AC 2012-4040: CHOCOLATE CHALLENGE: THE MOTIVATIONAL EFFECTS OF OPTIONAL PROJECTS IN AN INTRODUCTORY ENGINEERING CLASS

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Chocolate Challenge: The Motivational Effects of Optional Projects in an Introductory Engineering Class

Abstract

Introductory engineering classes typically aim to challenge the average incoming freshman. However, as a result of superior education, talent or both, some incoming students enter engineering programs prepared for more challenging activities. Offering a series of optional challenge projects spanning multiple disciplines is proposed as a means to maintain student engagement and motivation for learning. Specifically, we studied the motivational effects of offering optional challenge projects to freshmen engineering students enrolled in an introductory engineering course. The structure of these activities consisted of an initial challenge followed by a related, though more complex, second challenge. Rewards were commensurate with the challenge such that the award for the second level was more significant. We used an experimental design where some students were offered the opportunity to complete the challenges and others were not. In all cases, participation in challenges was voluntary. We implemented a pre/post survey design using the Motivated Strategies for Learning Questionnaire (MSLQ), a reliable and valid survey instrument designed to assess motivation in college courses. The MSLQ contains sub-scales for a variety of motivation constructs including goal orientations, task values, and self-efficacy. Though posttest response rates proved too low to yield statistically significant comparisons, quantitizing responses from open-ended qualitative data yielded meaningful results. In particular, our study shows the importance of providing challenges that are of an appropriate difficulty level for the students based on their current knowledge.

Introduction

Introductory engineering classes typically aim to challenge the average incoming freshman. However, as a result of superior education, talent or both, some incoming students enter engineering programs prepared for more challenging activities. Introductory courses also deliver a particular breadth of material in a fixed format to students with various interests and learning styles. Unfortunately, either the course's emphasis or delivery style may differ with students' expectations. The consequences for better prepared students or those with different expectations may be dissatisfaction, disengagement, and potentially disillusionment with engineering. Offering a series of optional challenge projects spanning multiple disciplines is proposed as a means to maintain student engagement and promote motivation for learning. Specifically, we study the motivational effects of offering optional challenge projects to freshmen engineering students enrolled in an introductory engineering course.

Framework

Motivation directly relates to engagement in learning in classrooms [1]. In particular, research shows that motivation influences the strategies students use to approach learning [2]. Because we examine motivation and learning, our study is situated in a self-regulated learning (SRL) conceptual framework proposed by Pintrich [3]. Generally, SRL models take into consideration cognitive, motivational and affective, and contextual aspects to learning and are grounded on four general assumptions:

1. The learner actively participates in the learning process by constructing "meaning, goals and strategies" using their own beliefs and inputs from the surrounding environment.
2. Learners have the potential to "monitor, control, and regulate certain aspects of their own cognition, motivation, and behavior" although they may not actually do so.
3. Learners can set standards or goals, monitor progress towards these goals and make appropriate adjustments in cognition, motivation, and behavior to reach such goals.
4. Self-regulation mediates the relationship between personal/contextual characteristics and learning/achievement.

These assumptions give the learner's agency, or freedom to act, prominence in the learning process. In this approach, goals and learning strategies are not matched one to one, and learners choose appropriate learning strategies based on a variety of factors.

Figure 1 is a simplified diagram of Pintrich's conceptual framework. It shows four stages that operate sequentially (center circle) across each of four domains (boxes). Note that the full cycle of stages can operate in each domain.

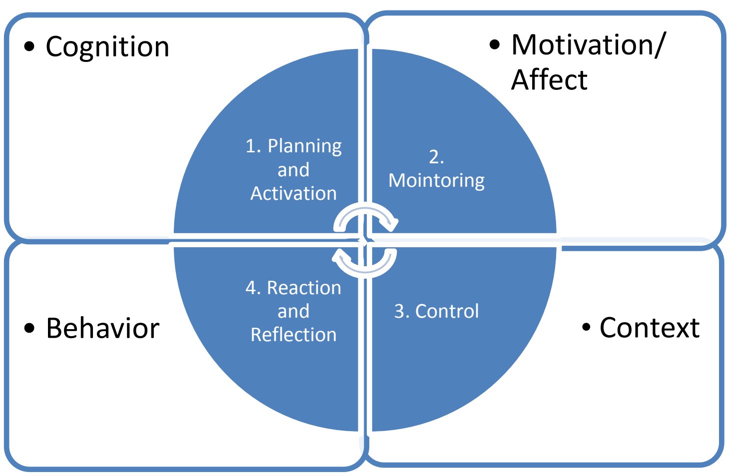

Figure 1: Simplified Diagram of Pintrich's Self-Regulated Learning Framework

Our project is centered in the Motivation/Affect domain where we seek to understand how an intervention impacts motivation for learning. In this framework, as in much of Pintrich's work, motivation is defined broadly and includes elements firmly grounded in a variety of different motivation theories [1, 4]. Capitalizing on this broad definition, our Chocolate Challenge interventions were designed to be consistent with suggestions from a variety of frameworks for promoting increased student motivation.

Chocolate Challenges consist of two sequential challenge problems. The first level engages application and analysis level cognitive skills while the second aims to inspire synthesis. The first level invites all students to solve mathematical or applied engineering puzzles with a difficulty level slightly beyond that expected of the average engineering freshman. Average is based on the standard engineering curriculum. For example, if a problem requires multivariable calculus when the standard engineering curriculum does not sequence it until the second or third semester, then the problem can be considered somewhat ahead of the average engineering student. Winners receive recognition, a large chocolate bar (hence the name) and the right to engage in the challenge's second level. Second level challenges require students to independently obtain and apply discipline oriented engineering knowledge. As detailed in the challenge descriptions, successful application results in a tangible benefit to the student directly related to the type of engineering activity undertaken. The student keeps the fruit of his engineering labors. Four of these bi-level challenges were offered during the semester. Each challenge's theme touches on a different field of engineering. Each challenge is described in greater detail in the Methods section.

The key motivational design features of the Chocolate Challenges include: 1) challenge level, 2) variety in task, 3) voluntary participation, and 4) appropriate rewards. Comparing these features to Pintrich's generalizations about motivation and suggested learning activity design principals we find significant overlap [4]. First, to promote motivation through building competence beliefs, Pintrich suggests "Design tasks that offer opportunities to be successful but also challenge students". The Chocolate Challenges were intended to be just beyond average first-year engineering students' abilities. To promote intrinsic motivation, Pintrich suggests, "Provide stimulating and interesting tasks, activities, and materials, including some novelty and variety in tasks and activities." Pintrich further recommends, "Provide content material and tasks that are personally meaningful and interesting to students." The Chocolate Challenges included a variety of topic areas and task activities. To motivate students by promoting a sense of control, Pintrich suggests, "Provide opportunities to exercise some choice and control." The Chocolate Challenges are not mandatory, do not count towards grades, and students had the choice to enter one or more challenges. To motivate students through appropriate goal setting, Pintrich suggests, "Use task, reward, and evaluation structures that promote mastery, learning, effort, progress, and self-improvement standards and less reliance on social comparison or norm-referenced standards." In the Chocolate Challenge, we attempted to incorporate a variety of reward structures including personal recognition of winners (but not identifying unsuccessful attempts), tangible rewards such as the chocolate bars and intrinsic rewards of the opportunity to enter another challenge level.

Methods

To assess the impact of these optional challenge projects on student motivation, we used an experimental design. Students in one lecture section were offered Chocolate Challenge opportunities while students in the control group were not. All lecture sections were large (200+ students each), and although different instructors taught the experimental and control groups, the common syllabus and lecture materials used in the courses provided continuity over sections. The course is designed to introduce students to engineering and includes topics such as approaches to problem-solving, developing familiarity with different engineering majors, graphing, flowcharts, basic programming, sketching, and ethics. We implemented a pre/post survey design using the Motivated Strategies for Learning Questionnaire (MSLQ). We added several open-ended questions to the posttest to help us understand any measured changes. The following sections describe the challenges, participants, data collection, and data analysis approaches.

Detailed Descriptions of the Challenges

Chocolate Challenge 1: Analysis and Manufacture of Geometries

The first problem challenges class members to determine the volume of a truncated right cone (cone frustum) using multi-variable calculus (See Figure 2). The first student to submit a correct analysis wins the first level and the right to pursue the challenge's second level.

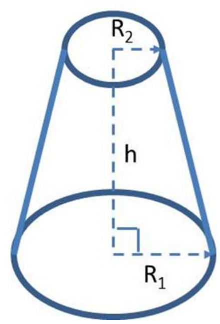

Figure 2: Cone Frustum

The second level requires a student to build a part of his own design using a rapid prototyping machine. Working independently, the student learns to use Autodesk Inventor, a 3D modeling software package, and a rapid prototyping machine. If successful, the student keeps his part as a tangible reminder of the value of learning.

Chocolate Challenge 2: Programming and Computers

The second challenge begins with a request for the students to build a Sodoku region solver using Matlab, a high-level programming language. Sodoku is a popular mathematical puzzle game played on a nine by nine grid that divides into nine three by three regions in which a player may enter integers one through nine subject to certain constraints (See Figure 3). The challenge is to program an algorithm that automatically solves one of the nine regions given a user defined set of initial numbers for the region.

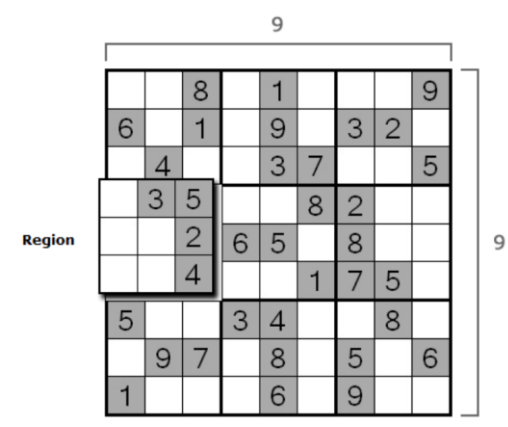

Figure 3: Sodoku Game Grid with Highlighted 3x3 Region

Of the four challenges, the second level of this one pushes a student farther than any other. The winner of the first level gains the opportunity to design and build a Microsoft Windows driven version of an iPad. This challenge draws inspiration from the accomplishment of Liu Xinying, a Chinese computer store worker who designed and built an iPad replica from commercially available components that uses a Microsoft operating system. The successful student keeps his iPad replica and earns a cash prize exceeding Liu Xinying's stated cost of materials (~$310).

Chocolate Challenge 3: Structure of Materials

The third challenge first directs students to build two triangles from 12 rigid spheres, six spheres per triangle. Taking two additional spheres, the challenge then asks students to assemble them into a perfect cube (See Figure 4). Using the resulting face centered cubic (FCC) model, the students must calculate the cube's edge length as function of sphere radius to complete the first level.

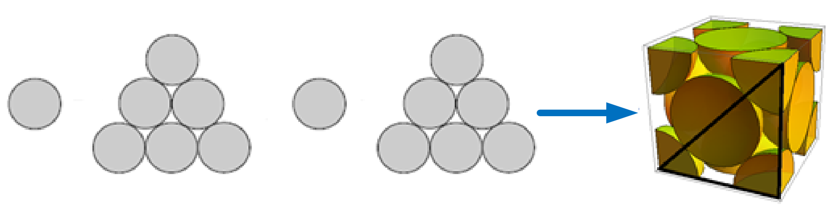

Figure 4: Rigid Spheres Assembled as a Cube

The comparatively straightforward second level challenges a winning student to use the newly gained knowledge of the atomic structure with given mass, density, and atomic radius to calculate the number of atoms in a given length of silver wire. If successful, the student keeps the wire as a memento of drawing material knowledge from models and geometric reasoning.

Chocolate Challenge 4: Probability and Games

To introduce concepts in probability and statistics of importance in electrical, nuclear, and other areas of engineering, the fourth challenge asks students to calculate the probabilities of drawing certain five card stud poker hands from a 52 card deck. Five card stud is a game of poker in which a player receives five cards from a dealer, and after viewing the cards, the player makes certain betting decisions based on his hand. For the purposes of this challenge, it is assumed that only one player is present, and he simply draws five cards in a row. To win, students must calculate the probability of drawing four aces, the probability of drawing any four of a kind and the probability of drawing any four of kind with Jacks wild. Offered late in the semester, the fourth and final challenge differs from the others in that it lacks a second level. Finals, final projects and other classwork draw too much attention to allow a winning student the proper time to complete a second level.

Data Collection and Analysis

Data were collected through online surveys administered twice during the semester. The pretest was given in the second week of the semester. The posttest was administered following the final exam. For each administration, participants were invited to take the survey via email with a link to the survey. An initial email and two reminders were sent for the pretest and an initial email with one reminder was sent for the posttest. The pretest included items from the MSLQ as well as demographic information. The posttest included the same questions as the pretest with additional open-ended questions designed to further explicate impacts of the Chocolate Challenge.

Participants

All study participants attend a public university in the mid-Atlantic region of the United States. Approximately 244 students in the Chocolate Challenge group and 331 students in the comparison group received invitations to participate in an online survey at the start of the semester. Contact lists were generated from the course rosters for each section. The pretest yielded 95 complete, usable responses with 48 in the experimental group and 47 in the control group. The overall pretest response rate was approximately 17%. Although low, this is not unusual for online surveys [5]. Excluding the 12 participants that did not indicate gender, our pretest sample was 21% women. Excluding the 12 participants that did not indicate ethnicity, our pretest sample was 84% White, 7% Hispanic, Latino/a, or Spanish origin, 8% Asian American, and <1% indicated “Other”. These are approximately representative of the engineering population at this university as a whole.

Response rates on the posttest were extremely low and insufficient for rendering results with any statistical significance. However, the data still offer meaningful insights on the effectiveness of the Chocolate Challenge and ways to improve the technique for future implementations. Posttest responses yielded only 27 complete and usable responses. The responses included 14 in the experimental group and 13 in the comparison group. Of the posttest responses, only 9 had matching pretest scores with five in the experimental group and four in the comparison group. The 27 responses included: 7 women, 11 men and 9 participants who chose not to report gender.

Data Collection Instruments

The MSLQ is a Likert-scaled, self-report instrument to assess the motivational orientations and the use of different learning strategies by college students in college courses. All items are scored on a seven point scale where 1 and 7 are anchored (*not at all like me* = 1 and *very true of me* = 7), but values between are not. The MSLQ includes a total of 81 items divided into two sections: 1) Motivation and 2) Learning Strategies. Although the entire instrument was administered, this analysis used data from the motivation section which includes 31 items that address a student's intrinsic and extrinsic goals, task value beliefs, beliefs about control over learning, self-efficacy, and test anxiety. The MSLQ is scored by calculating a separate score for each scale. The score represents the mean for responses for all questions within a given scale.

The MSLQ is a valid and reliable instrument as extensively described in the literature supporting the development of the instrument [6, 7]. Internal consistency scores (α) for each of the motivation sub-scales are shown in Table 1. These values are generally acceptable for education research.

Table 1: Internal Consistency Scores for MSLQ Motivation Scales

Sub-Scale	**# Items**	**α**
Intrinsic Goal Orientation	4	0.74
Extrinsic Goal Orientation	4	0.62
Task Value	6	0.90
Control of Learning Beliefs	4	0.68
Self-Efficacy for Learning and Performance	8	0.93
Test Anxiety	5	0.80

Pretest data were analyzed using t-tests to determine the initial equality of the groups. Due to the low response rates on the posttest, it was not possible to repeat the t-test between groups to determine overall differences nor was it possible to do a statistical pre/posttest comparison. However, we qualitatively examined the quantitative data to identify possible themes/patterns worthy of further investigation.

To analyze the free response questions from the post survey, open coding was used to develop general themes and categories based on each questions independently, but quantitization was also used to understand the frequency of responses. Quantitizing data is a form of data transformation where qualitative components such as themes are given quantitative characteristics such as numbers to understand the impact of a finding [8]. In traditional qualitative research, often it is believed that qualitative work cannot be evaluated with numbers, but quantitizing data is an accepted practice among mixed methods researchers allowing one to draw additional meaning from qualitative research aside from simply themes, trends, and quotes [9]. The themes generated from the free response items along with the quantitized components appear in tables in the following sections.

Results

Using a t-test we compared the pretest scores for each of the motivation scales for the experimental and control groups. Means and standard deviations are shown in Table 2. No statistically significant differences were found, demonstrating the equivalence of the two groups.

Table 2: Pretest Results for t-test Comparison Between Groups

Sub-Scale	Experimental		Comparison	
	Mean	St. Dev.	Mean	St. Dev.
Intrinsic Goal Orientation	5.1	1.1	5.2	0.9
Extrinsic Goal Orientation	5.5	1.1	5.6	0.9
Task Value	5.6	1.2	5.5	1.1
Control of Learning Beliefs	5.6	0.9	5.6	1.0
Self-Efficacy for Learning and Performance	5.5	0.8	5.3	1.1
Test Anxiety	4.1	1.2	4.2	1.2

Recalling that the sub-scales include answer ranges of 1 to 7, the results of the pre-survey suggest higher than a mid-point value of 3.5 across all scales. Note that the MSLQ is believed to be course specific as it is anticipated that students might have different motivational factors and/or use different learning strategies in different classes. The students are instructed to consider "this class" when responding to the items. Moreover, this means that blanket score norms are not provided and should be developed for individual courses over time.

The low response rate on the post-test may also be indicative of the relatively few students that turned in completed attempts for the challenges. Table 3 documents the number of submissions and the number of correct submissions for each challenge.

Table 3: Submission Data for the 1st Level of the Chocolate Challenges

Chocolate Challenge	Number of Submissions		Percent of Experimental Class Submitting	Correct Answer
	Male	Female		
1	6	0	2.5	3
2	2	0	< 1	1
3	2	0	< 1	1
4	5[a]	2	2.9	0[b]

Notes: a includes one resubmission; b three were partially correct

Noticeably fewer women submitted attempts to challenges, and women only submitted attempts for the fourth challenge. Women initiated only 12% of submissions even though approximately 21% of the Institute's engineering population is female and at least 25% of the post survey group consists of women.

The post survey contains five free response questions included to understand participants' views on their motivation over the course of a semester and their general opinions on the Chocolate Challenge. The first question focused on the students' perceived change in overall motivation from the beginning to the end of the semester. Table 4 summarizes the results.

Table 4: General Changes in Motivation During the Course

Overall Response	Theme	Explanation	Number of Participants
Increase (1)	Peers	This student indicated that their motivation over the semester increased as they made connections to other students in their program.	1
Decrease (14)	Material	These students did not see the value in the course material. They commented that the material in the overall course was either irrelevant or they could not see the application of the topics. The material often led to disinterest among the students decreasing their motivation.	7
	Grade and Work Misalignment	These students felt there was an inequality between the amount of work they were completing and the grades they were receiving.	3
	Lecture	A couple students felt their motivation decreased because of the lectures specifically. This also related to content, but only content in the lectures, not the entire course.	2
	Time	Student mentioned the time commitment for the course was very high which lead to a decrease in motivation.	2
No Change (13)	No Themes	N/A	13

Notes: 28 responses were gathered for this item.

From Table 4, students most commonly reported that their motivation decreased over the course of a semester. Students who reported a decrease in motivation most commonly cited the course material as the reason for the decrease. These students did not see the value in the material; they often commented that the content was irrelevant. One student commented that, “there were some times when I was disinterested in the course because of the current material.” Only one student cited an increase in motivation stating that, “I became more engaged as I became more familiar with the other students in class.” This student was able to make connections to his peers which he felt had an impact on his motivation. Thirteen students reported no change in motivation. These students also did not provide any justification for the lack of change. It should be noted that this survey was given at the end of the semester right after the final examination; so, slightly negative results might be expected.

The second set of free response questions focused specifically on the challenge activities offered to students during the semester. The reasons students reported for participating in the Chocolate Challenge appear in Table 5.

Table 5: Reasons Cited for Participating in the Chocolate Challenge

Theme	**Explanation**	**Number of Participants**
Knowledge	A few students felt that the activities required knowledge that was beyond them; so, they were discouraged from completing the challenges. These students often attempted the problems, but they never completed them.	3
Time	Some students felt the time required to complete a challenge was too great. These students were generally positive in their views, but the demands of other course requirements prevented them from working on the challenges.	2
No Grade	One student chose not to participate in challenges because the activity lacked a grade. This student focused on activities that contributed to course credit and the final course grade.	1

Notes: 9 participants mentioned the Chocolate Challenge specifically. 5 participants indicated they attempted or completed a challenge. No reasons were given for why students chose to participate

The most prominent theme that students indicated related to the knowledge required to complete the challenges. These students felt that the Chocolate Challenges required skills beyond their current abilities, and therefore, these students did not complete the challenges even though many at least attempted them. One student commented that, “I attempted the triple integral because I had no idea how hard it was. I also tried the poker hand possibilities, and I was able to do the first two parts, but the last part was just beyond what I had learned of probability.” Many students commented that while they did not complete the challenges, they did attempt them or were at least interested in trying them. The five students who indicated that they did at least attempt the Chocolate Challenges also commented that the time commitment deterred them from completing the assignments. Additionally, they chose not to fully complete the challenges because the assignments were ungraded.

Finally, a free response question asked students about their willingness to participate in future challenge activities. Of those submitting the survey, 26 students responded to the question, and 18 indicated that they would participate in future challenges. For example, one student stated, “Yes I would [participate in future challenges] because they are great ways to learn new things and develop an analytical thought process.” Fun and enjoyment gained by engaging in challenges proved the most common theme reported by participants interested in future attempting future challenge activities. Conversely, six students said they would not participate, citing a lack of enjoyment. Table 6 summarizes the findings from the future participation question.

Table 6: Willingness to Participate in Future Challenges

Overall Response	Theme	Explanation	Number of Participants
Yes (18)	Fun	These students felt the projects were rewarding and provided them with enjoyment.	4
	New Knowledge	A few students reported an interest in these activities because they require them to gather new knowledge and apply that knowledge in different ways.	3
	Competition	A couple students would participate in these activities because they enjoyed the competition with their classmates.	2
	Time	These students indicated they would most likely participate in the future, but they were concerned that the activities would require too much of a time commitment.	2
No (6)	Lack of Enjoyment	These students did not find the activities to be enjoyable or fun.	2
Maybe (2)	Uncertainty	A couple of students were uncertain about their future involvement due to the uncertainty of the assignment structure. They were concerned about their knowledge and assignment structure.	2

Notes: 26 responses were gathered for this item.

Aside from the data presented in the table, a few unique findings were observed across the entire free response data set. First, every student seemed to have a range of feelings towards the class. For example, if a student experienced a decrease in motivation over the semester that did not lead to a negative response for the remaining questions. Also some students cited other engineering extracurricular activities as highly motivating (student engineers council, baja design team, etc.) in the survey. While these activities were not specifically part of the course, students found other ways to remain motivated beyond the course and the Chocolate Challenges.

Discussion, Limitations, and Implications

Discussion of Results

We set out to influence student motivation in a first-year engineering course by providing optional challenging activities, i.e., Chocolate Challenges. We focused on four design features to increase student motivation including: 1) challenge level, 2) variety in task, 3) voluntary participation, and 4) appropriate rewards. While students self-reported decreases in motivation for the course as a whole, there were positive responses towards the Chocolate Challenges. Recalling our small sample size (discussed further in the Limitations section), we offer this discussion of patterns in the data as opposed to statistically supported conclusions.

Given the small number of students that submitted completed attempts and the comments about difficulty and time commitment, it is possible that the challenges were too hard to be motivating for many of the students. However, the simplest challenge (in the instructor's opinion), Challenge 3, tied for the fewest submissions while the most demanding first level challenge,

Challenge 4, garnered the largest number. This is somewhat surprising given that Challenge 3 required hands on, visual work while Challenge 4 was purely analytical. The fourth challenge presented the problem in a series of increasingly difficult steps which potentially built student's confidence. It also used the familiar card game context to introduce a topic. Stepwise presentation and a familiar context may partially mitigate the demotivating effects of absolute difficulty.

The fact that fewer women submitted completed attempts may also be linked to the difficulty level. Research in engineering education has shown that women have a tendency to suffer from lower competence beliefs [10-13]. The perception of a higher task difficulty may have deterred women from participating in the challenges.

Variety in tasks was not specifically mentioned by students in open-ended responses although different students attempted different tasks. The open-ended responses do suggest that while some students thought the challenges were interesting others did not. The challenges covered multiple topics related to engineering, but none of them connected with engineering activities related to "helping" professions. Absence of a caring connection may contribute to a lower response from female students. Research shows that women have a tendency to prefer careers related to helping people and/or benefiting society [14-17]. Regardless of demographics, the difficulty of the challenge is likely to affect students' interest in and value for the task. Motivation theory, specifically expectancy-value theory, suggests that task value/interest decreases with decreasing beliefs about the possibility of success [18, 19]. Therefore, task variety may have been sufficient.

Although the tasks were voluntary, devoting time to such activities at the expense of grades is a concern for participants. In this case, "time" became a cost value (as described by expectancy value theory [18, 19]) such that the cost of participating had to be overcome by other benefits. The rewards of the challenge are one such benefit. It is believed that the reward structure was appropriate as students commented about seeking new knowledge (intrinsic goal orientation) as well as the competitive aspect (extrinsic goal orientation) of the challenges.

Finally, results indicate a divergence between motivation in the class and motivation to explore engineering in general. Most respondents experienced a fall in motivation during the semester, but a majority expressed interest in engaging in future challenges. This is not uncommon in college classrooms [2]. Challenges could not change students' overall perception of the class. However, the extra activity offered by the Chocolate Challenges helped maintain interest in engineering for students whose interest may have been reduced by standard class activities. This suggests that the technique positively impacted the target audience, those in danger of becoming disillusioned by the standard elements of an introductory engineering course.

Based on these outcomes, a critical question remains: Why did so few students participate in the challenges? As described above it is possible that the challenge level was too hard on most topics and that a familiar context and stepwise support is needed. The challenge level may also have impacted interest such that the tasks did not have sufficient appeal to students despite variety. Perhaps seeking input from students at the start of the semester as to the topics and/or types of challenges they would find interesting would enhance the motivational impact of the variety of topics by ensuring appeal to the cohort of students who would be offered the challenges. A remaining "cost" to participation then is the time commitment. However, it is possible that appropriate challenge level and increased interest would make the cost less significant and ultimately increase participation.

Limitations

A critical limitation in this study is the low response rate on the posttest. This is most likely due to general survey fatigue associated with this course. At the end of the semester, students are given an online feedback survey from the University as well as one from the course instructors. In future studies, the authors would consider offering incentives to students for completing the survey, as this approach has proven effective with college students [20]. An incentive which increases for students completing the pre and posttest survey might be of particular use. For example, entering students' names into a raffle for a gift card with the number of times a name is entered doubling or tripling if the participant also completes the posttest.

Implications for Research and Practice

This study has implications for researchers and practitioners alike. For engineering education researchers, our study shows promising results on which to build future studies. The concept of the challenges shows potential to motivate students. Importantly, motivational benefits accrue to students potentially disaffected by standard elements of introductory engineering courses. Success in a lecture context opens the door to studies of the impact of challenges in other educational settings ranging from labs to seminars. Moreover, the framework and data collection instruments are an appropriate fit. Greater effort should be focused on recruiting participants.

For practitioners, our study suggests the importance of learning activities that present an optimal challenge to students, i.e., they are neither too hard nor too easy. Experience with deploying challenges points to possible means of mitigating the discouraging aspects of difficult problems. Stepwise presentation, use of familiar contexts , and, seeking input from students on topics of interest are techniques practitioners might explore. Several development and assessment iterations of classroom activities might prove necessary to find the right balance.

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