Factors Impacting Engagement and Achievement in a First-Year Design Thinking Course

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Introduction

Student engagement, as measured by cognitive, affective, attentional participation in an educational setting, is prominent in recent engineering education [1], [2]. It is inextricably intertwined with students' motivation, and those two constructs have a strong impact on student's meaningful learning experience, academic achievement, and knowledge development [3].

Project-based learning with authentic hands-on experiences in a collaborative setting is believed to promote students' motivation and engagement in an engineering education setting [4]–[7]. For the first-year engineering students, experience project-based learning from the early age of the engineering curriculum help students improve teamwork, leadership, communication, and relevant knowledge [8]. Further, the learning through a collaborative project can be integrated into later years of the engineering curriculum [9].

Project-based learning is widely implemented in teaching design thinking in the engineering curriculum [10]. However, just forming a project-based learning environment does not automatically guarantee enhanced engagement due to the nature of teamwork [11], [12]. The individual, contextual difference in engagement may result in ineffective collaborative experience, dampen students' motivation, and deter in-depth learning [13].

This paper examines how varying degrees of engagement mediates students' motivation, learning environment, and achievement in the hyflex design thinking course. By considering engagement in relation to other factors, situational motivation (intrinsic motivation, internal regulation, external regulation, amotivation), learning environments (collaborative experiences and learning supports), this study aims to figure out how engagement mediates students' academic achievement.

Background

Design Thinking in Engineering

Design thinking is a problem-solving approach that fosters identifying and framing the problems, enables developing new solutions, and helps address creative perspectives on our social landscapes [14]–[17]. The idea of design thinking as a framework for solving the problems effectively and innovatively [18] was first stated by Herbert Simon [19], who identified design as the knowledge, a set of processes that follows by a well-defined problem. He saw design thinking as creating 'the desired state of affairs [1, pp. 210],' which can be applied to the areas like engineering, management, and economics. Ever since Herbert [1] first discussed the notion of design thinking, researchers have sought to validate the nature of design thinking in a diverse context.

In an engineering education context, engineering design is defined as "a systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients' objectives or users' needs while satisfying a specified set of constraints" [7, pp. 104]. Engineering design thinking implements a complex cognitive process associated with the skills and abilities adopted by good designers (e.g., handle uncertainty, make decisions, tolerate ambiguity, inquiry, maintain sight of the big picture) [10]. By implementing a focus on the 'client and user' in the context of engineering education, design thinking provides additional and essential insights to engineering students through exposing them in a real-life setting (e.g., user experiences, possible barriers, expenses, time), while engineering promotes hands-on experiences for prototyping [20]–[22]. Hence, design thinking in engineering situate students' ideas within the realities and helps them generating feasible products using the engineering knowledge out of the routinized, formalized way of thinking.

Engineering design thinking process as an effective problem-solving algorithm includes seven iterative stages [15], [23]: (a) identify the need and formulate the problem, (b) identify/ search for solutions for similar cases in the past, (c) use knowledge and creativity to generate new ideas, (d) evaluate and decide on the best idea: iterate until there is only one solution concept left, (e) analyze/ test, and (f) reformulate the problem. The design thinking procedure could elaborate on meaningful solutions facilitating elaboration, mutation, and recombination [26], promoting logical understanding of engineering design thinking [27], and developing alternative solutions to complex, ill-defined, multifaceted problems [10].

Relationship between Motivation, Learning Environment, and Engagement

Engagement is the behavioral and emotional quality of students in the process of learning [24], [25], which has a critical impact on students' academic success [26], student retention [27], academic resilience, and coping strategies [28]. Previous studies have suggested engagement is malleable [29], which can be improved via effective pedagogical interventions (e.g., instructional programming and learning activities, teacher and mentor support) [30], [31]. Further, quality of student motivation (e.g., intrinsic goals and motivation, psychological needs like autonomy, competence, relatedness, self-endorsed values), and learning environment (relationships with teacher and peers, feedback, evaluation, optimal challenges, interesting activities) have a dialectical relationship with student engagement [32].

Situational Motivation and Engagement

The term motivation is derived from the Latin word meaning "to move," and motivational psychologists investigated what 'moves' people to do something and why people make that voluntary effort [33]. Studies have come to identify two classes of motivation, extrinsic and intrinsic. The former one is related to self-actualization, inherent joy, and satisfaction of doing something, while the latter one is connected to external influences (e.g., compensation, validation from others, rewards). Like an engagement, motivation is situated in current activities students are engaging in. In other words, motivation is not a static characteristic of a learner, instead, it is a dynamic, contextually-embedded psychological construct that depends on the learning environment [34], [35].

Researchers conceptualized that motivation and engagement are inherently connected [32], and engagement is an externalization of motivation [36]. In this vein, high self-determined motivation is significantly related to strong engagement [3], [35], [37]. However, motivation and engagement are two distinctive constructs, which means one can be motivated and not engaged, or the opposite [31]. For instance, engagement arises from intrinsic motivation and identified regulation, while external, introjected regulation hampers student engagement [38]. Like engagement, motivation and the relationship between engagement and motivation are tied to the learning context where they are situated [13].

The Learning Environment, Motivation, and Engagement

Contextual factors and instructional practices (e.g., value, competence, relatedness, and autonomy) also have an impact on the iterative relationships with motivation and engagement and how those two factors emerge in the classroom context. The learning environment is defined as a network of conditions, forces, and external stimuli that affect students' learning outcomes [39]. It includes a variety of contextual factors influencing students' motivation of learning (e.g., interpersonal relationships, structures of the setting, teaching styles, course content) [40]–[42]. The traditional model of engineering education faced criticism due to the 'closed learning environment [43],' excluding critical thinking, decision-making, and problem-solving of socio-technical problems, which are positively related to students' motivation [44]–[46]. Within engineering disciplines, a number of researchers are now seeking an open learning environment that can enhance student engagement and motivation. Significant responses have been the implementation of student-centered learning [2], [47], [48], project-based learning [49]–[52], collaborative project-based learning approach [7], [53]–[55], collaborative learning [56]–[59] to motivate students and to support students' constructing practical, adaptable knowledge to a real-life setting.

Project-Based Collaborative Learning in Engineering

In an engineering context, the term 'project' is perceived as a 'unit of work,' on the basis of client(s)' needs [60]. Project in an engineering education setting is multi-disciplinary and highly related to a real-life situation, and project-based learning requires the creation of concrete artifact (e.g., a design, model, simulation) [8], from which students are able to develop the skills to cope with incomplete, unpredictable situation real-life can pose. Project-based is designed based on collaboration with teammates and self-direction while teaching staff mostly take an advisory role. Hence, the exposure to cooperative and self-guided problem-solving benefits students in developing sophisticated knowledge with high self-motivation, engagement, and agency of the problem, solution, and learning process [60], [61].

Level of Engagement: ‘Social Loafing’ and the ‘Free-rider’ Problem

Although numerous studies attested to the benefit of project-based learning enhancing students’ collaboration, engagement, motivation, and advanced understanding, studies also identified barriers to successful learning in project-based learning [57]. One of the most notable aspects of project-based learning is that all students possess different motivation and engagement levels, which is situated in the learning environment. While the students who are more motivated, equipped with relevant pedagogical knowledge, skills, and in-depth understanding dedicate more time and effort to the final deliverables, the free-riders are dependent on the contributions of other team members without fulfilling their assigned responsibilities in a collaborative task [12]. Further, when an individual recognizes their dedication is undervalued or overlooked by other team members, the level of engagement decrease [62]. Students’ perception of group work also affects their engagement level. For instance, students may put forth less effort in the group project than they would do to their individual work due to the presence of others [63]. This is called ‘social loafing,’ which describes the reduction of motivation and engagement while working collaboratively [64]. The difference in motivation, engagement, and contribution bring about ineffective project-based learning.

Research Hypothesis

This study assumed that a level of engagement in the project-based engineering education setting is a distinctive component of the relationship between learning environment and motivation. Therefore, this study is designed to investigate the difference between a high-engaged group of students (HE) and a low-engaged group of students (LE) in terms of motivation, learning environment, and achievement in a collaborative, project-based design thinking course. The research hypotheses (see Figure 1) are as below:

H1. HE and LE possess different relationships between situational motivation, instructional support, collaborative experience.

H2. Situational motivation (intrinsic motivation, external regulation, identified regulation, and amotivation) predicts student engagement.

H3. Instructional support (teaching presence, undergraduate teaching assistant professionalism) predicts student engagement.

H4. Satisfactory collaborative experience (face to face, online, and teammates) predicts student engagement.

H5. Student engagement in collaborative project-based learning predicts grades on group submission.

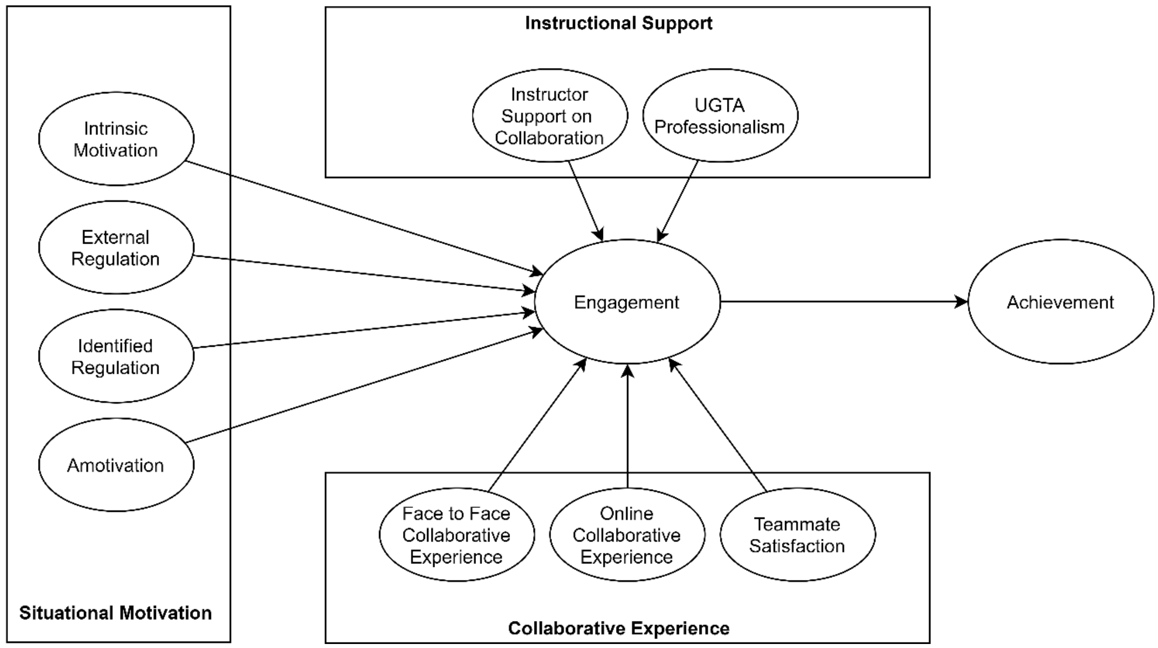

Figure 1. Hypothesized model: motivation, learning environment, and achievement in a collaborative, project-based design thinking course

Research Design and Methods

Participants and Data Collection

A total of 760 freshmen students enrolled in the Design Thinking Course at a large Midwestern university in the United States during Fall 2020 participated in this study. This research was approved by the university's Institutional Research Board.

Measures

Student Motivation: SIMS

The situational motivation scale (SIMS) [65] (Appendix 1) was designed to measure four situational motivational constructs: intrinsic motivation, identified regulation, external regulation, and amotivation [66], [67]. The SIMS contains a total of 16 items, four items for each construct. Items are scored on a 7-point Likert scale (1: not at all in agreement to 7: completely in agreement). This scale approaches the measurement of motivational behavior by asking 'why,' and this approach helps researchers understand the very nature of motivation by placing the items on the grounds of the conceptual definition of motivation [66], [67].

Student Engagement: CATME

Comprehensive Assessment of Team Member Effectiveness (CATME) [68] (Appendix 2) was developed to offer confidential, research based behaviorally anchored team member evaluation tools and corresponding guidance to improve team member contribution. The

CATME is a 5-point Likert scale (strongly disagree-strongly agree) measures five dimensions of student dedication and engagement: team contribution, interaction with teammates, keeping their team on track, motivates team members to strive for quality, and have relevant knowledge, skills, and abilities. This study adopted five dimensions of CATME and team member satisfaction survey (Appendix 2) from the team-maker survey.

UGTA scale: Instructional support from Undergraduate Teaching Assistant

The undergraduate teaching assistants (UGTAs) are carefully selected from the outstanding students who took the Design thinking course in previous semesters, then trained and supported by course coordinators. To measure instructional support from UGTAs, researchers started from the teacher behaviors checklist [69]. Teacher behaviors checklist was originally developed to suggest the requirements of 'master teachers,' who are well versed in their instruction with a well-organized presentation, and promotes student learning [70]. Based on the teacher behaviors checklist, researchers converted it as an instrument to assess teaching competency and effectiveness were developed for the instructors [71]. Later on, this scale is implemented in the context of the instruction and support from undergraduate teaching assistants [72]. Based on its reliability and validity, the current course adopted this scale and revised terms and items (UGTA scale, Appendix 3) to measure and discover positive undergraduate teaching assistant behavior to promote student motivation, engagement, and academic achievement.

The Community of Inquiry: Teaching Presence & Collaborative Experience

As online communities of practice becoming the new norm for learning, the community of inquiry (CoI) model [73] was developed to explain a process of collaborative and constructivist learning. This model postulates that social, cognitive, and teaching presence cultivates deep and meaningful online (blended) learning [74]. The community of inquiry survey [75], [76] (Appendix 4) is developed and validated to measure the constructs of CoI. This survey was using the 6-point Likert scale with 34 items to evaluate the effectiveness of the online (blended) instruction, collaboration and inquiry process, and durable learning experiences [76], [77]. In this study, we adopted two subscales of the CoI scale (teaching presence and social presence) to investigate external contextual factors of students' learning environment. Teaching presence subscales are used to measure 'instructional support' from the instructor on collaborative learning. Within the social presence subscale, we selected items about 'face to face' collaborative experience and 'online collaborative experience' to identify the impact on Hyflex learning model current course adopted.

Grade

During the project-based learning, students were required to submit group assignments and individual assignments, respectively. This study used the grade students received as a result of their 'group submission.' The final grade students receive different from their group grade because they calibrate the group grade based on the CATME dedication score each student receives.

Grouping Criteria

Absolute and relative dedication to the group project altogether were considered as significant grouping factors to assess the engagement level (see Table 1). Out of 760 students, the participants of this study consisted of 327 students, who were selected from the grouping process (Table 2). The absolute engagement score was defined by the CATME score of five teamwork dimensions (see Appendix 2). Students whose CATME scores where higher than their class peer means, above 4.0 and one standard deviation above the entire course (all section) mean were considered as 'high engagement' (HE) group, while those who scored lower than their class peers, below 3.0 and one standard lower than the course mean were considered as 'low engagement' (LE) group. The relative contribution was decided by comparing individual students' CATME scores with their group members and the entire section.

Table 1. Grouping Criteria, High Engagement and Low Engagement

Group	Grouping criteria
High Engagement (N = 202)	1) CATME Individual Means > CATME Peer Means AND 2) CATME Individual Means > 4.0 AND 3) CATME Individual Means > 1 Std. Dev above the Entire course CATME mean
Low Engagement (N = 127)	1) CATME Individual Means < CATME Peer Means AND 2) CATME Individual Means < 3.0 AND 3) CATME Individual Means < 1 Std. Dev below the Entire course CATME mean

Table 2. Socio-demographic Characteristics of Study Participants (N=327)

Socio-demographic characteristics		Counts (N)	Percents (%)
Age	<19	267	81.65
	20-21	133	40.67
	21>	14	4.28
Grade	Freshman	177	47.58
	Sophomore	75	20.16
	Junior	27	7.26
	Senior	19	5.11
	Unknown/Prefer not to say	74	19.89
Gender	Female	86	26.3
	Male	241	73.7
Ethnicity	Asian	44	13.46
	Black	10	3.06
	White	197	60.24
	Hispanic	12	3.67
	Multiracial	11	3.36
	Unknown/Prefer not to say	53	16.21

Data Analysis and Results

Parceling

Parceling is "aggregating items into one or more parcels [74, pp. 261]" to make each parcel into the indicator of the latent variable [79]. It is used to enhance the scale communalities, to cancel out the effects of different idiosyncratic parts and random errors, and to distill true score and total score [80]. From the validation studies of the surveys, researchers were aware of item-level relations and construct validity. Based on the previous literature, this study selected parceling items for the UGTA survey, based on item contents and factor validity so that each parcel compose of the theoretically meaningful cluster (see Appendix 3).

Structural Equation Modeling: Multigroup Path Analysis

This study conducted multiple group analysis of structural equation modeling (SEM). Multigroup path analysis was followed to examine if there are any significant differences in the structure exists. The baseline model with no equality constraints and the constrained model with all parameters constraints were compared. The structural path of the two groups are not invariant if the chi-square test result is significant. The overall fit of the model was examined by fit indices: chi-square test (χ^2), robust Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Goodness of fit (GFI), Standardized Root Mean Square Residual (SRMR), and the Root Mean Square Error of Approximation (RMSEA).

The cut-off for a good fit is $\chi^2 > 0.05$, CFI > 0.90, TLI > 0.90, GFI > 0.90, SRMR < 0.08, and RMSEA < 0.08 [81], [82]. The results of baseline model indicated a good fit χ^2 (928) = 1769.26, CFI = 0.924, TLI = 0.914, GFI = 0.983, SRMR = 0.060, and RMSEA = 0.075. The constrained model also presented good fit χ^2 (936) = 1785.84, CFI = 0.924, TLI = 0.914, GFI = 0.983, SRMR = 0.063, and RMSEA = 0.075. The chi-square results revealed there is a significant difference between two models, $\chi^2_{difference}(8) = 16.579$, p= 0.032, which means the relationship among motivation, engagement, collaborative experiences, instructional support, and achievement is different for HE and LE students.

Results

H1. HE and LE possess different relationships between situational motivation, instructional support, collaborative experience.

Figures 2 and 3 show the final SEM models with standardized regression weights. The paths statistically not significant were marked as a dotted line. The structural models report that determinants of the HE group were different from the LE group.

H2. Situational motivation (intrinsic motivation, external regulation, identified regulation, and amotivation) predicts student engagement.

The constructs of situational motivation predicted the engagement of both groups, but the two groups showed different aspects of prediction. In the HE group's model, identified regulation only predicted student engagement while intrinsic motivation predicted LE group's engagement.

H3. Instructional support on collaborative project-based learning (instructor support, undergraduate teaching assistant professionalism) predicts student engagement.

Instructional support predicted LE group's and HE group's engagement. For the LE group, instructors' support and UGTA professionalism both had a significant impact on student engagement. However, teaching presence was not significantly predicted HE groups' engagement.

H4. Satisfactory collaborative experience (face to face, online, and teammates) predicts student engagement.

Both face-to-face and online collaborative experiences predicted the HE group's class engagement. However, the perceived satisfaction of their teammates did not predict engagement. In LE groups' case, face-to-face collaborative experience and teammate satisfaction was important to their engagement in project-based learning.

H5. Student engagement in collaborative project-based learning predicts grades on group submission.

HE group's engagement predicted group grades, while LE group's engagement did not predict group grades.

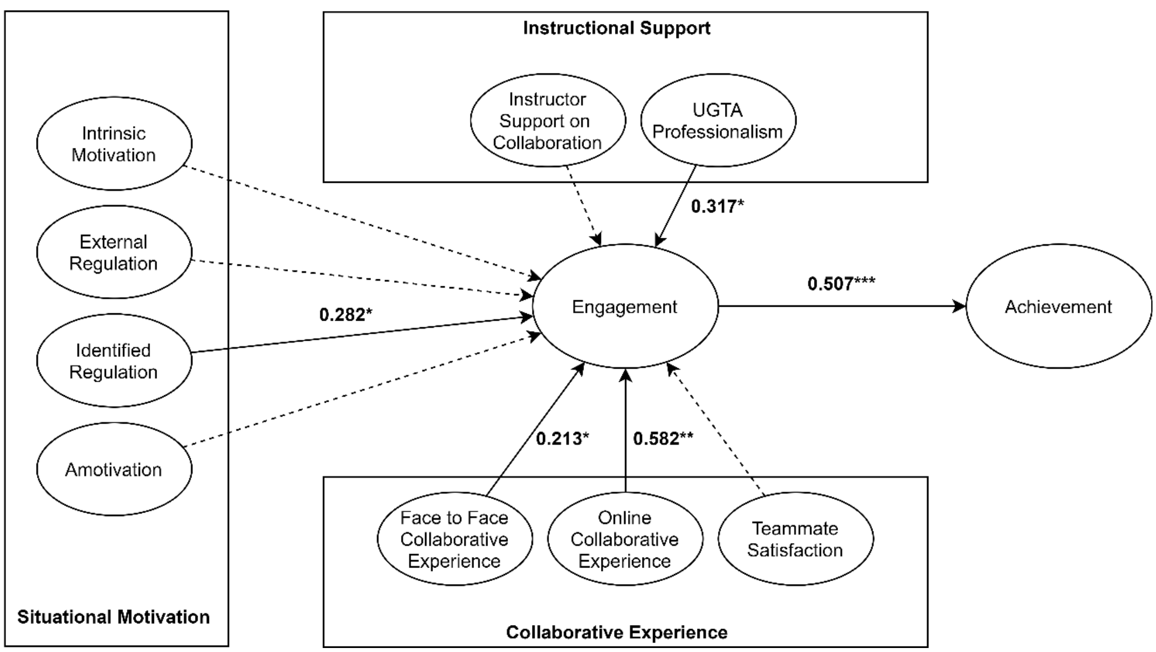

Figure 2. High Engagement (HE) Group: standardized results from multigroup path analysis.
Note. *p < 0.05, **p < 0.01, ***p < 0.001 (2-tailed)

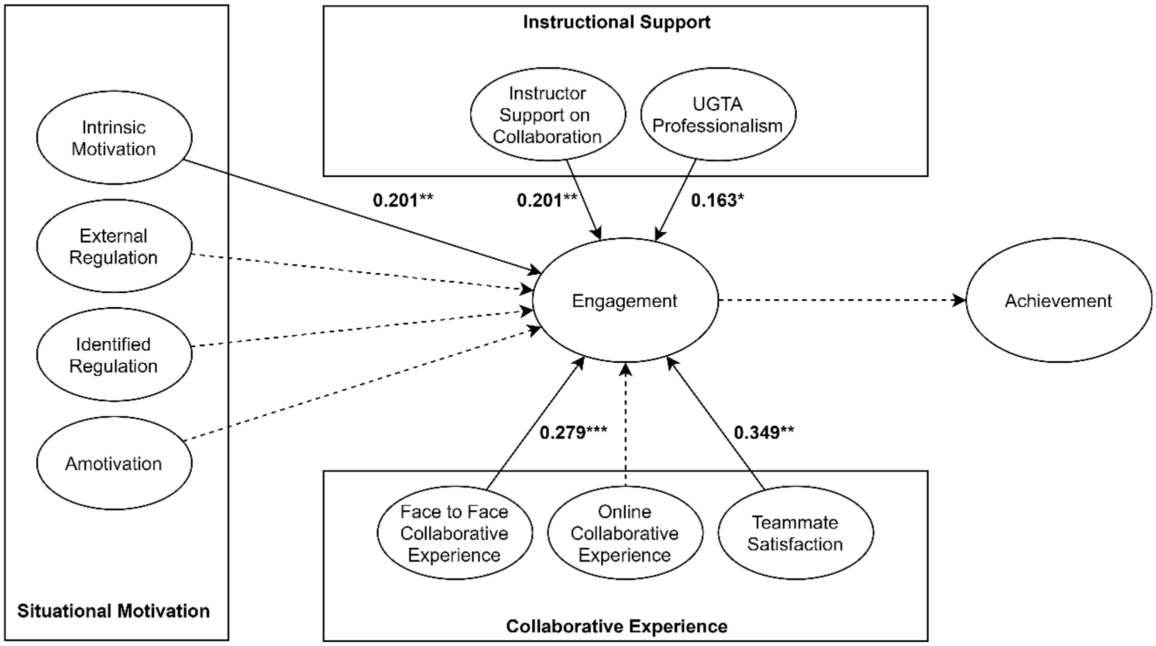

Figure 3. Low Engagement (LE) group: standardized results from multigroup path analysis
Note. *p < 0.05, **p < 0.01, ***p < 0.001 (2-tailed)

Conclusion and Discussion

Situational Motivation

This study investigated mediated effect of engagement in the project-based, collaborative engineering education context. Considering that project-based collaborative learning is highly student-centered, it is plausible that external regulation could not predict students' engagement for both of the groups. A notable difference between the HE group and LE group is that engagement is predicted by different motivational constructs. Highly engaged students find their reason and motivation for the engagement in their own good, personal decision, and importance, while the low engagement group of students were more engaged when the given project was pleasant, fun, and feeling good.

Previous literature showed that motivation, especially intrinsic motivation and internal regulation, is closely related to students' engagements [13], [28]. However, student motivation may be diminished in group work, especially when an individual contribution is not identified or when others are free-riding on one's contributions [11], [57], [83]. In this vein, the reason that intrinsic motivation of the HE group did not predict students who were dedicated and contribute a large portion of the project may be strongly engaged regardless of intrinsic motivation. Another possible explanation is the rewards, good grades, in this context, may have an impact on students' motivational behavior. From students' perspectives, taking a course is not only a learning process but also entails evaluation. This course grades 50+ assignments from students, so students may be conscious of their grades.

Teaching Presence: Instructional Support

LE students get more engaged in project-based learning when UGTAs are equipped with professional teaching strategies, are caring, and respond to their needs. Also, when the instructor promotes collaborative group work, they become more engaged. HE students were more strongly influenced by UGTAs' professional support, though they maintained their high level of engagement regardless of the instructor's encouragement of collaborative work. In this course, UGTAs are comprised of previous students who outperformed in this course. They provide advice, support, and feedback from students' perspectives and get involved in the group project to promote collaborative learning. The HE group students may feel more engagement with UGTAs because they also are highly-engaged students like UGTAs, and put more effort, time, and dedication to their peers.

Collaborative Experience

Satisfactory collaborative experience (online, face-to-face) and teammates predicted student engagement differently for HE and LE groups. HE group's engagement was predicted by satisfactory collaborative experiences but not predicted by teammate satisfaction. Considering that HE groups' motivation was predicted by identified regulation (own good, importance, for themselves), they contribute significantly regardless of teammate composition. However, LE groups' project engagement was not predicted by online collaborative experiences. Rather, pleasant, satisfactory teamwork experiences predicted LE groups' engagement.

Achievement

HE students' engagement predicted grades, while LE students' engagement was not predicted grades the group received. It shows group's grade is decided by the contribution of highly engaged students. This relationship might put more responsibilities on the highly engaged students, making them more highly dedicated to the group project. From the perspective of LE students, the fact that their engagement does not lead to the group's grade may dampen their motivation to be more engaged. At the same time, researchers and instructors need to figure out how to turn students' engagement into meaningful achievement.

Implication, Limitation, and Future Study

Though this study found notable relationships of motivation, engagement, learning environment, and achievement, the present study is not without limitations. First, surveys and sub-scales adopted to establish a factor are borrowed from the community of inquiry survey. To ensure the factor structure and validate the analysis, exploratory factor analysis and confirmatory factor analysis will need to be presented. Second, the limitations coming from the weakness of the survey itself (e.g., careless responding, non-responses, the possible gap between perception and reality) may lead to less representative results. Finally, since this study is strictly limited in its pursuit of concrete, statistical relationships, it can lead to researchers overlooking the broader context of undergraduate students learning, relationships between peers. In spite of the technical rigor of the process, the results do not provide a conclusive reason for the existence of a prediction model between the factors. Thus, future research should go beyond the interrelationships between the variables using follow-up qualitative interview studies.

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Appendix 1. SIMS (Situational Motivation Scale)

Subcategories	Code	Item
Intrinsic Motivation	IMTV1	Because I think that this activitiy is interesting
	IMTV2	Because I think that this activity is pleasant
	IMTV3	Because I think that this activity is fun
	IMTV4	Because I feel good when doing this activity
Identified Regulation	IRGL1	Because I am doing it for my own good
	IRGL2	Because I think this activity is good for me
	IRGL3	Because I do this by personal decision
	IRGL4	Because I believe that this activity is important for me
External Regulation	ERGL1	Because I am supposed to do it
	ERGL2	Because it is something that I have to do
	ERGL3	Because I don't have any choice
	ERGL4	Because I feel that I have to do it
Amotivation	AMTV1	There may be good reasons to do this activity, but personally I don't see any
	AMTV2	I do this activity but I am not sure if it is worth it
	AMTV3	I don't know; I don't see what this activity brings me
	AMTV4	I do this activity, but I am not sure it is a good thing to pursue it

Appendix 2. CATME Five Teamwork Dimensions and Peer Evaluations

1. Contributing to the Team's Work (C)

Rating	Description of Rating
5	• Does more or higher-quality work than expected. • Makes important contributions that improve the team's work. • Helps teammates who are having difficulty completing their work.
4	• Demonstrates behaviors described immediately above and below.
3	• Completes a fair share of the team's work with acceptable quality. • Keeps commitments and completes assignments on time. • Helps teammates who are having difficulty when it is easy or important.
2	• Demonstrates behaviors described immediately above and below.
1	• Does not do a fair share of the team's work. Delivers sloppy or incomplete work.

2. Interacting with Teammates (I)

Rating	Description of Rating
5	• Asks for and shows an interest in teammates' ideas and contributions. • Makes sure teammates stay informed and understand each other. • Provides encouragement or enthusiasm to the team. • Asks teammates for feedback and uses their suggestions to improve.
4	• Demonstrates behaviors described immediately above and below.
3	• Listens to teammates and respects their contributions. • Communicates clearly. Shares information with teammates. • Participates fully in team activities. • Respects and responds to feedback from teammates.
2	• Demonstrates behaviors described immediately above and below.
1	• Interrupts, ignores, bosses, or makes fun of teammates. • Takes actions that affect teammates without their input. Does not share information. • Complains, makes excuses, or does not interact with teammates. • Is defensive. Will not accept help or advice from teammates.

3. Keeping the Team on Track (K)

Rating	Description of Rating
5	• Watches conditions affecting the team and monitors the team's progress. • Make sure that teammates are making appropriate progress. • Gives teammates specific, timely, and constructive feedback.
4	• Demonstrates behaviors described immediately above and below.
3	• Notices changes that influence the team's success. • Knows what everyone on the team should be doing and notices problems. • Alerts teammates or suggests solutions when the team's success is threatened.
2	• Demonstrates behaviors described immediately above and below.
1	• Is unaware of whether the team is meeting its goals. • Does not pay attention to teammates' progress.

	• Avoids discussing team problems, even when they are obvious.

4. Expecting Quality (E)

Rating	Description of Rating
5	• Motivates the team to do excellent work. • Cares that the team does outstanding work, even if there is no additional reward. • Believes that the team can do excellent work.
4	• Demonstrates behaviors described immediately above and below.
3	• Encourages the team to do good work that meets all requirements. • Wants the team to perform well enough to earn all available rewards. • Believes that the team can fully meet its responsibilities.
2	• Demonstrates behaviors described immediately above and below.
1	• Satisfied even if the team does not meet assigned standards. • Wants the team to avoid work, even if it hurts the team. • Doubts that the team can meet its requirements.

5. Having Relevant Knowledge, Skills, and Abilities (H)

Rating	Description of Rating
5	• Demonstrates the knowledge, skills, and abilities to do excellent work. • Acquires new knowledge or skills to improve the team's performance. • Able to perform the role of any team member if necessary.
4	• Demonstrates behaviors described immediately above and below.
3	• Demonstrates sufficient knowledge, skills, and abilities to contribute to team's work. • Acquires knowledge or skills as needed to meet requirements. • Able to perform some of the tasks normally done by other team members.
2	• Demonstrates behaviors described immediately above and below.
1	• Missing basic qualifications needed to be a member of the team. • Unable or unwilling to develop knowledge or skills to contribute to the team. • Unable to perform any of the duties of other team members..

6. Team Satisfaction (CATME Team Satisfaction)

	Item Code	Item
Team Satisfaction	TSQ1	I am satisfied with my present teammates
	TSQ2	I am pleased with the way my teammates and I work together
	TSQ3	I am very satisfied with working in this team

Appendix 3. Undergraduate Teaching Assistant Professionalism Survey

Subcategories	Item#	Item
Personality (Parcel #1)	1	My [Course Title] undergraduate teaching assistant is approachable (e.g., smiles, invites questions, and responds respectfully to student comments).
	2	My [Course Title] undergraduate teaching assistant is confident (e.g., speaks clearly, makes eye contact, and answers questions correctly).
	8	My [Course Title] undergraduate teaching assistant has a positive attitude (e.g., makes the course enjoyable, laughs with students, and helps prevent students from giving up when frustrated).
	9	My [Course Title] undergraduate teaching assistant is humble (e.g., admits mistakes, does not brag, and does not take credit for others' successes).
	14	My [Course Title] undergraduate teaching assistant is respectful (e.g., is polite to students, does not interrupt students while they are talking, does not humiliate or embarrass students in class, and does not talk down to students).
	16	My [Course Title] undergraduate teaching assistant is personable (e.g., talks to students before/after class, smiles).
Support (Parcel #2)	4	My [Course Title] undergraduate teaching assistant is an effective communicator (e.g., speaks clearly, speaks at an appropriate volume, uses precise language, and provides clear/compelling examples).
	5	My [Course Title] undergraduate teaching assistant encourages and cares for students (e.g., provides praise for good work, helps students who need it, and knows student names).
	6	My [Course Title] undergraduate teaching assistant is accessible outside the classroom (e.g., provides assistance outside of the classroom, and responds to email in a timely fashion).
	17	My [Course Title] undergraduate teaching assistant is responsive (e.g., makes sure students understand material before moving to new material, repeats information when necessary, and asks questions to check student understanding).
Professionality (Parcel #3)	10	My [Course Title] undergraduate teaching assistant is knowledgeable about the course material (e.g., easily answers students' questions, does not read straight from the book or notes, and uses clear and understandable examples).
	11	My [Course Title] undergraduate teaching assistant is professional (e.g., conducts themselves appropriately, attire is neat and clean, proper language is employed, and profanity is never used).
	15	My [Course Title] undergraduate teaching assistant is technologically literate (e.g., proficient in the software used in the course, and can assist students with submission issues).
	18	My [Course Title] undergraduate teaching assistant is prepared (e.g., brings necessary materials to class, is never late for class, and understands the day's agenda).
	19	My [Course Title] undergraduate teaching assistant is helpful.
	20	My [Course Title] undergraduate teaching assistant is accessible.

Appendix 4. Community of Inquiry Scale

1. Teaching Presence: Instructor-oriented Supports of Collaborative Work

Subcategories	Item #	Item
Teaching Presence	7	The instructor helped to keep course participants engaged and participating in productive dialogue
	8	The instructor helped keep the course participants on task in a way that helped me to learn.
	10	Instructor actions reinforced the development of a sense of community among course participants
	11	The instructor helped to focus discussion on relevant issues in a way that helped me to learn.
	12	The instructor provided feedback that helped me understand my strengths and weaknesses relative to the course's goals and objectives.

2. Face-to-face Collaborative Experience

Subcategories	Item #	Item
Social Presence	18	I felt comfortable participating in the course discussions.
	19	I felt comfortable interacting with other course participants.
	20	I felt comfortable disagreeing with other course participants while still maintaining a sense of trust.
	21	I felt that my point of view was acknowledged by other course participants.

3. Online Collaborative Experience

Subcategories	Item #	Item
Social Presence	16	Online or web-based communication is an excellent medium for social interaction.
	17	I felt comfortable conversing through the online medium.
	22	Online discussions helped me to develop a sense of collaboration.