faculty development workshop activities has grown in usefulness to workshop participants and has proven to be an efficient way of addressing difficulties in integrating CBI into the workshops. Integration was important to the authors because they believe that this pedagogy is effective, even if the students are faculty members, and that the faculty will be more highly motivated to adopt pedagogy that they have experienced themselves. The use of the Wiki website devoted to this CBI dissemination project facilitated the training process by improving the quality of the faculty workshops while also reducing the required time investment of faculty and the workshop team. Over several semesters, with the input of workshop participants, the site has grown to include a breadth of CBI examples that are now well integrated into the workshop activities. The site gives faculty a platform for sharing ideas in the "Generate Ideas" step of the process where faculty are likely to find input on the specific course and possibly the topic they are considering. In the "Multiple Perspectives" step, through the Wiki website, faculty now have access to detailed examples of CBI in most STEM fields (Biology, Chemistry, Computer science, Electrical Engineering Manufacturing Engineering and Technology, Mathematics, Mechanical Engineering, Physics, and Geology). Finally, after using the Wiki website throughout the workshop the faculty are motivated to add new examples to the resource and provide assistance to other faculty. The structure of a Wiki also facilitates the assessment and refinement process. This process is carried out by the users who in this case are most qualified and motivated to assess and refine the materials.

Thus, the developed Wiki website by the authors offered a friendly way for sharing knowledge among faculty members, an effective tool to motivate faculty, a ways to monitor learning, and a way to monitor individual faculty progress (i.e. individual accountability). Furthermore, the developed Wiki served as the means to promote the pedagogy, to collect documentation, and to facilitate knowledge creation.

Wiki Site Development and Promotion

Development of the Wiki was supported by over 100 STEM faculty from two institutions who participated in over 20 hours of workshops and workdays. The Wiki is comprised of participating faculty briefs on the development and implementation of a single CBI lecture for a STEM course. Over the course of the three year grant as new groups of 20 cycled through the workshops, the Wiki briefs served as a powerful resource for new faculty and as a useful platform for ongoing development and interaction.

In the Wiki website, backwards design is the method presented as a structure for the development of effective CBI. As the name suggests, the backward design framework first focuses on learning objectives and assessment before the design of the challenge. In order to provide faculty with an outline of the backwards design framework, a template was designed and made available to faculty at the wiki website. Figure 2 shows the CBI development template using the backwards design framework The template is usually completed in the workdays and initial feedback is provided by the group. By the end of the workdays, the goal is that each

faculty member would have developed and documented a lesson for their STEM courses using CBI. The goal is also to have CBI examples in the different STEM disciplines. In fact, the completed templates have served as a valuable resource for other faculty in subsequent workdays and for faculty who are finding out about CBI. Most faculty members that participated in the faculty development workshop have enthusiastically embrace the challenge to implement CBI in at least one of their STEM courses and assess the outcome. To date, more than 120 faculty members have completed the workshop and CBI course development workdays. A number of faculty and student surveys are being used to assess the level of implementation and identify where continued support is needed. The surveys also provide additional data to support the effectiveness of the pedagogy across several STEM disciplines and faculty demographics including experience, age, gender, and nationality. The wiki site has recently been adopted for use with a Department of Defense grant to further promote CBI among faculty at four additional institutions. As previously mentioned, it is expected that a cadre of faculty who experienced the effectiveness of CBI will inspire and train other faculty at all different institutions.

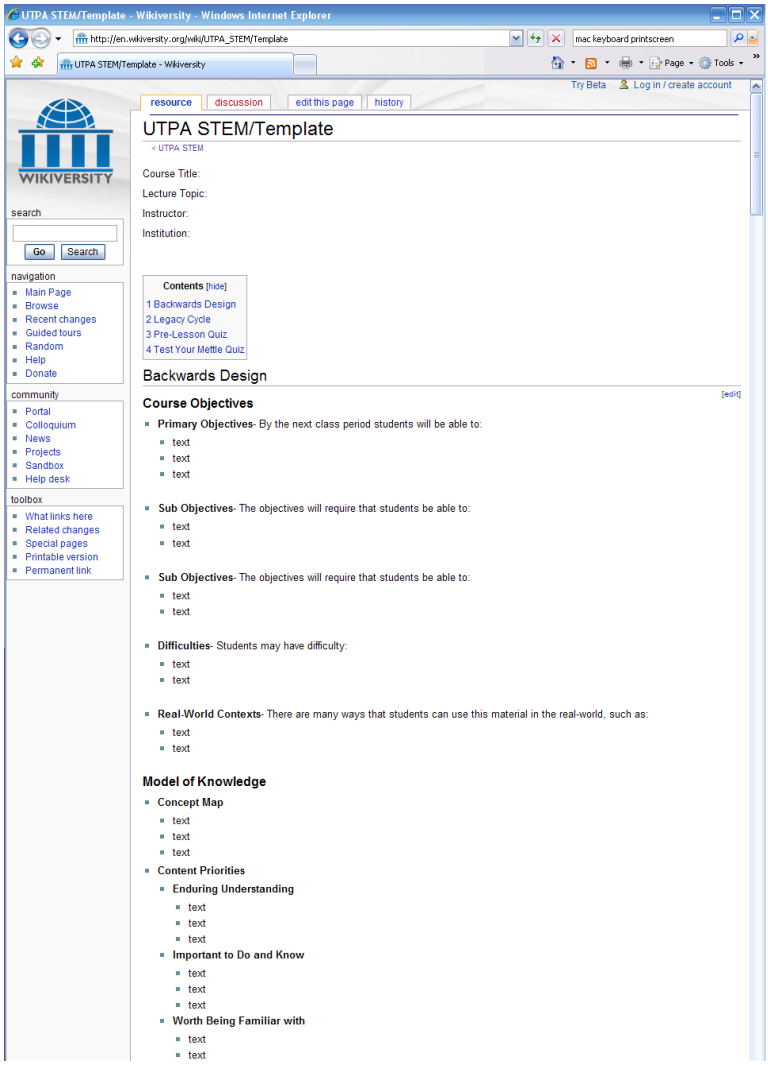

Figure 2. CBI Development Template at Wiki Website Using Backwards Design

Wiki CBI Examples

A partial list of the STEM courses that have implemented CBI include those listed in Table 1. STEM Wiki-Media platform can be found at *http://en.wikiversity.org/wiki/UTPA_STEM*. This website contains information for CBI content development and implementation for each of the courses in Table 1. To date the site includes CBI content covering approximately 80 STEM courses developed by over 120 STEM faculty from two institutions. Several of the courses on the web site include multiple CBI challenges that cover several content areas. The Introduction to STEM course is an example of a course listed on the web site that covers a variety of course content with multiple challenges. As an example, the design and implementation template for one of the Challenges for Thermal Systems Design and Optimization is shown in Figure 3. The STEM Wiki website can be searched by course, topic, instructor, or institution as shown in Figures 4-6. Both the standardized structure and the wide variety of examples make it a useful tool for beginner and advanced STEM CBI developers. The STEM Wiki website has been and effective public forum for the CBI learning community and posting of CBI materials to the Wiki website has continued after the faculty development workdays.

Table 1. Selected List of Course Content Posted on CBI Website

Anatomy and Physiology	Design of Steel Structures	Manufacturing Processes Lab
Applied Linear Algebra	Digital Systems	Measurements
Applied Hydrology	Dynamics	Mechatronics
Aquatic Entomology	Educational Testing	Microbiology
Assembly Programming	Element Algebra	Microprocessor System Design
Animal Parasitology	Elementary Statics and Probability	MEMS & NEMS
Beginning Machining	Engineering Economics	Numerical Methods and Statistics
Business Algebra	Environmental Chemistry	Nutrition
Business Calculus	General Chemistry I	Operating Systems
Biology I	General Chemistry II	Organic Chemistry
Biology II	General Microbiology	Organic Chemistry II
Biomedical Engineering	General Physics I	Particles and Waves
Calculus I	General Physics II	Physical Chemistry
Calculus II	Geometry and Measurement	Physics I for Engineers
CAM	Graduate Seminar	Physics II for Engineers
Cell Biology	Engineering Graphics	Precalculus
Circuits II	Intermediate Algebra	Probability and Statistics
College Algebra	Introduction to Mechanical Engineering	Quantum Mechanics
Computer Networks	Introduction to STEM	Soil Mechanics
Communication Theory	Introduction to VLSI	Statics
Computer Science	Materials	Thermodynamics
Databases		
Data Structures and Algorithms		

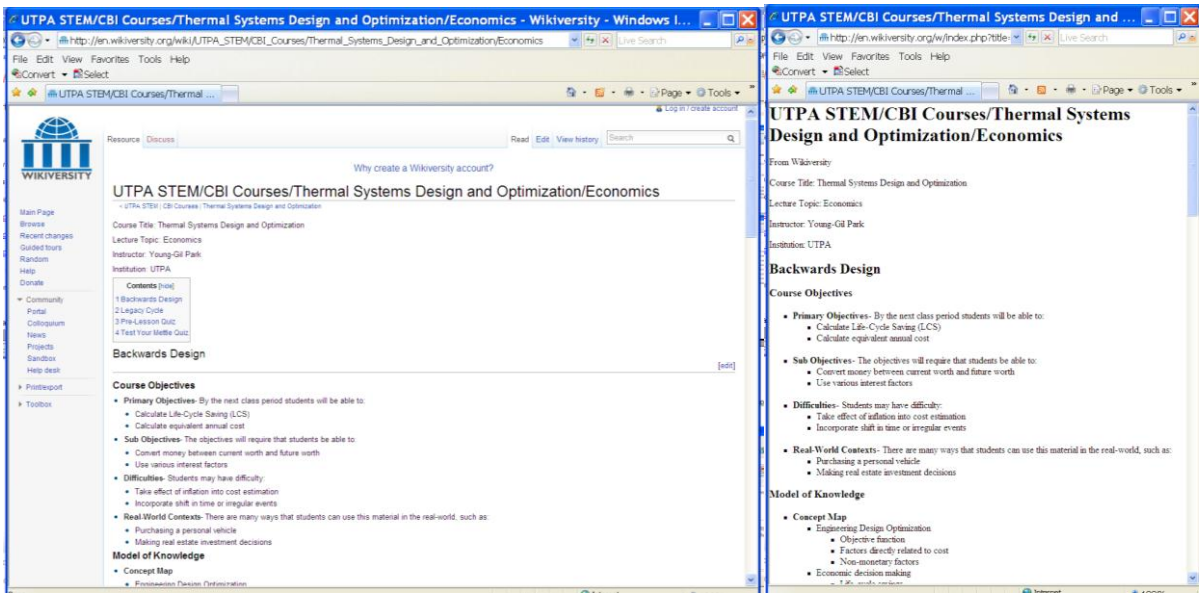

Figure 3. Example of CBI Design and Lecture Content Posted on CBI Website and Printable Version.

Figure 4 UTPA STEM Wiki-Media Platform

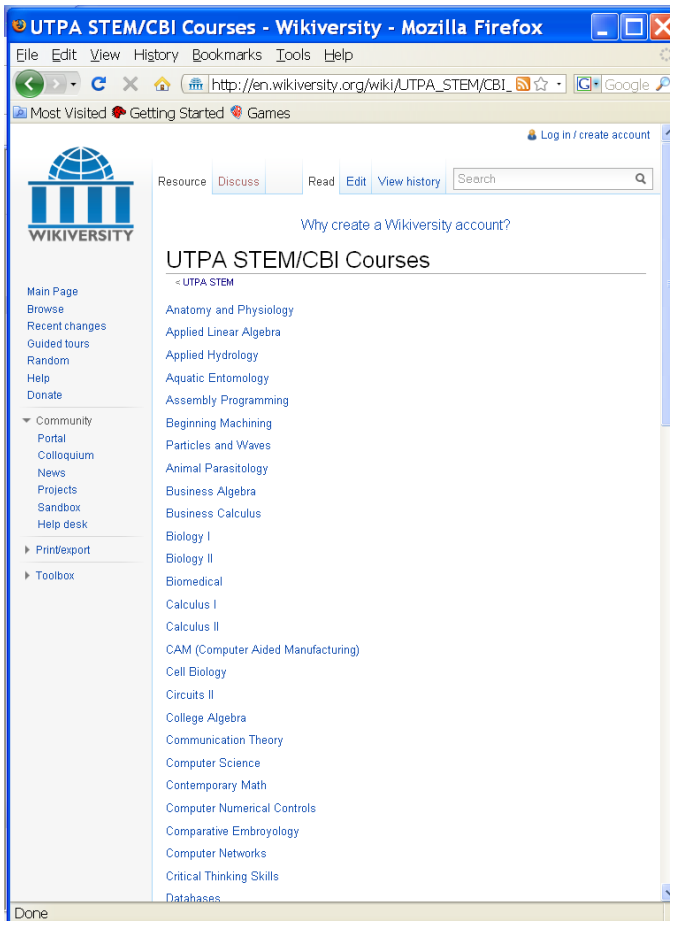

Figure 5 Example of CBI Courses in UTPA STEM Wiki

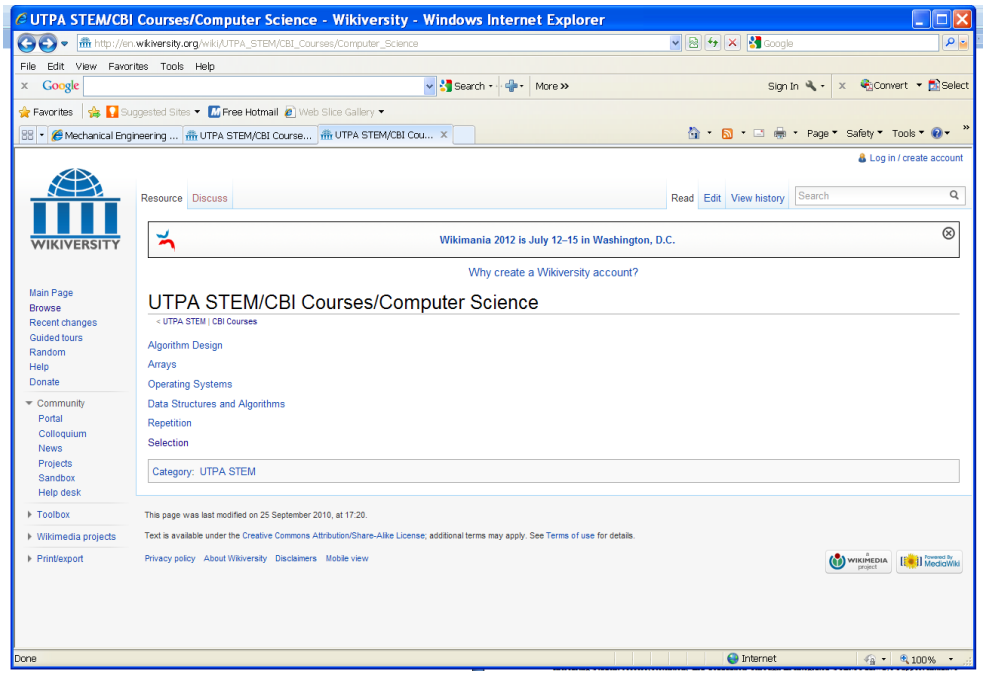

Figure 6 Examples of Challenges in Computer Science

Lessons learned: Successes and Challenges

Faculty who participated in the faculty development program have been browsing the CBI lecture content on the wiki website for ideas as they create their own content. Faculty interested in learning and/or finding about CBI have also access the wiki website. The wiki website has proven to be an asset to many faculty, including faculty who rotate in teaching various STEM courses, who are looking for the latest pedagogical improvements for their courses. The structure of the wiki website is easy to browse by instructor, course name, and lecture topic. Faculty participants who had little exposure to the use of wikis as part of a learning environment were exposed to and became familiar with the use of this emerging tool. Additionally, the current wiki-media platform allows for the growth of the site as instructors add new content and comment or add to existing content. The examples below have been highlighted as exemplars of CBI course content at *http://en.wikiversity.org/wiki/UTPA_STEM/CBI_Courses*:

- Thermal_Systems_Design_and_Optimization/Economics
- Manufacturing_Processes_Lab/t-statistic
- Introduction to STEM

The first two examples were chosen because they are good examples to show first time implementation of CBI for beginners that are not threatening to faculty and students. The scope and complexity of these challenges fit within the context of a single lecture and would demonstrate typical cost and learning outcomes of CBI. The third exemplar illustrates the success of the wiki environment where a user goes beyond the expectations by posting multiple challenges on the STEM CBI wiki website.

Among the challenges encountered with the implementation of the wiki website is the need to backup the information periodically in case users accidentally overwrite information. This is primarily a problem with new users. Supervision and tutorial materials may be required to address this issue. Occasionally, some faculty members had difficulty navigating and using the wiki website. Faculty were provided with assistant in developing the materials on site or give the option of completing the template on their own platform (MS Word) and assistance was provided to upload their information. Although the open format allows for easy user development and collaboration, it also introduces the possibility of malicious attack. Possible ways to address this threat include periodic backups and limiting editing access to approved users.

Conclusions

The use of a Wiki devoted to faculty development proved to be an invaluable resource assisting the dissemination of a new pedagogy to STEM faculty. The wiki website was used to support several elements of CBI used throughout the faculty develop activities. Most importantly the wiki facilitated the documentation and transfer of CBI examples from 120 STEM faculty who participated in a faculty development workshop and now serves as a significant resource for future CBI course development. Although the initial structure was setup by the developers (templates and a few examples) the majority of site has been developed and maintained by the users. The site has recently been adopted for use with a Department of Defense grant to further promote CBI among faculty at four additional institutions. Future work includes additional

evaluation studies to further understand how the Wiki website facilities faculty's collaborative learning.

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