Student Motivation and Engagement Across Time and Context Through the COVID-19 Pandemic

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WIP: Student motivation and engagement across time and context through the COVID-19 pandemic

Abstract

Motivation is a multi-faceted construct encompassing orientation towards certain types of goals, the value and expectation of achieving those goals, and attributional beliefs. Our unique dataset tracks cohorts of mechanical engineering students through time and across multiple courses, allowing us to study context-dependent variables across time. We measured intrinsic goal orientation and extrinsic goal orientation in two cohorts of mechanical engineering students at the beginning and end of the Fall 2019 and Fall 2020 terms. Though our original study was designed to evaluate instructional interventions in a "difference-of-differences" design, our cohorts were significantly impacted by the COVID-19 pandemic.

Based on the ongoing stress of the COVID-19 pandemic as well as widespread dissatisfaction with remote learning, we expected students to be less motivated overall in Fall 2020 compared to Fall 2019, and for motivation to erode more rapidly over the semester. Although intrinsic motivation was indeed lower in Fall 2020 compared with Fall 2019, the decrease in motivation over the course of the semester was the same. Furthermore, the availability of recorded lecture videos and class content may have mitigated against an expected drop in level of engagement for some students. Average student engagement, as measured by responses to in-class polling exercises remained constant between Fall 2019 and Fall 2020, and it appears that more students were able to maintain a 100% participation rate in the remote context, though there is significant variation in engagement within the class.

We seek input from the engineering education research community on this work-in-progress study. We especially invite a discussion about how to make sense of survey results in dramatically different teaching contexts.

Introduction

The rapid shift to remote instruction in Spring 2020 due to the COVID-19 pandemic had broad, immediate, and lasting impacts on college students. In a very short time, colleges and universities around the country closed their campuses, evicted students from dormitories, and shifted to online instruction [1]. Instructors and students, many of whom had no prior experience teaching or taking online courses, were suddenly faced with the additional burden of remote learning [2]. During this time, the prevalence of stress, anxiety and depression has increased in the general population [3] and in college students worldwide [4, 5].

Stress is a significant mediator of academic motivation, and can have a positive or negative effect depending on the type and context of the stress. LePine et. al. in a study of 696 college students found that “challenge stress” (resulting from experiences believed to promote growth or learning) was positively associated with motivation, while “hindrance stress” (resulting from experiences believed to hinder growth or learning) was negatively associated with motivation. Students faced a swath of hindrances to learning in emergency remote instruction in 2020 including illness, unstable internet access, financial uncertainty, and social isolation [6, 7]. Dissatisfaction with online learning may cause students to disengage over time as well. Understandably, given the immense challenges in delivering quality remote instruction in an emergency context, many students reported being dissatisfied with remote learning in 2020 [8]. Based on these observations we expect students to report lower academic motivation as a result of the COVID pandemic, and for motivation to erode at a faster rate in Fall 2020 than it did for students in Fall 2019. We also expect student participation and engagement with class activities to suffer in the online instruction setting.

By now (spring 2021), a number of studies on student motivation and attitudes towards remote instruction have been published. In a retrospective survey of 270 college students, Aguilera-Hermida found that motivation declined after the transition to remote instruction and that students strongly preferred in-person learning [8]. Another retrospective comparison survey of 98 Canadian college students by Daniels et. al. showed consistent declines across several motivational constructs and measures of engagement, with the largest decline in mastery-approach goals [9].

So far, the effects on student outcomes seems to be less clear. Meeter et. al. found similar retrospective self-reported declines in motivation, satisfaction with instruction, and effort investment in a study of Dutch college students [10]. However, students reported earning more credits during remote instruction, a result which was verified by administrative data. Amazingly, Gonzales et. al. found that Spanish University students performed *better* on identical assessments during lockdown, compared with students in previous years, which they attributed to more efficient study strategies [11]. There is a clear need for more studies of student outcomes that compare results from identical assessment methods before and during remote instruction, as well as studies that disaggregate outcomes by factors like study environment and economic privilege, which impact students’ dramatically different experiences of the same global pandemic.

The Cornell Active Learning Initiative is a broad effort to improve undergraduate instruction across multiple departments through evidence-based teaching practices. A major thrust of our project in Mechanical & Aerospace Engineering is to make connections between concurrent courses in the Junior year through cross-cutting projects and examples. Thus, variations in students’ attitudes and motivations for learning between different course contexts is of central interest. Towards that end we deployed surveys at the beginning of the year to track changes in attitudes and motivation across cohorts, and deployed end-of-term surveys in each participating course to track within-subject variation across course contexts.

Fall 2019 was designated as the control group, in which assessment instruments were developed and deployed, but no direct effort by project personnel was invested in developing or implementing new instructional strategies. Fall 2020 was intended to be the first treatment cohort. Although many of the original research and intervention plans were disrupted by COVID-19, project personnel instead invested resources into facilitating and improving (primarily) remote instruction. The same survey and assessment instruments were still deployed in Fall 2020, offering a unique opportunity to study student motivation, engagement, and outcomes during the COVID-19 pandemic. This study is situated in the context of the three Fall courses that are part of our Active Learning Initiative project.

The research questions that guide this investigation are:

1. How did students' extrinsic and intrinsic motivation change during and as a result of the COVID-19 pandemic? (RQ1)

2. How did student engagement with lecture activities change as a result of the remote setting? (RQ2)

Methods

Participants

Data was collected from two cohorts of students enrolled in three junior-level mechanical engineering courses at Cornell University: fluid mechanics, mechanics of engineering materials, and mechatronics. Data collection took place during Fall 2019 (pre-COVID cohort) and Fall 2020 (COVID cohort). A total of 283 students consented to data collection out of a total of 363 students enrolled in any of the three courses. Only students in all three courses (for RQ1), or Mechanics of Materials (for RQ2) were included in the analysis. The majority of non-consenting students were enrolled in only one course (Mechatronics), and therefore the exclusion of their data does not introduce any significant potential bias. This study was approved by the Cornell University Institutional Review Board under protocol #1708007347. Demographic breakdowns of the two cohorts are summarized in Table 1.

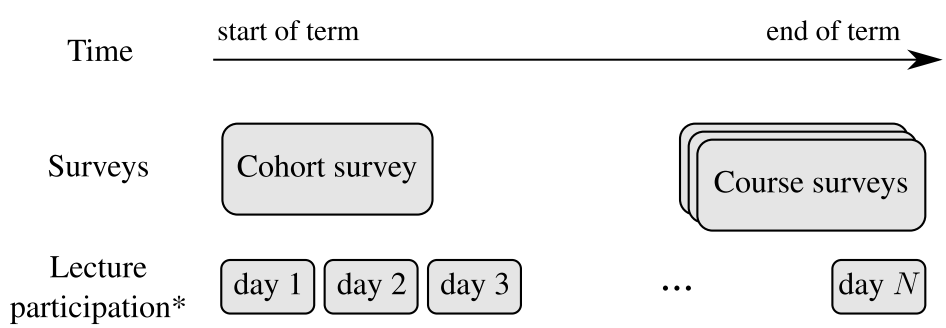

Figure 1: Illustration of data collected for a single student in one cohort. **Participation data only collected in the mechanics of materials course.*

Surveys

Students enrolled in any of three courses were invited to complete a survey (the "cohort survey") about their attitudes towards all of their mechanical engineering courses, as well as basic demographic information during the third week of classes. Three of the motivation subscales

Table 1: Sample demographics summary.

	Fall 2019	Fall 2020
Total enrollment	175	188
Fluid mechanics	124	118
Mechanics of materials	123	134
Mechatronics	149	135
All three courses	102	74
Survey completion (%)		
Cohort survey	146 (85%)	101 (54%)
All 3 course surveys	49 (50%)	42 (57%)
Academic year[a] (%)		
Sophomores	13 (8%)	25 (13%)
Juniors	127 (74%)	124 (67%)
Seniors	21 (12%)	25 (13%)
Other	10 (6%)	12 (6%)
Gender[a] (%)		
Men	77 (53%)	46 (46%)
Women	66 (45%)	48 (48%)
Other/Unknown	3	7

[a] Percentages are calculated with respect to survey respondents only.

(intrinsic goal orientation, extrinsic goal orientation, and control of learning beliefs) were adapted from the Motivated Strategies for Learning Questionnaire developed by Pintrich et. al. [12]. Items were modified by replacing the words "this course" with "my MAE courses." All items from the MSLQ are rated on a scale of 1 ("Not at all true of me") to 7 ("Very true of me").

Later, during the 11th and 12th weeks of classes, students were asked to complete a survey during lecture in each of the three courses. The course survey included questions from six subscales of the MSLQ: intrinsic goal orientation, extrinsic goal orientation, task value, self-efficacy for learning and performance, metacognitive self-regulation, and peer learning. Additionally, three questions about the perceived value of lecture time were added. Specific changes made in adapting the original MSLQ items are described elsewhere [13].

Student engagement

We collected student responses to lecture polling questions as a measure of engagement with lecture content in one of the three courses (mechanics of materials). In Fall 2019, polling questions were conducted in-person using iClickers (Macmillan Learning, New York). In Fall 2020, polling questions were conducted using Poll Everywhere (Poll Everywhere, San Francisco). Polls remained open for 24 hours so that students viewing the lecture asynchronously could still participate. Students received a small amount of participation credit in both terms; full credit was awarded for 80% participation and pro-rated below that threshold. In Fall 2020, students had the choice to participate in the course fully-remotely, or to participate in in-person discussion sections led by a graduate teaching assistant. 29 students enrolled in in-person discussion sections while 101 students enrolled in the fully-remote option. The lecture meetings were fully-remote for all students, regardless of discussion section instructional mode.

Analysis

The latent factor structure of the survey data collected in Fall 2019 has been described elsewhere [13] and was generally found to conform with theoretical expectations. The Fall 2020 cohort surveys and course surveys were evaluated by confirmatory factor analysis assuming an identical model to the Fall 2019 data. Goodness-of-fit parameters for the course surveys suggest a marginally acceptable model fit (RMSEA = 0.085, CFI = 0.830). Exploratory factor analysis suggested that Task Value and Intrinsic Goal Orientation loaded onto a single factor, and a few other isolated items loaded weakly onto their respective subscales.

Only those students who responded to the cohort survey and all three course surveys were included in this analysis. The intrinsic motivation scores were averaged across courses for each student to obtain a single measure at the 11th/12th week time point. The same procedure was repeated for the extrinsic motivation scores. Although we have previously shown that intrinsic motivation is only moderately correlated across contexts, the three courses studied were the same in both cohorts and therefore would not bias the mean results [13].

Student responses to in-class polling questions was used as a proxy for engagement with lecture material in the mechanics of materials course. Data was analyzed for 34 class sessions in Fall 2019 and 32 class sessions for Fall 2020. Each student received a binary score according to whether or not they entered any response (not necessarily correct). An overall lecture engagement rate was calculated by finding the fraction of sessions in which the student participated.

Results

Motivation

Mean scores on the two motivation subscales considered are shown in Fig. 2. Extrinsic motivation is strongly correlated across course contexts (r = .82, n = 94) and across time—i.e., between week 3 and the average of the three course surveys at week 11 (r = .62, n = 79). Intrinsic motivation is only moderately correlated across course contexts ($.44 < r < .46$, n = 94), but strongly correlated across time (r = .71, n = 79).

We predicted intrinsic and extrinsic goal orientation using a linear model of the form

$$Y = \beta_0 + \beta_{term}(\text{Fall 2020}) + \beta_{time}(\text{Week 11}) + \beta_{int}(\text{Fall 2020 } \textit{and} \text{ Week 11}) \quad (1)$$

Two models were considered: (A) a model considering only main effects β_{term} and β_{time}, and (B) a model including an interaction effect β_{int} allowing for different changes in motivation over time in the two cohorts. The dependent variable has been scaled to have $\mu = 0$ and $\sigma = 1$. Thus β_{term} represents the effect size for cohort (COVID and non-COVID) and β_{time} represents the effect size for time point within the term (week 11 vs. week 3).

For intrinsic motivation, support was found for the hypothesis that motivation would decrease in the Fall 2020 cohort (β_{term} = -0.321, p = 0.037) from model A, which only considers the main effects. Note that motivation decreased in both cohorts over the course of the semester (β_{time} = -0.438, p = 0.004). However, model B did not support the hypothesis that motivation would

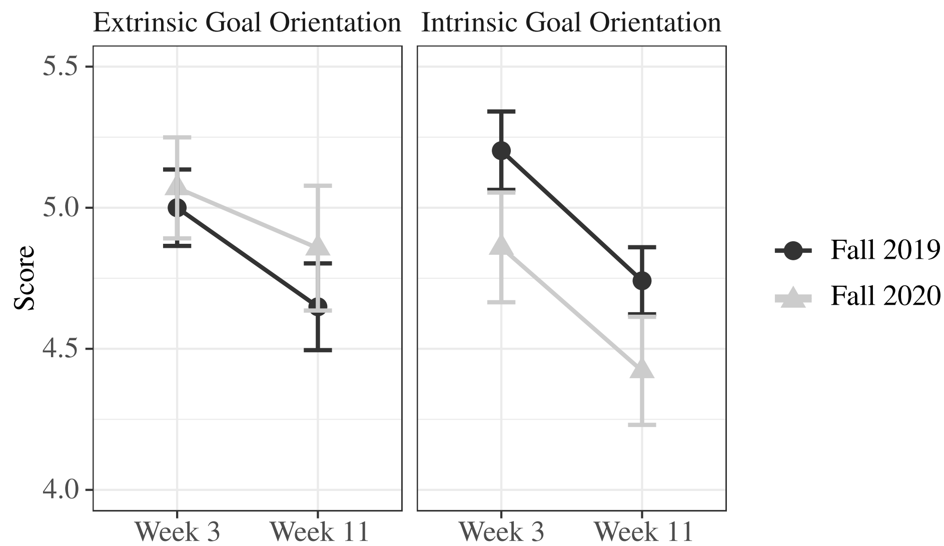

Figure 2: Change in motivation constructs over time for the two cohorts.

decrease more over time during Fall 2020 than in Fall 2019 (β_{int} = 0.023, p = 0.94). Note that the parameter estimates for the main effects in Model B are almost identical to those of model A, but β_{term} failed to reach statistical significance due to the decrease in power.

For extrinsic motivation, none of the model parameters reached significance.

Lecture engagement

There was no significant difference in the mean lecture engagement rate between Fall 2019 and Fall 2020 (Welch's t-test: p = 0.178). Similarly, no difference was found between students registered for in-person discussion sections and students participating fully-remotely (p = 0.826). The distribution of participation rate (Fig. 3) suggests that more students participated in every polling activity in Fall 2020. One benefit of remote instruction is that students were still able to view the lecture and engage with the polling questions, even if occasional circumstances made it impossible to participate synchronously.

There appear to be more students with low engagement rates in Fall 2020 (which is offset by students with 100% engagement rates). We suspect the pandemic affected certain students more, and in different ways, than other students. This remains a priority in our ongoing research.

Table 2: Model parameters for motivation subscales.

	Model A		Model B		
	β_{term}	β_{time}	β_{term}	β_{time}	β_{int}
Intrinsic Goal Orientation	-0.321*	-0.438**	-0.333	-0.448*	0.023
Extrinsic Goal Orientation	0.135	-0.287	0.068	-0.341	0.134

*: $p < 0.05$, **: $p < 0.01$

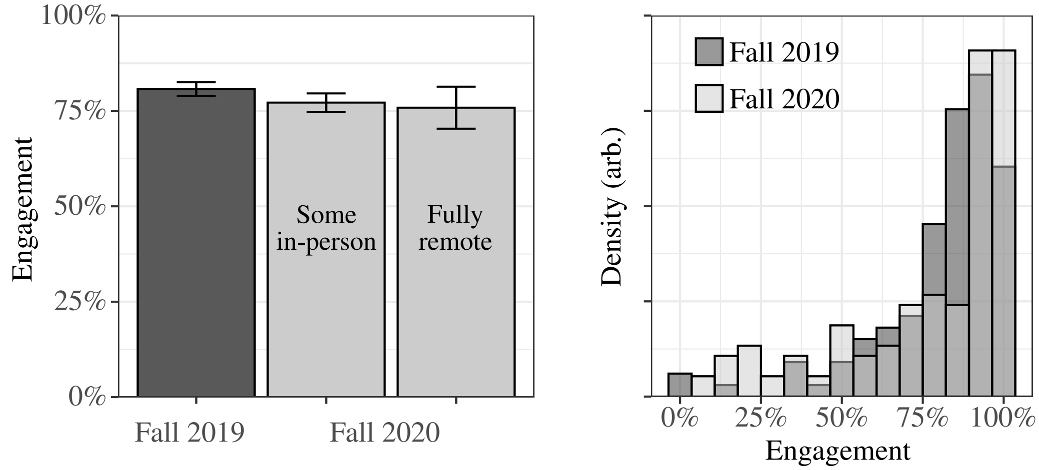

Figure 3: Lecture engagement, as measured by fraction of polling questions answered. **(left)** Mean engagement rates. **(right)** Normalized distribution of engagement rate.

Discussion

Our study is, of course, a natural experiment, not a controlled trial. Many factors varied between the two cohorts besides the effects of the COVID-19 pandemic, including the instructor for the mechatronics course. Most instructional changes were made in response to COVID-19, but others were planned improvements as part of our ongoing project to improve teaching and learning. It is also possible that intrinsic differences in the two cohorts of students could explain any systematic differences. However, we believe that these results are robust for the following reasons: First, the cohort sizes are fairly large, and thus systematic differences by random variation are unlikely. Second, the distributions of class year within the two cohorts are statistically indistinguishable.

Although the gender ratio in our cohorts is almost equal, women are slightly over-represented among cohort survey respondents in Fall 2020. However, we have seen no evidence for systematic differences in intrinsic motivation between men and women in either cohort. Therefore it seems unlikely that self-selection bias played a significant role.

Our findings suggest that students were less motivated to learn in Fall 2020 (remote instruction) than in Fall 2019. However, the decrease in motivation over the course of the semester was identical in both conditions. This consistent decline may be an artifact of multiple surveying, or may simply reflect the inevitable decline in enthusiasm under the burden of exams, impending project deadlines, and extracurricular commitments.

Our unique dataset offers a narrow glimpse into the effect of COVID-19 on our students. However, we have assumed that the constructs measured by our survey instrument can be meaningfully compared in two dramatically different learning contexts. More qualitative work is needed to understand how students make sense of survey items that were originally developed and validated in a familiar, in-person context.

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Appendix

Table 3: Cohort survey items. The complete cohort survey included other questions not discussed in this paper.

Item	Subscale	Question
3	IGO	The most satisfying thing for me in *my MAE courses* is trying to understand the content as thoroughly as possible.
6	IGO	When I have the opportunity in *my MAE courses*, I choose course assignments that I can learn from even if they don't guarantee a good grade.
8	IGO	In *my MAE courses*, I prefer material that arouses my curiosity, even if it is difficult to learn.
11	IGO	In *my MAE courses*, I prefer material that really challenges me so I can learn new things.
1	EGO	Getting a good grade in *my MAE courses* is the most satisfying thing for me right now.
5	EGO	The most important thing for me right now is improving my overall grade point average, so my main concern in *my MAE courses* is getting a good grade.
7	EGO	If I can, I want to get better grades in *my MAE courses* than most of the other students.
10	EGO	I want to do well in *my MAE courses* because it is important to show my ability to my family, friends, employer, or others.
2	CLB	If I try hard enough, then I will understand the material taught in *my MAE courses*.
4	CLB	If I don't understand the material taught in *my MAE courses*, it is because I didn't try hard enough.
9	CLB	It is my own fault if I don't learn the material in *my MAE courses*.
12	CLB	If I study in appropriate ways, then I will be able to learn the material in *my MAE courses*.

IGO=Intrinsic Goal Orientation, EGO=Extrinsic Goal Orientation, CLB=Control of Learning Beliefs.
Items adapted from [12]. Changes indicated in *italics*.

Table 4: Course survey items.

Item	Subscale	Question
5	EGO	The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade.
13	EGO	I want to do well in this class because it is important to show my ability to my family, friends, employer, or others.
23	EGO	Getting a good grade in this class is the most satisfying thing for me right now.
29	EGO	If I can, I want to get better grades in this class than most of the other students.
8	IGO	When I have the opportunity in this class, I choose course assignments that I can learn from even if they don't guarantee a good grade.
24	IGO	In a class like this, I prefer course material that arouses my curiosity, even if it is difficult to learn
30	IGO	In a class like this, I prefer course material that really challenges me so I can learn new things
33	IGO	The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible
2	TV	I like the subject matter of this course
3	TV	I think I will be able to use what I learn in this course in other courses
9	TV	It is important for me to learn the course material in this class.
17	TV	Understanding the subject matter of this course is very important to me.
26	TV	I think the course material in this class is useful for me to learn.
28	TV	I am very interested in the content area of this course.
22	LV	I think attending the lectures for this course is a valuable use of my time.
27	LV	I think I learn more in lecture for this class than from out-of-class readings or multimedia (video etc.) material.
31	LV	In this class, I don't feel that I really learn anything new in lecture. *(Reverse coded)*
6	SE	I'm certain I can understand the most difficult material presented in the readings for this course
7	SE	I'm confident I can do an excellent job on the assignments and tests in this course
11	SE	I believe I will receive an excellent grade in this class
18	SE	I'm confident I can learn the basic concepts taught in this course
19	SE	Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class
25	SE	I'm certain I can master the skills being taught in this class
32	SE	I expect to do well in this class
34	SE	I'm confident I can understand the most complex material presented by the instructor in this course
1	MSR	I ask myself questions to make sure I understand the material I have been studying in this class
12	MSR	When I become confused about something I'm reading for this class, I go back and try to figure it out
14	MSR	Before I study new course material thoroughly, I often skim it to see how it is organized
16	MSR	When studying for this course I try to determine which concepts I don't understand well
20	MSR	When I study for this class, I set goals for myself in order to direct my activities in each study period.
21	MSR	If course readings are difficult to understand, I change the way I read the material
4	PL	When studying for this course, I often try to explain the material to a classmate or friend
10	PL	When studying for this course, I often set aside time to discuss course material with a group of students from the class
15	PL	I try to work with other students from this class to complete the course assignments

TV=Task Value, TV(L)=Lecture Value, SE=Self-Efficacy for Learning and Performance
MSR=Metacognitive Self-Regulation, PL=Peer Learning
Items adapted from [12].