The Influence of Active, Passive, and Mixed Classroom Activities on Student Motivation.

Dr. Jennifer E. Holte, University of St. Thomas

Jennifer Holte is on the faculty in the Mechanical Engineering Department at the University of St. Thomas and serves as the School of Engineering's Community College and Transfer Coordinator. She holds a Ph.D. in Mechanical Engineering from the University of Minnesota.

Ryan J. Endres, University of St. Thomas

Ryan Endres is a student at the University of St. Thomas majoring in Mechanical Engineering with a minor in Business Administration. He has had experience interning at Geronimo Energy, Best Buy Corp., Daley Electric and currently is the Philanthropy Chair of the ASME Club at St. Thomas. Ryan intends to graduate in May of 2021.

Dr. Deborah Besser P.E., University of St. Thomas

Dr. Besser, PE, ENV SP, holds a PhD in education and MS and BS in civil engineering. Currently, she is civil engineering chair and Center for Engineering Education director. Previous experience includes faculty positions in diverse universities where she has taught a variety of coursework including steel, timber, concrete and masonry design, construction, engineering economy, engineering graphics and engineering education. Prior to teaching, Dr. Besser, a licensed engineer, was a design engineer with HNTB-CA, where she worked on seismic retrofits and new design of high profile transportation structures.

Dr. Doug Dunston, University of St. Thomas

Doug Dunston, D.M.A. is KEEN Program Coordinator in the School of Engineering at University of St. Thomas and Professor Emeritus of Humanities at New Mexico Tech. He designs and delivers focused workshops and retreats for faculty and short lectures and modules on listening, improvisation, and systems thinking for students. Dr. Dunston holds degrees in physics (BS, Harvey Mudd College and MA UC-Berkeley) and music (DMA, Claremont Graduate University).

The Influence of Active, Passive, and Mixed Classroom Activities on Student Motivation

Abstract

The primary investigator has developed a variety of active, passive, and mixed classroom activities for the instruction of a machine design course. Active classroom activities are those in which the instructor provides guidance to the students and then allows the students to engage somewhat independently with each other and the instructional materials to discover meaning on their own. Passive classroom activities are more traditional lectures in which the instructor disseminates the information in a structured lecture format while students take notes and ask questions as needed. Mixed classroom activities combine elements of active and passive learning into a single class period. The purpose of this study is to explore to what extent the types of activities employed during the class period affect student motivation.

As a part of the course, in addition to engineering content, all students received instruction on different types of motivation and learning theories. Fourteen times throughout the semester, at the end of the class period, the students completed "Situational Motivation Scale (SIMS)" surveys. SIMS is a validated, self-report scale that measures situational amotivation, external regulation, identified regulation, and intrinsic motivation. A final question was attached to the end of each survey which asked the student to describe the one aspect of the classroom activity that most influenced their attitude toward it. At the end of the semester, students were also invited to participate in a reflective survey. All students enrolled in the class participated in the SIMS surveys. However, survey results were only included in the study for those students who consented.

Twenty-two of the 29 students enrolled chose to participate in the study, providing a total of 260 SIMS survey responses. Using the Self-Determination Index (SDI) as a measure of overall motivation, motivational differences among students appear to be greater than the differences among activities. The study did not identify any one mode of teaching that was more effective in motivating students than others. The students' motivation appears to be more significantly tied to how much they value the content than to the mode of delivery. While intrinsic motivation often increased with more active use of the class period, amotivation also increased on some of the more active learning days with some students indicating they didn't see value in the content. Also, while students frequently expressed their preference for hands-on learning in their comments, only two students showed a motivational preference for active learning, and even then, the preferences were not particularly strong. The authors also observed that three of the students seemed to be highly motivated no matter what instructional methods were used.

This initial study on student motivation raises an interesting question which might be explored more deeply in the future through the addition of personal interviews with the students: Is the connection between the students' perceived value of the content a stronger influence on their motivation than the instructional methods employed?

I. Introduction

As our knowledge of how students learn expands, so does the use of more active learning exercises in our classrooms, because as Nie and Lau [1] state, "learning is not passively receiving knowledge, but an active process of constructing meaningful representations of knowledge." We must address students' misconceptions [2], tap into their existing knowledge, and motivate them to actively engage in their learning. We recognize different learning modes [3] and the importance of learning flexibility [4] [5]. A variety of instructional methods can help students to succeed in more modes of learning in the classroom and beyond.

In engineering education, there's also an emphasis on non-technical aspects of engineering. ABET outcomes [6] focus not just on applying principals of engineering, science, and math, but also addressing social concerns, communicating effectively, recognizing ethical responsibilities, etc. A growing number of engineering institutions are joining the KEEN network [7] and embracing KEEN's three pillars of fostering curiosity, making connections, and creating value. This non-technical content is even less suited to passive forms of instruction.

In light of these developments, the primary investigator's teaching of statics, mechanics, dynamics, and machine design has evolved over the years in terms of content and modes of instruction. The students are engaged in discussions, modeling real devices, deriving equations, or doing mini experiments on content that is both technical and non-technical.

Over five years of teaching machine design, the primary investigator had assembled a variety of classroom activities and began to wonder: "to what extent do individual activities employed during the class period affect student motivation within the course?"

II. Background

Deci and Ryan [8], Cavanagh [9], and Eccles and Wigfield [10] provide summaries of current motivation studies and conclude that the more self-determined and intrinsically motivated the student is, the more conceptual learning, cognition, and retention is achieved. By introducing active learning, we aim to support student's self-determination. In Self-Determination Theory (SDT) [8], Deci and Ryan define non-drive-based motivation as intrinsic. Intrinsic motivation comes from our need to feel competent and to be self-directing. Our work examines the effect of classroom activities on four of Deci and Ryan's modes of regulation. From most to least self-determined, they are as follows: intrinsic motivation, identified regulation, external regulation, and amotivation. Intrinsic motivation refers to behaviors that are engaged in for their own sake (because it is interesting or enjoyable). Identified regulation implies the behavior is chosen as a means to an end. Extrinsic regulation occurs when the behavior is motivated by external rewards or punishments, and amotivation refers to behavior that has no perceived value. A more detailed description of Self-Determination Theory can be found in Ryan and Deci [11]. In SDT, internalization, i.e. movement toward more self-determined behavior, is a process [12]. Many behaviors are not initially intrinsically motivated, but they can become more so if their value becomes internalized. "Choice, acknowledgement of feelings, and opportunities for self-direction" all enhance intrinsic motivation [13].

Problem-based learning (PBL) is one approach to engaging students more actively. Findings regarding the impact of PBL have been varied. Sungar and Tekkaya [14] found PBL had a positive effect on learning strategies and task value. Stefano et al. [15] observed PBL increased some student learning strategies, but decreased strategies related to time management and study environment, and they saw no shift in motivational orientations. Stolk et al [16], on the other hand, found PBL increased intrinsic motivation and lowered external regulation and amotivation. Still, others found that uncertainty and controlling features of PBL can decrease students' intrinsic motivation [17]. The mixed results of PBL studies indicate that the chosen pedagogy may not be as important as providing an autonomy- and competence-supportive environment, as observed by Stolk et al. [16].

Prince [18] provides an extensive literature review on the effectiveness of active learning and concludes that even brief activities introduced into the lecture can increase learning. The entire course need not be project-based. Simply adding discussions can have a positive impact on students' intrinsic motivation [19]. If we use Bonwell and Eison's [20] definition of active learning as "anything that involves students doing things and thinking about the things they are doing," the possibilities are vast. Nie and Lau [1] found adding small activities that encourage students to explore in-depth, analyze, discuss, write, apply, or question increased students' deep processing strategies and increased self-efficacy. Felder and Silverman [21] also conclude that a small number of techniques such as alternating lecture with pauses for reflection, discussion, or activity can be effective in reaching students given their wide variety of learning styles.

The primary investigator has chosen to teach via a variety of active, passive, and mixed classroom activities. Active classroom activities are those in which the instructor provides guidance to the students and then allows the students to engage somewhat independently with each other and the instructional materials to discover meaning on their own. Passive classroom activities are more traditional lectures in which the instructor disseminates the information in a structured lecture format while students take notes and ask questions as needed. Mixed classroom activities combine elements of active and passive learning intermittently. The authors note that while some classroom activities in this study are labeled active and passive, all instruction is mixed to a degree. Active learning is always combined with at least some instruction for students to follow and information that is shared in verbal or written form. Passive classroom activities may not involve getting the students up out of their chairs, but they do include intermittent check-ins via paper clickers, and students are frequently asked to turn to their neighbors to discuss the concepts on which disagreement among the students is observed. In this paper, the label "active" implies that students were engaged in active learning for the majority of the class period.

Over the years, the primary investigator has collected informal feedback from students regarding individual classroom activities and their design. However, this study has been the first attempt at looking specifically at whether the activities increase students' motivation. Motivation can be measured by observing time spent on a task under free will or by self-report [22]. Situational Motivation Scale (SIMS) surveys [23] allow users to report situational intrinsic motivation, identified regulation, external motivation, and amotivation, via a 16-question survey. Each question is answered on a seven-point Likert scale. The four sub-scales of motivation can be graphed facilitating visualization of how motivations vary situationally. The graphed motivation profiles tell a more nuanced story than a one-dimensional motivation index can. However, when comparing the overall motivational impact of activities, a single index is helpful. Various researchers have used weighting of the motivational sub-scales to compute a single one-dimensional Self-Determination Index [24] [25] [26] [27] [28]. Less self-determined motivations (such as amotivation and external regulation) are given negative weighting. More self-determined motivations (such as intrinsic and identified regulation) are given positive weighting. The self-determination index (SDI) corresponding to the four sub-scales measured by SIMS surveys is formulated as follows: $-2\ AM - 1\ EX + 1\ ID + 2\ IN$ where AM = amotivation, EX = External regulation, ID = identified regulation, and IN = intrinsic motivation [27]. The result is an SDI that ranges from -18 to +18 with a higher score indicating a higher level of self-determination.

III. Procedure

One section of Machine Design at the University of St. Thomas, St. Paul, MN, was the subject of this case study. Twenty-nine students were enrolled in the section. Course content ranged from linkage design to fatigue failure and included ABET Outcome 3: the ability to communicate with technical and non-technical audiences [6]. In addition to three 65-minute lectures per week, the students attended a 3.5-hour lab section one time per week. In the lab section, the students design, build and test a remote-controlled machine applying concepts taught in the lecture section. The lab sections are taught by several different lab instructors, and motivation toward lab activities was not included in the study.

Fourteen times throughout the semester, lecture class periods were ended five minutes early, and students were asked to complete a SIMS survey [23] online via Qualtrics [29]. Survey questions were modified slightly to indicate past tense. A listing of the questions is provided in the appendix. Along with the 16-question SIMS survey, the students were asked to state one aspect of the activity that most influenced their attitude toward the activity.

Table 1 shows a summary of the classroom activities on which students were surveyed. Activities are referenced by their keyword in this paper. The first letter of the keyword indicates whether the class period was active (A), mixed/blended (B), or passive/traditional lecture (L).

Each student was assigned a random 4-digit personal code at the start of the term by one of the co-investigators. The Qualtrics surveys pushed identified attendance points to Canvas [30], but the actual survey responses were stored by the 4-digit personal code without personal identifiers, and the personal codes were never disclosed to the instructor. Thus, the instructor was able to view survey results and respond to student concerns and motivations throughout the semester while maintaining the anonymity of the students’ responses.

Increasing students’ understanding of motivation and learning styles was one of the course objectives. The four types of motivation measured in the SIMS surveys were presented to the students before their first survey, and brief discussions were facilitated twice more during the semester about learning theory [31] [32] and the different roles of the teacher and the student. SIMS survey results were shared with the student in real time via a Qualtrics-generated situational motivation profile, which the student could view and save at the completion of each survey. Toward the end of the semester, students were provided a complete summary of their personal survey results and engaged in a class discussion about motivation and instructional design specific to this course.

Date	Keyword	Topic	Activity Description
02/06/19	A1DOF	Degree of Freedom (DOF)	Students follow instructions to assemble links via pins and slots and eventually derive Gruebler's equation to determine DOF.
02/08/19	B1DOF	Degree of Freedom	Students work in pairs to classify joints by DOF. Instructor periodically polls the class on responses and shares examples.
02/11/19	B2DOF	Degree of Freedom	Students alternately work alone, work in pairs, or observe as instructor evaluates the DOF for a variety of mechanisms.
02/18/19	A2SRT	Four-bar Linkage Design	Students work in pairs to identify a variety of defects in physical models. (Defects were defined in previous lectures.)
02/20/19	B3LNK	Four-bar Linkage Design	Physical models with branch defects are studied to answer the question: how could we predict a branch defect?
02/22/19	L2LNK	Four-bar Linkage Design	Instructor demonstrates graphical design technique for four-bar linkages including how to avoid defects.
03/04/19	L3OGR	Ordinary Gear Trains	Instructor lectures on determining gear ratios for compound ordinary gear trains with examples.
03/15/19	L4PGR	Planetary Gear Trains	Instructor lectures on determining gear ratios for planetary gear trains with examples.
04/01/19	A3WHL	Design Process	Students brainstorm wheelchair design improvements, then use wheelchairs, and return to the classroom to discuss.
04/08/19	A4WHL	Design Process	Students bring "magazine" articles they wrote on empathic design and engage in a peer evaluation activity.
04/12/19	L5STF	Static Failure Theory	Instructor lectures via PowerPoint on static failure theories for ductile materials.
04/15/19	L6STF	Static Failure Theory	Instructor lectures via notes and examples on static failure theories for brittle materials
04/26/19	A6FTG	Fatigue Failure	Students do group research and make posters to persuade management of dangers of ignoring fatigue failure for an application.
05/03/19	L7FTG	Fatigue Failure	Instructor presents textbook of example determining the life of a rotating shaft.

Table 1: Chronological Summary of Activities and their Keywords

Initially, all students were required to complete the survey as part of the course objectives. However, by the fifth survey, we discovered some students were entering the same response to all 16 questions on the SIMS survey, indicating they were not engaging with the questions, but rather completing the survey as quickly as possible to get their attendance points. Therefore, the Qualtrics survey was modified and students were informed that attendance points would be recorded even if they left the survey questions blank.

Survey results were collected throughout the semester. In one of the final class periods, students were invited to participate in the study. Twenty-two of the 29 students enrolled consented to the use of their survey results in our study. After the course was complete, all students were also invited to complete a post-course reflective survey for the study. Seven of the 29 students consented to and completed the reflective survey by which students could report whether they found the surveys helpful or intrusive. The final survey also asked students to report what types of classroom activities were most motivating to them and whether they liked the mix of activities. (See Appendix for survey questions.)

IV Findings

Within the case study, no one type of classroom activity appeared more effective at motivating students than the others. While active class periods generally increased students' intrinsic motivation, they also tended to decrease their identified regulation and increase their amotivation, as seen in Figure 1. Possible causes for the increase in amotivation and decrease in identified motivation are discussed later in the paper, but first, we consider the effect of active, passive, and mixed classroom activities on the overall student motivation as measured with the SDI.

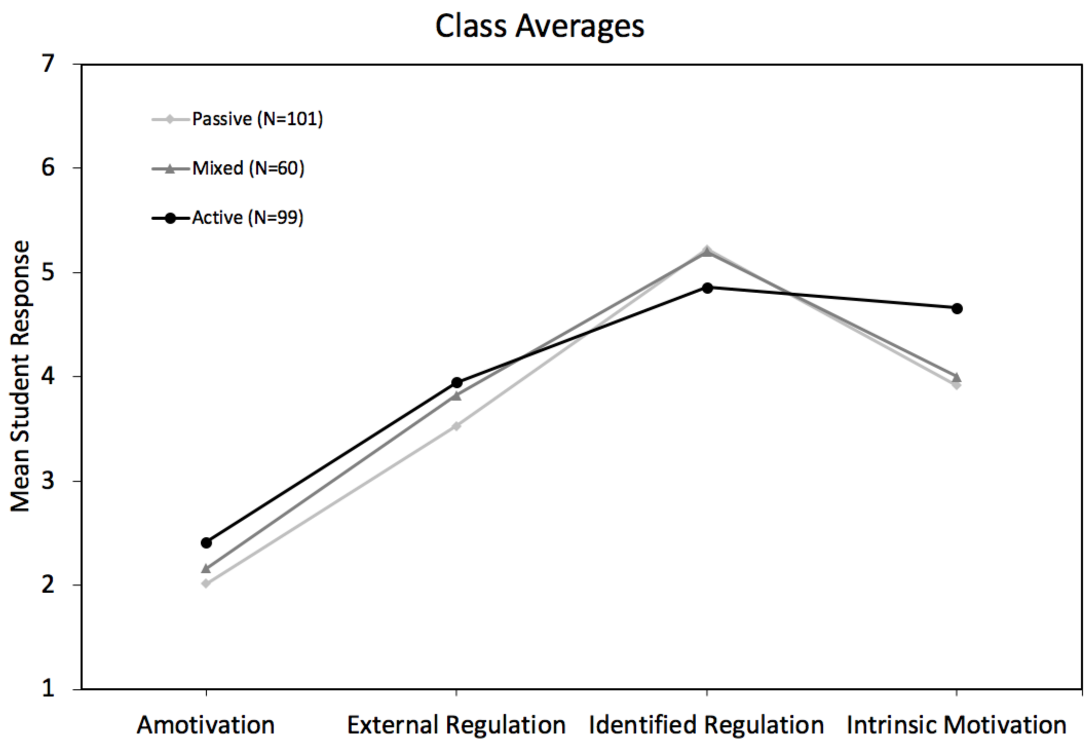

Figure 1: Class Average Values in Amotivation, External and Identified Regulation, and Intrinsic Motivation for Passive, Mixed, and Active

a. Motivation is Personal

The data show that students' personal orientation (Deci and Ryan, 1985) was a strong influence on their situational motivation toward classroom activities—perhaps stronger than the teaching methods employed. Table 2 shows the Self-Determination Index (SDI) from the student SIMS surveys for every activity. The average SDI reported for each given activity varied from 3.7 to 8.5, while the average SDI reported for each student had a range of -0.4 to 11.7, showing that the differences among students are stronger than the differences among activities.

One cause for the larger range of averages by student is that each student measures motivation with their own unique scale – making direct comparisons of SDI values problematic. To remove the scale factor, we looked at how activities were ranked by each student. Table 3 shows a list of all the activities and the number of students that ranked the activity as their most motivating and least motivating, again, based on the SDI value. In the event of a “tie” for most motivating or least motivating, both activities are recorded—which explains why the total counts in each category exceed the number of students.

Personal Code	A1DOF	A2SRT	A3WHL	A4WHL	A6FTG	B1DOF	B2DOF	B3LNK	L2LNK	L3OGR	L4PGR	L5STF	L6STF	L7FTG	Student Average	Student Std Dev
1078	4.5	1.5	4.3	7.5	7.5	2.8	5.8	2.0	7.5	7.3	3.8	0.5	3.5	1.8	4.3	2.5
1312	-0.8	3.3	9.3	-4.5	1.3	2.5	5.0	3.5	9.3	6.3	5.3	0.8	4.5	4.5	3.6	3.7
1387	4.5	-1.0	7.8				-1.0								2.6	4.3
1661	10.5	12.8	11.5	12.8	7.8	11.0	9.3	11.3	14.0	8.8	8.3	9.3	9.3	12.3	10.6	1.9
2338	2.8	-1.3	0.5	3.5	1.8	3.0	1.0	-5.5		0.3	-4.3	6.8	6.0	2.5	1.3	3.5
2370	4.0	0.8	4.3	6.5	15.0	1.0	4.8	1.8	3.0	5.0	5.0	0.3		7.0	4.5	3.8
2949	7.3	0.3		10.5		17.0	15.8		4.5	3.5		-3.8		13.0	7.6	7.1
3119	12.8	1.0	-5.8	-13.0	3.0	12.3	7.5	4.5	15.5	9.0		10.5	9.0		5.5	8.2
4287	4.3	4.3	13.5	10.3	8.5	12.3	7.0	10.0	8.5		10.3	8.5		7.5	8.7	2.8
4786	11.8	9.3	14.0	10.3	7.3	15.3	12.0		13.0	10.3		11.3	10.8	10.5	11.3	2.1
4970	8.0	2.0	1.5	3.0	-1.5	6.5	2.0	-1.5	-0.5	1.0	1.5	2.3	4.5	3.0	2.3	2.7
5242	3.5	4.5	5.5	3.5	3.8	4.0	3.3	7.3	5.0	2.0	3.0		2.0		3.9	1.5
5431	9.5	10.8	10.8	8.5	-2.5	10.8	4.3	9.0	10.8	19.8	7.5	7.8		9.8	9.0	4.9
5834	14.5			1.5		4.5	1.5	5.3	16.5	6.3				0.8	6.3	6.0
7238	3.8	9.5	9.0	8.8		2.8	-3.0		6.5	-1.3	-0.8	-1.0		-1.8	3.0	4.8
7520	11.8	12.5	13.5	11.3	15.0	15.0	12.3	11.0	11.5	10.0	9.5	7.5		10.8	11.7	2.1
8042	5.0	1.3	-8.0	6.5		-2.5	-3.0	-1.0		-1.0	-2.5	3.3		-2.5	-0.4	4.1
8561	8.0	8.8		8.0	2.3	2.0	5.0	2.0	9.5	6.3		8.0		6.3	6.0	2.8
8864	5.0	10.3	12.0	7.0	-2.0	6.8	5.8	-6.3	9.0	-2.8	11.0	0.5		-4.8	4.0	6.3
9142		1.3	9.8	-12.0	4.3		0.3	4.8	1.8	6.5	2.5	5.0		2.8	2.4	5.5
9296	0.3	3.5	-0.3	-2.0	5.3	3.8	1.5	1.3	5.0	3.5	4.5				2.4	2.4
9357	11.5	8.5	6.3	4.0	2.0	5.0	5.0	6.5	10.5	6.3	9.5	-0.5		4.5	6.1	3.4
Activity Average	6.8	4.9	6.3	4.4	4.6	6.8	4.6	3.7	8.5	5.3	4.6	4.3	6.2	4.9		
Activity Std Dev	4.2	4.6	6.4	7.1	5.1	5.5	4.8	5.2	4.6	5.1	4.6	4.5	3.1	5.2		

Table 2: Comprehensive Table showing all Average SDI scores for Students and Activities

The students’ most and least motivating class activities were fairly evenly split between modes of instruction (see Table 4). There were 18 instances of active or mixed being most motivating and 19 instances of active or mixed being least motivating. The class was evenly split in how many found a passive lecture the most and the least motivating. The tally shows that motivation is not necessarily increased for all students by adding active learning components. In fact, the class period that was rated the most motivating by the largest number of students was the passive lecture, L2LNK. This lecture on linkage design was rated most motivating for six students and least motivating for zero students. The PowerPoint lecture, L5STF, arguably the most passive activity in the group (L5STF was the only lecture all semester that was entirely reliant on PowerPoints) was the least motivating for the largest number of students, and yet, was still rated the most motivating activity by one student.

Chrono. Order	Activity	Most Motivating	Least Motivating
1	A1DOF	2	1
4	A2SRT	1	2
9	A3WHL	5	1
10	A4WHL	2	4
13	A6FTG	4	4
2	B1DOF	3	1
3	B2DOF	0	2
5	B3LNK	1	4
6	L2LNK	6	0
7	L3OGR	1	1
8	L4PGR	0	0
11	L5STF	1	5
12	L6STF	0	1
14	L7FTG	0	1
Total Count		26	27

Table 3: Count of Most and Least Motivating Activities

Activity Type	Most Motivating	Least Motivating
Active	14	12
Mixed	4	7
Passive	8	8

Table 4: Count of Most and Least Motivating by Activity Type

Examination of individual students tells an interesting story of what may be behind their personal motivations. Some students displayed very little change in motivation over the 14 different classroom activities. Of the five students in the lowest quartile for standard deviation of the SDI, three reported high motivation regardless of the activity (see students 1661, 4786, and 7520 in Table 5).

Student 7520's average SDI by activity type did show, on average, higher motivation in more active learning settings. Comments revealed that passive classroom activities were not as "enjoyable" to this student, but their motivation was still high compared to other students due to consistently low amotivation and relatively high identified regulation. Student 7520's lowest SDI of 7.5 corresponded to the passive lecture L5STF, commenting that "A PowerPoint on a Friday is kind of hard to pay attention to, especially when the lectures are typically more engaged." Student 7520's responses reflect the increased motivation that investigators hoped active and mixed classroom activities would trigger.

Row Labels	Active	Mixed	Passive	Average SDI	Standard Deviation
1078	5.1	3.5	4.0	4.2	0.6
1312	1.7	3.7	5.1	3.5	1.4
1661	11.1	10.5	10.3	10.6	0.3
2338	1.5	-0.5	2.3	1.1	1.2
2370	6.1	2.5	4.1	4.2	1.5
2949	6.0	16.4	4.3	8.9	5.3
3119	-0.4	8.1	11.0	6.2	4.8
4287	8.2	9.8	8.7	8.9	0.7
4786	10.5	13.6	11.2	11.8	1.3
4970	2.6	2.3	2.0	2.3	0.3
5242	4.2	4.8	3.0	4.0	0.8
5431	7.4	8.0	9.3	8.2	0.8
5834	8.0	3.8	7.8	6.5	2.0
7238	7.8	-0.1	0.4	2.7	3.6
7520	12.8	12.8	9.9	11.8	1.4
8042	1.2	-2.2	-0.7	-0.6	1.4
8561	6.8	3.0	7.5	5.8	2.0
8864	6.5	2.1	2.6	3.7	1.9
9142	0.8	2.5	3.7	2.3	1.2
9296	1.4	2.2	4.3	2.6	1.3
9357	6.5	5.5	6.1	6.0	0.4

Table 5: Average SDI for Active, Mixed and Passive Activities
(Note: Student 1387 has been removed due to insufficient survey data)

Student 1661 also expressed enthusiasm for active learning in their comments and, in general, reported high intrinsic motivation and greater SDI for mixed and active activities. However, student 1661's lowest SDI of 7.75 corresponded to an active learning experience (A6FTG). Their comment that "this tied well with the article project by showing that engineers do so much more than surface level [calculations]…but it did feel rushed and this made it feel required," suggests that implementation is critical in maintaining student motivation in all settings. Student 1661's highest SDI of 14 corresponded to L2LNK, a traditional lecture on linkage design. Their comment that "It felt like what we were doing has culminated into this!" is a great reminder that the success of the course is dependent not on a single experience on a single day but on the arc of learning that occurs over the course of the semester. The authors discuss this further in section IV c.

Another student in this consistently highly motivated group, student 4786, reported virtually zero amotivation and consistently high identified regulation across all classroom activities, but as shown in Table 2, their motivation did not generally hinge on an active component. In fact, student 4786's SDI of 11.25 for the PowerPoint lecture, L5STF, far exceeded their lowest recorded SDI of 7.25 for the research/poster making activity, A6FTG. Student 4786 commented on the PowerPoint lecture stating, "slides were very helpful, class seemed to flow better".

Like Dillon and Stolk [28] and Eccles & Wigfield [10], we found that some students are consistently positive, and yet, the distinct differences even among these three highly motivated students demonstrate how personal motivation is. There is far more than the mode of instruction influencing the students' motivations.

b. For Some Students, Performance Pressures Persist in Every Setting

Student 3119 makes a fascinating case study on the external influence of a desire to perform well on homework and exams. For student 3119, every class period seemed to be measured against this performance goal.

Looking first at the numbers, Student 3119 reported strong identified regulation and intrinsic motivation on the first active learning day (A1DOF), but all other active learning days, this student's identified regulation and intrinsic motivation dropped dramatically and their amotivation rose. Figure 2 shows motivation profiles for student 3119 averaged for active, mixed, and passive activities. Mixed activities (like working on problems with a partner or interacting with physical models followed immediately by lecture) seem to motivate this student, while they clearly indicate amotivation toward the more self-directed "active" learning class periods.

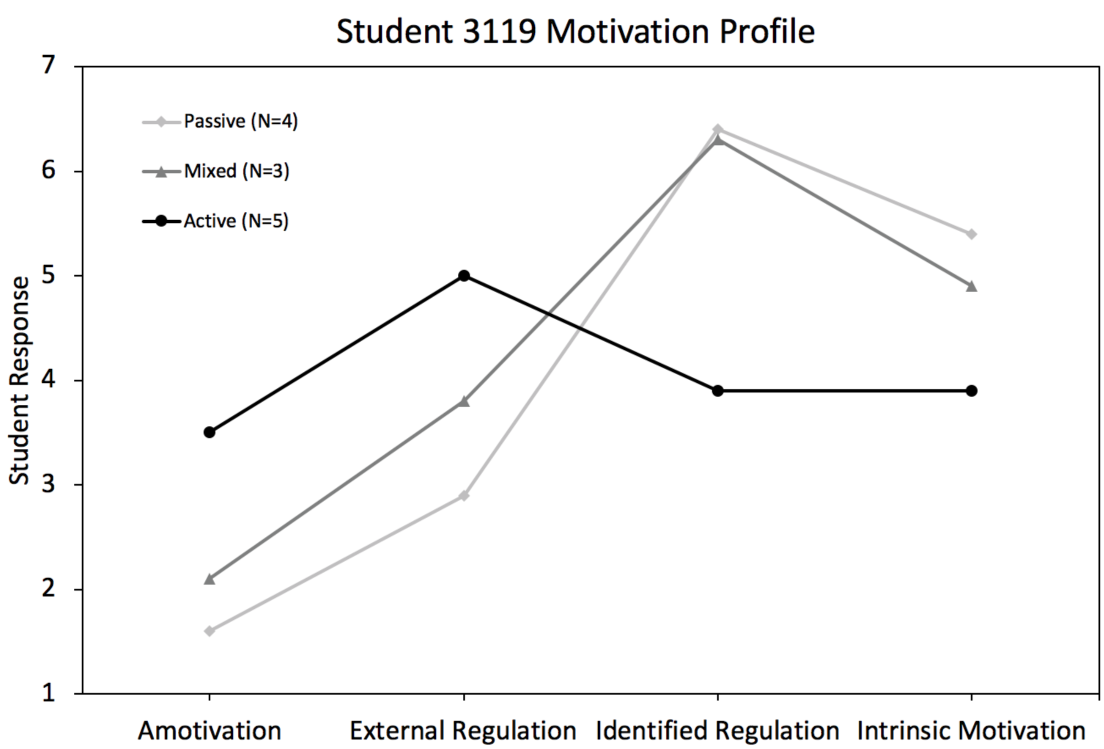

Figure 2: Student 3119 Average Values of Amotivation, External and Identified Regulation, and Intrinsic Motivation for Passive, Mixed, and Active

The comments are even more revealing. Student 3119's comments, like "time could've been spent reviewing problems," "it felt like a wasted day," and "no review of textbook material or other engagement," expose the pressure this student is feeling to be able to perform well on homework problems and exams. Even when the student expressed liking the passive activity

L2LNK, their anxiety over exams surfaced in their comment, “Very cool topic. Waiting to see example of homework/test related question.”

Student 3119 teaches us that we can’t just provide active learning experiences for the students and hope that the enjoyment of the activity will draw them into learning, especially if the students believe they will be judged, not on their new insights, but on their ability to crank out equations on an exam. The external rewards and penalties enforced over many years of participation in the educational system will continue to influence our students, and we must look for ways to demonstrate that all the types of learning that we value. Alternate assessment methods that emphasize critical thinking, leadership and communication could perhaps help increase the value of more active learning in the students’ minds.

c. Influence of Perceived Value

Not every student expressed the pressures of course performance as clearly as student 3119. However, seeing the value of the classroom activity seemed to have a strong influence on the students’ overall motivation even when their intrinsic motivation (enjoyment) was high. Three of the four SIMS survey questions related to identified regulation directly ask if the student sees value in the activity using phrases like “good for me,” “important for me,” and “for my own good.” When students don’t see the value, it seems to affect the other types of motivation as well. Table 6 was created to examine the relationship between the tone of student’s comments and the motivations they reported. Surveys that primarily included positive comments had an average SDI of 6.5, and surveys with negative comments were predictably lower with an average SDI of 2.7. Negative comments included criticism of the pace or clarity of the activities or the student’s own feelings of incompetence. But, more dramatically when students outright state that the primary influence on their motivation is that they don’t see the value in the activity saying things like “feels like a wasted day” or “can’t see how this is helpful,” the average SDI plummets to -6.4. This is a very small sample size, but it leads to interesting questions for future work. What is important to students? What makes them see an activity as “important” and “good for” them, and can we influence what they value?

Tone of Comments	Count of Surveys	Amotivation	External	Identified	Intrinsic	SDI
Neutral / Positive	213	2.1	3.7	5.2	4.3	5.9
Positive	142	2.1	3.6	5.3	4.5	6.5
Negative	47	2.6	4.0	4.5	3.7	2.7
Doesn't See Value	5	4.5	5.1	2.9	2.4	-6.4

Table 6: Table Showing Average Motivations Categorized by the Tone of Comments

One non-intuitive result is that students’ amotivation increased along with their intrinsic motivation in active classroom settings (see Figure 1). This phenomenon was also observed by Dillon et al. in 2016 [19] and Guay et al. in 2000 [23]. By studying the students’ comments, we found clues that the topic may be influencing the students’ motivation as much as the instructional methods. Students appear to be more motivated in active settings when they see a technical application. The non-technical course exercises which focused on the importance of empathy in design and communication to non-technical audiences (A3WHL, A4WHL, A6FTG) had the most dramatic increase in amotivation – even though the students found the activities intrinsically motivating. Figure 3 shows a comparison of motivations in active learning on technical vs. non-technical topics. We see that the amotivation only increases markedly for the activities focused on non-technical topics. Once again, this is a small sample size, but points to interesting questions for future studies. How can we increase students' identified motivation toward the non-technical aspects of their education and careers? Have we effectively communicated the value of non-technical skills?

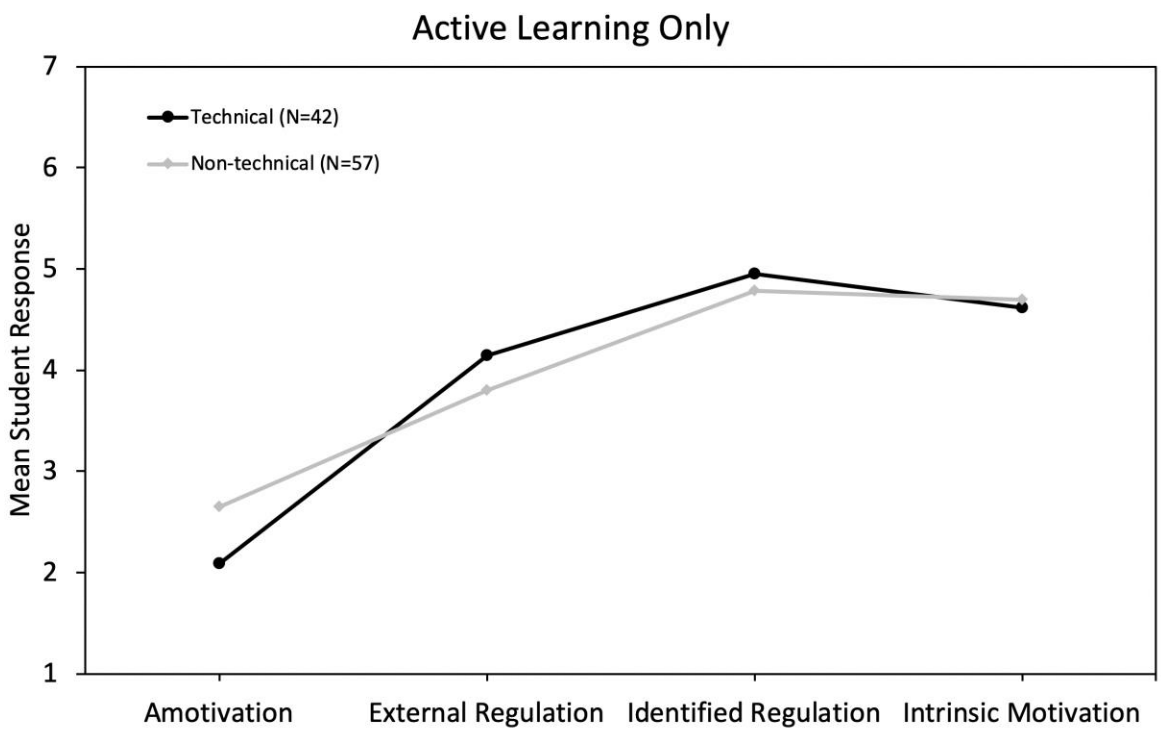

Figure 3: Situational Motivation in Technical vs Non-Technical Active Learning

d. Situational Motivations are Influenced by the Arc of a Course

One of the more interesting discoveries in this case study was the students' increased motivation toward activity L2LNK, a passive lecture on linkage design. When considering the classroom activities in the chronological order, as shown in Table 7, one can see the SDI dropping for some of the active- and mixed-learning activities building up to L2LNK. In those activities, the students are asked to wrestle in a hands-on manner with physical defects in four-bar linkages and how to identify them—which can be perplexing and frustrating. Then, lecture L2LNK brings together many of the previous experiences and finally reveals concrete graphical techniques for designing four-bar linkages without defects. Student 5834 commented early in the semester on an active learning day, "I like how it was hands-on activity. That is the way I learn best." Yet, when the same student completed the survey for passive lecture L2LNK, they commented, "This was by far my favorite class…I thought I learned more in this class than any other so far." Another student wrote, "It felt like what we were doing has culminated in this!" The placement of the active and mixed activities preceding the lecture was intentional and specifically designed to support better understanding of the linkage methods presented in lecture L2LNK. The students' comments reveal that it is not just the learning mode that affects their motivation. The context in which the activities take place influences their situational motivation.

Students who expressed increased amotivation and/or decreased identified regulation in some of the activities building to lecture L2LNK may, in retrospect, have a new context which changes how they value those past experiences. Future studies might incorporate student reflection on the value of past activities once or twice throughout the semester. If students were asked to assess the extent to which past activities were "good for me," "important for me," and "for my own good," would the results differ from their situational motivations?

Class Activity	Average of SDI Values
A1DOF	6.8
B1DOF	6.8
B2DOF	4.6
A2SRT	4.9
B3LNK	3.7
L2LNK	8.5
L3OGR	5.1
L4PGR	4.6
A3WHL	6.3
A4WHL	4.4
L5STF	4.3
L6STF	6.2
A6FTG	4.6
L7FTG	4.9

Table 7: Chronological Table of Class Activities and Average SDI Values

V. Conclusions

The main observations drawn from the study were that the mode of instruction (active, passive, or mixed) is only one influence on students' situational motivation. Situational motivation is personal, performance pressure influences situational motivation, perceived value of content influences situational motivation, and "situations" are defined, not just by the present learning environment and activity, but also by the historical arc leading to the present activity.

Our study reaffirms Deci and Ryan's assertion that some people are more autonomous than others [8]. Trait-like differences can influence people's level of curiosity, preference for challenges, and mastery mindset [10] [33]. However, motivation is also situational, and personal orientations can be changed over time [12]. Our trait-like differences are in part due to the cumulative effect of past experiences. Thus, situational motivation matters, and we should not rule out the possibility of influencing our students' motivational orientations over time.

Our case study revealed at least three students with highly autonomous personal orientations who were consistently motivated in every classroom setting, and yet, for numerous other students, motivation was significantly influenced by situational factors. We were not able to determine that active learning alone increases self-determination. There are many other factors influencing motivation. Prince [18] warned of the "small negative effects of self-paced and self-directed learning," and our experience bears this out. The students reported details such as pacing of the activity and clarity of guiding instructions as negative influencers of their motivation. Activity is a proven way to engage the students and increase their learning, but it must be implemented carefully to support autonomy, relatedness, and competence [34]. Even the difference between supportive and controlling language ("may" and "can" vs. "must" and "should") can affect intrinsic motivation [35]. Asking for student feedback immediately following activities, as was done in this study, provides direction for improving the instructional design.

For at least one student in our study, the external academic pressures had significant influence over their situational motivation. Studies show that external motivation does not necessarily increase effort [24] and can lead to denial and projection. Rewards that affirm competence can increase intrinsic motivation, but rewards that are contingent upon performance undermine self-determination [36]. Yet, educators are generally required to measure and reward performance, creating a conundrum. In the machine design course being studied in this work, the majority of the active learning was ungraded. Students were given participation points only. The activities were designed to provide conceptual learning that will be useful to the students later (in their careers or in completing assignments within the course). However, convincing the student that an activity is of "value," even when it is not immediately graded, is a challenge, since students do not have the long view of how the new knowledge will be used.

Perceived value of the activities influences more than just the "identified regulation" sub-scale of motivation. Deci et al [35] show that "usefulness" also affects intrinsic motivation. They contend that two of three contextual factors (choice, usefulness, and interest) must be present for behaviors to be intrinsically motivated. Thus, students can be intrinsically motivated to do "boring" things if they have a sense of autonomy and purpose. In our post-course reflection survey, students were asked, "Is there anything else that you'd like me to know related to our reflections on motivation?" One student replied, "I found that I was most motivated in class when I thought I was doing something valuable. When we made the poster or did the peer review, I did not find value." This statement affirms what the authors saw in the data. Students had increased amotivation and decreased identified regulation while engaged in activities related to non-technical content related to ethics, empathy and communication. Somehow, engineering educators have failed to demonstrate the value of non-technical content to the students' future careers. One of the reasons cited for project-based learning's success in motivating students is that students perceive applied content as more useful and important [14]. It falls to us as educators to provide meaningful rationale for the learning we hope to inspire. Perhaps site visits and engaging professional engineers in some of the classroom activities could better demonstrate the importance of non-technical interactions in the engineering profession.

Not surprisingly, the SIMS data collected in this study showed that active class periods are significantly more interesting or “fun” to students, yet when considering all four sub-scales of the self-determination index, the passive lecture on linkage design was ranked as most motivating to the most students. The results seem to point again to the perceived value of the content. Students were sitting passively in their desks, but they also had a sense that everything was leading to this lecture. Students are eager to put their knowledge into action—action with a purpose. Learning to design four-bar linkages using all the building blocks they had assembled over the previous class periods must have been satisfying to them. We know that their situational motivation wavered some during the preceding activities, but we don’t know the exact influence those preceding activities had on the students’ learning or their ultimate ability to successfully design defect-free linkages. The authors would like to think the motivational success of the passive linkage-design lecture L2LNK was a direct result of the active learning leading up to it, but further study is required.

The investigators did have some reservations about over-surveying the students and the effect on students’ self-reported motivation. Students were able to opt out of completing the surveys which helps ensure that those who participated answered carefully. However, students with lower situational motivation may have been more likely to opt out, potentially skewing our results. Fortunately, most students did not appear to find the surveys too intrusive. In the final class discussion, some students reported that they looked forward to survey days. Only seven students completed the post-course reflection survey, but all seven either agreed or strongly agreed that completing the SIMS surveys provided useful data to the instructor and made them feel the instructor valued their input. Students were less sure that reflecting on their personal motivation was useful to themselves. Collecting feedback regularly from the students did provide a wealth of useful information to the instructor for future course modifications.

Overall, this case study led to many new questions which the investigators hope to explore in future studies.

Bibliography

[1] Y. Nie and S. Lau, "Differential Relations of Constructivist and Didactic Instruction to Students' Cognition, Motivation, and Achievement," *Learning and Instruction,* pp. 411-423, 2010.

[2] J.D. Bransford, A. L. Brown, and R. R. Cocking, How People Learn: Brain, Mind Experience, and School: Expanded Edition, Washington, D. C. : National Academy Press, 2000.

[3] D. A. Kolb, Experiential Learning: Experience as the Source of Learning and Development, Englewood Cliffs, NJ: Prentice Hall, 1984.

[4] A. M. Passarelli and D. A. Kolb, "Using Experiential Learning Theory to Promote Student Learning and Development in Programs of Education Abroad," in *Student Learning Abroad: What our Students are Learning, What They're Not and What We can Do About it.*, Stylus Publishing, 2012, pp. 137-161.

[5] R. M. Felder, D. R. Woods, J. E. Stice, A. Rugarcia, "The Future of Engineering Education II. Teaching Methods that Work," *Chem. Engr. Education,* vol. 34, no. 1, pp. 26-39, 2000.

[6] ABET. [Online]. Available: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2019-2020/#GC3. [Accessed 21 January 2020].

[7] "Engineering Unleashed," [Online]. Available: https://engineeringunleashed.com/mindset-matters.aspx.

[8] E. L Deci and R. M. Ryan, Intrinsic Motivation and Self-Determination in Human Behavior, New York: Plenum Press, 1985.

[9] M. Cavanagh, "Students' Experiences of Active Engagement through Cooperative Learning Activities in Lectures," *Active Learning in Higher Education,* vol. 12, no. 1, pp. 23-33, 2011.

[10] J. S. Eccles and A. Wigfield, "Motivational Beliefs, Values, and Goals," *Annual Rev. Psychol.* , vol. 53, pp. 109-132, 2002.

[11] R. M. Ryan and E. L. Deci, "Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being," *American Psychologist,* vol. 55, pp. 68-78, 2000.

[12] E. L. Deci, R. J. Vallerand, L. G. Pelletier, and M. R. Ryan, "Motivation and Education: The Self-Determination Perspective," *Educational Psychologist,* vol. 26, no. 3 & 4, pp. 325-346, 1991.

[13] R. M. Ryan and E. L. Deci, "Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being.," *American Psychologist,* vol. 55, pp. 68-78, 2000.

[14] S Sungar and C. Tekkaya, "2006," *Effects of Problem-Based Learning and Traditional Instruction on Self-Regulated Learning,* vol. 99, no. 5, pp. 307-320, 2006.

[15] C Stefanou, J. D. Stolk, M. Prince, J. C Chen and S. M. Lord, "Self-regulation and autonomy in problem- and project-based learning environments," *Active Learning in Higher Education,* vol. 14, no. 2, pp. 109-122, 2013.

[16] J. D. Stolk, Y. V. Zastavker, and M. D. Gross, "Gender, Motivation, and Pedagogy in the STEM Classroom: A Quantitative Characterization," in *ASEE Conference,* 2018, 2018.

[17] L. Wijnia, S. M. M. Loyens, and E. Derous, "Investigating Effects of Problem-Based versus Lecture-Based Learning Environments on Student Motivation," *Contemporary Educational Pyschology,* vol. 36, pp. 101-113, 2011.

[18] M. Prince, "Does Active Learning Work? A Review of the Research," *Journal of Engineering Education,* vol. 93, no. 3, pp. 223-231, 2004.

[19] A. E. Dillon, J. D. Stolk, Y. V. Zastavker, M. D. Gross, "Motivation is a Two-Way Street: Pedagogies Employing Discussion in Addition to Lecture Display More Positive Stdent Motivational Response," in *ASEE 123rd Annual Conference & Exposition*, New Orleans, LA, 2016.

[20] C. C. Bonwell and J. A. Eison, "Active Learning: Creating Excitement in the Classroom.," ASHE-ERIC Higher Education Report No. 1 The George Washington University, School of Education and Human Development, Washington, D. C., 1991.

[21] R. M. Felder and L. K. Silverman, "Learning and Teaching Styles in Engineering Education," *Journal of Engineering Education,* vol. 78, no. 7, pp. 674-681, 1988.

[22] R. M. Ryan and E. L. Deci, "Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions," *Contemporary Education Psychology,* vol. 25, pp. 54-67, 2000.

[23] F. Guay, R. J. Vallerand, C. Blanchard, "On the Assessment of Siuational Intrinsic and Extrinsic Motivation: The Situation al Motivation Scale (SIMS)," vol. 24, pp. 175-213, 2000.

[24] R. M. Ryan and J. P. Connell, "Perceived Locus of Causality and Internalization: Examining Reasons for Acting in Two Domains," *Journal of Personality and Social Psychology,* vol. 57, no. 5, pp. 749-761, 1989.

[25] R. J. Vallerand, and R. Bissonnette, "Intrinsic, Extrinsic, and Amotivational Styles as Predictors of Behavior: A Prospective Study," *Journal of Personality,* vol. 60, no. 3, 1992.

[26] C. M. Blanchard, L. Mask, R. L. Vallerand, R. de la Sablonniere, P. Provenchar, "Reciprocal Relationships between Contextual and Situational Motivation in a Sport Setting.," *Psychology of Sport and Exercise,* vol. 8, no. 854-873, 2007.

[27] F. Guay, G. A. Mageau, and R. J. Vallerand, "On the Hierarchical Structure of Self-Determined Motivation: A Test of Top-Down, Bottom-Up, Reciprocal, and Horizontal Effects," *Personality and Social Psychology Bulletin,* vol. 29, no. 8, pp. 992-1004, 2003.

[28] A. Dillon and J. Stolk, "The Students are Unstable! Cluster analysis of motivation and early implications for education research and practice," in *Proceedings of the 2012 IEEE Global Engineering Education Conference (EDUCON),* Seattle, WA, 2012.

[29] [Online]. Available: https://www.qualtrics.com/research-center/.

[30] [Online]. Available: https://www.instructure.com/canvas/.

[31] Passarelli, A. M. and D. A. Kolb, "Using Experiential Learnging Theory to Promote Student Learning and Development in Programs of Education Abroad," in *Student Learning Abroad: What Our Students Are Learning, What They're Not, and What We Can Do About It,* Stylus Publishing, 2012, pp. 137-161.

[32] D. A. Kolb, Experiential learning: Experience as a Source of Learning and Development, Upper Saddle River, NJ: Prentice Hall, 1984.

[33] C. S. Dweck, "Mindsets and math/science achievement.," Carnegie Corporation of New York, Institute for Advanced Study, Commission on Mathematics and Science Education, 2008.

[34] E. L Deci and R. M. Ryan, "The “What” and “Why” of Goal Pursuits: Human Needs and the Self-Determination of Behavior," *Psychological Inquiry,* vol. 11, no. 4, pp. 227-268, 2000.

[35] E. L. Deci, H. Eghrari, B. C. Patric, D. Leone, "Facilitating Internalization: The Self-Determination Theory Perspective," *Jouranl of Personality,* vol. 62, pp. 119-142, 1994.

[36] E. L. Deci, R. Koestner, R. M. Ryan, "Extrinsic Rewards and Intrinsic Motivation in Education: Reconsidered Once Again," *Review of Educational Research ,* vol. 71, no. 1, pp. 1-27, 2001.

[37] E. L. Deci, R. M. Ryan, "The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior," *Psychology Inquiry,* vol. 11, pp. 227-268, 2000.

Appendix:

SIMS Survey and Open-Response Question

Students were provided 7-point Likert scale to indicate how well each statement corresponds:

Why did you engage in today's classroom activity?

1. Because I think that the activity is interesting
2. Because I was doing it for my own good
3. Because I was supposed to do it
4. There may be good reasons to do the activity, but personally I don't see any
5. Because I think that the activity is pleasant
6. Because I think this activity is good for me
7. Because it is something that I had to do
8. I did the activity, but I am not sure if it was worth it
9. Because the activity is fun
10. By personal decision
11. Because I didn't have any choice
12. I don't know; I don't see what the activity brings me
13. Because I felt good when doing the activity
14. Because I believe this activity is important for me
15. Because I felt that I had to do it
16. I did the activity, but I am not sure it is a good thing to pursue it

Questions 1, 5, 9, and 13 measure intrinsic motivation.
Questions 2, 6, 10, and 14 measure identified regulation.
Questions 3, 7, 11, and 15 measure external regulation.
Questions 4, 8, 12, and 16 measure amotivation.
Average response was computed for each category to create the motivation profile.

State the one aspect of this activity that most influenced your attitude toward the activity. Please, limit your response to one sentence.

Reflective Survey

1. Students were provided 5-point Likert scale to indicate to what extent they agree with the following:

- I liked completing the surveys.
- The surveys provided useful data to the instructor.
- Reflecting on my personal motivation through surveys and class discussions was useful to me.
- Completing the surveys made me feel that instructor valued my input.
- The surveys were a waste of time.
- The surveys took too much time away from more important class activities.

2. Multiple choice question:
The number of surveys was ___ (too few, about right, too many).

3. Students were provided with definitions of Active, Blended (mixed) and Passive and the following free-response questions:

- Which type of classroom activity *(Active, Blended, or Passive)* is the most motivating to you? Please, briefly explain.
- Did having a mix of classroom activities increase or decrease your motivations to learn the course material? Please, briefly explain.
- Do you think completing the SIMS surveys has influenced your motivations toward classroom activities? Please, briefly explain.
- Is there anything else that you'd like me to know related to our reflections on motivation?