

Using blended learning to enhance student comprehension of drilling operations: A case history

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ABSTRACT

The great crew change is now forcing petroleum educators worldwide to adopt innovative strategies to address manpower development needs. This paper provides a case study of how commercially available eLearning materials were incorporated into the existing drilling engineering curriculum at Missouri University of Science and Technology (S&T). The format of instruction used has been come to be known as *blended eLearning*. The objective of the eLearning software was to improve the practical understanding of drilling operations for first-year petroleum engineering students, as well as prepare them for more rigorous engineering courses. Students were required to take eLearning courses and pass online quizzes before coming to class. The average midterm score for upper level drilling engineering students participating in the blended learning format showed a slight increase even though the student to instructor ratio increased fourfold. Increased efficiency in course delivery was realized through a structured approach that first involved assigning students self-study tutorials, accessed online, which contained media rich animations and interactive learning exercises. Topics that are considered as foundation materials to the course were studied via the computer on the student's own time, and their own pace. The requirement to take eLearning courses before lectures also increased class participation. Teaching efficiency increased because instructors were able to devote more lecture time to mathematical descriptions, theoretical aspects, and other topics requiring considerably more explanation and individualized instruction. After evaluating the results at S&T for more than 100 students receiving 1900 hours of online eLearning through an informal arrangement with PetroEd Multimedia, the blended learning approach provided an enhanced learning environment for students, and demonstrates it is a tangible solution for improving learning efficiency.

INTRODUCTION

The expected change in age demographics among petroleum engineers has been for the last decade labeled ‘the great crew change’. Based on Society of Petroleum Engineering (SPE) member data, it can clearly be seen that the age distribution has changed (Figure 1). The total number of regular SPE members has also increased from 48 thousand in 1997 to 71 thousand in 2010 (Figure 1). The group between 35 to 49 years of age accounted for 55% of the SPE member body in 1997. The same group was down to 30% in 2010. The age group of 50+ has increased in its relative share of the SPE member body and currently, 41% of the SPE membership is accounted for by a group who will to a large extent, leave active employment in the next decade, or have already done so. The group of young professionals under the age of 35 has also increased in relative importance as well as absolute numbers from 7 thousand to 17 thousand in 2010.

The increase of younger engineers paired with the retirement of more experienced engineers requires less experienced personnel to take on more responsibility earlier in their careers. In addition, companies expect new hires to gain experience faster. This dynamic is compelling universities that provide petroleum engineering programs to increase their focus on teaching practical engineering skills in addition to giving students a sound theoretical foundation.

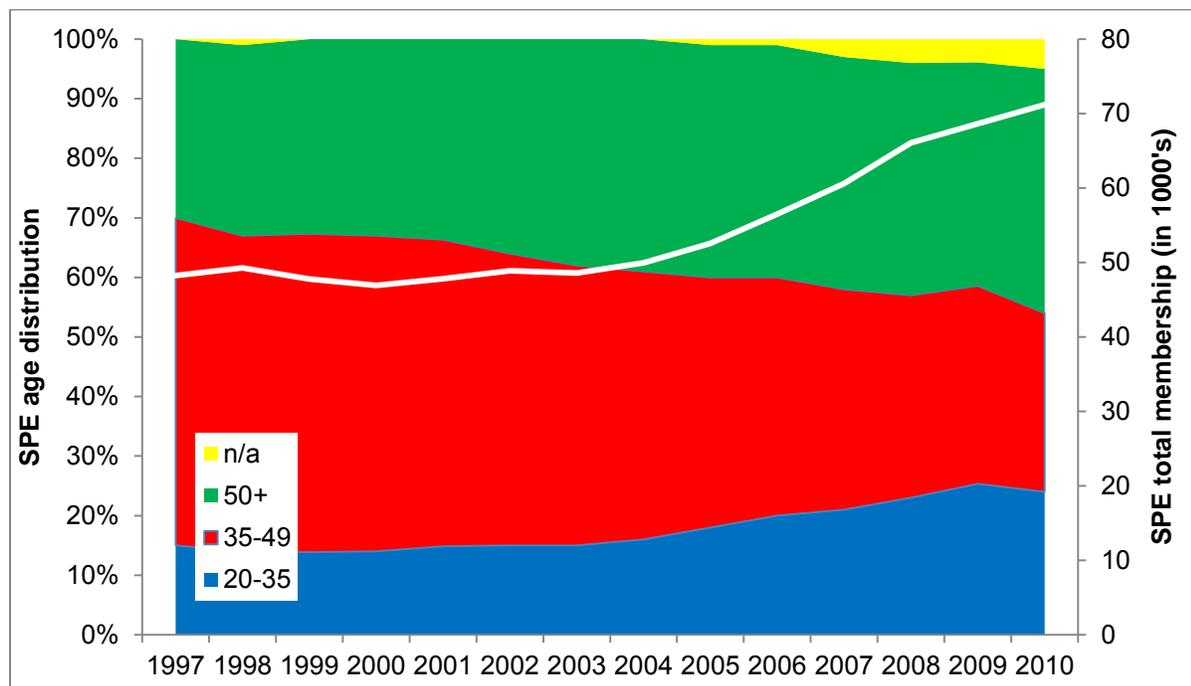


Figure 1. SPE member demographical distribution over the last 13 years (SPE, 2012).

Industry attention on the great crew change coupled with high student enrollments have significantly increased the number of students signing-up for American petroleum engineering programs (Table 1). Enrollments have occurred without a concomitant increase in instructors so the student/faculty ratio has escalated from 13 in 2000 to 26 in just ten years (Table 1). An increasing student to faculty ratio evidently will give a higher student number in each class as well.

Table 1. US Petroleum engineering programs enrollment number and student faculty ratio

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total US. Ugrad.	1307	1411	1742	1603	1621	1603	1673	1865	2107	2477	3009	3710	4385	4660	5014
Total S&T student	54	49	53	40	34	38	43	39	40	42	51	88	128	128	200
Ugrad. per faculty	11	12	16	13	13	13	12	13	15	17	19	21	26	25	26

Universities are faced with the challenge of teaching more students higher educational standards in theoretical and applied drilling topics, possibly without additional faculty, labs, or funds. Missouri University of Science and Technology faced this challenge during the last five-year period when the student population quadrupled while resources towards drilling education remained constant. This paper addresses the approach that was taken at Missouri S&T to meet this challenge.

Traditionally the drilling curriculum at S&T contained a three credit well design and drilling engineering course and a one credit drilling fluid laboratory. The instruction was lecture based from the SPE textbook on applied drilling engineering (Bourgoyne et al. 1986) with weekly homework, with occasional quizzes in class and two separate exams. As part of each lecture, students solved problems so the instructor could evaluate if they had understood the material. With class sizes of less than 10 to 15 students, the instructor had ample time to address the student's questions and offer individual assistance. However, when the class sizes started to grow, this important aspect of the teaching experience was significantly impacted.

As part of the revision of the petroleum curriculum, the drilling engineering curriculum was divided into two courses. First the freshman students took a one credit introductory drilling class. In their junior year, the students completed a three credit drilling engineering and well design class with an accompanying drilling fluid lab. With the change in course structure, the course delivery method of the material was also addressed with the goal to increase the learning outcome of the course.

IMPLEMENTATION OF BLENDED LEARNING INTO S&T DRILLING COURSE

Traditionally, the drilling course was structured around instructor-led, classroom lectures based on classic textbook material. This delivery format required intensive edits to lectures to update drilling equipment and technologies not included in the textbook. Examples of technologies not included in the textbook were top drive units to rotate the drill string and rotary steerable systems to create directional change. Describing these types of drilling processes and related tools required substantial instruction time.

Several definitions of blended learning exist, including the use of multiple modes of technology, combining pedagogical approaches, or the blending of instructional technology with face to face student and instructor interaction (Graham, 2006.). Blended, hybrid, or mixed-mode learning are interchangeably used (Martyn, 2003). The concept of blended learning was evaluated as a new method to teach the drilling courses at S&T. Faculty within the petroleum engineering department decided to implement a blended approach by embracing modern technology to increase student knowledge about new drilling methods and tools, ensuring students were prepared before coming to class, and that face to face time with an instructor both in class and in laboratory sessions used to reinforce knowledge and test student understanding.

The corner stone of the new drilling curriculum was that students, *before class*, had to engage in online eLearning sessions and pass an online quiz before coming to class. By utilizing eLearning in this manner, face to face time was concentrated towards student interaction with instructors and other students, particularly in problem solving activities. This focused interaction with students and provided the lecturer with an opportunity to identify specific concepts that the students found particularly challenging. To be able to get student feedback during class time the automatic respond cards (clickers) were used during the lecture. To better use instructor time an online forum was created where the students could ask questions, discuss homework, lecture material, and labs. The online forum was monitored by the professor and teaching assistant which provided responses to the students as required. Finally a rig visit was included to reinforce what had been addressed through online tutorials and lectures previously.

eLEARNING MATERIAL

The eLearning materials provided by PetroED Multimedia use multimedia to explain basic drilling concepts; such as rig systems, drilling tools and processes. The field of drilling engineering is inherently difficult to teach because the majority of operations occur downhole, and cannot be readily observed. The eLearning multimedia approach allows both surface and subsurface operations to be visualized through the use of 3D animations; this made the technical details of the tools and other technical components more easily learned. The online material is electronically maintained from a central server and therefore content can be revised more often than a textbook. Having a source with updated material reduced the need for the lecturer to spend time on preparing up-to-date technical material and illustrations. By requiring students to pass the quiz based on the eLearning material before attending lectures, S&T students came to class better prepared with a stronger foundation of vocabulary and concepts. Because the online sessions were more engaging than a textbook, it was more likely that the students would complete the online tutorial than finish the reading assignments before class.



Figure 2. The above screenshot shows the online lecture software. The software allow the student to study the material in its own pace (and language) and the student can self evaluate their progress by post assignments.

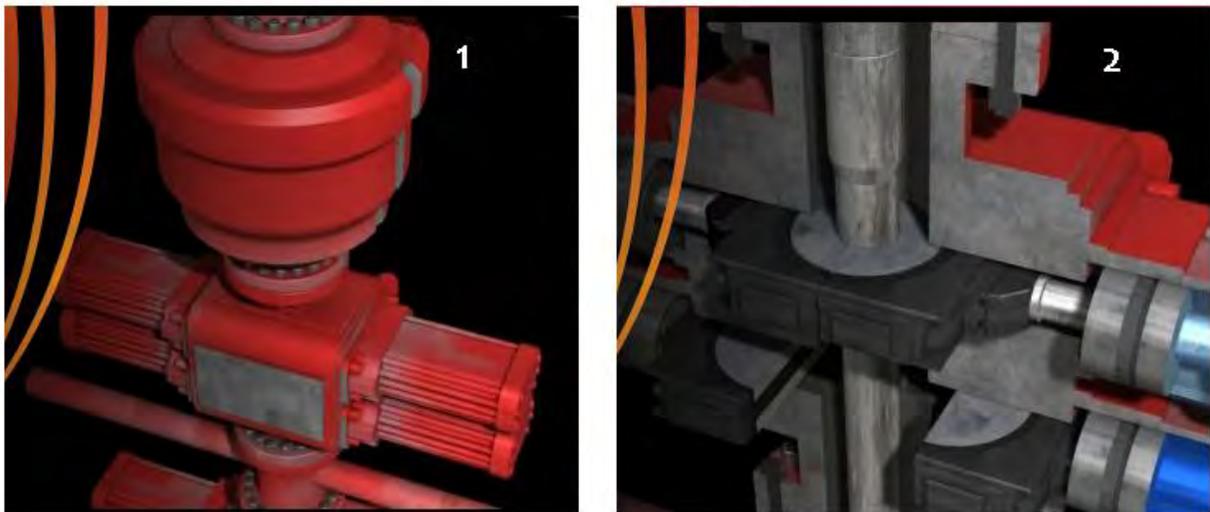


Figure 3. These two screen shots capture some of the animation which reveals the mechanisms of the BOP that are normally invisible. The 3D animation helps students understand the process and purpose of the BOP via visual learning.

The international nature of the petroleum industry also creates demand for multilingual training capabilities. Multilingual students using the software were able to study material in the language of their choosing. The software's multilingual capabilities increased the accessibility of the training knowledge, and helped accelerate student comprehension. Non-English speaking

students also gained educational benefits from the use of technical 3D animations. 3D animations are capable of communicating complex technical processes in ways that transcend language. This visual learning can help educate a geographically diverse population.

STUDENT AND FACULTY FACE-TO-FACE TIME

Due to the change in the delivery method, the content of the student face-to-face time with the lecturer was also modified. More class time was spent on problem solving and to develop practical skills among the students. In-class problems were worked out and the student had to answer questions by using electronic response cards (clickers) which gave the instructor immediate feedback if the student mastered the material or not. The combination with online lectures before coming to class and the use of clickers made it possible for students to be engaged even when class sizes were growing to over 70 students. With this number of students in the class, the lecture typically turns into a monologue, which modern learning research has shown to be less effective for the majority of students. The online tutorial also reduced the preparation time of creating new material for the lecturer, which could be spent on more direct contact with the students.



Figure 4. Student visits drilling rig.

To re-emphasize the material that was covered in the online tutorials a rig was visited at the end of the semester in the introduction class. The student spent a day going over the rig's systems and different components. After the rig visit, students received a quiz where they had to recognize major components of a drilling rig and describe how the equipment operates. Student scores averaged over 95% on this quiz, which clearly indicates they are able to recognize rig components and how these components work. Previously, on drilling rig visits that were not preceded with online tutorials, the lecturer observed that students could not as easily recognize rig components even though data was not recorded in order to affect a direct comparison.

EVAULATIONS

The change in the course delivery method to blended learning was initiated without a plan to measure its effectiveness. Ad-hoc observations by lecturers indicated that students were more engaged during lectures and had more questions before lectures. It is also clear that students are more likely to prepare for lectures when they have to do an online tutorial compared to a reading assignment. 100% of the students responded that they had viewed the online tutorials for the majority of the lectures prior to attending. Prior to implementing the blended learning concept at S&T, quizzes before class clearly indicated that students had not read textbook assignments.

In order to gain a quantitative indication of the effectiveness of the blended learning approach, -midterm exam grades for the upper level drilling engineering course were used. It was decided to study the midterm exam where the students had most of the material covered in the online lectures. The final exam covered more advanced topics, which were to a lesser extent covered in the online tutorials. Figure 5 shows mid-term exam scores presented by year. Prior to 2009, blended learning was not used. The data shows that while these scores held fairly constant, these results were achieved during a significant upsurge in student enrollment. It is import to note that the number of faculty did not change during this period, so the implementation of the blended learning strategy was important in the success of the program.

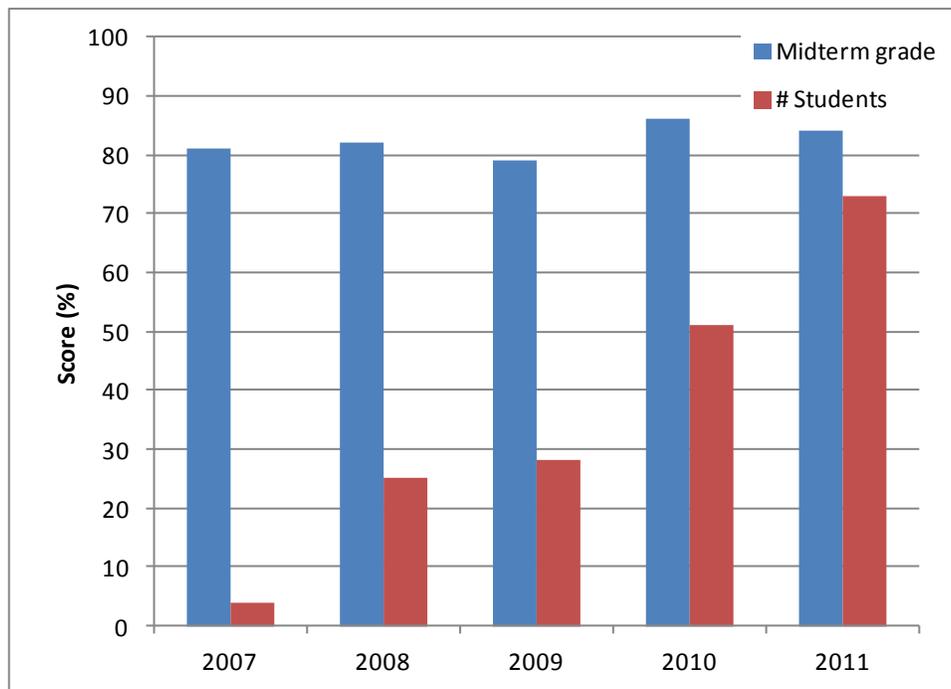


Figure 5. Midterm grade results.

CREATING A GLOBAL INITIATIVE

The blended learning initiative that S&T pioneered represents what might possibly be termed a pilot for the industry. Based on initial qualitative indications of this success, PetroEd Multimedia started the OPEN program to help alleviate the manpower and knowledge crisis currently being

faced by the oil and gas industry. The Open Petroleum Education Network (OPEN) gives qualifying colleges, universities and students access to internet-based training for the oil and gas industry. The program is available during the 2011/2012 academic year at no charge to institutions or individuals that qualify.

The Open Petroleum Engineering Network (OPEN) initiative, started by PetroEd Multimedia in 2010, is committed to providing modern petroleum eLearning courseware to petroleum educators. Based upon the results from the Missouri S&T Petroleum Engineering program, the OPEN initiative is maximizing instructor efficiency by allowing students to take online courses before attending class, and increasing focus on class deficiencies and more advanced subject matter.

Currently, the OPEN program supports over 1,000 students worldwide. Institutions other than Missouri S&T using OPEN courseware include Colorado School of Mines, Texas A&M Qatar, the Universidade do Estado do Rio de Janeiro, and Tomsk Polytechnic University

CONCLUSIONS

This paper describes how blended learning has been implemented into a university drilling curriculum where the use of a commercial online eLearning coursework was a major component. The following conclusions can be drawn based on the observations from this case study.

- The online material is easily updated and was kept up-to-date so the instructor could spend less time preparing technical illustrations and shift the focus of the face-to-face time. Instructor time with students was better utilized in problem-solving activities.
- eLearning courses were set up with a quiz so that the student had to pass this preparatory material before coming to class; this helped to ensure that students were prepared for class and made classroom interactions much more meaningful.
- The online dynamic of the online material with 3D animations helped to explain drilling tool operation and methods, many of which occur downhole where they cannot be readily observed. International students benefited by having access to eLearning content that had been translated into their native language.
- S&T's blended learning approach demonstrated that midterm exam scores were not impacted by increased class sizes where the student to instructor ratio increased by a factor of four.

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