Motivational Factors of Undergraduate Engineering Students in Introductory Non-technical Courses

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Motivational Factors for Undergraduate Engineering Students in an Introductory, non-Technical Course

1.0 Introduction

Undergraduates that enroll in engineering programs across the country are highly motivated in mathematical, computer coding, and technical courses that they believe will enable their future success. Prior to even reaching the university campus, first-year students understand those as core courses that will enable them to perform professional engineering tasks after graduation. Incoming first-year students also draw upon their prior successes within technical courses in secondary school (high school), as well as standardize tests, which are largely linked to tests and problem sets that are based upon individual performance. This prior experience further shapes the students' expectations for how engineering education will be conducted and how their performance will be evaluated. However, engineering firms and other employers want undergraduate engineers that have skills to diagnose and solve complex problems in team-based projects with colleagues and clients from diverse backgrounds [1]. Universities have responded to the demands of industry to prepare engineers to work in groups and team problem solving that rely upon metacognition and greater self-awareness [2].

In alignment with industry expectations for professionalism, ABET established standards that speak to critical thinking, communication, and demonstrate other professional skills. To achieve the ABET standards, some engineering schools require courses that arise from liberal arts traditions and thus, address issues of ethics, professionalization and the broader societal context. Those courses often provide a gateway for a student's collegiate experience and affect every incoming student's sense of belongings in engineering. As many engineering courses are being redesigned with an emphasis on group-based learning strategies as a means to enhance students' abilities in critical thinking, effective communication and collaboration. Yet, negative group-based interactions and learning experiences may further disadvantage students from historically underrepresented backgrounds in non-technical courses that emphasize group work, communication, and professionalism [3]. Thus, it is critical to create an inclusive learning environment that will engage all students from diverse backgrounds by improving the quality and efficacy of group-based projects.

Collaboration among students from diverse backgrounds may yield ineffective group work and it may diminish a student's intrinsic motivation, interests, and even learning performance. There is a paucity of research into the factors that affect first year engineering students' motivation and interests, specifically in non-technical courses. The goal of this conference proceeding is to explore various factors that inform undergraduate engineering students motivation to learn in diverse groups. The concept of motivation is expanded upon in the next section, while the study context investigates 380 first-year students that enrolled in a mandatory course at University of Virginia in fall 2017.

2.0 Background: Conceptual Framing and Literature Review

The framework of the proposed project is centered around multiple educational theories focusing on student learning engagement in science, technology, engineering and mathematics (STEM). What this collaboration does is bridge critical gaps between the institutional intentions to be a diverse learning community [4] and connect that institutional priorities to classroom management techniques and ultimately with individual student motivation [5].

To guide our research, we draw upon a multilevel approach that starts with the individual level of self-determination theory (SDT). SDT theory argues student engagement is enhanced when three innate psychological needs (i.e., autonomy, competence, and relatedness) are met [6]. Learners are likely to demonstrate deep engagement where they perceive the capability to determine their own behaviors (autonomy), feel efficacious in their learning (competence), and experience a connection between individual learning goals (relatedness). SDT theory, deeper engagement ultimately promotes learner's intrinsic motivation, which refers to behaviors enacted for one's inherent interest and how autonomy, competence and relatedness are important secondary factors that contribute towards enjoyment, as opposed to extrinsically motivated learners that exhibit learning behaviors, instrumental performance to achieve outcomes separable from the activity itself, intrinsically motivated students results in high-quality learning [6].

The next level attends to classroom and pedagogical approaches. To design engaging learning environments, this project leverages Keller's [7] ARCS motivational design principles and its four major concepts: Attention, Relevance, Confidence, and Satisfaction (ARCS). By synthesizing theoretical components of motivation (e.g., Bandura [8], Kuhl [9]), Keller provides a learning environments design framework of optimal instructional strategies and a directed analysis of these strategies. Based on the Keller's ARCS learning motivation model, this research seeks to describe both intrinsic and extrinsic factors that affect student motivation. It explains what each aspect of learner motivation could mean for the design of non-technical Engineering courses. The ARCS model suggests that by increasing learner motivation there is an improvement in learning outcomes [7]. This can be achieved when the learning environment is enhanced with specific and focused motivational strategies [10]. These validated instructional theories and their assessment techniques offer a means to frame this project in the broader context of the student experience in University of Virginia, while delving more deeply into the classroom setting.

2.1 Background: Course Context

The course that is the object of study at University of Virginia is a non-technical, introductory course, required for graduation by all undergraduate engineers. The course's learning objectives include, "To be true professionals, engineers need to have a sense of how people design and invent technology, how intentions reflect the needs and wishes of a society, and how inventions diffuse through a culture. Without a thoughtful sense of technological change, engineers cannot design the technology that will create the future in which their children will live." (course syllabus, p 1.). The course is structured in two parts with a large lecture and smaller discussion sections. Each semester there are lecture sessions that each occur once per week with over 150 students enrolled in the lecture. The lead-instructor offers content and then encourages discussion in pairs and in plenary. The students are evaluated on the lecture and reading-based portion on the course in two multiple choice exams that account for 40% of their course grade, which is an individual measure of success in the course.

The lecture sessions are complimented by nine Discussion Sections with 15-40 students enrolled in each section. The Discussion Sections are led by three Graduate Teaching Assistants (GTAs) with at least two GTAs present at all times in all nine of the Discussion Sections. Student attendance and participation counts toward their grade (10% course grade), as does a written assignment for their "Technical Description" of a simple office device (i.e. stapler) is worth 15% of their grade. The students need to complete more than 75 entries in an "Idea Notebook" (10% of course grade) that contribute towards a summative assignment of a patent application, which builds upon the technical description and their own creative and novel ideas. The "Provisional Patent Application" (20% of course grade) is completed as a group-based assignment with three other students that work through a process of down selecting from all student's ideas in their notebooks to one idea that is put forward by the group. The learning objective for the group is to move through a series of exercise that support idea generation, critical thinking and concept refinement, as well as verbal presentations called a, "Rocket Pitch" which is a graded assignment (5% of course grade). The grading structure for the discussion section of the course emphasizes group work in the Participation, Rocket Pitch, and Provisional Patent Application (35% of total course grade).

Groups are formed in the second week of the Discussion Section when students are given an opportunity to form their own groups, given a short set of rules that guide the process. The rules address gender and require two women at a minimum per group of four persons, as well as addressing racial identity by requiring at least two non-white students to be present in any group. The rules are intended to avoid isolating women and historically underrepresented students in any group. The students typically work through this process in 10-15 minutes. Once groups are formed, students are required to sit with their group members at all times during the discussion sections. There are no written policies in the syllabus about group rules, conflict resolution, or arbitration when disputes arise. In short, once groups are formed, they remain intact for the duration of the semester.

The discussion sections engage in a series of individual and group-based activities that are designed to prepare the students for the upcoming summative assessments. The first-half of the semester focuses on technical writing and how to represent complex engineering ideas with visuals and written descriptions. The second half of the course focuses on down selecting from all the creative concepts in the individually-generated Idea Notebooks to one that will be presented as part of the Rocket Pitch. Then the students are given three weeks to work within the discussion section on their provisional patent applications.

3.0 Research Design

The project entails data collection at multiple levels that attend to the course design, pedagogy, and classroom environment that affect the students' motivation. At the course design level, this project will bring evidence to bear on a motivational learning theory called ARCS (as introduced above). Within instructor and student level, this paper delves more deeply into understanding student learning experiences during individual and group-based learning activities and interactions between the graduate teaching assistants (GTAs) and the first-year undergraduate students, as observed by undergraduate teaching assistants (UTAs).

The research design relies upon internal resources provided by the University of Virginia to hire one UTA in their third or fourth year (Junior/Senior) for each of the nine discussion sections. The purpose and aims behind the addition of the UTAs, who previously took the course, are two-fold. First, the UTAs might serve as aspirational peers that are more relatable and approachable to the first-year engineering students. With this intention in mind, the UTAs typically circulated through the classroom in the second half of the semester during "work days" when the first-year students were working on the provisional patent application assignment. Further, UTAs offered office hours and selected a location in the student work area. Secondarily, the UTAs took field notes following semi-structured observational guidelines that described the interactions and activities in the discussion section. The UTAs met with the research team to review the field notes and deliberate on the activities every other week for the duration of the semester. The UTAs often generated ideas on how to incrementally change the activities or with additional mini-lessons that would support the first-student's experience. The research team was comprised of two faculty, one person is a learning environment design expert and the other specializes in science and technology studies. The research team met with the eight undergraduate students every other week to synthesize the key issues and discuss alternative approaches to address those issues.

The research question that guides our research is: What factors influence student-motivation within group-based projects? We hypothesized multi-layers of factors (i.e., course activities, classroom, and instructors) influenced students' engagement in the course and group-based activities. To address this question, data was gathered from a mandatory course at University of Virginia with 380 students enrolled in nine Discussion Sections in the form of classroom observations, and interviews with current and former instructors and graduate teaching assistants (GTAs). The classroom observation only took place in the nine Discussion Sections where group-based activities and projects are conducted, while the lectures are attended by 150+ students and thus, are not designed to facilitate group-based activities.

In each of the nine discussion sections, one third or fourth-year undergraduate engineering student (UTA) observed the classroom and took semi-structured observation reflection notes on a weekly basis. The semi-structured observation protocol focused on examining student behaviors and responses to assignments as a means to understand the first-year students' individual and group engagement in the course activities. Secondarily, after identifying common themes and issues, the UTAs proposed ideas on promoting student's engagement in the course. For example, the observation prompts include questions on individual student's engagement in individual-based activities (e.g., student's participation level in the class-wide discussion and group discussion) and group-based (e.g., group interaction patterns, equitable participation of each group member in the activity, gender and diversity composition of group members), and suggestions based on the observation of the day (e.g., what do you want to suggest to improve student engagement in today's class). At the conclusion of the semester, the full research team met with the course instructors and all the graduate teaching assistants. During that meeting, the UTAs shared their initial findings on the issues and opportunities for improvements. The post-semester debrief meeting served to immediately offer the instructors a synthesis of the semester-long observations. This approach made transparent the observations to the course instructors and GTAs at the end of the semester and afforded the instructors an opportunity to re-interpret, rebut, or reformulate any of the observations, initial findings, and suggestions. As such, the instructors were privileged with the initial results and afforded an opportunity to reform or modify aspects of the course in the upcoming semester. What follows is an articulation of the key motivational factors affecting students in the Discussion Sections in this course.

4.0 Findings

The findings from this study identified eight key opportunities for improvement and specific suggestions that each aligned with elements of the ARCS Model and Self-Determination Theory. Figure 1, below, offers an overview of the opportunities for improvement and maps them to the core concepts from the ARCS model and SDT. Table 1 synthesizes the opportunities for improvement that were noted in numerous UTA observations and deliberated during the research teams' meetings. The table also includes an exemplary excerpt from the observational field notes and alternative approaches and suggested changes per suggestion. Taken together, this research demonstrates how UTAs, working in concert with faculty can support the observation, reflection and re-design of the course. The balance of the findings offers in depth insights into the identified opportunities to enhance student motivation with suggestions of alternative ways to re-design the course.

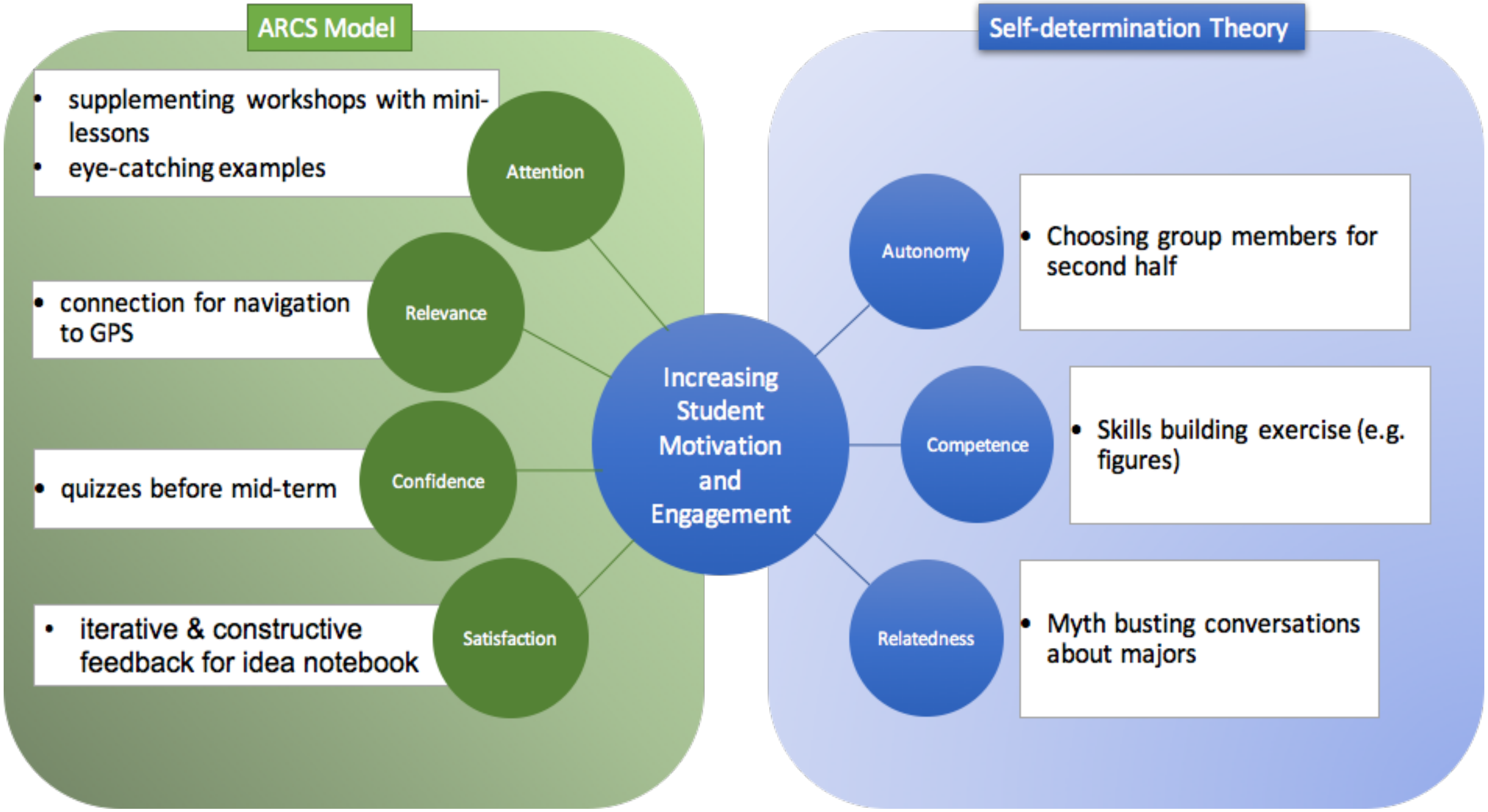

Figure 1. Increasing student motivation and engagement. Observations by UTAs brought to light opportunities for improvement across all the core concepts that support motivation.

Opportunity for Improvement	Observation Excerpt	Example of Suggested Alternatives
Generate and hold student attention with short, poignant presentations by a diversity of instructors.	After presentation by librarian, “Class is very engaged and asked a lot of questions about trolling and obviousness” (UTA, 3) “During prior art search [by Maggie Nunley], group discussions seemed to range from groups who were very excited and all working on their own laptop to other groups who were only huddled around one laptop and working together.” (UTA, 8)	Supplementing workshops with mini-lessons that augment students’ competence in readings and presenting. Bring in more subject matter experts, like Maggie Nunley.
Lack of examples to give students and understanding of expectations.	“Some confusion over what parts should be included in a PPA - maybe helpful to provide them with a past example from the class?” (UTA, 6)	Offering eye-catching examples of prior student’s work or the work of fourth-year students.
Lack of relevance between the course and engineering profession.	“Standing around, not a lot of discussion, some people just looking” (UTA, 1) “What was the point of this activity? And how did the reading support this?” (UTA, 7)	Connection between key lessons for navigation to GPS as a way to adapt assignments to make the tasks more authentic. Ensure that lecture materials precede discussion section activity to make better connections.
Lack of confidence, high anxiety about mid-term.	“Midterm notes: Too specific at certain points, say that beyond a certain point it didn’t matter how much you studied unless you memorized all of the info” (UTA, 7)	Offer quizzes before mid-terms as formative assessments that will build students’ confidence
No feedback on idea notebooks allowed for procrastination.	“Students were directed to write in their idea journals afterwards; several just sat there or used their laptops and phones” (UTA, 3) “Most didn’t really understand what a good choice should have [been].” (UTA, 6)	Create mechanisms for iterative and constructive feedback for the Idea Notebook to earlier in semester to demonstrate key aspect of instructor-student relationship and to change emphasis from “what is a good idea” to “creative and novel ideas” to foster satisfaction.

Dysfunctional group dynamics and inability to make changes.	"Functional groups tend to get along personally and I will see them laugh and joke around (sense of camaraderie). This atmosphere seems to be more conducive to easily relaying thoughts and communicating opinions. The more dysfunctional groups are either there to only talk about the bare minimum or get out of class as soon as possible. (UTA, 2). "Groups needed a notetaker for beginning part of assignment. In every group with a female, a female was the note-taker." (UTA, 5) "Students filled out the evaluation form once again at the beginning of class" Seems like they definitely tried to fill it out as completely as they could, but passed sheet around for each student." (UTA, 7)	Increase student autonomy and involvement in groups by allowing for reformation of groups for the second half of the course as a way to enhance or change group dynamics. Revise peer review process to preserve anonymity and ensure that feedback is autonomous and not overly influenced by group peer-pressure. Create clear roles within groups for facilitator, note-taker, etc.
Students did not demonstrate growth in key professional communication or presentation skills.	"A lot of the questions were formatting related such as how in text citations should be written, how APA works. […] It could be helpful to review how to cite things in APA or different methods so that the students have a uniform understanding. (UTA, 2) "HUGE difference in caliber between graphs but I would make sure to drive home in the future that their rough drafts have to have figures because MANY did not." (UTA, 4)	Create opportunities for skills building activities, such as how to format citations, create figures and illustrations.
Difficulty relating the course to engineering major or career.	"I actually felt helpful (!) when I was able to share about my own experience" (UTA, 1) "Easier to walk about the class today; students started approaching me as well." (UTA, 3)	Make activities more relevant to engineers' life experience through "myth busting" conversations and interactions with fourth-year students.

Table 1. The left-hand column notes the opportunities for improvement, as well as an excerpt from the undergraduate teaching assistants' classroom observations and then a suggested alternative.

4.1 ARCS Model of Motivation

4.1.1 Attention: Peer-to-peer mini-lessons

The identified opportunity to improve student motivation and engagement was that the time spent in the discussion section was often underutilized by the first-year students. The UTAs observations routinely noted that the less structured time made many students feel that it was acceptable to skip class and nothing happens, as they don't miss any particular instructions. First-years often wondered why they even came to class, since they could do the group work outside of the designated time and place offered by the course. The course design provides the first-students the time and space to work in their groups, rather that challenging them to schedule time outside of class to complete the Provisional Patent Application assignment. The UTAs suggested to offer structured activities each week that would take less than five minutes and designed to bring attention to different technical and non-technical aspects of the course. The suggested topics includes how to schedule group meetings with different software, how to address potential conflicts or how to provide feedback. Furthermore, the Idea Notebooks were due at the end of the semester and the UTAs observed how students completed them at the last minute. The suggestion was made to conduct Idea Notebook checks every other week or to have the Idea Notebooks completed before the selection of the project for the provisional patent application assignment. The aim is to increase the generation of ideas in the students' notebook early in the semester to avoid "social loafers" [11] in the group later on when the provisional patent application was the primary focus.

4.1.2 Relevance: Adopting authentic tasks

The UTAs observed that students lacked motivation to complete the established activity that relied upon compasses and string. The opportunity identified here was to make the task more related to their lived experience and ability to find their way from one location to another. The case of Prince Henry and global navigation raised issues of relevance, as the UTAs observed first-year students commenting on the associated activity as unrelated to their lived experience. The navigation system employed by Prince Henry's captains contributed to the expansion of the Portuguese empire in the 15th and 16th century and is offered as a lesson about the dynamics between technology and society. The UTAs also suggested that global position systems (GPS) offered a direct translation for the students and that the activity could be shifted to present challenges associated with GPS-enabled navigation.

4.1.3 Confidence: Scaffolding readings and offering formative assessments

The first-year students expressed anxiety and stress prior to the two exams, which stemmed from insufficient opportunities to build confidence in their preparation and knowledge of the subject matter. This created the need for the GTAs to make statements intended to assuage their anxiety and to reassure them. It was not surprising that the first-year students felt anxiety prior to the mid-term exam (worth 20% of their grade) when they had not received any feedback from formative assessments or summative assessments of small modules and lessons offered in the first half of the course. Understanding this, the UTAs felt that formative quizzes (while not popular and strongly debated) would give the students some earlier feedback on their reading comprehension and proficiency in grasping the core concepts of the course. The quizzes could be in class, pass/fail, and kept as study guides for the later exams.

Secondarily, the first-year students expressed frustration after receiving grades that were lower than their expectations on the Technical Description assignment. The frustration stemmed from a few places, but one critical factor was the lack of prior formative assessment of the students technical writing ability. The students were actually overconfident in their ability to describe the object. This overconfidence might lead to high expectations about their grades and thus yielded frustrations when those expectations were not met. The suggestion was to augment the prior lesson, which required reading and discussing a piece of technical writing, with the additional requirement to describe a masonry brick. The simplicity of the object would place the emphasis on the writing and the first-year undergraduates' ability to craft a technical description of that object.

4.1.4 Satisfaction: Receiving and giving constructive feedback

First-students frustrated due to lack of opportunities to receive positive feelings for personal efforts and accomplishment in the class. To promote student satisfaction on the learning process, the performance requirements should be consistent with stated expectations and evaluated with consistent measurement standards for their accomplishments. However, we found the misalignment between the provided instruction and the measurement of the outcome. The course was extensively designed with project-based learning formats and asked students to present individual or group activities. Without providing any supporting instruction that would support successful or unsuccessful presentation, students were assessed with their presentation skills and abilities they achieved before taking the course. Undergraduate TAs suggested providing chances to build a satisfaction on the course by providing formative feedback or rewards that could reinforce positive feelings for individual effort and accomplishment. For example, providing mini-sessions or supporting resources (e.g., access for free visualization tools, free introductory videos to use the visualization tools) to build advanced skills to present project outcomes can be options to be considered.

4.2 Self-Determination Theory

4.2.1 Autonomy: Increase students' autonomy and involvement

A key finding related to autonomy was the group formation and inability for students to change groups and experience alternative group dynamics. The UTAs observed that some groups 'clicked' and chatted and bantered prior to class, while in other groups the student sat silently, routinely put their head on the table, or looked at their phone or laptop rather than freely engaging in social interactions with their group members. The requirement to always sit with your group at a designated table was found to originate from the need to take attendance and seeing four people at a given table made attendance far easier. The UTAs felt that CATME (http://info.catme.org/), for example, might be a useful tool that could guide group formation based on their "Team Maker Survey", which moves away from demographic considerations for group formation. While the group formation demands further inquiry and reflection, and setting that aside, the UTAs felt that the first-year students needed support in the group work through the form of contracts; providing group-work guidelines for each assignment or project; rotating roles between notetaking, facilitator, summarizer, and resource-finder; and an opportunity to change groups at mid-semester.

Secondarily, the UTAs identified a key challenge and opportunity for improvement in the topics selected and used as examples in the discussion sections. The established topics discussed in the course rely heavily upon historical examples of how technical designs and societal factors coevolved differently. Returning to the Prince Henry navigation lessons, the UTAs felt that this case could be translated by students into various web applications and devices that support wayfinding today. The selection of the contemporary topics related to wayfinding might afford a greater level of autonomy and involvement. The suggestion was for the first-years to build a portfolio of articles, resources, and examples of contemporary cases that reflected the lessons learned from the established historical cases offered by the instructors. The learning objective "how intentions reflect the needs and wishes of a society, and how inventions diffuse through a culture" would still be at the forefront, but the emphasis would shift from memorizing historical cases to exploring and self-directed learning about contemporary instances. From choosing formats of project submission (digital version or paper-based) to choosing or switching group members, the more options undergraduate students can have to independently manage and monitor their learning process, the deeper engagement in the course is expected.

4.2.2 Competence: Skills building

Offering chances to build a competence to successfully achieve course requirements is also suggested by the UTAs. The key skills that stood out in the observations by the UTAs included, surprisingly, the issues of reading comprehension, exam preparation and creating figures and graphical representations. Not understanding how to study for an exam in a non-technical course was observed to induce stress. This undermined the students' competence in the subject matter and influenced their stress levels (prior to exams) and frustration at receiving poor grades on assignments that demanded figures and technical descriptions. To increase students' competence, the UTAs made a few suggestions. First, they felt that one of the early readings in the course should be annotated by the instructor or GTAs in such a manner that helped show the students how to read, what to pay attention to and headings supported the organization of longer papers. Once a reading is annotated in pdf, it can be reused from one semester to the next. This then could support the students' confidence (discussed above), as the annotated reading could be the foundation for an in-class quiz. The second suggestion was to offer short less than 10-minute lessons on how to study for the mid-term or final exam. The UTAs might present notes from the readings, summaries from the lecture, or other tools and techniques they used to recall the information that was likely to be in the final exam. The final key skill that needed attention was the creation and depiction of figures or graphics. The UTAs suggested that they could provide less than 10 minute tutorials on the use of Excel, Figma, Blasamiq or other software/website applications that support graphical representations.

4.2.3 Relatedness: Myth Busting Conversations

The relevance of the course to the first-year students is commonly expressed as a negative comment in past course evaluations. The position of the course in the School of Engineering and Applied Sciences curriculum is not clear to the first-year students that enroll in engineering and falsely believe that they can avoid any need to read, write, or consider societal factors. The first-year students are unclear about the relevance of the course and how it supports their aspirations to become professional engineers in their majors. The UTAs and faculty reviewed a program from the prior year that brought together fourth-year students with first-year students for an evening of "myth busting" conversations. The fourth years offered brief presentations on their technical capstone projects, as well as the human and social dimensions that were critical to those projects. Then the fourth years engaged in informal conversations with the first-years about the requirements for the different majors, types of capstone projects offered and future courses that addressed the human and societal aspects of engineering. The Discussion Sections were seen as a great opportunity to foster deliberation between the incoming and outgoing students about the relevance of the course and the need to consider human and societal factors during the engineering and design processes.

Establishing relatedness of the course activities to individual student's learning interest is indicated as one of the biggest factor that affected student engagement in the course. Non-technical courses are registered by students from different majors. Depending on the major or prior experiences and knowledge level on the Engineering fields, individual student's learning interests and motivation were not fully considered in the instruction and it demotivated some student's engagement in the course. Providing chances to prospect or understand how the non-technical course may positively influence on the successful pursuit of each major is suggested by undergraduate TAs. Invited speaker sessions or panel-discussion session, where undergraduate students can meet and talk with senior undergraduates who took the course and are moving toward to the end of their program, are suggested by UTAs.

5.0 Discussion

This research demonstrates how aspects of Keller's [7] Motivational Learning Environment Design model can explain the student experience in an introductory course where the students' attention and satisfaction are influenced by a lack of relevance and confidence. Furthermore, Self-determination Theory [6] explains factors affecting learning motivation when students are afforded very little autonomy in the course and there are few opportunities for them to develop competence through low-stakes, formative assessments. The observations and suggestions offered by the research team were not intended to be overly critical of the course design or instruction. Rather the goal was to offer insights from an alternative perspective – i.e. from the undergraduate teaching assistants who previously took the course and perceived the value of the course, and thus work to improve the course through iterative feedback and adaptive course management.

What this study suggests is that UTAs can offer genuine and thoughtful insights about the opportunities to improve and re-design liberal arts courses. In this study, the UTAs generated strong, plausible suggestions and alternative solutions to the issues identified. UTAs are typically remanded to low-skill tasks such as, attendance or pass/fail grading, and medium-skill tasks such as tutoring and assignment support. UTAs offer a valuable asset to course instructors, course designers, course evaluators, and ultimately to their fellow classmates as their perspective can offer critical reflection and support to the instructors and course designers.

Based on the findings and following ARCS model of learning theory, we offered possible instructional strategies that instructors might be able to adopt to promote student motivation. Re-designing the course with motivational learning design principles and activities that will catch student's attention as will provide supplemental workshops with mini-lessons with authentic examples. Providing students with chances to relate individual learning needs and goals to the course's activities may increase student motivation. To increase student's confidence (which will ultimately promote student motivation) there is a need to offer formative quizzes before mid- and final exams. To increase learner satisfaction, UTAs emphasized that providing feedback to the student's prior, submitted assignments is critical as that feedback is a key piece of the relationship between instructor and student.

5.1 Limitations

This initial research project is limited in ways that need to be stated explicitly and informed the interpretation of the results. First, the observations were semi-structured, and not completed for every single session of the discussion sections. This paper looks at the classroom during one semester, as a pilot study, and does not account for longer-term changes over time. The survey data collected from the students during the pre- and post-tests have yet to be analyzed and will offer additional information on the motivations expressed by the student-body. Furthermore, interview data with faculty, instructors, and students has yet to be compiled and systematically analyzed for important themes, which will also inform the course redesign. Nonetheless, the findings from this research offer numerous pathways forward and support the enrollment of UTAs in course evaluation and re-design efforts.

6.0 Conclusion

Liberal arts courses that comprise key aspects of the engineering curriculum require consistent evaluation, re-thinking, and both incremental and radical restructuring. The UTAs in this project demonstrated how undergraduates can be more than graders and peer-mentors and can aid in the course re-design efforts. The opportunities for change presented to the instructor and GTAs offer numerous pathways forward, which the research team will trace and evaluate the efficacy in the subsequent time periods. The research design will capture changes in student motivation and relate those back to the course design, activities, and assignments that are made by the instructors and GTAs. Analysis of survey data, additional interviews, programmatic review by the Associate Dean for Undergraduate Education at University of Virginia are underway. Undergraduate teaching assistants (UTAs) offer a critically important perspective to faculty and institutions that are working to make curricular reforms, course re-design, course design and course evaluations.

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