Use of Adaptive Learning in an Engineering Technology Course: A Case Study

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Work in Progress-Use of Adaptive Learning in an Engineering Technology Course: A Case Study

Abstract

This study explores the use of an adaptive learning module implemented in a sophomore-level course for engineering technology and construction management students. Adaptive learning provides personalized learning pathways for students through the use of computers. Just-in-time feedback is one of its innovative features that helps to accomplish a unique student learning environment. While adaptive learning is explored in other disciplines, there is limited literature in the engineering education context. The research goal of this study is to examine student learning and behavioral engagement when an adaptive learning module is introduced. The topic for this module, "Pumps," was selected due to a need to improve traditional instruction for this topic, indicated by student performance on the associated assignment. The adaptive learning module was designed to further engage students in personalized instruction and was used as a supplement to the instructor's in-class lectures on the topic. The researchers gathered and analyzed 42 students' data on learning, performance, and user pathways on the adaptive learning platform, Smart Sparrow. Preliminary results show 81 percent demonstrated mastery across all modules. In total, 65 percent interacted with at least one adaptive learning module due to assessment, and 24 percent had more than one interaction. Time spent with the adaptive content was much shorter than the original content interaction, suggesting many students were able to resolve uncertainty within the lesson efficiently. By implementing adaptive learning technology, students experience a tailored learning experience, specific to their learning path towards their mastery of the given topic. Expanded research in the engineering education context can lead to more closely aligning instructors' teaching styles and students' learning styles.

Introduction

It is well established that there is often conflict between the instructor's teaching style and students' learner styles in the engineering classroom [1]. The use of adaptive learning as a teaching style facilitates several learning styles, complementary to the traditional lecture style. Learning styles including sensory, intuitive, visual, auditory, inductive, deductive, active, reflective, sequential, and global [1], can all be incorporated into traditional lectures complemented with an adaptive learning module. The use of adaptive learning as an active learning strategy is increasing in classrooms throughout the U.S. STEM introductory courses and in flipped classroom settings [2].

Adaptive learning provides personalized learning pathways for students. Lowendahl et al. [3, pp.14] define adaptive learning as a process that "dynamically adjusts the way the instructional content is presented to students based on their comprehension of the material as revealed in their responses to embedded assessments or learner preferences such as visual presentation of materials." Similarly, Kaw et al. [2, pp. 664] describe the technique as a "tailored delivery of content feedback and assessment via computers that account for the unique needs of each individual." The linear, traditional module for the topic does not always accomplish a student-centered experience. On the other hand, adaptive learning platforms are smart systems that use algorithms to adapt to the user's learning profile. By implementing adaptive learning technology, students will experience a tailored learning experience, specific to their learning path. Adaptive learning is another form of active learning that places the responsibility of learning on the student.

Despite the potential to transform learning, there are still drawbacks to implementing adaptive learning. A national study completed by Yarnell et al. [4] showed that there was no perceptible impact on grades for most implementations of adaptive learning in courses. Concerning online classes, the report stated that there was a small positive impact on grades when a shift from non-adaptive to adaptive learning was implemented. However, Yarnell et al. [4] did find that adaptivity at an individual lesson or learning object level yielded higher student outcomes than those with adaptivity at a macro level.

The purpose of this study was to examine student learning, behavioral engagement, and student perception when an adaptive learning module is introduced. The following questions guided this study: (i) Which adaptive learning content do students access to increase their learning? (ii) How does behavioral engagement (time spent, frequency) relate to student performance in adaptive learning? (iii) What are student perceptions of learning and engagement with adaptive learning?

Methods

***Context**:* This work explored the development and use of an adaptive learning module in a sophomore-level engineering technology and construction management course. The course is Introduction to Environmental Engineering Technology and includes topics such as water quality, hydraulic and hydrologic fundamentals, water and wastewater treatment, groundwater contamination, and solid waste management. The total number of students in this course for the semester of the study was 48 students, of which 42 students completed the consent forms to use their data and completed all the activities. All students were either civil engineering technology or construction management majors at the four-year university where the study took place. There was an instructional need to improve engineering technology students' performance on two of the course learning objectives, which addressed the topic of "Pumps." Hence, an adaptive learning module was introduced to provide a supplementary form of instruction to the primarily traditional lecture-style used in this course. The two course learning objectives that the adaptive learning module addressed included:

1. Explain centrifugal pump system characteristics and how the pump functions within a water distribution system.
2. Select an appropriate centrifugal pump for a given situation based on efficiency and functionality within a water distribution system.

Adaptive Learning Module Development: This multimedia instructional module included an opportunity to practice each learning objective, a simulation activity, and a graded quiz. The Smart Sparrow digital learning platform was used to host the module due to its interactive tools for lesson creation and the ability to retrieve real-time data analytics about students' performance and use. An intended outcome of this instructional module was to assist the engineering technology undergraduate students with improving their concept comprehension. First, the centrifugal pump was introduced, beginning with a video of what it looks like and how it works. Further content explored critical features of the centrifugal pump and a pump head curve diagram within a water distribution system. The students then progressed to combine their knowledge of the centrifugal pump head curve and its similarities and differences by viewing an interactive water distribution system, *system head curve* diagram. Subsequently, the students brought in previously learned content together to gain a broader picture by combining the pump head curve and system head curve knowledge to learn about the pump operating point and efficiency. Lastly, students used affinity laws and formulas to calculate centrifugal pump efficiency and pump power. Fig. 1 shows the topics by sequence in the adaptive learning module.

Practice activities in the form of quiz questions were used to test students' knowledge learned during the module. There was one question for each topic covered. If students answered correctly on the first attempt, they could continue the lesson. If students answered incorrectly on the first attempt, they were rerouted to the previous content page. If a student answered incorrectly on the second attempt of the same question, there was an explanation of the correct answer; then, they could continue the lesson. Only two incorrect attempts were programmed into the module.

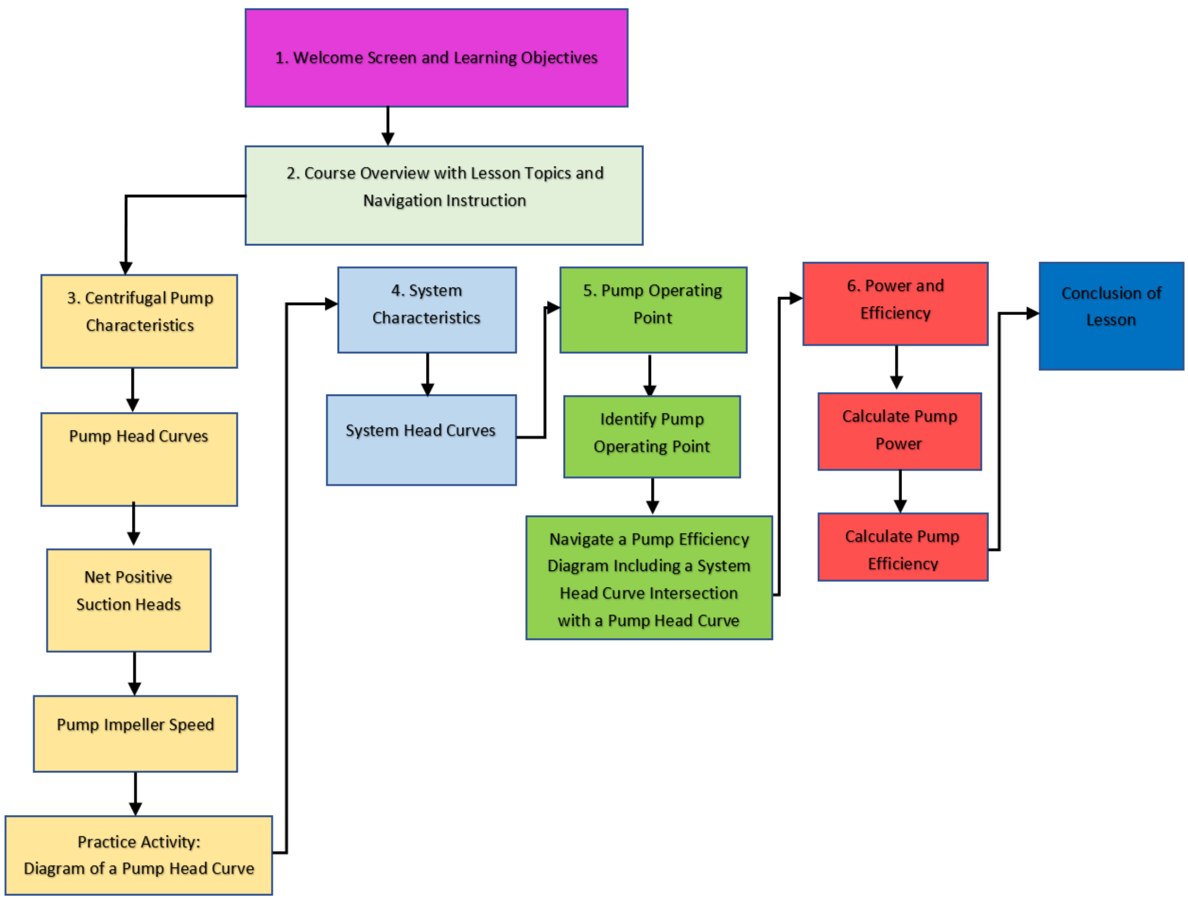

Fig. 1: The topic sequence of the adaptive learning module

Student Adaptive Learning Perception Survey: Students were asked to complete a survey to rate their experiences and give their perceptions about using the adaptive learning module for the learning activity. They rated seven statements about the module on a 5-point Likert scale from "strongly disagree" to "strongly agree." Additionally, students were asked to respond to three open-ended questions. Student responses were anonymous, and they were free to choose whether they wanted to participate or not.

Results and Discussion

Student Learning and Behavioral Engagement: The researchers gathered and analyzed 42 students' data on learning, performance, and user pathways on the adaptive learning platform, Smart Sparrow. Results show that 81 percent demonstrated mastery across all modules. In total, 65 percent interacted with at least one adaptive learning module due to assessment, and 24 percent had more than one interaction.

Adaptive content was obtained in response to assessment results on each of the four activities and associated quiz questions. In each case, all 42 students accessed the activity. For the impeller speed activity, 36 percent of students either left the question blank (10 students) or answered incorrectly (5 students) before accessing supplemental four accessed adaptive content. Of the 15 students accessing this adaptive content, 67 percent of students answered the question correctly, while 33 percent answered incorrectly or left the assessment blank. For the net positive suction head (NPSH) activity, 31 percent of students answered left the question blank before reviewing the adaptive content. Of the students 13 accessing the adaptive content, 69 percent answered the question correctly, while the remaining 31 percent answered incorrectly or left the assessment blank. For the system characteristics activity, 24 percent of students left the question blank before accessing the adaptive content. Of the ten students accessing the adaptive content, 60 percent answered correctly, and 40 percent answered incorrectly or left the assessment blank. For the pump efficiency calculation activity, 10 percent of students left the question blank before accessing the adaptive content. Of the four students accessing the adaptive content, 50 percent answered correctly, and half answered incorrectly.

Time spent with the adaptive content was much shorter than the original content interaction, suggesting many students were able to resolve uncertainty within the lesson efficiently. Overall, the average time spent on the adaptive content was 44.1 seconds (n=43; SD = 60.7 seconds). The median time spent on the adaptive content was 17 seconds. After accessing the adaptive content, the average time spent before a correct response was 58.1 seconds, whereas for students selecting an incorrect response or leaving the question blank, the time averaged only 20.5 seconds. However, considerably more variation exists (p=0.004) in the time spent earning a correct response (n=27; SD = 68.6 seconds) versus incorrect (n=16; SD = 34.8 seconds). A two-tailed t-test for the difference in means of the time spent answering the questions assuming unequal variances was significant (p=0.02), indicating that students who eventually answered correctly spent more time on the adaptive content.

Student Perception: The most repeated and apparent student perceptions are reported here concerning the module's strengths and weaknesses, and what would make the instructional module better. 38 responses were attained for 8 of the 10 questions; 37 responses were attained for one question; 35 responses were attained for one question. The lack of difficulty was one of the most reported weaknesses, followed by the type and length of the videos used in the module. For example, students stated, "I feel like it was too easy to cheat the system," and "it's too easy to just select an answer." When asked what would make this instructional activity better, students said that less and shorter videos would improve this module along with more problems, examples, and interaction. Students' responses focused on the content of the module more so than the design of the module. However, a few responses focused on the design, which gave helpful feedback for future improvements in that respect. For instance, the feedback loops led to some uncertainty. One student mentioned that they were uncertain when they had finished since the module kept circulating back to the beginning. Another disliked that "it just sends you back to the previous screen when a question was answered incorrectly."

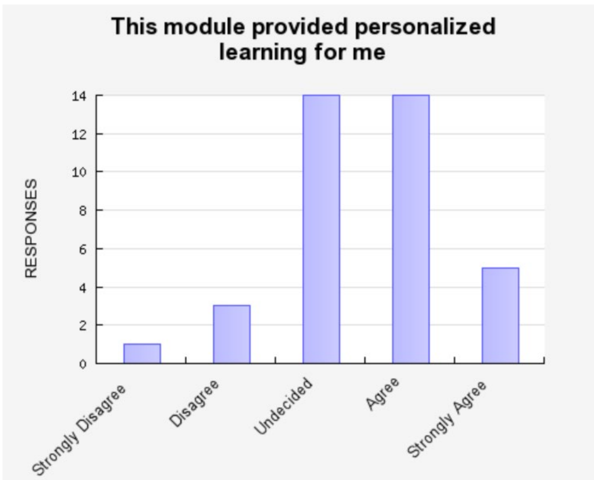

Fig. 2: Responses to one survey question

One of the main goals of adaptive learning is to provide personalized learning pathways. However, there appears to be more room for improvement in the module design to optimize personalized learning for students. 37 students responded to the statement, "This module provided personalized learning for me" as shown in Fig. 2: 1 student (2.70%) strongly disagreed; 3 students (8.11%) disagreed; 14 students (37.84%) were undecided; and 14 students agreed; 5 students strongly agreed (13.51%).

Conclusion

The goal of the adaptive learning module was to create non-linear paths to cater to individual learning needs. While this was accomplished to an extent, the module developed for this study can be improved to have more interactive content and increased complexity in assessments. The latter will lessen students guessing to obtain the correct answer. As the researchers continue to develop modules, the adaptive learning technique will further provide a unique learning experience for each student at his or her own pace.

References

[1] R. M. Felder and L. Silverman, "Learning and Teaching Styles in Engineering Education," Engineering Education, vol. 78, no. 7, pp. 674-681, 1988.

[2] A. Kaw, R. Clark, E. Delgado, and N. Abate, "Analyzing the use of adaptive learning in a flipped classroom for preclass learning," *Computer Applications in Engineering Education,* vol. 27, no. 3, pp. 663-678, 2019, doi: 10.1002/cae.22106.

[3] G. Morgan, J.-M. Lowendahl, and T.-L. Thayer. Top 10 Strategic Technologies Impacting Higher Education in 2016.

[4] L. Yarnall, B. Means, T. Wetzel, "Lessons Learned from Early Implementations of Adaptive Courseware," SRI Education. SRI Project Nos. 21987 and 22997, 2016.