Learning Modules: Iterating the Flipped Classroom

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Abstract:

A perennial goal in education is how to encourage students to develop life-long learning skills and how to best prepare students for a world that is constantly changing. Pursuing this goal, we are developing learning modules, an iteration of flipped classrooms; these learning modules are integrated into engineering design I course to help students demonstrate competency of skills, mastery of concepts, and extended learning via self-directed problem solving. Various topics can be presented to students in these modules, and students in later years in the program can revisit the material on their own, as needed. We established a structural guide for creating a learning module based on studies of the contemporary learner's engagement. This upcoming academic year, we will implement the modules and evaluate their effectiveness in learning as well as both student perception and motivation.

Introduction

A common question in engineering education is how to best address content, problem solving, and group work in a traditional course that has regular face-to-face meeting times. One answer is a flipped classroom approach, moving lecture content online for students to view, read, and prepare between class meetings, and using meetings for problem work either individually or in groups (Zhu, 2016) (Holdhusen, 2015) (Gross & Dinehart, 2016). Lecture content in these studies was often voiced-over lectures or videos of lectures and examples. Others have tested out a fully online project-based design course, in which meetings are virtual, content is available online for students to work on at their own pace, and projects are completed by teams using virtual meeting spaces and other collaborative tools (James-Byrnes & Holdhusen, 2012). In some cases, discussion boards provide a place for students to collaborate and reflect after viewing videos in their flipped class (Zhu, 2016).

Multiple studies have found that flipping content delivery and problem solving activities results in similar results to traditional classes, and students are positive or neutral about the change. At best, it is more efficient for students, and at worst, it results in similar grades and evaluation results as traditionally presented courses (Zhu, 2016) (Holdhusen, 2015) (Gross & Dinehart, 2016) (Sun, 2016). In the case where a fully online course was compared to a traditionally presented course, faculty involved reported that students were more engaged and provided better quality project deliverables than students in the traditional course, though variation of students in the small samples may also explain the discrepancy (James-Byrnes & Holdhusen, 2012).

Others have demonstrated that there are some practices that improve student engagement, performance, and even motivation. In one case, a traditional engineering graphics course was converted into a hybrid course with a robust online component that included a mix of voiced over lectures, online quizzes related to textbook readings, and videos demonstrating related skills (Branoff, Wiebe, & Shreve, 2011). In another, online modules with a combination of videos and quizzes, structured using conditional release tools, which improved end-of-semester working drawings for a design project (McInnis, Sobin, Bertozzi, & Planchard, 2010). Providing assessment with content delivery outside of class has been shown to be effective at encouraging students to complete content preparation outside of class (Branoff T. , 2007). Recently, others are reporting that intentional instructional design can improve student motivation and possibly reduce gender-based gaps in motivation (Stolk, Zastavker, & Gross, 2018). Based in Self Determination Theory (SDT), the group was looking to investigate if motivation varied by course design or by gender. They show that motivation is positively influenced to be more intrinsic and identified, internal modes of motivation, in courses that emphasize project-based and non-traditional formats. They also found less of a gender-based gap in motivation in non-traditional courses (Stolk, Zastavker, & Gross, 2018). Previous work shows support for certain practices, including mixing content delivery, assessing content prior to using it in class, moving content delivery out of face-to-face meetings, and incorporating project work.

We look to take existing experience and research related to flipped classrooms and other non-traditional approaches to course design to create a variation on the more common definition of flipped. We are moving content delivery to outside of class meetings, but the focus of our work is designing and testing a learning module template that will increase student engagement with the content. In future semesters, we hope to develop learning modules for use throughout the curriculum; our initial rollout is for a first-year engineering design course. Goals for our learning modules are to 1) allow students to learn content and skills, solve hands-on problems, and complete self-inquiry outside of the classroom; 2) create modules that can be revisited later in semester or in future semesters as needed; 3) prove out a module development template, driven by engagement principles, that can be used for a variety of content areas; and 4) equip students with the confidence and capacity for self-led learning and information literacy.

Learning Module Template and Pilot

Before developing the learning modules for an introductory engineering design course, we established a structure to encourage engagement and positive motivation in students. We planned four areas for each module: Instruction, Examples, Exploration, and Self-Inquiry. Instruction will contain a mix of videos, readings, or recorded lectures, content-specific.

Examples could range from videos showing software tools or equipment instructions, to worked problems or simple assignments or demonstrations. Exploration requires a deliverable, potentially a quiz or assignment, and is intended to both require that students demonstrate understanding of the content and skill from the first two areas, as well as to provide an opportunity for students to stretch beyond the minimum requirement. This allows students who may be ahead or who are excited about the module to challenge themselves, while also supporting those students who may have started with less experience. The final piece of each module, Self-Inquiry, requires students to both reflect on what they've learned, as well as consider how the module relates to their personal areas of interest.

In implementing these modules, not only will the content vary, but the rigidity can also vary to the preference of the instructor and as appropriate for the material and the learners. Titled "Engineering Wizardry", the first learning module developed introduces microprocessors (Figure 1). At certain points in the module, students are required to demonstrate mastery of fundamental skills by scoring a minimum on quizzes before moving on. To demonstrate understanding of concepts, problem solving, and self- explorations, students are required to submit written responses, discussions, photos and videos of their solutions, inquiries, and findings. Students can move at their own pace through the lessons in the module.

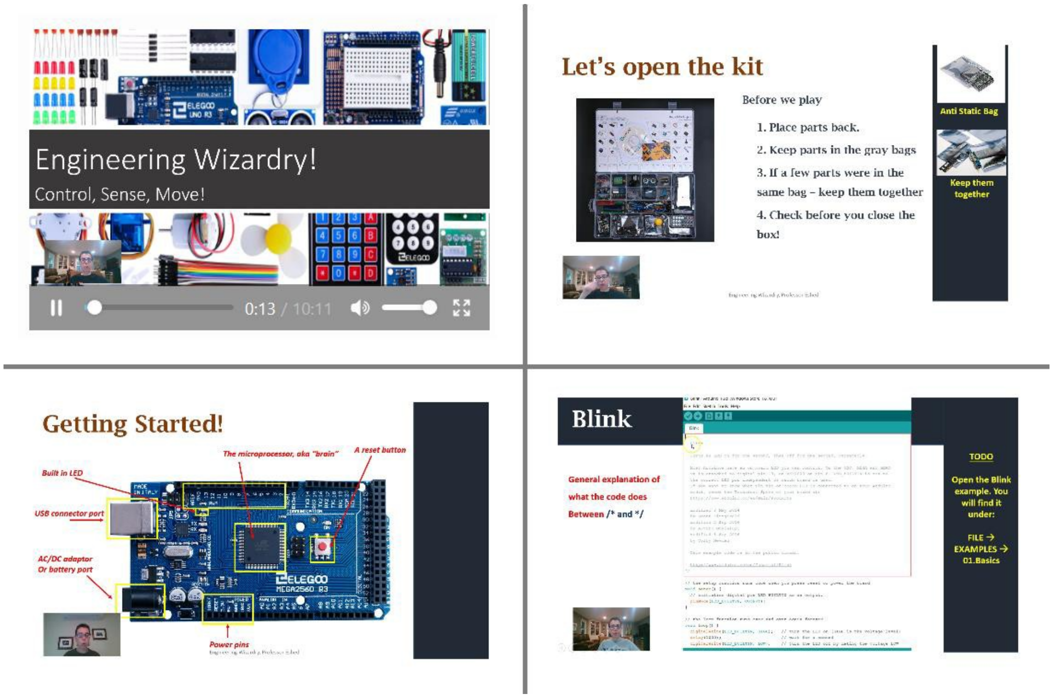

Figure 1: Images from "Engineering Wizardry" instruction video

This module is being completed by first-semester engineering students over multiple weeks, and part of our inquiry is investigating how much structure is needed for our first- semester students. A second module covering basic SolidWorks skills is also being employed with the same students, and modules will also be developed for use in a first- year programming course for computer science students.

Built in to the pilot learning modules is student feedback; while the content of the feedback is not graded, students receive credit for completing this end-of-module survey. Our goal is to consider both the motivation of students at the completion of each module, as well as student opinions on the structure, content, and assessment of each module as we begin this implementation. Student will also self-report how much time they spend on each module.

Future Work

By providing learning modules that are completed outside of weekly class meetings, we have already met our first goal, and our second goal is met by creating a central repository for all engineering students, enabling them to return to learning modules in later semesters when they need to refresh their skills and knowledge in a certain area. Content areas currently being considered for module development are in first-year engineering design and first-year computer science courses. The template presented here will be tested through implementation over several semesters, with student and faculty feedback collected to improve upon the template as needed; our third goal will take several semesters to complete. Once the initial implementation is complete over two semesters, we will be able to add some quantitative analysis of motivation, and over the longer-term may be able to survey students and faculty about perceptions and ability surrounding student- led learning. We hope that developing these modules in sufficient areas will enable project- based classes to have more team-building and project work during class meetings, but will also better prepare students by their junior and senior year to learn skills such as programming and software skills on their own by seeking out content, readily available online. This skill will be invaluable to graduates in an ever-changing workplace.

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