Work in Progress - An Empirical Study of Virtual Dissection and Student Engagement

Marie C. Paretti, Yanfeng Li, Lisa D. McNair, Deborah Moore-Russo, Janis Terpenny
Virginia Tech, mparetti@vt.edu, liyf@vt.edu, lmcnair@vt.edu, dam29@buffalo.edu, terpenny@vt.edu

Abstract - This paper reports preliminary results from a study of physical and virtual dissection activities. Nine universities are developing virtual dissection tools to supplement and/or replace physical dissections. Student engagement was measured using the Situational Intrinsic Motivational Scale (SIMS). We describe the assessment methodology and preliminary findings. The results highlight the role virtual dissection can play in engaging students in engineering.

Index Terms - Product dissection, virtual dissection, cyber-infrastructure, student engagement, motivation.

INTRODUCTION: THE CYBER-COLLABORATORY

Product dissection has long played a critical role in undergraduate engineering education as a tool to teach both fundamental engineering principles and product design [1, 2]. Such activities, however, are resource intensive in that they require products, tools, and space. As class sizes grow, virtual tools offer a cost-effective supplement or replacement. To that end, nine universities are collaborating in an online dissection laboratory – a cyber-collaboratory – that uses a shared set of cyber-repositories, design tools, and teaching materials. The project has four educational goals:

1. Improve students’ understanding of engineering principles
2. Improve students’ practice of design
3. Improve cyber-infrastructure (CI) competency of engineering students
4. Enhance student engagement with respect to engineering in general and design in particular.

Each goal has a unique assessment plan. The remainder of this paper addresses Goal 5, student engagement.

RESEARCH QUESTIONS

Anecdotal evidence suggests that hands-on activities such as product dissection increase student engagement and enhance motivation. Students get excited when they are able to work directly with physical objects to understand and/or improve them. But few studies to date have attempted to understand or measure this engagement. Engagement is particularly important to the cyber-collaboratory project as we seek to supplement or, in some cases replace, physical dissection with virtual dissection. The study of student engagement in this project thus seeks to answer four questions:

1. What motivations underlie students’ physical dissection activities?
2. How do physical dissection activities affect student engagement with engineering?
3. What motivations underlie students’ virtual dissection activities?
4. How do virtual dissection activities affect student engagement with engineering?

These questions address student engagement with respect to dissection compare physical to virtual activities to determine what is lost and what is gained. Coupled with data on Educational Goals 1-4, the assessment of the cyber-collaboratory project will provide powerful insights into the role of product dissection activities in student learning.

THE SITUATIONAL MOTIVATION SCALE (SIMS)

Student engagement was measured using the Situational Motivation Scale (SIMS), developed by Guay et al.[3, 4]. SIMS assesses four constructs of motivation that, according to self-determination theory, underlie the initiation and regulation of human behavior. Self-determination theory conceptualizes human behavior in terms of true free choice. The four types of motivation differ in their inherent levels of self-determination according to their position on a continuum that includes intrinsic motivation, identified regulation, external motivation, and amotivation (Table 1).

<table>
<thead>
<tr>
<th>TABLE 1: CONTINUUM OF MOTIVATION CONSTRUCTS</th>
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<tr>
<td>Intrinsic motivation:</td>
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<td>Identified regulation:</td>
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<td>External motivation:</td>
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<td>Amotivation:</td>
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Self-determination theory “postulates that the needs for competence, autonomy, and relatedness are central concepts” [3, p. 177] to understanding motivation. Validation of the SIMS [3] indicates that intrinsic
motivation and identified regulation lead to the most positive outcomes, such as persistence; that external motivation can lead to the decrease of intrinsic motivation; and that amotivation leads to the most negative outcomes, such as depression and feelings of incompetence. However, the SIMS is purposely designed not to assess these needs or outcomes, but rather to measure self-reports of motivation. The SIMS is a self-report measure of situational motivation, i.e., “toward a single current situation” \[3\]. Thus, in experimental settings it has been used during and after a specific task, in this case, dissection. Assessment follows the data collection plan outlined in Table 2.

<table>
<thead>
<tr>
<th>Date</th>
<th>Instrument</th>
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<tbody>
<tr>
<td>Week 1</td>
<td>Survey 1: SIMS addressing engagement in engineering</td>
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<tr>
<td>After dissection</td>
<td>Survey 2: SIMS addressing engagement in dissection</td>
</tr>
<tr>
<td>Final week</td>
<td>Survey 3: SIMS addressing engagement in both engineering and dissection Focus group interview</td>
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This approach enables us to track two critical issues: (1) **Student engagement in the dissection activity.** Asking students to respond both immediately after completing the dissection and at the end of the semester helps identify the degree to which students responded to the dissection in the context of the course. (2) **Student engagement in engineering.** While dissection will not be the only factor here, the survey provides a broader perspective on students’ engagement with the field and, together with focus groups, helps identify factors affecting engagement in engineering.

**PRELIMINARY RESULTS**

Figures 1 shows results for four cohorts at one university:

The bar graph indicates the relative importance of each type of motivation by normalized average scale scores:
- Cohort 1 (C1): Sophomore mechanical engineering course; physical dissections only (N=20).
- Cohorts 2 and 3 (C2, C3): Two sections of a first-year engineering course; virtual dissection followed by physical dissection (N_{C2}=178; N_{C3}=257).
- Cohort 4 (C4): First-year introduction to engineering course; physical dissection only (N=259)

C2, C3, and C4 were team-taught by the same pair of instructors; C1 had a separate instructor.

Internal consistency was checked using Cronbach’s alpha for each factor in four cohorts; all values were acceptable (α>0.7) except the identified regulation in Cohort 1. The data suggest three tentative results. First, not surprisingly the level of amotivation for sophomores in their selected discipline is lower than that of freshmen in a general engineering course (C1 vs. C4, p-value < 0.05), indicating that upper-level students participate in activities with a clearer purpose. Second, the level of amotivation for those who participated in virtual dissection act (C2 + C3) was lower than those participating in physical dissection only (C4) (p-value<0.05). Third, the scale score of identified regulation for those who participated in virtual dissection improved significantly when compared to those participating in only physical dissection (p-value<0.05), and intrinsic motivation and external regulation decreased (p-value<0.05). These results suggest that virtual dissections can affect students’ intrinsic and extrinsic motivation. Future analysis will include results from additional cohorts at this and other universities, as well as analyses by demographic data such as gender and race.

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**AUTHOR INFORMATION**

Marie C. Paretti, Virginia Tech, mparetti@vt.edu
Yanfeng Li, Virginia Tech, liyf@vt.edu
Lisa D. McNair, Virginia Tech, lmcnair@vt.edu
Deborah Moore-Russo, SUNY Buffalo, dam29@buffalo.edu
Janis Terpenny, Virginia Tech, terpenny@vt.edu

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