A Model Workshop for Helping New Faculty Engage Students in the STEM Classroom

Dr. Clifton B. Farnsworth, Brigham Young University

Clifton Farnsworth received B.S. and M.S. degrees in civil engineering from Brigham Young University and a Ph.D. in civil engineering from the University of Utah. He worked as a geotechnical engineer for eight years with the Utah Department of Transportation, spent three years as an Assistant Professor of civil engineering at The University of Texas at Tyler, and has a current appointment as an Assistant Professor of construction and facilities management at Brigham Young University.

Dr. Donna Harp Ziegenfuss, University of Utah

Donna Harp Ziegenfuss, is an Associate Librarian in Graduate and Undergraduate Services in the J. Willard Marriott Library at the University of Utah. She has an Ed.D. in Academic Leadership/Higher Education and an MS degree in Applied Technology/Instructional Design. She has over 10 years of experience teaching, designing instruction, and doing qualitative research both in and outside of a library context. Her research interests focus on library and technology-based instructional planning and course design, assessment and evaluation topics, as well as online teaching and learning.

Dr. Matthew W Roberts, Southern Utah University

Dr. Roberts has been teaching structural engineering topics for 15 years. He recently joined the faculty in the Engineering & Technology Department at Southern Utah University.

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Abstract

In May 2016 a workshop entitled "*Engaging Students in the STEM Classroom*" was presented to faculty at Southern Utah University. Although not exclusive to new faculty, the target audience and predominant attendees, were new faculty from the science, technology, engineering, and math (STEM) disciplines on campus. The three-day workshop focused on basic principles of effective learning and teaching, aligning learning outcomes to assessments and teaching activities, methods for active learning, and strategies for effective classroom presentation. The workshop curriculum was centered around the following goals: 1) promoting broader awareness of alternative teaching strategies for STEM classrooms, 2) increasing faculty comfort level in using alternative teaching strategies, 3) increasing adoption of active learning and other evidence-based pedagogies, 4) building a campus community dedicated to improving teaching, and 5) increasing multi-disciplinary collaborations amongst faculty attendees. The purpose of this paper is to provide an example of a model workshop designed to help new faculty engage students in STEM disciplines, and includes the planning, implementation, and assessment of this workshop. The paper begins by introducing the development of the workshop, including the logic model and assessment plan, the curriculum outline, and preparation processes. The paper also explores the implementation lessons learned. Finally, this paper includes the assessment results of the effectiveness of the workshop in meeting the workshop goals. This includes a pre- and post-workshop comparison of the participant's attitudes regarding evidence based pedagogies and their perceived competency in using them. This paper is useful for engineering educators in developing teaching expertise, researchers interested in faculty attitudes and perceived competency in using alternate teaching strategies, and faculty and administrators planning to create professional development opportunities to help faculty of all levels become more proficient in evidence-based pedagogies. This paper also serves as an example of a model workshop to develop interdisciplinary communities of educational practice, as well as strengthen the abilities of a new faculty in establishing an engaging and effective classroom.

Introduction

In May 2016 a workshop entitled "*Engaging Students in the STEM Classroom*" was presented to faculty at Southern Utah University (SUU). This three-day faculty development workshop was designed through a collaboration of two engineering faculty and a faculty developer from three different institutions, who were previously introduced during an NSF grant-funded engineering infrastructure curriculum development symposium. Although not exclusive to new faculty, the target audience and predominant attendees, were new faculty from the science, technology, engineering, and math (STEM) disciplines on campus. The three-day workshop focused on basic principles of effective learning and teaching, aligning learning outcomes to assessments and teaching activities, methods for active learning, strategies for effective classroom presentation, and demonstrations of effective classroom presentation techniques. The workshop fully supported the mission and strategic plan of SUU, which has "engaging students" as a major theme. The goal of the workshop was to help faculty, especially new faculty, create more engaging classrooms that will lead to higher retention, and more engineering and science

graduates. The workshop curriculum was centered around the following goals: 1) promoting broader awareness of alternative teaching strategies for STEM classrooms, 2) increasing faculty comfort level in using alternative teaching strategies, 3) increasing adoption of active learning and other evidence-based pedagogies, 4) building a campus community dedicated to improving teaching, and 5) increasing multi-disciplinary collaborations amongst faculty attendees.

The workshop facilitators were selected because of their extensive experience in helping other faculty provide an engaging learning experience for students. The three collaborators used a logic model planning process[1] to identity and align the workshop program goals with learning activities, outcomes, and impacts. All three collaborators were involved in teaching, demonstrating teaching strategies, and facilitating discussion during the workshop. Initial inspiration during the development of this workshop was drawn from the American Society of Civil Engineers (ASCE) Excellence in Civil Engineering Education (ExCEEd) teaching workshop, which two of the workshop facilitators had attended. This workshop was intended to be an "ExCEEd style" workshop, particularly with regard to providing participants a chance to teach each other and receive feedback during the workshop. The purpose of this paper is to provide an example of a model workshop designed to help new faculty engage students in STEM disciplines, and includes the planning, implementation, and assessment aspects of this workshop. The paper begins by introducing the development of the workshop, including the logic model and assessment plan (see Appendix A), the workshop content and learning objectives (see Appendix B), and preparation processes. The paper also explores the implementation lessons learned. Finally, this paper includes the assessment results of the effectiveness of the workshop in meeting the workshop goals, including a pre- and post-workshop comparison of the participant's attitudes regarding evidence based pedagogies and their perceived competency in using them. This paper is useful for engineering educators in developing teaching expertise, researchers interested in faculty attitudes and perceived competency in using alternate teaching strategies, and faculty and administrators planning to create professional development opportunities to help faculty of all levels become more proficient in evidence-based pedagogies. This paper also serves as an example of a model workshop to develop interdisciplinary communities of educational practice, as well as strengthen the abilities of a new faculty in establishing an engaging and effective classroom.

Literature Review

In higher education, changing student demographics and an evolving pedagogical literature about how people learn demands consideration of new or alternative teaching approaches in college classrooms.[2,3,4] A seminal education article by Barr and Tagg[5] made a case for shifting from a teaching paradigm to learning paradigm, and set the stage for new a new body of literature on learner-centered teaching[6] and the benefits and challenges of active learning.[7,8] However, active learning implementation, which requires reducing time of lecture in the classroom and increasing the time of active engagement in learning activities, is not as widely adopted as thought. A recent meta-analysis study of 225 other academic studies looking at the differences between student performance in lecture and active learning classrooms has subsequently generated more interest in how to facilitate an active learning environment, thus enhancing the importance and visibility of this topic.[9]

Teaching in an active learning classroom requires a shifting from a teaching "sage on the stage" persona to a "guide on the side" facilitation style of teaching, and more rigorous pre-course planning.[10,11] Unfortunately, higher education faculty do not traditionally receive training in course design and often only receive their teacher training through trial and error experiences in the classroom or through occasional faculty development workshops.[12,13,14] However, Ho et el. (2001) contend that faculty need a faculty development experience beyond a single workshop where they can interact and learn from other faculty and where they can integrate teaching knowledge with hands-on teaching activities.[15]

There are also numerous references in the engineering education literature that support the value of active learning. Active learning studies have documented how students learn: while working in small groups;[16] when using online lectures to allow more face-to-face time for applied learning;[17] and when exploring and analyzing case studies.[18] Active learning has also been found to effectively support multiple learning styles far more effectively than traditional lecture-based courses.[19,20] During the development opportunity, there also must be tools to measure how faculty perceptions about teaching in a more active learning environment change, not just their actions. In this program, we measured the pre and post-workshop perceptions of the faculty participants about active learning strategies and using a different process for designing instruction. By using the Fink Model of Backwards Design[10] we focused on helping faculty to think differently about course design and instruction by going to the end of instruction, setting outcomes, and working backwards to design the course. This faculty development workshop also included the component of social aspect of learning with other faculty in a learning community,[21] where they learned new content and strategies, observed demonstrations of new strategies and then integrated what they learned, and taught a brief excerpt of a lesson to their peers and received feedback from the community of learners. Also used as an assessment tool for this workshop is an instrument called the Concerns-Based Adoption Model (CBAM),[22,23] to measure how workshop participants thinking and concerns about active learning changed across the workshop. This tool has been used in both K-12 and higher education contexts to plot a visual profile that demonstrates how participants concerns change over time.

Faculty instructional development is important for several reasons, including meeting accreditation standards, retention of engineering students, and in order to benefit from recent advances in cognitive sciences.[24] The workshop described in this paper included several topics recommended by Felder, et al., such as writing and using learning objectives, engaging students, effective lecturing, and active learning.[24] The curriculum for this workshop was also informed by the ASCE ExCEEd teaching workshop, which is based on the following aspects of the ExCEEd model for effective teaching: creating structured organization, maintaining an engaging presentation, generating enthusiasm, establishing positive rapport with students, providing frequent assessment of student learning, using technology appropriately, and the teacher serving as a positive role model.[25] Key elements from the ASCE ExCEEd teaching workshop are readily available in the literature, including the following: using the board,[26] organizing and delivering classroom instruction,[27] using questioning techniques to engage students in active learning,[28] incorporating suspense and surprise in the classroom,[29] using physical models and other demonstrations,[30] the ExCEEd model as a model instructional strategy,[31] and methods for assessing teaching.[32] Since the ExCEEd teaching model already serves as an example workshop for training new faculty[33] and has been proven to be effective for training new civil engineering

faculty,[34] a number of these key elements were drawn upon for our own workshop. However, we also wanted to focus this workshop more heavily on incorporating elements of active learning and curriculum design, and these additional elements were included within our STEM faculty development workshop. Further, the authors acknowledge that although the ExCEEd teaching workshop has filled a fairly high demand within civil engineering, it can't, unfortunately, meet the needs of all new faculty across all engineering and especially other STEM disciplines nationally. This paper serves to hopefully inspire others to step forward on a more local level and begin to fill this need.

Workshop Administration and Logistics

The workshop development process was a truly collaborative effort of three individuals at three different institutions in one state, using "backward design" to articulate their vision for the three-day workshop.[35] The authors began the workshop development process by first developing a logic model. This document defined the inputs (necessary resources to accomplish workshop goals), activities (measurable deliverables), and outputs (evidence of progress) that were sought after in this workshop. From that vision, short (soon after the workshop), medium (one to three years), and long term (three to seven years) outcomes were established. The logic diagram developed for this workshop can be found in Appendix A. The logic diagram then naturally lent itself to the further development of the corresponding content, learning activities, formative assessments, and workshop agenda. During the workshop preparation phase, an online supplementary website was developed in the campus learning management system (LMS) that could continue to be used after the workshop series was over. The LMS that was selected was already used by two of the three participating institutions. The materials used for this workshop are available at this site: https://utah.instructure.com/courses/368648. The event was planned so that participants would have some didactic sessions, some demonstration sessions, and then an opportunity to use what they learned and create a short teaching exercise for peer review. The SUU college administration were especially excited about the prospects of the new faculty interacting with each other and beginning an open dialogue regarding appropriate and effective techniques for actively engaging students within the classroom.

Sixteen faculty from the following disciplines participated in the three-day faculty development workshop: engineering, physics, biology, math, chemistry, academic advising, and political science. The event kicked off with a welcome from the Dean of the College of Science & Engineering, which was evidence of the support received from the university administration. Lunch was provided each day, which created an informal atmosphere for faculty to interact across disciplines and get to know each other better. The sessions ran from 8:00 a.m. (after a light breakfast) until 5:00 p.m., except for day three which finished a little earlier (at about 3:30). Learning objectives were articulated for each session on the agenda. Several different topics were presented each day, with each day generally organized such that the mornings were more informational and the afternoons were more applied. In the afternoon sessions, participants worked on their short teaching excerpt lessons and then all participants were given an opportunity to teach in front of some of their peers and receive feedback the next day.

Workshop topics were selected based on the perceived need and author experience in helping train new faculty in effective teaching methods. A complete list of session topics and the

corresponding learning objectives can be found in Appendix B. The first session introduced principles associated with effective teaching and learning in the classroom. A unique element of this workshop was helping new faculty recognize the idea that student learning bottlenecks and threshold concepts exist across a wide spectrum for every course and discipline. By recognizing these bottlenecks and threshold concepts and developing activities and classroom material focused on helping students overcoming these hurdles, student learning can be enhanced. Thereafter the participants were introduced to effective classroom presentation strategies for visual communication, including recommending an increased use of in-class board work (i.e. using the whiteboard or chalkboard) and appropriately using other types of teaching technologies (e.g. presentation software). Participants were also provided an overview of effective classroom presentation strategies for verbal communication, including maintaining a strong vocal presence and using questioning techniques to enhance student engagement and learning. Similarly, participants were provided a session focusing on understanding the importance of effectively using and reading nonverbal behavior.

Another session introduced participants to Lowman's 2D model of teaching, which suggests that faculty can become better teachers by increasing their intellectual excitement and interpersonal rapport.[36] This idea can be quite powerful for new faculty attempting to rapidly increase their effectiveness in the classroom. A subsequent session focused on presenting different types of learning styles that exist in students, and the importance of teaching across a variety of learning styles.[19] The final sessions focused on understanding the benefits and challenges of active learning and selecting appropriate active learning strategies to incorporate within the classroom. This further included ensuring that active teaching and learning strategies aligned with learning outcomes and assessing the impact of active learning occurring in the classroom through the use of classroom assessment techniques (CAT's). Participants were taught to incorporate these latter elements through a backward design process.[10]

Another significant part of this workshop was the active participation element incorporated into the workshop of having participants teach each other and be assessed by their peers. This particular strategy has found tremendous success in the ExCEEd teaching workshop,[34] and a similar strategy was adopted for this workshop. Participants were asked to teach two 25 minute lessons in front of several of their peers, and provide assessments of each other's teaching. Assessment focused on the various workshop elements being taught; the workshop assessment sheet was based on Estes et al. (2006)[32] and is shown in Appendix C. Because participants came from a wide variety of backgrounds (predominantly STEM disciplines), this strategy allowed participants to focus on different workshop elements of effective teaching without having to worry about receiving a peer review of the content. Although the participants gained experience in assessing each other, one of the principal goals was having the participants learn to assess their own teaching, thus allowing them to further improve their teaching on their own following the workshop. Additionally, two demonstration classes of effective teaching were provided by two of the authors (one demonstration each) during the workshop, in an effort to provide examples of effective incorporation of the principles being taught. The principal goal was to help participants observe a seasoned teacher incorporate the workshop elements within a single lesson, yet with an emphasis of recognizing the need to be themselves in the classroom and make each lesson their own.

Assessment Methodology and Results

Assessment planning of the three-day workshop was embedded into the event planning process. We used the Center for Disease Control and Prevention (CDC) framework for program evaluation[37] to structure the assessment process and data collection points for this workshop. Although this may sound like a strange reference point for a STEM teaching workshop, the CDC framework in a general sense is an effective tool across a wide variety of disciplines. The CDC program evaluation steps are: 1) **engage stakeholders** when planning; 2) use a logic model to **describe** the program**;** 3) **focus** on and assess the most important aspects of the program; 4) **gather credible evidence** that helps to answer questions about the program; 5) use data collected to **justify conclusions**; and 6) **share lessons learned** and disseminate findings .[37] The CDC evaluation steps and all supplementary materials from the CDC website were included in the LMS workshop page so that interested faculty participants could use these materials as well in their own planning.

To engage participants in the three-day workshop before they even started, we provided learning materials and a pre-workshop CBAM survey to gather information about concerns participants might have about using active learning in their teaching. We created an overall agenda so participants would see the overall structure of the program from the beginning. We also created a LMS webpage for each day of the event, where we compiled the daily presentations, handouts, and supplementary materials. When we focused in on the most important aspects of the workshop we decided to collect data on pre- and post-concerns about active learning (CBAM), participant perceptions about good teaching (sticky exercise), end of workshop survey, and a 6+month follow-up survey (see Table 1). We have analyzed the faculty participant data that was collected so that we could use those findings to plan future faculty development events. We are also planning one-year follow-up interviews as well. The last step of the CDC evaluation structure relates to sharing lessons learned. Although not a principal motivator in running this workshop, an important last step and one of the purposes of this paper is to disseminate the planning, evaluation structure, and findings of this study to the engineering education community, a key component within the STEM education community. The program evaluation loop is appropriately closed through the sharing of lessons learned with others.

Table 1. Assessment Data Collection Timeline.

	Pre-workshop	During workshop	Post-workshop
Concerns based adoption model survey	X		X
Brainstorming exercise – good and bad teaching experience data		X (beginning of workshop)	
End of day assessment – muddiest and most valuable experience		X	
End of three-day survey		X (last day and online)	X
Six-month survey data			X
One-year interview data (pending collection)			X

Pre and post workshop Concerns Based (CBAM) surveys

The purpose of the CBAM survey used in this research is to measure the concerns that faculty have when trying something new in their classroom, or testing out a new innovation. The 35 question assessment was designed so it could be adapted to measure any type of teaching and learning innovation or change. It is a validated survey used in both K-12 and higher education contexts.[38] Likert-scale data on a scale of 1-7 is collected to measure how concerned faculty are about the change implementation they are involved in across seven different stages of concern: Stage 0: awareness of the innovation; Stage 1: informational – which measures if respondents are concerned that they need more information; Stage 2: personal – where respondents rank their perception of how the innovation is personally impacting them; Stage 3: management – how confident or how concerned respondents are about managing this new innovation or change; Stage 4: consequence – how concerned respondents are about the consequences of implementing the innovation or change; Stage 5: collaboration – how comfortable respondents are in collaborating with others; and Stage 6: refocusing – the highest level, where respondents are less concerned and now trying to figure out how to implement the change or innovation. Giving up power in the classroom to students who are engaged in constructing their own learning can be a stressful paradigm shift for faculty. Novices just beginning to adapt to change usually have the highest concerns in stages 0-2, because they might not be aware or they might want to make sure they have all of the information. If the concerns are highest in stages 3-4, this might indicate that they have the knowledge about the change or innovation, and are now trying to figure out how to implement it with their students and understand the challenges and consequences of changing their teaching approach. If values are the highest in the last two stages, 5 and 6, this could mean that they are more confident with the change and are now collaborating with others to improve or that they are adapting the change or innovation to meet their own needs. To evaluate CBAM data, Likert score means are compiled by stage, and then a conversion chart is used to create a percentile score for each stage.[39] The percentile scores are plotted on a chart by stage. Pre and post scores are overlaid on the same chart to show if a change took place at the 7 different levels. Figure 1 shows an example of two different CBAM profiles, one where little change in concerns is demonstrated and the other where a change in certain levels of concerns is demonstrated.

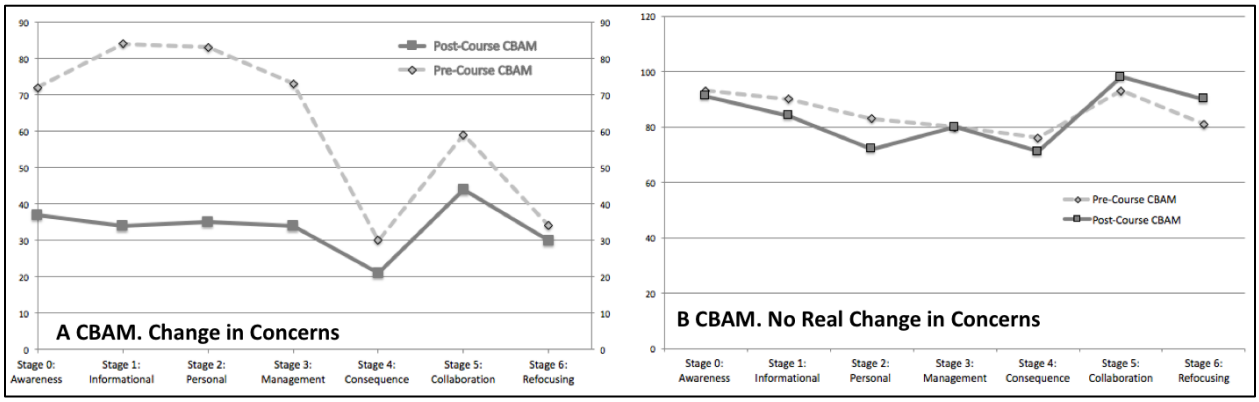

Figure 1. CBAM profiles for (a) a participant who reported significant change in their concerns and (b) a participant who did not demonstrate change in their concerns.

Of the 16 workshop participants, 11 completed a pre- and post-CBAM assessment. The scores were compiled by the 7 different stages of concern, converted to a percentile and then plotted on

a chart for each individual participant. The mean of each pre- and post-CBAM score is shown plotted in Figure 2. This data shows a small decrease in concern about active learning in the stages of awareness, information gathering, personal impact, and consequences. The area of thinking about how to manage active learning did not show any change in concern. However, with regard to learning about active learning, participants on average expressed higher concerns about collaborating with others and customizing what they learned for their own learning contexts.

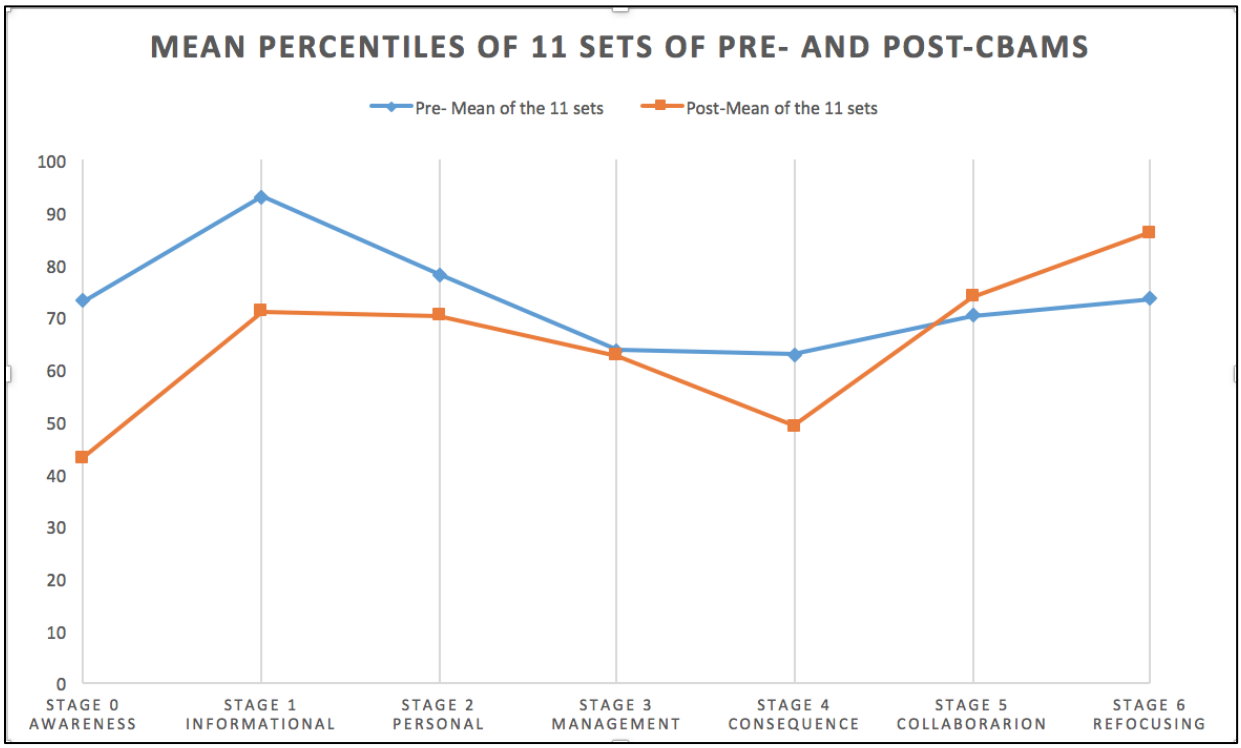

Figure 2. Pre- and post-CBAM profile means of 11 sets of CBAM data.

Teaching and Learning Perspective Data

On the first day of the workshop, we conducted a "sticky" brainstorming activity to understand how the workshop participants felt about good and bad teaching strategies. In this activity we asked the participants to list as many examples of teaching they could think of, from their own experiences as a student and a teacher. The group then collated the stickies into common groups or themes of teaching practice. Table 2 shows the most common categories of teaching experiences. The most common type of teaching and learning experience remembered by the workshop participants was quite negative, and identified as what the group called "painful lectures." Some of the actual participant quotes for this category were:

- "*covering so much material that you get lost*"
- "*she read directly from the text in a monotone featureless voice!!!*"
- "*sitting through a horribly boring lecture*"
- *"teacher did not have good sense of students' understanding and so did not pace material well (too fast, too slow)*"

- *"board with back to students"*
- "*followed information and order in textbook exactly"*

The second highest category of stickies identified by the participants was more positive, regarding student involvement. Some of the actual participant quotes included:

- *"practically all of the class time was spent on student demonstrations of solutions to problems"*
- *"ambassador exercise - 3 groups of students on 3 topics"*
- *"using an online tool to make a jeopardy game that was used to practice what was learned"*
- *"having an instructor connect information I thought was unconnected into a beautiful whole picture"*
- *"lots of personal experiences (stories)"*

Table 2. Types of teaching approaches experienced by the workshop participants.

Teaching category	# of stickies /category
Painful lectures	28
Student involvement	19
Hands-on	16
Delivery	14
Demonstration	4
Instructor concerns	3
Embarrassing students	2
No value / relevance	2
Total stickies	**88**

End of Day Formative Data Collection about the Session for that Day

At the end of the first day we collected formative assessment data about the workshop experience. Seventeen different comments were collected about what their muddiest points were (things they still did not understand), what they still needed or would like to see, and several recommendations. The most common muddiest point focused on unclear terminology, principally with regard to the wording used in Lowman's model. Additionally, comments about what they still needed focused on a desire for more specific teaching strategies. Finally, participant recommendations focused on establishing a better balance of pace and content.

The Post-Workshop Survey

Participants were asked to complete a post-workshop survey to explore perceptions of the overall workshop and identify the perceived level of learning that occurred. Some of the participants took the survey on the last day of the workshop and others took it a little later. The survey consisted of 12 Likert-scale questions (on a scale of 1-5) and some open-ended questions about their experience. Table 3 shows the average results for the Likert-scale questions, sorted from

highest score through the lowest. The highest score was a 4.8 for the facilitators creating a comfortable environment for learning. It is presumed that this particular category is also a key element in setting the tone for participants to effectively learn. The lowest score recorded in the Likert style questions was a 4.0, recorded in two different categories: how helpful was the workshop and how likely participants are to interact with their peers that they met at the workshop. Although this latter question received the lowest score, the actual score is encouraging in that these STEM faculty provided an indication of the creation of a new network of peers interested in continuing to improve the teaching and learning occurring on this campus.

Table 3. Likert-scale mean scores on the post-workshop survey.

Questions	**Mean**
The facilitators created a comfortable environment for learning.	4.8
The facilitators encouraged questions, opinions and discussion.	4.7
I found the interaction with peers outside of my department during this workshop to be very valuable.	4.7
How likely will it be that will you try to implement strategies you learned about in this workshop in your fall 2016 classes?	4.6
The facilitators demonstrated thorough knowledge.	4.5
How likely are you to recommend a teaching and learning workshop like this one to other faculty in your department?	4.4
How likely is it that you be willing to participate in a Teaching and Learning Community of Practice with other SUU faculty and share what you have learned with others?	4.4
How likely is it that will you continue to try to schedule time for reading and learning about teaching practice and pedagogy?	4.2
I would be interested in attending a workshop like this in the future.	4.1
The length of the workshop was just right for me.	4.1
The workshop materials were helpful.	4.0
On a scale of 1-5, how likely will you continue to interact with peers you met at this workshop?	4.0

The open-ended questions that participants were asked included:

- What was your most valuable take away for you from this workshop?
- What could be done to make future workshops like this better?
- What other type of workshops or workshop topics would you be interested in attending?
- Can you describe one example of an interaction you had with another faculty member that you found valuable and/or useful for your teaching practice?
- Of all of the information presented in these workshops, which strategies or techniques do you think will work best in your discipline and be something you would try in your classes?
- Of all of the information presented in these workshops, which topics were least valuable to you?

The main themes that emerged from the open ended feedback included several different categories, as shown in Table 4. The most positive comments were in the teaching techniques & strategies theme, and the learning from each other theme. Representative comments found amongst these themes included value on learning from watching their peers teach, learning new teaching techniques like think-pair-share, starting class with a thought-provoking question, using colored markers to enhance board work, and designing learning activities. The least valuable topics and experiences were related to the amount of pedagogical content presented on the first day of the workshop, which participants identified as too much, too broad, and too fast. Additionally, participants wanted "*more hands-on demos everyday w/engagement activities*" and "*to go deeper into less techniques w/practice*". They also made recommendations on the timing of the workshop to be later in the summer and better marketing to target new instructors.

Table 4. Themes for the Post-Workshop Survey.

Identified Themes	# of comments
teaching techniques & strategies	28
learning from each other	23
workshop logistics	12
workshop materials	11
designing instruction	7
future needs	6
perception change	3

Figure 3. Word Cloud of Post-Survey Comments.

Figure 3 presents a word cloud diagram showing the types of words that respondents used when providing feedback in the open ended responses. Word clouds, such as this, are an effective tool for graphically indicating which words appear most often, typically correlating with those themes that were collectively significant (whether for good or bad) to the participants. Notice

that the idea of "learning" was the theme that collectively appeared the most within the workshop comments. The next most notable themes included "workshop" and "students." There are a number of words that seem to support the idea of participants having a positive experience and helped paint a favorable impression of the workshop, although these words were not as common as others. These words included "valuable, deeper, better, and good." There were very few words occurring multiple times that could be considered negative, although the context for each occurrence would have to be examined to consider the word truly as negative feedback. The only word identified with negative overtones was "difficult." This type of analysis is useful for looking for potential problems that may have occurred during workshop delivery, and this diagram did not seem to indicate any major collective concerns amongst the participants.

Assessment Findings

Participants in this three-day teaching and learning workshop could identify examples of good and bad teaching strategies and were eager to learn even more new strategies and techniques. When asked to grade the three-day session overall, they scored the comfortable environment for learning, the engaged facilitators, and the interaction with their peers the highest. The lowest Likert-scale scores related to the workshop materials and how likely they would be to continue to meet with their colleagues after the workshop. It should be noted that the Likert-scale score of 4.0 out of 5 is in conflict with the value they placed on interacting with peers in the comment section of the survey. We recently conducted the 6-month follow-up survey, but as of this time only four responses have been received. Of those participants who did reply, the discussion focused primarily on the value of their workshop experience and identified what elements of the workshop they integrated into their courses this past fall semester. Survey comments included the following:

- *"Activities, group-work, pair and share, hands on, discovery, interactive computer modules"*
- *"The most common was the sticky note - instant survey. We incorporated other types of active learning into our course"*
- *"Frequent "bite-sized" activities - brief activities interpreting graphs or working through problems aimed at challenging concepts. More planned-out board work. More moving around"*
- *"Very little--it is so hard to break habits! A small change I have tried to make is using more "directed questions" (directing a question to a specific student). Previously, in large part I relied on "volunteer questions."*

Of the four respondents, all were able to take some element of the workshop and incorporate it into their teaching. One of the respondents indicated difficulty in breaking bad habits, but did acknowledge incorporating small elements. The authors acknowledge that becoming a better teacher is a process, and attempting to incorporate everything that is taught in a workshop like this would be foolish. Therefore, even small changes can be considered a success. In that regard, all 6-month follow up comments can be considered a positive indication that the workshop was able to have a positive effect on improving the teaching for these STEM related educators. Unfortunately, with only four responses, there is not a significant sample size at this time to indicate that the workshop had a positive effect on the majority of the workshop participants. A

one year follow-up survey will be conducted this summer. To ensure that more significant response is received the authors will utilize a strategy with a proven record of higher response rate and perform these interviews over the phone.

Conclusions

Based on the participant feedback from the three-day STEM teaching workshop, the workshop purpose and goals were met. The short- and mid-term outcomes of this project to develop a broader awareness on campus of alternative teaching strategies for STEM classrooms and increase comfort level in using alternative teaching strategies, such as active learning, was achieved. Participants demonstrated alternative teaching strategies in their individual short peer reviewed teaching demonstrations. However, the goals to develop relationships and increase communication between the multiple STEM departments at SUU were less successful. The post-survey data is somewhat contradictory. The lowest Likert-scale numbers indicate that some of the participants are less likely to follow-up with the peers they met at the workshop, yet participants reported in their open ended responses that the peer interaction and peer review of teaching methods was one of the most important take-aways from the workshop. This evidence indicates that more creative strategies for providing opportunities for faculty to continue to interact and talk about their teaching needs should be pursued at this institution. Hatch[40] contends that faculty must make their teaching practice more public, and be provided opportunities to share ideas about teaching with peers if they are to grow and develop as teachers. Therefore one recommendation of this project might be to establish a more explicit way for faculty to share teaching ideas beyond this workshop. One way might be to highlight teaching practices of some faculty in College of Science faculty meetings. Time constraints might prevent faculty from meeting together separately to talk about teaching, but if a focus on teaching is embedded in the college and department faculty meetings and culture, that might create opportunities for more open discussion about teaching.

For others thinking about offering a multi-day teaching and learning workshop for STEM faculty, the planners of this workshop recommend analyzing the teaching culture at their institution and customizing the sessions to their individual faculty needs. In the case of this workshop project, we could have provided less pedagogical information and at a more realistic pace, and customized sessions at a deeper level aligned to the concerns of workshop attendees. We plan to do a one-year follow-up with participants to see how this opportunity has impacted their teaching practice in the long run. Post workshop data are promising, in that workshop participants are trying to implement, in some small ways, elements of the workshop that struck a chord within them, and ultimately to improve their teaching practice. How can we provide support for these small victories? Providing teaching technique options as well as instructional design strategies may help faculty connect their teaching practice with sound pedagogical outcomes and principles and provide a broader vision for their teaching practice.

The authors have further determined that the following changes might enhance the effectiveness of a future follow up workshop. One specific option is increasing the length of the workshop from three to five days, so that the new faculty attendees have more time to practice and critique each other. Although this poses challenges in requiring a greater time commitment, it is felt that this would ultimately provide a more significant learning experience. Second, regarding

additional curriculum that would supplement the additional time, the authors would like to add some coverage of deliberate practice within the workshop, and set up a framework for the attendees to deliberately practice teaching over the following year. Deliberate practice is a proven method in optimizing improvement and achieving expert performance.[41] Third, the authors would like to do a better job of building a community of teaching with the workshop participants. The incorporation of deliberate practice may help in this regard. Finally, the authors would like to bring back participants from the first workshop to play a more significant role in the workshop development and implementation, and especially with regard to assessing the instruction of new faculty. This will further enhance the community of teaching and allow other new faculty to continue to strengthen their own personal development. Additionally, future workshops should incorporate the feedback received by recent participants, especially with regard to establishing a better balance of pace and content. As of right now, the next iteration of this workshop is being planned for summer of 2018. Additional time will ultimately tell if the most recent version of the workshop has provided participants with a comfort level of taking more risks and trying new and innovative things in their classroom teaching. In the meantime, this does appear to be a step in the positive direction.

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References

[1] Frechtling, J.A. *Logic modeling methods in program evaluation*. Jossey-Bass, 2007.

[2] National Research Council. *How students learn: History, mathematics, and science in the classroom*. National Academies Press, 2004

[3] Mazur, E. Farewell, lecture? *Science*, 323(5910), 50-51, 2009.

[4] Ambrose, S.A., Bridges, M.W., DiPietro, M., Lovett, M.C., and Norman, M.K. *How learning works: Seven research-based principles for smart teaching*. John Wiley & Sons, 2010.

[5] Barr, R.B. and Tagg, J. From teaching to learning—A new paradigm for undergraduate education. *Change: The magazine of higher learning*, 27(6), 12-26, 1995.

[6] Weimer, M. *Learner-centered teaching: Five key changes to practice*. John Wiley & Sons, 2002.

[7] Handelsman, J., Miller, S. and Pfund, C. *Scientific teaching*. Macmillan, 2007.

[8] Ebert-May, D., Brewer, C., and Allred, S. Innovation in large lectures: Teaching for active learning. *Bioscience*, 47(9), 601-607, 1997.

[9] Freeman, S., Eddy, S.L., McDonough, M., Smith, M.K., Okoroafor, N., Jordt, H., and Wenderoth, M.P. Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, 111(23), 8410-8415, 2014.

[10] Fink, L.D. *Creating significant learning experiences: An integrated approach to designing college courses*, 2nd edition. John Wiley & Sons, 2013.

[11] Blumberg, P. *Developing learner-centered teaching: A practical guide for faculty*. John Wiley & Sons, 2009.

[12] Lawler, P.A, and King, K.P. *Planning for Effective Faculty Development: Using Adult Learning Strategies. Professional Practices in Adult Education and Human Resource Development Series*. Krieger Publishing Company, Krieger Drive, Malabar, FL 32950, 2000.

[13] Ziegenfuss, D.H. and Lawler, P.A. Collaborative course design: changing the process, acknowledging the context, and implications for academic development. *International Journal for Academic Development*, 13(3), 151-160, 2008.

[14] Ziegenfuss, D.H. A phenomenographic analysis of course design in the academy. *Journal of Ethnographic & Qualitative Research*, 2(1), 2007.

[15] Ho, A., Watkins, D., and Kelly, M. The conceptual change approach to improving teaching and learning: An evaluation of a Hong Kong staff development programme. *Higher Education*, 42(2), 143-169, 2001.

[16] Michaelsen, L.K. and Sweet, M. Team-based learning. *New directions for teaching and learning*, 2011(128), 41-51, 2011.

[17] Foertsch, J., Moses, G., Strikwerda, J., and Litzkow, M. Reversing the lecture/homework paradigm using eTEACH® web-based streaming video software. *Journal of Engineering Education*, 91(3), 267-274, 2002.

[18] Herreid, C.F. and Schiller, N.A. Case studies and the flipped classroom. *Journal of College Science Teaching*, 42(5), 62-66, 2013.

[19] Felder, R.M. Reaching the Second Tier--Learning and Teaching Styles in College Science Education. *Journal of College Science Teaching*, 22(5), 286-90, 1993.

[20] Moore, A.H., Fowler S.B., and Watson, C.E. Active learning and technology: Designing change for faculty, students, and institutions. *Educause Review*, 42(5), 42-61, 2007.

[21] Cox, M.D. Introduction to faculty learning communities. *New Directions for Teaching and Learning*, 2004(97), 5-23, 2004.

[22] Hall, G.E. and Hord, S.M. *Implementing change: Patterns, principles and potholes* (4th ed.). Upper Saddle River, NJ: Pearson, 2015.

[23] Horsley, D.L. and Loucks-Horsley, S. CBAM brings order to the tornado of change. *Journal of Staff Development*, 19(4), 17-20, 1998.

[24] Felder, R.M., Brent, R., and Prince, M.J. Engineering instructional development: programs, best practices, and recommendations. *Journal of Engineering Education*, 100(1), 89-122, 2011.

[25] Estes, A.C., Welch, R.W., and Ressler, S.J. The ExCEEd teaching model, *Journal of Professional Issues in Engineering Education and Practice*, 131(4), 218-222, 2005.

[26] Ressler, S.J. Whither the chalkboard? Case for a low-tech tool in a high-tech world. *Journal of Professional Issues in Engineering Education and Practice*, 130(2), 71-73, 2004.

[27] Ressler, S.J., Welch, R.W., and Meyer, K.F. Organizing and delivering classroom instruction. *Journal of Professional Issues in Engineering Education and Practice*, 130(3), 153-156, 2004.

[28] Estes, A.C., Welch, R.W., and Ressler, S.J. Questioning: bring your students along on the journey. *Journal of Professional Issues in Engineering Education and Practice*, 130(4), 237-242, 2004.

[29] Estes, A.C. Shock and awe in the civil engineering classroom. *Journal of Professional Issues in Engineering Education and Practice*, 131(1), 1-5, 2005.

[30] Schaaf, R.V. and Klosky, J.L. Classroom demonstrations in introductory mechanics. *Journal of Professional Issues in Engineering Education and Practice*, 131(2), 83-89, 2005.

[31] Welch, R.W., Ressler, S.J., and Estes, A.C. A model for instructional design. *Journal of Professional Issues in Engineering Education and Practice*, 131(3), 167-171, 2005.

[32] Estes, A.C., Welch, R.W., and Ressler, S.J. The assessment of teaching. *Journal of Professional Issues in Engineering Education and Practice*, 132(1), 2-10, 2006.

[33] Quadrato, C., Welch, R.W., and Albert, B.C. Training faculty to teach civil engineering. *Journal of Professional Issues in Engineering Education and Practice*, 131(2), 111-117, 2005.

[34] Estes, A.C., Welch, R.W., Ressler, S.J., Dennis, N., Larson, D., Considine, C., Nilsson, T., O'Neill, R.J., O'Brien, J., and Lenox, T. Ten years of ExCEEd: making a difference in the profession. *International Journal of Engineering Education*, 16(1), 141-154, 2010.

[35] Fink, L.D. A self-directed guide to designing courses for significant learning. Dee Fink Associates, 2005. Available at: *https://www.deefinkandassociates.com/GuidetoCourseDesignAug05.pdf*

[36] Lowman, J. *Mastering the techniques of teaching*. Jossey-Bass, San Francisco, CA, 1995.

[37] Centers of Disease Control. Program Performance and Evaluation Office (PPEO) - Program evaluation steps website, 2011. Available at: *https://www.cdc.gov/eval/steps/index.htm*

[38] Hall, G.E., George, A.A. and Rutherford, W.L. Measuring stages of concern about the innovation: a manual for use of the SoC questionnaire. Austin, TX, Southwest Educational Development Laboratory, 1986.

[39] George, A.A., Hall, G.E., and Stiegelbauer, S.M. Measuring implementation in schools: the stages of concern questionnaire. Southwest Educational Development Laboratory, 2006.

[40] Hatch T. *Into the classroom: developing the scholarship of teaching and learning*. Jossey-Bass, San Francisco, CA, 2006.

[41] Ericsson, K.A., Krampe, R.T., and Tesch-Römer, C. The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, 100(3), 363-406, 1993.

Appendix A: Logic Model for planning SUU Faculty Development Workshop: "Engaging Students in the STEM Classroom"
Goal(s)/Objectives: To engage STEM faculty in alternative teaching strategies focused on student-centered learning

What will be invested	What we will do	Deliverables from our activities	Short term outcomes	Broader – midterm outcomes	Bigger picture outcomes or impacts
INPUTS *In order to accomplish our goals will need the following resources*	**ACTIVITIES** *Accomplishing the following activities will result in the following measurable deliverables*	**OUTPUTS** *Accomplishing these activities will result in the following evidence of progress*	**SHORT TERM OUTCOMES** *We expect the following measurable changes soon after the symposium is over*	**MEDIUM TERM OUTCOMES** *We expect the following measurable changes within the next one to three years*	**IMPACTS OR LONG TERM OUTCOMES** *We expect the following impacts/trends within the next three to seven years or more*
Having a successful Symposium/ Workshop ● Agenda for the 3 day event ● Lessons and outlines for each of the sessions ● Handouts and teaching materials ● SUU financing for food and presenters	● Establish strategy for getting the word out about the symposium ● Define workshop/seminar outcomes ● Create lesson plans for sessions ● Develop an assessment/evaluation plan to assess the value of the workshop/symposium	● Faculty satisfied with the active learning symposium ● Evidence of faculty interest in incorporating new strategies into their courses ● Faculty will demonstrate their teaching ideas (and what they learned) in the practice teaching sessions ● Report to admin on the evaluation of the symposium	● Broader awareness of alternative teaching strategies for STEM classrooms ● Increased comfort level in using alternative teaching strategies ● More courses incorporating alternative teaching strategies	● Increased adoption of active learning strategies in STEM classes ● Publications and presentation about their new approaches to teaching ● Effective use by multiple instructors of our new active-learning classroom ● Increased student attainment of learning outcomes	● Development of a community of faculty who support each other in trying new strategies in the classroom ● Teaching practice becomes more public and collaborative ● Faculty participants will become leaders on campus and advocate for student centered learning ● Increased student retention and satisfaction
Building Community around Teaching ● SUU admin support for the event and future teaching projects ● CETL support and advertising ● Departmental & collaborative partner support ● Canvas course for an online community around teaching	● Meet with departments to promote the symposium and develop partners for teaching practice ● Create an online course to post tutorials, links, designed lessons, and related materials to support instructors using alternative strategies in the STEM classroom ● Plan for follow-up activities (brown bags, presentations, etc) to keep the conversation going (CETL)	● The Canvas site will become a public showcase of disciplinary examples of alternative teaching strategies that will benefit all campus ● Design and development of sharable assessment tools for faculty to use to gather student feedback from their students as they try new strategies	● Compilation of lessons and strategies in one place for faculty to share ● Increased faculty multi-disciplinary collaboration	● Increase over time of more courses using active learning strategies ● Symposium faculty become leaders in teaching ● Evidence of student satisfaction with new approaches (use assessment tools to gather student feedback) ● Grant proposals submitted for STEM education projects/research ● Creation of a community of practice in active learning	● A community of faculty experts now mentor other faculty ● Instructors have integrated active learning into their teaching and there is an increased interest in teaching and learning pedagogy and assessment on campus ● Evidence for accreditation reviews

Appendix B: Workshop Seminar Topics and Learning Objectives

Principles of Effective Teaching and Learning
1) reflect on the aspects of "good" teaching and learning
2) describe some best practices in teaching
3) identify student learning bottlenecks / thresholds in your course / discipline

Strategies for Effective Classroom Presentation – Visual Communication
1) demonstrate effective techniques for using the board
2) identify effective uses of other instructional technology

Strategies for Effective Classroom Presentation – Verbal Communication
1) speak using appropriate articulation, and variation in volume, speed, and pitch
2) explain the benefits of using in-class questioning
3) use effective questioning techniques
4) respond appropriately to student questions and answers

Lowman's Model
1) describe Lowman's 2D model of teaching
2) apply Lowman's 2D model of teaching to faculty development

Active Learning Techniques
1) describe benefits and challenges of active learning
2) select effective active learning strategies to add to your teaching toolbox
3) describe the levels of Bloom's taxonomy and/or Fink's learning taxonomy
4) write learning outcomes using appropriate "Bloom's" verbs

Aligning Learning Outcomes
1) align active teaching and learning strategies to outcomes
2) integrate active learning strategies into your teaching plans
3) design specific learning activities that align with learning outcomes
4) assess the impact of active learning (i.e. classroom assessment techniques (CAT's))

Learning Styles
1) explain different learning styles
2) prepare classroom lessons / activities that teach to different learning styles

Non-Verbal Communication
1) explain how nonverbal communication affects teaching and learning in the classroom
2) use nonverbal techniques to enhance your communication with students in the classroom
3) use nonverbal cues to read student engagement in the classroom

Appendix C: Workshop Teaching Assessment Sheet (after Estes et al., 2006)[32]

Teaching Assessment Worksheet

Instructor: _____ Assessed By: _____

Lesson Topic: _____ Date: _____

Strengths:

Areas for Improvement:

Key Teaching Elements: (if applicable)	Needs Work	Good	Excellent	Comments
Command of the subject matter				
Lesson objectives				
Enthusiasm, energy, confidence				
Orientation to subject matter				
Clarity of presentation material				
Clarity and precision of explanations				
Voice (volume, speed, variation)				
Questioning and answering questions				
Contact with students				
Visual aids and demonstrations				
Time management				
Active-learning strategies				
Activities aligned with outcomes				
Formative assessment strategies				

Specific areas to focus during your next class:

1. _____

2. _____

3. _____