AC 2008-1064: ACTIVE LEARNING IN ACTION, UNDERSTANDING THE EFFECTS: WHAT HAPPENS WHEN THE "NEW" WEARS OFF IN TEACHER TRAINING

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Understanding the Effects of Active Learning in Action: What Happens When the "New" Wears Off in Teacher Training

Abstract

In-service teacher training that focuses on Active Learning to teach Science, Technology, Engineering and Mathematics (STEM) education topics in K-12 has become quite prevalent. One such program, Design Technology and Engineering for America's Children (DTEACh), has offered summer STEM training workshops for teachers for over fifteen years. The participants are usually excited about the new training and the changes that they plan to make in classroom instruction. After the excitement fades, though, do the teachers implement the techniques presented in the training workshops? This study looks at the effects of the DTEACh training program on participants. A survey of the immediate effects and opinions of teachers was conducted at the end of each day of the two-week training held in 2004. Results show the teachers have a positive perception of the training. This paper seeks to investigate the effects of the DTEACh program on the instructional style of the teacher participants. Are the techniques presented in the training used by the teachers years later? Do the teachers recognize the method they are using? To answer these questions and others, teachers who participated in a DTEACh summer training workshop within the last seven years were surveyed to determine the instructional styles they use in the classroom. The results show that the majority implement the instructional techniques presented in the training. However, less than half of the teachers could describe the 5-step DTEACh teaching method presented to the participants and used to structure the training. This lack of recognition of the method is an unexpected finding, deserving of further investigation. The results of the study also revealed that the teachers who took the DTEACh training workshop three or more years before the survey showed very similar responses to teachers who attended the workshop more recently, thus indicating that use of techniques presented in the training workshop is not diminishing significantly with time.

Introduction

Active Learning is an approach developed to improve learning, and typically consists of techniques requiring students (as the name implies) to be actively engaged in learning through specially designed activities, followed by reflection upon what they have done[1]. This method is distinct from classical passive learning pedagogy, typified by lectures that present subject area content. Many types of activities have been developed over the past decade to improve student learning via the Active Learning techniques[2,3,4,5,6,7,8,9,10,11]. For example, several researchers report on the success of using LEGO® to assist with engineering concept explanation[12,13,14,15].

Active Learning techniques are often presented to teachers through professional development institutes. One such program, the Design Technology and Engineering for America's Children (DTEACh) program, demonstrates to teachers how the engineering design problem-solving process provides a way for students to learn mathematics and science concepts through the 5-Step Active Learning method. But, are teachers who are trained with Active Learning using

these teaching methods in the classroom? Do teachers using these methods recognize the Active Learning methods presented to them? This paper analyzes the DTEACh program to investigate these and other questions about teaching with Active Learning. This study focuses on K-12 teachers who have taken a DTEACh summer training workshop to determine what techniques and practices they are using in their classrooms.

DTEACh Program

For over fifteen years, the DTEACh training institutes have been instructing K-12 teachers in STEM concepts with Active Learning techniques[16,17]. The DTEACh program demonstrates to teachers how the engineering design problem-solving process provides a way for students to learn math and science concepts through Active Learning. DTEACh is supported by the Cockrell School of Engineering at The University of Texas at Austin, and is led by engineering professors. The program provides guidance to K-12 teachers on how to use open-ended problems in their classrooms. Each institute comprises one week of instruction in engineering concepts through the use of everyday technology, directed laboratory activities, and design briefs. The pedagogy used in the institutes, summarized in the next section, is similar to the 5E method (Engage, Explore, Explain, Elaborate, and Evaluate)[18]. The institutes are designed to model the teaching methods the participants are expected to use in their classrooms. Previous research has focused on the immediate effectiveness of the institutes using end-of-the-day surveys[19]. The current study looks beyond the institutes to determine their influence in the classroom.

Methodology

The DTEACh institutes are based on a teaching method that emphasizes design activities and the use of everyday objects as examples of engineering concepts. The DTEACh 5-Step teaching model is based on the Kolb model and Bloom's Taxonomy. The DTEACh 5-Step model is designed to allow students to experience all four aspects of the Kolb cycle: Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation. The Kolb model describes an entire cycle of the learning experience[20]. Bloom's Taxonomy describes six levels in which learning can occur. The levels in the taxonomy range from basic memorization of information to evaluation and critiquing of a topic[21]. These learning models have been embodied in the DTEACh model (hands-on technology exploration, interactive discussions, exploratory labs, open-ended design problems, and project reporting process.) The DTEACh training is structured according to this model so that the participants experience this method of teaching in the training workshops. The steps in the model and examples of implementation in the DTEACh training are described below:

1. *Hands-on Technology Exploration*: Introducing a topic to students/participants through examples of everyday objects that have meaning to them. This approach provides the participants with a link to something they understand and thus empowers them to observe the world around them to identify other examples of mathematics, science, and engineering concepts.

Example: The teachers are introduced to control concepts with real world examples. The teachers are asked to select a device on a table, and analyze how it works. Example products are a wind-up alarm clock, toy car, a washing machine timer, a thermostat, etc.

2. *Interactive Discussions*: Discussing engineering principles illustrated by technological examples to which students/participants can relate. The approach uses participants' intuition about examples to introduce terms and concepts that the participants may have heard. This thought provoking discussion leads the participants to in-depth discussions of the mathematics and science concepts underlying the engineering subject area.

   Example: The teachers are asked to describe to the class how the device they have selected works. As the teachers described in their own words how the devices worked, the instructor records the technical terms related to the concept that the teachers introduce in the description. The instructor uses these terms to begin an in-depth discussion of the content with the teachers.

3. *Exploratory Labs*: Activities and experiments that allow the participants to experience the engineering concepts in a controlled manner. This step allows them to gain understanding and become more comfortable with the engineering concepts, experience that will enable the participants to be successful in solving open-ended problems.

   Example: Teachers follow a written procedure to create a working automatic door with LEGO® MINDSTORMS® NXT hardware and software to expand their understanding of control devices. Additionally, they gain experience in LEGO® construction techniques.

4. *Open-Ended Design Problems:* Provides the participants an opportunity to apply concepts to solve new problems. This step closely models experiences that engineers practice in the workplace. Design projects allow for the integration of multiple concepts and cause-effect reasoning.

   Example: The teachers create devices that could solve one of several control design challenges presented to them, such a scale model of an amusement park rider or a colored ball sorter.. They solve the challenge using a LEGO® MINDSTORMS® NXT kit combined with other materials they choose. Examples of solutions created in a recent DTEACh institute are shown in Figures 1 and 2.

5. *Project Reporting*: Presenting design solutions to the rest of the participants reinforces the accomplishments made and provides an opportunity for the instructor to assess the participants' understanding of a topic and provide feedback on the quality of the solution. Reporting also provides an excellent opportunity for participants to practice written communication skills.

Example: The teachers present and demonstrate the design projects they created. This allowed the teachers to discuss common problems, share lessons learned, and generate ideas on classroom implementation.

Figure 1. Design challenge: an amusement park ride.

Figure 2. Design challenge: color ball sorter "factory".

Instrument Development

To evaluate the influence of the DTEACh program on teachers after they have had the opportunity to work with students in the classroom, a survey was designed to answer the following research questions.

- Do the teachers use the DTEACh 5-step process?
- How do the teachers assess student learning in their classroom?
- How are the teachers interacting with their students?
- How do the teachers perceive the training program?

To address the research questions and how the answers change with time, the survey inquires about general classroom information (size, grade, and subject), teachers' awareness and understanding of the DTEACh model, and the instructional practices the teachers are using in the classroom. The survey was based on previous survey instruments[22,23]. The survey questions are

presented in a Likert Scale format with the exception of the demographic information. As part of the survey development process, the survey questions were reviewed by engineering and educational faculty and an engineering education specialist. The survey was refined after learner evaluation with a group of graduate students not involved in DTEACh, who performed one-to-one evaluation of the survey in accordance with the phases of formative evaluation from Instructional Design[24]. The survey was designed to require less than 15 minutes to increase the number of responses[25]. The survey consists of 32 statements to assess the four research questions (see Appendix A). The statements were worded positively and negatively to check for internal consistency. To maximize survey distribution and convenience, the survey was implemented in an electronic Web format. After development feedback, the format was changed from an internal university-developed survey format to the commercial program "SurveyGizmo" to comply with recommended Web formatting guidelines (SurveyGizmo, Boulder, Colorado)[25].

Data Collection

The survey was sent on November 3, 2007 to 308 teachers who had participated in DTEACh summer training programs in the last seven years. A follow up email was sent on Friday November 9, 2007 to increase the response rate. At the close of the survey on November 12, 2007, 77 completed responses had been received. The survey was purposefully sent out after school started and several weeks before the Thanksgiving holiday to attempt to maximize the number of teacher responses. An independent control group was not used because this is not an experimental design study. The email addresses were not independently verified so it is likely that some of the surveys were sent to inactive email accounts.

Participants

All participants involved in the study are current K-12 teachers. The participants all attended a DTEACh summer institute that was either five or eight days long. Each teacher participated in the training program once between 2000 and 2007. The 77 responses represent a 25 percent response rate, which is below the average of 30 percent for Web surveys but a high enough rate to give a ten percent precision level for the survey responses[26,27]. Table 1 lists the demographic information of the teachers participating in the survey. The survey indicates a representative sample of the teachers in the DTEACh program. Roughly, half the teachers surveyed participated in the DTEACh training workshop in the 2000-2005 period (n=38) and half participated in the 2006-2007 period (n=37). This separation of survey participants into two groups was used to analyze how responses change with time.

Table 1. Demographic Information

Gender	
Male	19(25%)
Female	56(73%)
Preferred not to answer	2(3%)
Year of DTEACh Workshop	
2000	5(6%)
2001	6(8%)
2002	4(5%)
2003	6(8%)
2004	7(9%)
2005	10(13%)
2006	14(18%)
2007	25(32%)
School Type	
Public	71(92%)
Private	4(5%)
Preferred not to answer	2(3%)
Race	
American Indian	1(1%)
Asian or Pacific Islander	3(4%)
Black, Non-Hispanic	3(3%)
Hispanic	9(12%)
White, Non-Hispanic	55(71%)
Preferred not to answer	6(8%)
Average years of experience in the classroom	
	14.2
Average number of students in the classroom	
	21.0

Results and Discussion

The goal of the survey was to determine whether the teachers are using the training in their classrooms. Are they adopting the techniques and the DTEACh 5-Step method? Does the adoption rate change with time? Representative results are shown below. Overall the survey reinforced the belief that teachers are using the techniques presented in the training institutes in their classrooms. Not only are they using the techniques immediately following the training, but they are continuing to use them at high rates years later.

Research Question One –
"Do the teachers use the DTEACh 5-step process?"

One desired outcome of the training institutes is that the teachers understand and use the DTEACh 5-Step process. While it is clear that the majority of the teachers are practicing the

method, most cannot articulate the steps in the process. The majority of the teachers could not describe the DTEACh 5-Step process, but the majority stated they frequently used each step of the DTEACh 5-Step process, as shown in Figure 3. Are the teachers practicing the results but not espousing the theory?

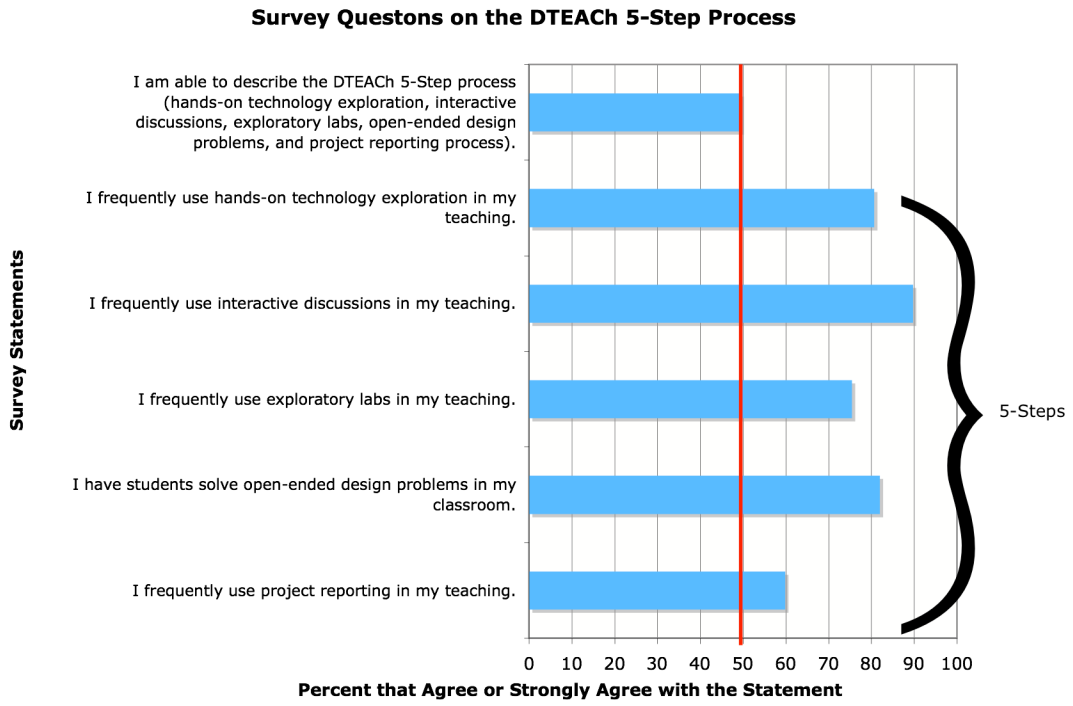

Figure 3. Chart of Survey Questions about the DTEACh 5-Step Process (n=77)

As part of the training, the DTEACh 5-Step Process is emphasized as an overall approach to enhancing STEM education with Active Learning. The scientific method and engineering design process are compared and contrasted as examples of systematic processes. These processes are then related to the DTEACh 5-Step model to emphasize its utility in teaching STEM subjects. We expected that the ability for the teachers to describe the process would be more prevalent in the more recent years. This assumption was not validated, as shown in **Figure 4**.

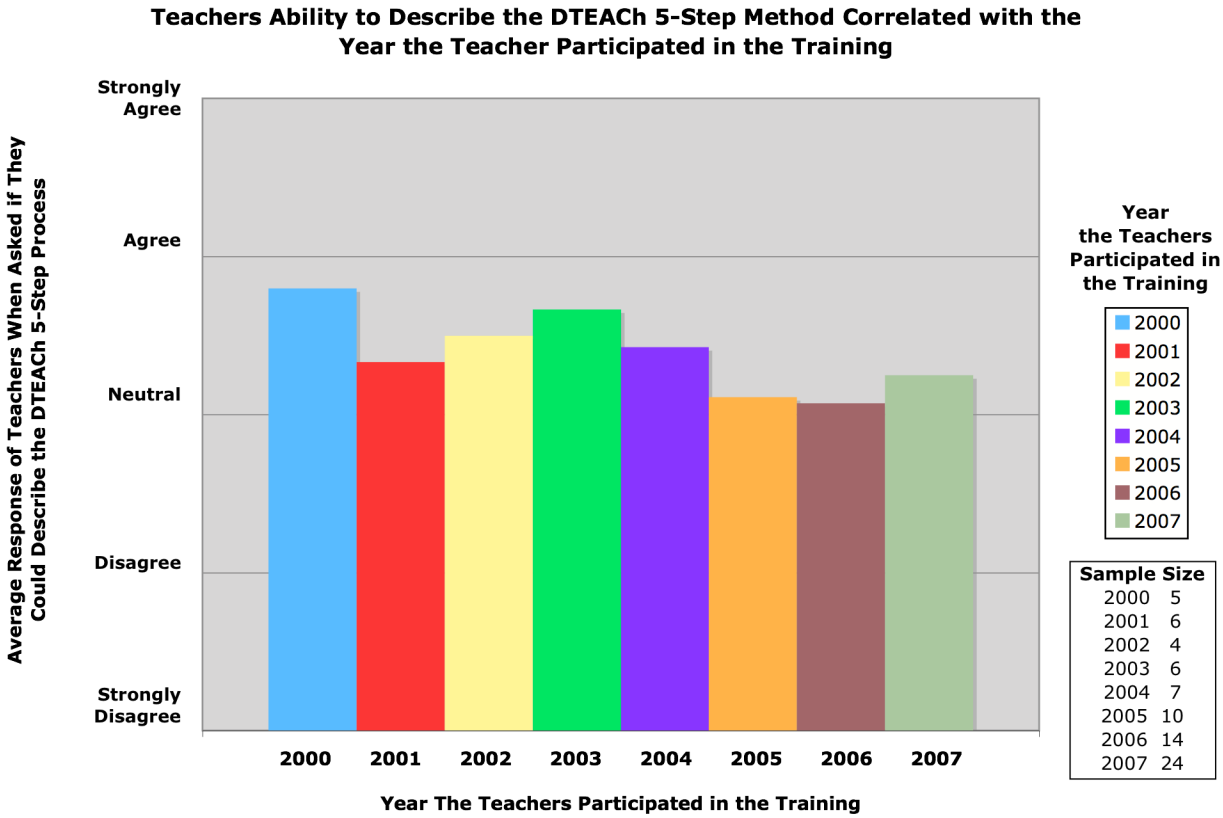

Figure 4. Teachers ability to describe the DTEACh 5-Step Process

The higher average rate of agreement with the statement in 2000-2004 is likely due to the small sample size when subdivided into separated years. Analysis of Figure 3 and **Figure 4** reinforces the results that teachers are using the individual steps in the method but do not recognize the method as such. The teachers who participated in more recent institutes do not exhibit any more ability to describe the method that those who participated earlier. More research with a larger sample size should be performed to determine the causes of this result.

Research Question Two –
"How do the teachers assess student learning in their classroom?"

One goal of the DTEACh program is to influence how teachers assess learning in their classrooms. Do the teachers primarily administer multiple choice and matching tests, which have set answers, or do they primarily assess students with open-ended problems? Figure 5 shows a representative sample of statements asked of the teachers to determine how they assess student learning. The teachers' strong rejection of statements emphasizing lower order assessment, for example using matching and multiple-choice tests, demonstrates the teachers' push towards having students use higher order thinking. The results indicate that the teachers are typically assessing the students with open-ended problems and rejecting worksheets as a primary tool in assessment. Some variation is seen between the teachers who participated in the training during the 2000-2005 period compared to the 2006-2007 period, but the data did not indicate that

the teachers from several years ago were using the techniques less than the teachers who participated recently. This finding indicates the teachers' use of the training was not diminished with time.

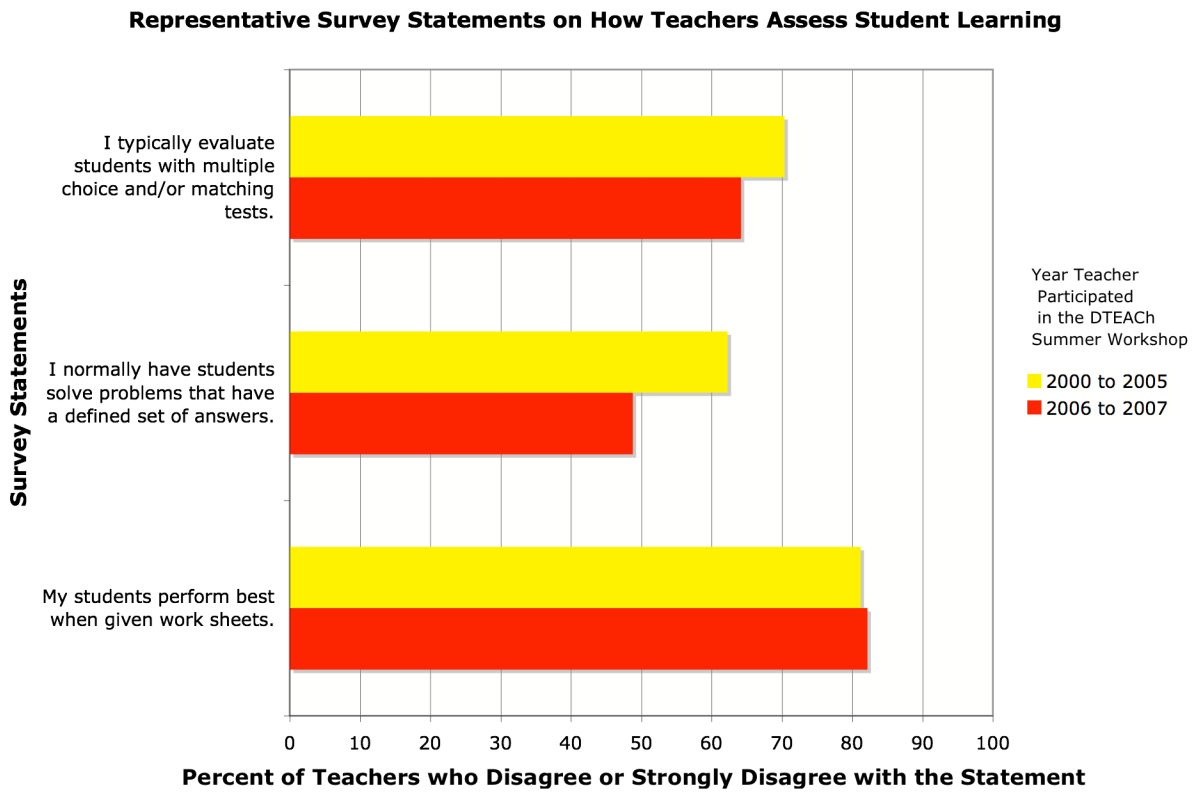

Figure 5. Chart of Representative Survey Statements on How Teachers Assess Student Learning (n=77, 2002-2005= 38, 2006-2007= 39).

Research Question Three –
"How are the teachers interacting with their students?"

Another goal of the training is to influence teacher and student interaction. Are the teachers using real-world examples of concepts to engage students in learning? Are hands-on activities a part of the teacher's learning environment? These examples are both representative questions of the teacher-student interaction techniques shown in Figure 6. The analysis shows that teachers are using DTEACh hands-on activities in the classroom as intended. The analysis shows that the teachers who took the training three or more years from the survey date are using the techniques, on average, at the same impressive rate as the teachers who more recently participated in the training.

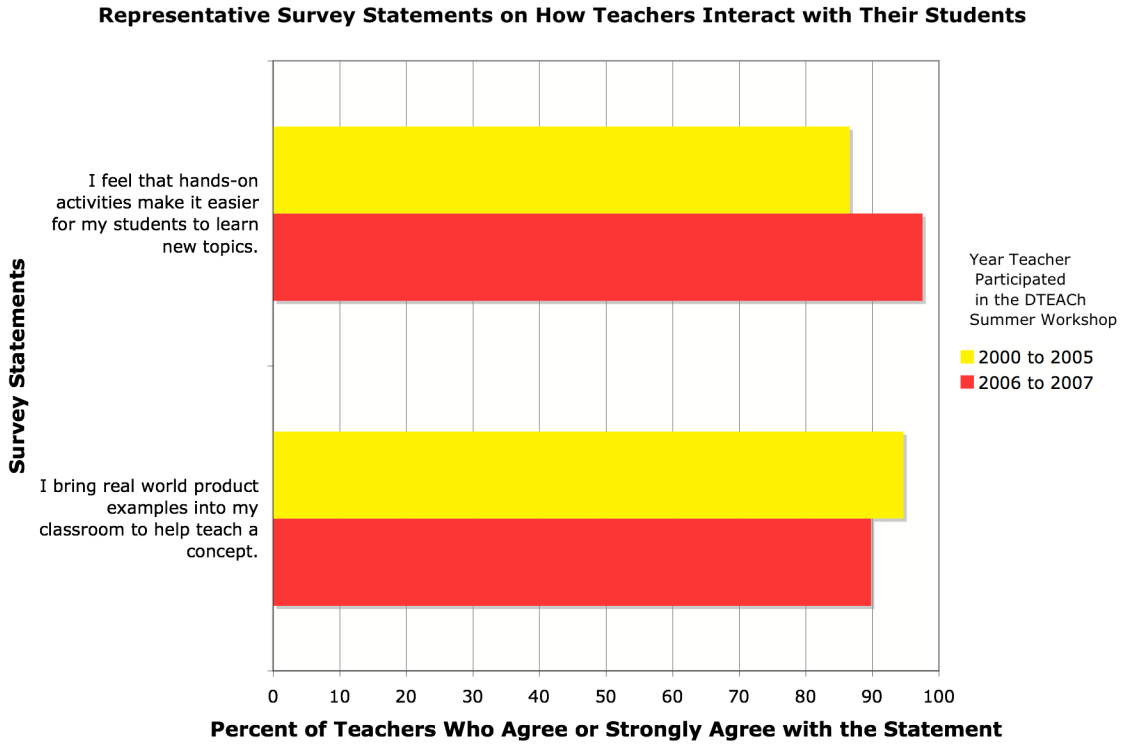

Figure 6: Chart of Representative Survey Statements on How Teachers Assess Student Learning (n=77, 2002-2005= 38, 2006-2007= 39).

Research Question Four –
"How do the teachers perceive the training program?"

We intend that the teachers enjoy and be motivated by the DTEACh training. An overwhelming ninety-three percent of the teachers agreed they enjoyed the training. Teachers who took the training more than three years ago only dropped agreement with the statement to eighty-nine percent. A sample of the anecdotal statements offered by the respondents is shown in Table 2. In general, these support the conclusion that they like and believe in the training. Daily survey assessment of DTEACh teacher training in 2004 showed overwhelmingly that the teachers thought the training was relevant and motivating[15]. The analysis indicates that the teachers, no matter when they took the training, enjoyed the experience.

Table 2. Qualitative Statements about the DTEACh Program

Illustrative Comments
"I love it!"
"An excellent program to attend."
"DTEACh strengthened my teaching and problem-solving."
"The DTEACh summer training was an amazing experience, and
I whole-heartedly support the use of its philosophies in
"Open ended projects and design help integrate learning and
connect to real world applications that create purpose for

Limitations

The conclusions that can be drawn from this study are limited. The survey data analyzed was self-reported. Therefore, it should be assumed that the results are based on what the teachers perceive they are doing. Unfortunately, it was not possible to conduct classroom observations as a part of this study. Classroom observation data could be used to verify the conclusions of the study. The survey was designed to minimize this shortcoming by asking multiple survey questions in different ways to address a single research question. It is likely that the survey respondents that participated in the 2000-2004 training are more enthusiastic about the training than those who did not respond, skewing the data somewhat. The results of the data assessment cannot assert that the DTEACh training was the only factor influencing teachers' instructional styles and practices, as the classrooms are multi-faceted environments influenced by many factors. Fifty percent of the teacher responded that they had attended other Active Learning training. It is difficult to isolate the exact cause of change, but the study does document the techniques the teachers are currently using. The enthusiasm for the DTEACh institutes supports the conclusion that the teachers *believe* the training has influenced their instructional methods.

Conclusions – Practice What You Preach

The analysis of the data supports the belief that using Active Learning to teach Active Learning methods is an effective way to influence teachers even years down the road. The analysis indicates the teachers are practicing instructional styles and methods that the DTEACh training institutes were designed to instill. The finding that many teachers cannot describe the method needs further investigation. There is no indication that the teachers do not understand the instructional theory. Perhaps they do not recognize the labels for the steps, or perhaps this an artifact of the survey wording. The analysis of this data indicates that the teachers also continue to practice the techniques up to seven or more years after the training workshop. These results indicate that using Active Learning in teacher training workshops to influence participants has lasting effects years later.

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Appendix A – DTEACh Likert Survey Questions

DTEACh Likert Survey Questions
The general concepts of engineering are a mystery to me.
I frequently use project reporting in my teaching.
I have students solve open-ended design problems in my classroom.
My students enjoy open-ended problems.
I frequently have students use LEGO Mindstorms in my classroom.
My students perform best when given work sheets.
I am able to describe the DTEACh 5-Step process (hands-on technology exploration, interactive discussions, exploratory labs, open-ended design problems, and project reporting process).
I frequently use the 5E (Engage, Explore, Explain, Elaborate and Evaluate) teaching process in my classroom.
I bring real world product examples into my classroom to help teach a concept.
I feel LEGOs are of little education value in the classroom.
I normally have students solve problems that have a defined set of answers.
I frequently use exploratory labs in my teaching.
I regularly integrate project based learning activities into my lesson plans.
Students in my classroom rarely ask questions.
I typically evaluate students with multiple choice and/or matching tests.
I enjoyed the DTEACh summer training.
I have students use flow charts to illustrate a process.
I feel that having open-ended project assignments helps me cover more TEKs with a single assignment.
I frequently use interactive discussions in my teaching.
After having DTEACh training, I created my own hands-on activities for the students.
I rarely use open-ended design problems in my teaching.
I feel that I have a good understanding of what an engineer does.
I frequently use hands-on technology exploration in my teaching.
My school administration is supportive of project based learning in the classroom.
I learned more than just building and programming LEGO Mindstorms in the DTEACh training.
I feel the DTEACh training changed the way I teach.
I feel that project based learning is too time consuming for use in my classroom.
I feel that hands-on activities make it easier for my students to learn new topics.
Prior to taking the DTEACh training program, I did not create hands on activities for my students.
I use project based learning in my classroom because I am mandated to do so.
I frequently ask my students questions in the classroom.
I found this survey to be a useful mechanism for giving feedback to the DTEACh program.