Abstract

Demonstration models allow students to readily grasp theory and relate difficult concepts and equations to real life. One major drawback of using demonstration models is that they are costly to purchase from vendors and that they take a significant amount of time to build. These two limiting factors pose a significant obstacle for adding demonstrations to the curriculum. This article presents an assignment to overcome these obstacles. To date the assignment has resulted in 24 demonstration models being added to the curriculum. The article also presents the results of student performance on course objectives as a result of the 24 demonstration models created being used in the classroom. Overall, significant improvement in student learning outcomes, due to the addition of demonstration models, has been observed.

Keywords

Demonstration models, hands-on learning, visualizing theory, student learning outcomes

Introduction

Numerous engineering courses lend themselves to teaching methods that utilize demonstration models. Demonstration models allow students to readily grasp theory and relate difficult concepts and equations to real life. One of the cornerstones of the highly successful ASCE ExCEED teaching model is the use of physical demonstrations. One major drawback of using demonstration models is that they are costly to purchase from vendors and that they take a significant amount of time to build. Faculty members are generally pressed for time and departments have limited funding for purchasing manufactured demonstrations. These two limiting factors pose a significant obstacle for adding demonstrations to the curriculum. This article presents an assignment to overcome these obstacles. Over the last 3 academic years a “Demo Design Challenge” has been issued to students in a senior level class at Florida Gulf Coast University to address the two major limitations for adding demonstrations to the curriculum. This article presents the “Demo Design Challenge” assignment in detail and discusses the effectiveness of creating models using this assignment.

Background and Justification

The use of physical models has shown to be beneficial in undergraduate education1-3 It addresses both the visual and kinesthetic learners in the classroom4-7 however it must be mentioned that learning styles theory has recently come under question8. Several articles9-13 have documented activities and benefits of models in the classroom. The American Society of Civil Engineering Excellence in Civil Engineering Education (ExCEEd) Teaching Workshop emphasizes the use of
physical models demonstrating effective implementation and encouraging participants to develop and employ models both in their “practice classes” during the workshop and later in classes back at their home institutions. What is less prevalent in the literature however is how these models can be effectively and efficiently developed. Some textbook publishers provide videos and several companies produce equipment that can be purchased if it falls within a department’s budget; but often it is left to the instructor to locate or develop meaningful course models. This paper presents an alternative to faculty developed models with the creation of an assignment in an upper level course for the fabrication of a model and related instructional presentation.

In addition to the benefits these models confer on students in the class in which they are utilized, the creation of both the model and the associated theory strengthens topic comprehension for the upper level students by supporting a constructivist learning theory. The creation of models is considered the highest level of learning in the revised Bloom’s Taxonomy and Meneske emphasizes that the group creation of knowledge is one of the highest levels of active learning. These seniors have seen models throughout the three course sequence in Water Resources, and thus have a basis on which to design an effective product. The familiarity with strong examples and how the work will be used is a critical component in receiving quality submissions.

Demo Design Challenge Assignment

The demo design challenge assignment was created in the fall of 2012 to address the lack of physical demos in the water curriculum at Florida Gulf Coast University, during a time of extreme financial duress. The idea was developed after viewing the “demonstration rooms” at West Point during the ExCEEd teaching workshop in the summer of 2012. The actual assignment that is given to students is displayed in Figure 1 and 2.

Semester Design Challenge

CWR 4540C Water Resources Design

Due 10/14/2014 at the start of class

To be completed in Project Teams of 4

Design and build a demonstration model that can be used to teach a concept from fluid mechanics, hydrology/hydraulics, or water resources. Please think back to your classes and try to identify an area where a demonstration model would have been helpful. Your project constraints are that your budget is not to exceed $60 ($15 per team member). If you already have construction material around the house it must be treated as if you had to purchase it. This is a design challenge and your grades will be based on how well your demonstration model is built and how well it can be used to teach a specific concept. There are no constraints on the material you can utilize. A list of possible ideas is included at the end of this handout. Please check with me and present your idea in detail before you start constructing anything. If you are having difficulties trying to come up with ideas I have a reference in my office that might be helpful. If you need additional resources please let me know.
The assignment expects each group of four students to pay the $60 for materials out of pocket and no financial assistance is received from the Environmental and Civil Engineering Department. The department does assist the teams with access to the machine shop and tools but the models must be built by the students themselves. The reference for idea mentioned in the description is “H2Oh! Classroom Demonstration for Water Concepts” edited by Amy Chan Hilton and Roseanna Neupauer and published through ASCE/EWRI. The board notes created by the students are collected in a “demo binder” so that they are readily accessible and using the demos requires minimal lesson preparation.

Demos Developed

Overall the assignment has been highly successful. Using the “Demo Design Challenge” assignment 24 demonstrations have been added to the water engineering curriculum at Florida Gulf Coast University (Table 1). Figures 3-9 display several of the models built by the students.
Table 1: Demonstrations Added to Water Curriculum

<table>
<thead>
<tr>
<th>Watershed model</th>
<th>Orifice apparatus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic rocket launcher</td>
<td>Hydraulic bridge</td>
</tr>
<tr>
<td>Manning’s channel for roughness</td>
<td>Curve Numbers (CN) plates</td>
</tr>
<tr>
<td>Buoyancy demonstration tank</td>
<td>Major and minor headloss</td>
</tr>
<tr>
<td>Stability boats</td>
<td>Fire tornado</td>
</tr>
<tr>
<td>Rainfall demonstration model</td>
<td>Hydrostatic force demo</td>
</tr>
<tr>
<td>Hydrostatic force calculation</td>
<td>Surface tension</td>
</tr>
<tr>
<td>Venturi effect in updraft carburetor</td>
<td>Flow lines (laminar/turbulent flow)</td>
</tr>
<tr>
<td>Viscosity of 6 fluid types</td>
<td>Vortex cannon</td>
</tr>
<tr>
<td>Hydrograph demo</td>
<td>A cubic foot of water</td>
</tr>
<tr>
<td>Centrifugal pumps</td>
<td>Multistage pumps</td>
</tr>
<tr>
<td>Bernoulli equation</td>
<td>Pressure gages</td>
</tr>
</tbody>
</table>

Figure 3: Watershed Model Capable of Showing Abstraction, Varying Slope and Urbanization Affects
Figure 4: Boats to Illustrate Stability and Center of Gravity

Figure 5: Infiltration and Abstraction
Figure 6: Buoyancy and Displacement

Figure 7: Fire Tornado and Bernoulli Equation
The assignment has resulted in the creation of high quality models. The knowledge that these models would become a permanent part of the curriculum inspired the students and gave them
the feeling that they were leaving a legacy for future students. The assignment also gives students a sense of empowerment as they are asked to address deficiencies in the curriculum that they observed.

The assignment has been introduced to colleagues in the U.A. Whitaker College of Engineering so that it can be utilized across our curriculum. In the summer of 2014 the assignment was presented at the ASCE ExCEEd teaching workshop hosted at Florida Gulf Coast University. It was well received and hopefully it can be utilized across the country in numerous engineering and science disciplines.

**Measurement of Demo Effectiveness**

To culminate each semester all courses in the Environmental and Civil Engineering Program at Florida Gulf Coast University are assessed and revised to continuously improve each offering. This detailed assessment allows for a direct measure of the effectiveness of models added through the demo design challenge assignment. For example one of the learning objectives for the fluid mechanics class is to solve buoyancy problems. In Fall 2011 students were given class instruction and homework problems as well as a test question. In Fall 2012 and Fall 2013, a buoyancy demonstration (Figure 6) was utilized. Table 2 summarizes the results of student proficiencies on the related test question for 2011, 2012, and 2013. The proficiency levels were jointly determined by the faculty to provide a standard for ABET assessment. The numbers indicate that a greater percentage of students achieved all levels of competency for this objective due to the addition of the buoyancy demonstration.

<table>
<thead>
<tr>
<th>Proficiency Levels</th>
<th>% of Students Meeting Proficiency Level 2011</th>
<th>% of Students Meeting Proficiency Level 2012</th>
<th>% of Students Meeting Proficiency Level 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 85%</td>
<td>21%</td>
<td>48%</td>
<td>53%</td>
</tr>
<tr>
<td>&gt; 70%</td>
<td>76%</td>
<td>90%</td>
<td>89%</td>
</tr>
<tr>
<td>≥ 65%</td>
<td>76%</td>
<td>90%</td>
<td>89%</td>
</tr>
</tbody>
</table>

One of the learning objectives for the hydrology/hydraulics class is to explain the hydrologic cycle and define a watershed. In Spring 2012 students were given class instruction and homework problems as well as a test question. In Spring 2013, a watershed model was added to the course (Figure 3). Table 3 summarizes the results of student proficiencies on the related test question for 2012, 2013, and 2014. The numbers indicate that a greater percentage of students achieved all levels of competency for this objective due to the addition of the model watershed.
Table 3. Student Proficiency Comparison for Explaining the Hydrologic Cycle and Defining a Watershed

<table>
<thead>
<tr>
<th>Proficiency Levels</th>
<th>% of Students Meeting Proficiency Level 2012</th>
<th>% of Students Meeting Proficiency Level 2013</th>
<th>% of Students Meeting Proficiency Level 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 85%</td>
<td>21%</td>
<td>65%</td>
<td>92%</td>
</tr>
<tr>
<td>≥ 70%</td>
<td>49%</td>
<td>87%</td>
<td>100%</td>
</tr>
<tr>
<td>≥ 65%</td>
<td>53%</td>
<td>89%</td>
<td>100%</td>
</tr>
</tbody>
</table>

One of the learning objectives for the fluid mechanics class is to identify proper units for fluid volumes. In Fall 2012 students were given class instruction and homework problems as well as a test question. In Fall 2013, a model of a cubic foot of water (Figure 8) was utilized. Table 4 summarizes the results of student proficiencies on the related test question for 2012 and 2013. The numbers indicate that a greater percentage of students achieved all levels of competency for this objective due to the addition of the model watershed.

Table 4. Student Proficiency Comparison for Defining a Watershed

<table>
<thead>
<tr>
<th>Proficiency Levels</th>
<th>% of Students Meeting Proficiency Level 2012</th>
<th>% of Students Meeting Proficiency Level 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 85%</td>
<td>43%</td>
<td>69%</td>
</tr>
<tr>
<td>≥ 70%</td>
<td>48%</td>
<td>91%</td>
</tr>
<tr>
<td>≥ 65%</td>
<td>48%</td>
<td>93%</td>
</tr>
</tbody>
</table>

In addition to the higher levels of student competency observed on learning outcomes due to the inclusion of models, a significant amount of positive feedback has been received from students and colleagues. The comments from students indicate that the models allow them to actually see the concepts being taught in class. They feel that the hands-on nature of the physical models teaches concepts in a way that relates to their own experiences and addresses their need for visual learning. The students also feel that the models connect the theory taught in class to the physical world around them. Comments from students also indicate that the models break up the lecture into more time appropriate sections and allow for maximum attention from the students.

Building the models also has some significant benefits for the students. The major benefit commented on by students is that they gain an understanding about the process of design and gain valuable skills about the construction process in a group environment. An additional benefit of model construction is that the students gain experience using a variety of materials and tools that they have not been previously exposed to.

The final benefit for students from the “Demo Design Challenge” comes from putting together board notes and presenting the model to the class. Student comments indicate that putting together the board notes reinforces the theory behind the model. The comments also indicate

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that the student gain valuable public speaking experience when they present their model and board notes to the class.

Conclusions

The benefits of having demonstration models and visual tools to illustrate engineering theory are enormous and are well documented. The drawback to having models in the classroom is that they are expensive to purchase and time consuming for a faculty member to build. The assignment presented here addresses a gap in the literature and presents faculty with a tool to efficiently and effectively create classroom demonstrations on a limited budget. The preliminary data collected about student learning outcomes indicates that the “Demo Design Challenge” has substantially improved student learning. The comments from student indicate that the assignment is well received and has several aspects that increase student learning. It is the authors’ great hope that the Demo Design Challenge is adopted in programs across the country and enhances student success and the effectiveness of engineering educators.

References


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