ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #40961

A Framework for Closing Workforce Knowledge Gap Through Engineering Education.

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ABSTRACT

Almost all engineers are well accustomed to advanced mathematical and scientific concepts. However, the non-engineering workforce may be vastly different from the typical engineering workforce. For non-engineers, the mathematics and physics concepts may be daunting when they need such knowledge to perform their job responsibilities in a meaningful way. In the workforce, such knowledge gaps may occur, and one such instance is the hydraulics knowledge needed by the environmental health specialists working for the state Department of Public Health (DPH) to examine swimming pool plans prior to approval. An agreement was reached between a public university and the DPH to meet this need for engineering education. This work focused on training to help in developing a non-engineering workforce to understand fundamental engineering concepts related to hydraulics. The training was divided into two portions: a classroom lecture and accompanying lab components. In order to encourage effective learning and to capture the attention of learners, the lecture and lab sections were sequenced in a scaffolding method where lessons were broken down into chunks, and the lab was used to reinforce learning through hands-on activities. A survey was conducted among the four different cohorts who participated in different sessions to observe the effectiveness of the method in training the non-engineering audience. The results from the surveys show that the participants appreciated the opportunity to learn the background materials and confirmed the importance of laboratory work in reinforcing engineering concepts for non-engineering audiences. Additionally, feedback from the training sessions suggests that engineering concepts delivered using the scaffolding method are generally acceptable for non-engineering audiences.

Introduction

Mathematical and scientific concepts are key components in any engineering discipline. During the first few semesters, all engineering programs focus on building these core understandings, making all qualified engineers accustomed to many applications of mathematical and scientific concepts. However, in some rare circumstances, professionals with no engineering background are expected to perform some duties that require background knowledge in engineering if they were to perform those tasks in a more meaningful way. One such occasion identified by a state agency is when the county environmental health specialists must engage in examining swimming pool plans prior to approval. This task requires an understanding of Water Resources, Hydraulics, and Fluid Mechanics knowledge for which they have never received formal training or education. Having recognized this need, the agency reached out to several universities with the intention of developing a training program mainly focused on this scenario. Accordingly, this paper documents the valuable collaboration between the state Department of Public Health and an engineering department at a public university to close the knowledge gap through engineering education.

Objective

The objective of this project was to train county Environmental Health Specialists (inspectors) on how to conduct plan reviews for new and existing public swimming pools, spas, recreational water park attractions, and other special-purpose pools. When reviewing plans, Environmental Health Specialists need to have basic knowledge and understanding of certain engineering principles involved with plan review, such as calculating friction loss, determining total dynamic head, selecting the correct recirculation pump, and other factors. During the past years of in-house training, the agency has noticed there is a knowledge gap between these topics and others among public health professionals. The goal of this proposal is to provide the necessary training, including hands-on activities, to overcome these knowledge gaps.

Literature review

Instructing non-engineers to perform basic engineering-related work is very different than instructing typical engineering students. Non-engineering students do not necessarily have a fundamental scientific background and thus may find the material challenging. Literature review shows there exist previous attempts to teach non-engineers to embrace and understand engineering concepts (Butler & Wilson, 2010). Butler and Wilson's work discusses techniques such as high-impact learning, course material structuring and alignment, etc. Shortly after that, (Hendrix et al., 2012) 12) performed a continuation of work done by Butler & Wilson, however, with a different focus. The goal of Hendrix et al.'s work is to address the issue of how to motivate non-engineering students to care about their learning. Hendrix's study presented data collected over several years on student's performance, course evaluations, and surveys of students' interests. This study is important, as it shows that the student's interest can vary based on different factors such as the enthusiasm of the instructor, the use of technologies, in-class demonstrations, etc.

The focus of our work in the current study is related to but differs slightly from the literature mentioned. Our work focuses on using the scaffolding method so that engineering concepts can be delivered to a non-engineering audience that does not get discouraged from learning. Instructional Scaffolding is not a new technique used in teaching but is an effective one. This technique was first introduced by (Wood, Burner, and Ross, 1976) and has been used by many educators in engineering education (Newstetter, 2005, Nelson, 2012, McCleod & van der Veen, 2019). The scaffolding technique typically involves teaching a concept, reinforcing the concept, and taking a step back to allow students to connect the concepts to practice. The authors applied this technique by structuring the training sessions such that the lectures, in-class activities, and laboratory sessions are staged to create alternating opportunities for classroom and hands-on learning.

Planned Training Structure

Basic engineering concepts are first taught in the classroom by relating back to what the participants see in the field. The training then slowly extends into more advanced concepts. When these concepts are presented, checkpoint activities are provided to participants to self-check their understanding. The checkpoint activities are then used as classroom discussion items for participants to interact and share knowledge among themselves. Once participants had gone through the checkpoint activities, the training proceeded to allow them to extend their understanding using laboratory activities. It was believed that by doing this, participants have the opportunity first to learn and then enhance and reinforce their learning and proceed by applying concepts during the lab independently. This same cycle is then continued to the next important concept or section.

The planned training structure that was used in this study is detailed in Figure 1.

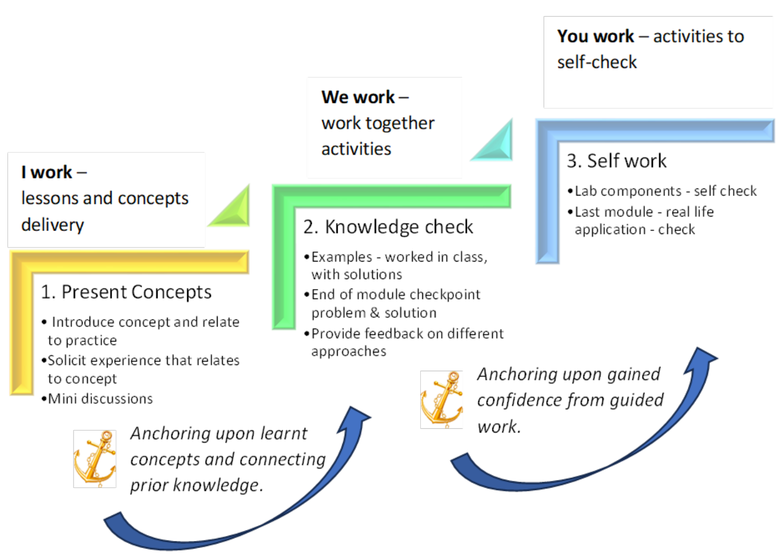

Figure 1: Planned training structure based on the scaffolding method.

Format of the Training Program

The program covered two full days of training on various principles related to the topics and hands-on activities in a fluid mechanics laboratory on the university premises. Upon the development of the draft materials, DPH reviewed the content and provided feedback, which was addressed to make the program more meaningful and beneficial to the participants. Recruitment of the participants was carried out by the DPH, and four cohorts were trained during the one-year time period. The first training session was conducted on March 6-7 with the participation of 12 individuals; the second session was conducted on March 20-21 with the participation of 17; the third session was conducted on May 16-17 with the participation of 18; and the fourth session was conducted on June 12-13, with the participation of 15. In order to save time, the program provided lunch at the training site.

Assessment of the Program

At the end of each training program, the team conducted a brief assessment so that the content and the delivery could be further improved. A sample of the survey instrument utilized is provided in Figure 2.

Training the Next Generation of County Environmental Health Specialists
Georgia Department of Public Health, Public Swimming Pool Program
Program Evaluation: June 12-13, 2023

1. Overall, the content of this course contributed to my knowledge and understanding of the topic.
a. Strongly Agree b. Agree c. Neither Agree or Disagree
d. Disagree e. Strongly Disagree

2. There was good agreement between what I expected to learn and the course content.
a. Strongly Agree b. Agree c. Neither Agree or Disagree
d. Disagree e. Strongly Disagree

3. The course increased my interest in the subject.
a. Strongly Agree b. Agree c. Neither Agree or Disagree
d. Disagree e. Strongly Disagree

4. I would suggest others in similar roles go through this training.
a. Strongly Agree b. Agree c. Neither Agree or Disagree
d. Disagree e. Strongly Disagree

5. Providing food was helpful in staying focused on learning.
a. Strongly Agree b. Agree c. Neither Agree or Disagree
d. Disagree e. Strongly Disagree

6. Other topics that would have been helpful include the following.
a. --------------------------------
b. --------------------------------
c. --------------------------------

7. Any other feedback?

Figure 2. The survey instrument used to gather feedback from the participants.

The average ratings for the five key questions that were included in the survey form are presented in Table 1, based on a 5-point scale. For each of the items considered, participants provided very high ratings, demonstrating the success of the program and the value of introducing this type of training to close the knowledge gap. Among the five factors, participants rated “Overall, the content of this course contributed to my knowledge and understanding of the topic” with the highest average satisfactory rating of 4.77. “I would suggest others in similar roles go through this training” and “There was good agreement between what I expected to learn and the course content,” followed by 4.66 and 4.64 average ratings, respectively.

In response to the open-ended question, the participants provided many positive responses that often times referred to the enthusiasm and passion of the instructor, the usefulness of hands-on activities that the participant had in the Fluid Mechanics lab, and suggestions to extend the program to longer durations were common.

Lessons Learned

While the experience was overwhelmingly positive for both sides, there were practical challenges in implementing and conducting the training. Such things include time management during the checkpoint discussions, which sometimes may extend beyond the planned duration and, in turn, affect the lab schedule. It might be easy to cut the discussion short; however, this comes at the expense of reduced opportunities for the self-learning component of the scaffolding method for participants to gain independence on the subject matter. Coordination of university facilities such as classrooms and labs also created challenges during the times when the semester is in session.

Observation was also made on the diversity of participants' level of understanding of physics concepts prior to the beginning of the training program. While the training was structured with the assumption that participants have no background knowledge in physics, more experienced DPH personnel might lose interest early on during the training. Engaging the more experienced participants early is therefore felt as important.

Table 1. Average ratings for the Five Key Questions

Item	Rating based on 5-point Scale			
	Cohort 1	Cohort 2	Cohort 3	Cohort 4
Overall, the content of this course contributed to my knowledge and understanding of the topic	4.67	4.82	4.78	4.80
There was good agreement between what I expected to learn and the course content	4.50	4.41	4.83	4.80
The course increased my interest in the subject	4.42	4.29	4.50	4.60
I would suggest others in similar roles go through this training	4.42	4.71	4.67	4.87
Providing food was helpful in staying focused on learning	4.50	4.60	4.33	4.53

Conclusions

This training program was an excellent example of how public agencies and universities could work together for the common good in the area of workforce development. All in all, the program provided a framework for future training sessions for generally non-engineering participants. While the participants rated the program very high, there are improvements that could still be made in any future training sessions. These improvements include incorporating the use of technology, such as the use of software to assist participants in checking their calculations, group-based hands-on activities in the lab, and videos to better relate the training to their fieldwork. These items may increase their interest and thus motivate them to self-learn beyond the material offered in the training.

Acknowledgments

The authors would like to thank the Georgia Department of Public Health for identifying the need and providing financial support for conducting this project, which consisted of delivering four training sessions. The authors particularly appreciate the support, enthusiasm, and involvement of Mr. Maurice Redmond, Program Director of the Public Swimming Pools, Body Art, and Tourist Accommodations unit of the Department of Public Health / Environmental Health Section. The authors would also like to thank and appreciate the support provided by Mike Frailey and Liza Hardison during the training program.

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