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Curious About Student Curiosity: Implications of Pedagogical Approach for Students' Mindset

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Abstract

Student curiosity compels learners to go beyond what is presented in the classroom, to connect what they have discovered with other concepts, and to finally create new items and knowledge to help address the world's problems. Encouraging this entrepreneurial mindset is a goal within a number of courses at our institution. While not every learner arrives in our classrooms innately curious about the course topic, by using alternative instructional approaches, perhaps curiosity might be fostered more broadly.

The goal of this study is to explore the hypothesis that courses that include open-ended, real-world problems will foster growth of the entrepreneurial mindset to a greater extent than courses that do not have these attributes. We used the SIMS instrument (Guay et al., 2000) for situational motivation in conjunction with a situational curiosity sub-scale (Chen et al., 1999) to assess the situational curiosity and motivational states of engineering undergraduates over the course of three semesters. Students and faculty reported on the extent to which open-ended, real-world problems were a part of each course, along with a host of additional factors including the voluntary nature of the course, whether or not projects resulted in a physical artifact, and if students worked on interdisciplinary teams. Results suggest that interdisciplinary work on "real" problems for actual clients has a significant positive correlation with students' intrinsic motivation and curiosity.

Introduction

Presented with the option to teach curious and intrinsically motivated students, most faculty would take it. While both of these states have dispositional elements that are unlikely to change much over the course of a semester in our classrooms, both motivation and curiosity are also situational – dependent on immediate environmental factors in the moment. While faculty would prefer to work with curious and motivated students, we may not be aware of the ways our course environments cultivate or discourage either.

The entrepreneurial mindset (EM), as defined by [1], rests on the three C's of "Curiosity, Connection, and Value-Creation." We use "curiosity" in this context as the habit of mind that leads students to seek additional information beyond what is presented. Students who are curious go beyond what they need to know for the test, ask "Why?" and are better poised to transfer knowledge between courses and in their ongoing careers. This first of EM's three C's is also recognized more broadly as a key attribute; for example, in "Curious" by Leslie, once demographic factors are accounted for, it is curiosity and conscientiousness that are correlated with student success [2].

Closely linked to curiosity, motivation helps describe students' intention to realize this curiosity. There are a number of lenses through which to view both curiosity and motivation. One useful theory for describing situational interest is Self-Determination Theory [3]. Self-determination theory posits that three overriding factors contribute to an individual's level of intrinsic motivation: autonomy, competence, and relatedness [3]. In our context, we understand these to mean that to cultivate students' interest, students should have a degree of choice and autonomy about a given course's activities, they should feel challenged but not overwhelmed by the difficulty of the task, and that through their work on the task, they connect with others in a meaningful way. Based on this theory as well as on our past experience with courses that appeared to foster entrepreneurially minded learning (EML), we hypothesized that the following six course design elements would contribute to an environment of increased intrinsic motivation and curiosity for students:

Six Elements

<u>Autonomy</u>:

1. Course is *voluntary*.
2. Student work is informed by *broad perspectives*.
3. There are multiple possible solutions and multiple paths to reach those solutions.

<u>Competence</u>:

4. In their coursework, students *realize* a design.

<u>Relatedness</u>:

5. The work involves an *interdisciplinary* group of students.
6. In their coursework, students work on *real* problems.

In this study, we administered a motivation/curiosity instrument to student volunteers engaged in a wide variety of activities in a number of courses. To a greater or lesser degree, these courses embodied the six elements described above. Using students' situational motivation and curiosity as an outcome, we then examined the extent to which these six elements indeed are correlated with students' state. It is our goal that these results will help inform course design and enable faculty to craft courses with environments that are likely to be more conducive to EML.

Methods

A multiple-choice instrument was used to assess participants' situational curiosity and motivation. For motivation, the Situational Intrinsic Motivation Scale (SIMS) was used [4]. The SIMS scale is a multiple-choice self-report based assessment of a person's levels of intrinsic motivation, identified regulation, extrinsic motivation, and amotivation during a given activity. During a given activity or class, students may embody a number of these motivational states simultaneously; for example they may find something interesting in its own right (intrinsic motivation) while also recognizing that this is something that will help them later in their careers (identified regulation). Extrinsic motivation would be a state where a student was undertaking an activity only because it is graded, and amotivation is the state where a participant does not know why they are engaged in an activity. Students do not need to understand the different types of motivation to respond appropriately to this instrument, they respond to questions from which their motivational states may be inferred. The SIMS scale was complimented with a further FIVE questions on situational interest (curiosity scale) from an instrument developed by Chen, Darst, and Pangrazi [5]. This team has previously used this instrument to assess and compare motivation and curiosity among students in a set of elective courses [6].

The study was deemed "exempt" by the IRB, and student participation was voluntary. The faculty member directing the study invited students to participate; names of participating students were not disclosed to instructors. Aggregate student response to surveys was not disclosed until after the end of the course and grades had been finalized. Three times throughout the semester – within approximately two weeks of the start, end, and middle – students were sent an email with a link to the SIMS/Curiosity survey and asked to complete it while reflecting on the most recent instance of their course. At the end of the semester, both students and instructors were asked to complete a survey describing the extent to which the six elements had or had not been part of their course in addition to other demographic questions. Students were offered an honorarium of $10 per completed survey and $10 if all four surveys were completed for a possible total of $50.

A sample of convenience was used in this study. Across two semesters, undergraduate engineering students in nine courses were invited to participate. These courses were aimed at 3rd and 4th year students and offered by faculty in Electrical, Chemical, and Mechanical engineering majors and typically have 10-35 students enrolled. Courses invited to participate were deliberately selected such that some courses in the sample possessed one or more of the six elements as well as courses that lacked one or more of the six elements. We are intentionally considering these course elements "in the wild" – in the context of courses that are not otherwise identical, in order to help broaden the possible applicability of the results. These courses included both elective and required courses. In order to maintain student and faculty anonymity, the courses are not named, however the relevant attributes of the courses as reported by both faculty and students were recorded in the final survey as described above.

For the present study, SIMS/Curiosity responses from only the end-of-semester survey were considered, n=92. Each response was scored for level of intrinsic motivation, identified regulation, and curiosity. These levels were then correlated with faculty and student response to the six-element questions. Responses were dichotomized into groups where the given factor was present or absent; neutral answers were omitted from analysis. Mean and median scores for intrinsic motivation, identified regulation, and curiosity were computed and compared between groups. Significance for differences between these groups was tested with oneway analysis of variance (ANOVA) and effect sizes computed unless otherwise noted. SPSS was used for all calculations.

Results and Discussion

What types of course environment best support students' intrinsic motivation and curiosity? We also considered "identified regulation", an intermediate motivational state between intrinsic and extrinsic motivation. Overall, we found no evidence that any of these elements discourage students' intrinsic motivation or curiosity. Each element is considered separately below.

Element 1: Course is Voluntary

There was significant debate among the faculty as to whether or not the elective nature of a course will or will not significantly impact students' motivation and curiosity. On one hand, there is clearly a higher level of autonomy associated with *elective* courses than with required courses during course registration. On the other hand, the instrument is looking at situational motivation and curiosity – how motivated and curious did *this week's activities* make the student. The autonomy exercised before the beginning of the semester in selecting this course might be overridden on a daily basis by a lack of autonomy over activities on that day. Results shown in Table 1 suggest that the voluntary nature of the course has a positive impact on intrinsic motivation that extend far into the semester.

Table 1: Impact on Intrinsic Motivation of "this course is a requirement for all majors in your department"

COURSE REQUIRED BY MAJOR	**Mean Score**	**Standard Error**
YES n = 80	12.60	.360
NO n = 32	14.34	.569

Element 2: Student work is informed by *broad perspectives*

Nearly every course in the study asked students to apply broad perspectives to their problem solving. The uneven nature of this distribution makes results suggestive rather than conclusive, it is unclear if the similarity of the agree and disagree groups reflects a lack of difference or a lack of sample. As with all elements of this study, we will consider this again as we gather additional data that may shed more light on the "disagree" portion of this element.

Table 2: Element 2 "Student work was intended to be informed by broad perspectives (ex: ethics, economics, value, political or regulatory concerns, etc."

	Intrinsic Motivation		**Identified Regulation**		**Curiosity**	
	Mean Score	Median Score	Mean Score	Median Score	Mean Score	Median Score
AGREE n = 66	13.30 SD = 3.24	14.00	15.83 SD = 1.73	16.00	17.99 SD = 3.71	19.00
DISAGREE n = 9	13.56 SD = 4.04	15.00	15.44 SD = 2.92	16.00	19.00 SD = 3.32	20.00

Element 3: There are multiple possible solutions and multiple paths to reach those solutions

This element surprised us by being the most lopsided in our data set. Even in courses that use relatively faculty centered pedagogies – more lectures and problem sets than problem-based-learning and design – students are encouraged to use multiple paths to problem solving. The very small sample in "disagree" means we do not have the statistical power to distinguish these two groups. We intend to collect additional data that will shed light on this difference.

Table 3" Element 3 "Students were able to try multiple paths even though they were not assured of success, they were 'free to fail;"

	Intrinsic Motivation		**Identified Regulation**		**Curiosity**	
	Mean Score	Median Score	Mean Score	Median Score	Mean Score	Median Score
AGREE n = 85	13.28 SD = 3.20	14.00	15.61 SD = 2.07	16.00	18.15 SD = 3.51	19.00
DISAGREE n = 2	14.00 SD = 1.41	14.00	16.00 SD = 1.41	16.00	17.50 SD = 2.12	17.50

Element 4: In their coursework, students *realize* a design

Our earlier work suggested that students who created a physical artifact were more likely to report high levels of curiosity and intrinsic motivation than those who did not [6]. In that study, students were asked to compare a course that had all or nearly all of the six elements with one that had as few of them as possible, of their own choosing. In that case, most students were comparing a course with a central project to a course where there may not have been any open-ended projects at all. In the case of the current study, Table 4 shows that there were students who realized a design and those who did not. But given the responses to other questions (see tables 2 and 3) we infer that most of the courses in the current study had some level of open-ended design-type problem solving in them. Therefore, the lack of difference between students who did and did not realize a design shown in Table 4 may not contradict our previous finding. Courses for which the answer was "no" still asked the students to solve open-ended design-type problems (as suggested by the results of table 3), they just stopped short of physical prototypes. It is further possible that physically realizing a design's main benefit is elsewhere – for example, in developing an understanding of the differences between theory and practice – and does not impact curiosity.

Table 4: Element 4 "Did you assign a realized design?"

	Intrinsic Motivation		**Identified Regulation**		**Curiosity**	
	Mean Score	Median Score	Mean Score	Median Score	Mean Score	Median Score
YES n = 70	13.24 SD = 3.36	14.00	15.53 SD = 2.16	16.00	17.91 SD = 3.69	19.00
NO n = 25	13.20 SD = 2.65	14.00	15.60 SD = 2.12	16.00	18.48 SD = 2.97	19.00

Element 5: The work involves an *interdisciplinary* group of students

Both intrinsic motivation and curiosity were significantly higher among students who interacted with people from other majors than those who worked only with members of their own major. This element touches on two parts of Self-Determination Theory. First, relatedness – the emphasis here is on students working together across disciplinary boundaries. Second, we hypothesize that a student's sense of competence might be enhanced by working with an interdisciplinary group, where they can be seen as a content expert. Looking at student feedback on this question, it's clear that students worked closely with people from other disciplines for both interdisciplinary courses and in courses where they were asked to seek additional guidance and customer interaction. Students were both significantly more intrinsically motivated and curious when they were working with an interdisciplinary mix of individuals.

Table 5: Element 5 "I expected students to interact extensively with people from a major other than their own"

	Intrinsic Motivation		**Identified Regulation**		**Curiosity**	
	Mean Score	Median Score	Mean Score	Median Score	Mean Score	Median Score
AGREE n = 21	14.71 SD = 2.67	15.00	16.05 SD = 2.11	16.00	19.48 SD = 3.56	20.00
DISAGREE n = 64	12.67 SD = 3.28	13.50	15.34 SD = 2.18	16.00	17.55 SD = 3.58	19.00

Element 6: In their coursework, students work on *real* problems

In our earlier work, [6; 7] we asked about this element using only the phrase "real problem." Subsequent debate showed that there was a diversity of opinion of what "real" likely means to students, so for this study, this element was assessed with three alternate phrasings in addition to asking students and faculty if they worked on "real" problems. As seen here, the alternates do yield slightly different results in terms of student motivation.

The responses to these questions were not evenly distributed between the two groups, so results are suggestive rather than conclusive at this time. However, as seen in Tables XX and XX, students do demonstrate higher levels of intrinsic motivation, identified regulation, and curiosity when they are working on problems like those they expect to see in their careers as well as problems that are important to them. For Table YY, we found that work for an external client was associated with significantly higher intrinsic motivation than work not so motivated ($p<0.01$).

Table 6: Element 6 "Student work in this course was motivated by real problems"

	Intrinsic Motivation		Identified Regulation		Curiosity	
	Mean Score	Median Score	Mean Score	Median Score	Mean Score	Median Score
AGREE n = 81	13.38 SD = 3.17	14.00	15.69 SD = 1.95	16.00	18.33 SD = 3.47	19.00
DISAGREE n = 5	10.00 SD = 3.81	12.00	12.40 SD = 3.21	12.00	14.60 SD = 2.07	14.00

Table 7: Element 6 "Students worked on problems similar to those I expect them to encounter in their careers"

	Intrinsic Motivation		Identified Regulation		Curiosity	
	Mean Score	Median Score	Mean Score	Median Score	Mean Score	Median Score
AGREE n = 51	13.67 SD = 2.98	14.00	16.04 SD = 1.78	16.00	18.57 SD = 3.44	19.00
DISAGREE n = 16	11.06 SD = 4.14	12.00	14.25 SD = 2.57	15.00	15.69 SD = 3.26	15.50

Table 8: Element 6 "In this course, students were lead to believe they could address issues that are important to them personally"

	Intrinsic Motivation		Identified Regulation		Curiosity	
	Mean Score	Median Score	Mean Score	Median Score	Mean Score	Median Score
AGREE n = 62	13.86 SD = 3.06	14.50	16.00 SD = 1.79	16.00	18.65 SD = 3.65	19.00
DISAGREE n = 4	8.75 SD = 4.35	8.50	13.75 SD = 2.63	14.50	15.00 SD = 2.16	14.50

Table 9: Element 6 “Student work in this course was important to an external client.”

	Intrinsic Motivation		**Identified Regulation**		**Curiosity**	
	Mean Score	Median Score	Mean Score	Median Score	Mean Score	Median Score
AGREE **n = 41**	14.51 SD = 2.48	15.00	16.12 SD = 1.58	16.00	18.93 SD = 3.02	19.00
DISAGREE **n = 40**	12.00 SD = 3.52	13.00	15.18 SD = 2.50	16.00	17.53 SD = 3.82	19.00

Conclusion

At the outset of this study, we hypothesized six elements that we believed would help cultivate students’ situational motivation and interest. We recognized, however, that it is not easy or even possible for all courses to adopt these elements; for example, it is not generally possible to turn required courses into electives. Therefore we sought in this study to identify how these elements work separately, so that faculty who are redesigning their courses could select and design in the elements that would be both available and impactful in their context.

The results of this study suggest that “real” problems – those for a real client, those that students find personally meaningful, or those that replicate engineering practice – cultivate students’ intrinsic motivation and curiosity. Further, if it is possible to open the course to multiple disciplines and have the students meaningfully work together, students are likely to be more curious and motivated. Elective courses also show higher levels of intrinsic motivation than do required courses. For two of our six elements, “Broad perspectives” and “Multiple solution paths”, there are insufficient data to draw meaningful conclusions at this time. Finally, the realization of a physical design did not correspond to greater intrinsic motivation or curiosity in the present data set. As a work-in-progress, we anticipate all of these results will evolve as we continue to collect additional data.

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