Workshop: Developing Videos and Support Materials for First-Year Engineering Design Courses

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Building on best practices in engineering, faculty at Rice University are creating instructional materials to enable teaching a first-year multidisciplinary engineering design course using a flipped classroom model. With the support of an NSF DUE grant (#1244928), the workshop leaders are developing videos, quizzes, and in-class exercises to be used at Rice University and other engineering schools. During the workshop, participants will participate in evaluating and producing video materials. The collective wisdom of the participants will enrich and strengthen the materials, which will be widely disseminated.

In most design courses, a traditional lecture format is used to teach students about the design process, and students spend time outside of class applying the design process to their particular project in order to develop a design solution. The innovative flipped classroom or inverted instruction model shifts course content with lower cognitive load to videos, screencasts, or other forms of rich media that students watch outside of the classroom [1] [2] [3] [4]. In a flipped classroom, "lecture" time is freed up for concrete progress on a team's specific project with support of faculty. Thus, student teams can receive in-class support during many steps in the design process, including establishing design criteria, ideation, evaluating solutions, and prototyping. Using class time for active learning is consistent with best practices in engineering education [5] [6] [7] [8].

To date, faculty and students have created twenty web-based videos (5-10 min in length) that focus on steps of the engineering design process (Table 1). By August 2014, we expect to have completed most of the listed videos, except for the proposed video segments.

TABLE 1.
WEB-BASED VIDEOS. COMPLETED VIDEOS (AS OF MARCH 2014) ARE IN ITALIC.

Overview of engineering design process	***Engineering decision making***
Attributes - What do you want?	***Making a Screening Pugh Matrix***
Constraints - What you must have!	***Screening Pugh Matrix - Examples***
User-designer-client triangle	***Making a Scoring Pugh Matrix***
Questioning strategies to elucidate attributes and constraints	***Scoring Pugh Matrix - Examples***
Conducting research	**What is a prototype and what makes a good prototype?**
Identifying current and existing solutions/techniques	**Building fast when making prototypes**
Design criteria - What are they and what's their purpose?	**Using simple materials for prototypes**
Design criteria - Examples	**Types of prototypes**
Establishing user-defined criteria	**Prototyping - Examples**
User-defined criteria - Examples	**Testing a prototype while building**
What is brainstorming & rules for brainstorming	**Direct testing**
Methods of brainstorming	**User defined testing**
Brainstorming - Examples	**Failure**
Purpose of and setting up a pairwise comparison chart	**What is a Gantt chart and how does it work?**
Pairwise comparison chart- Examples	**Constructing realistic Gantt charts, with examples**
Decomposition - How can I break this project down?	

The other deliverables for the project include ten online quizzes that monitor students' understanding of the information in the videos. A series of multiple choice and open-ended questions test students' knowledge and application of the technical content presented in the videos. Also, thirty in-class exercises that support active learning in the classroom are being developed. Exercises include those which strengthen students' understanding of the design

process and direct them to apply the design process to their team's specific project.

After a brief overview of the project and the developed materials in the workshop, we will break participants into small groups (2-3 people). These groups will watch and then critique the videos produced by the faculty, noting strengths and weaknesses. (Note, we would also be open to participants watching a few videos before the session, in order to spend in-session time on critique and production.) We are particularly interested in missed perspectives, unclear explanations, and anecdotes or examples that enhance the existing videos. For example, we would welcome participants to explain a type of brainstorming method that they use in their courses, or some tips for evaluating user needs, or an example of an exemplary testing method used by a design team to evaluate their product. Participants in the workshop will then make short videos (1-2 min) with their explanations or examples. We expect that some teams will be filming while others are critiquing. These video clips will be integrated in the existing videos, strengthening the materials by diversifying the voices of experts.

The audience for this workshop will be focused toward faculty who teach some components of engineering design in their first-year program. However, all participants are welcome to learn about the materials and give critical feedback. Individuals attending this workshop will be "working." The Rice team is also looking for partner institutions to begin using these materials in fall 2014 or spring 2015.

A second strand of the NSF grant is to answer the engineering education research question: Are there differences in student performance in executing the engineering design process when comparing delivery of engineering design process knowledge using a lecture format versus a flipped classroom model? Currently, limited research exists on the impact of the flipped classroom model in engineering, mathematics, or science courses at the university level; in particular, no published work evaluates the impact of a flipped classroom on first-year engineering design. While we have a research plan proposed, we believe that there are areas for improvement, opportunities to develop collaborations around the area of assessment, and the possibility to develop further research projects. The research aspect of this project will not be the focus of the workshop, however it is important to note that this work is being done in the context of a research-based project.

The team will bring the cameras and other necessary equipment to TAMU. We will bring five or six individuals to ensure that we have the manpower to execute this activity smoothly. We would ask for help in arranging for a small room with good acoustics to do the videotaping, in addition to a larger room where the small amount of lecture material will be presented and participants critique the material. We would like the flexibility for participants to tape during breaks on Thursday so that we can be sure to capture everything.

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