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Exploring the Relationship Between Achievement Goal Orientation and Situational Engagement During Engineering Problem Solving

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Abstract

Achievement goal orientation (AGO) plays a crucial role in shaping how engineering students approach solving complex problems. This motivational construct influences students' learning outcomes, their ability to sustain attention, and their motivation to remain engaged throughout tasks. AGO, therefore, hypothetically impacts the situational engagement, such as interest, skill, and perceived challenge, during learning, reasoning, and problem-solving. This research investigates the effect of various types of AGO on students' situational engagement while solving engineering problems, particularly in the Fundamentals of Electronics for Engineers class.

To investigate the impact of AGO on situational engagement, the researchers adopted a mixed-method approach. The quantitative data of this study were collected from a validated Achievement Goal Questionnaire Revised (AGQ-R) survey administered at a land-grant public university in the western United States. One hundred and three undergraduate engineering students have participated in this phase of data collection. The survey response illustrates two distinct AGO groups, such as mastery-oriented and performance-oriented. For in-depth qualitative analysis, eight students were purposefully selected uniformly from both mastery and performance-oriented groups. These eight students participated in an engineering problem-solving activity. To capture the variations in engagement during the problem-solving process, a situational-engagement questionnaire was administered at four intervals during the problem-solving activity. This questionnaire assesses students' interest in the task, skill, and perceived challenges across separate phases of a complex problem-solving task.

At the end of the problem-solving activity, participants responded to the same items in the post-problem-solving interview, where they elaborated on their experiences. Quantitative data were analyzed descriptively and inferentially to compare engagement patterns across achievement goal orientation groups, while qualitative responses were thematically coded to identify factors influencing situational engagement.

Findings demonstrated that students with mastery-oriented goals show greater consistency in perceived challenge and skill orientation over time, whereas performance-oriented goal students exhibit higher inconsistency and situational disengagement as cognitive demands peaked. The integration of AGO profiles with situational engagement metrics offers new insights into the dynamic nature of engineering problem-solving processes and has implications for the development of adaptive instructional tools.

Keywords: Achievement Goal Orientation, Mastery Goal Orientation, Performance Goal Orientation, situational engagement, problem solving

I. Introduction and Background

Achievement goal orientation (AGO) is a well-established motivational construct influencing students' engagement and success in academic activities. Several studies have demonstrated that AGO is associated with both positive and negative aspects of student engagement. AGO is defined as "an integrated pattern of beliefs, attributions, and affect that produces the intentions of behavior and that is represented by different ways of approaching, engaging in, and responding to achievement-type activities" [1]. On the positive side, mastery-approach goals are associated with deep learning strategies [1], reflective and integrative learning [2], use of cognitive and metacognitive strategies [3], a preference for challenging work [4], and persistence [5]. Mastery goal orientation (MGO) is defined as "In which individuals are concerned with increasing their competence. Mastery-oriented individuals might be pursuing learning goals," while Performance goal orientation (PGO) is defined as "In which individuals are concerned with gaining favorable judgments of their competence" [3], [4]. Studies on performance-approach goals are inconclusive with mixed findings. While certain studies highlight their positive association between performance-orientation and situational engagement (such as high achievement in challenging conditions [6] and high level of self-efficacy [7]), others found quite contrary motivations, including lower achievement test scores [8], avoidance of challenging tasks, and reluctance to engage in collaboration [9].

However, the engagement indicators used in these aforementioned studies reflect broad engagement patterns rather than situation engagement during problem-solving. Several researchers argued that engagement is not a fixed construct and can be influenced by certain factors. Therefore, they should be examined when students are involved in the task [10]– [12]. According to Xie et al. [13], engagement is a dynamic and context-dependent cognitive construct, fluctuating over time and shaped by the specific task in which a student is participating at a given moment. By capturing situational engagement within context, researchers can examine learning experiences and enable a more precise understanding of how contextual factors intersect with individual characteristics [14]. There is a certain correlation between engagement and situational engagement, but not consistent [13]. Schneider et al. [10] operationalized situational engagement in comparison to general engagement as "a state of involvement in a learning task identified by higher-than-average individual states of interest, skill, and challenge". Interest reflects the student's immediate enjoyment or curiosity toward the task, skill represents the student's perceived competence in handling the task demands, and challenge refers to the level of difficulty the task presents at that moment. The interaction of these three components determines whether a student becomes deeply involved in the activity, making situational engagement a dynamic and context-dependent construct. Thus, we aim to explore the relationship of AGO with the situational engagement, i.e., the momentary experience of interest, challenge, and perceived skill [10] during a specific learning episode.

Social cognitive theory (SCT) posits that learning is a reciprocal interaction between individual motivations, behavior, and contextual task features [15]. Because goal orientation represents a stable individual characteristic, and engagement fluctuates with task demands, SCT provides a strong foundation for studying how mastery and performance-oriented students engage differently during engineering problem solving. Achievement goal orientation, whether mastery or performance-driven, represents a key individual factor that determines how students interpret challenges, invest effort, and regulate their strategies during problem-solving. Previous research shows that situational engagement is shaped by individual motivational factors such as self-efficacy, motivation, and interest [16]– [17]. AGO, a core motivational disposition, is likely to influence students' real-time engagement during engineering problem solving. Although motivational constructs such as self-efficacy and autonomous motivation have been linked to situational engagement, prior work has not examined the role of goal orientation. This study contributes by identifying how mastery and performance orientations shape students' situational engagement during engineering problem solving. By integrating goal orientation theory with situational engagement models, this study offers a novel perspective on how personal motivational dispositions interact with contextual task demands.

II. Purpose of the Study

The purpose of this study is to investigate the relationship between students' achievement goal orientations and their situational engagement (interest, skill, and perceived challenge) during engineering problem solving. By capturing engagement at four phases of the task, the study aims to understand how mastery and performance-oriented students differ in their dynamic engagement patterns. The following research question guides this study: How does students' achievement goal orientation influence their situational engagement during engineering problem-solving activity?

III. Methods

This study employed a mixed-methods design consisting of a quantitative phase followed by a qualitative phase. First, a validated Achievement Goal Questionnaire Revised (AGQ-R) survey was administered to identify the motivational profile of engineering students. One hundred and three students participated during this phase of data collection. Based on students' responses, two motivational profile groups were identified, and a subset of eight students was purposefully selected to participate in the qualitative data collection phase, which included a detailed problem-solving activity. The situational engagement questionnaire was administered at four time points during this activity. A follow-up qualitative interview was conducted to elicit participants' reflections on their situational engagement during problem solving.

A. Data Collection

The goal orientation of students was measured using the 12-item Achievement Goal Questionnaire–Revised (AGQ-R) developed and validated by Elliot and Murayama [18]. The AGQ-R measures mastery-approach and performance-approach. Participants responded to all items on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Students' AGQ-R scores were used to classify participants as mastery-oriented or performance-oriented for subsequent analysis. In addition to dispositional goals, situational engagement during problem solving was assessed using momentary scores of interests, perceived skill, and perceived challenge at four time points throughout the activity. Consistent with Schneider et al.'s [10] conceptualization of situational engagement, these ratings captured students' in-the-moment cognitive and motivational states as they worked through the problem. Each dimension was measured with a Likert-type item scored from 1 to 4, allowing the analysis of dynamic engagement patterns across the four problem-solving phases. Qualitative data were collected through post-problem-solving, semi-structured interviews. During the post-problem-solving interviews, the students were asked to reflect on the same situational engagement dimensions: interest, skill, and perceived challenges.

B. Data Analysis

The quantitative and qualitative data were analyzed thoroughly to answer the research question. Statistical tests were conducted to analyze the quantitative data using SPSS 30. We conducted descriptive analyses and an inferential non-parametric test, specifically the Friedman test, to examine change in situational engagement across four time points. The thematic analysis was employed, combining both inductive and deductive coding. The deductive codes were derived from the theoretical framework on Schneider's framework of situational engagement and achievement goal orientation, which served as our initial coding scheme. As we coded the transcript, additional patterns that were not captured by a priori codes emerged, and these were incorporated as inductive codes. The analysis proceeded through iterative cycles of coding, memo writing, and theme refinement. Qualitative analysis was conducted using MAXQDA data analysis software. The quantitative and qualitative findings were then integrated to examine the relationship between students' goal orientations and situational engagement during problem-solving.

IV. Findings

Data collected from the AGQ-R survey were used to classify the participants into mastery goal-oriented (MGO) and performance goal-oriented (PGO) groups based on their scores. Participants whose mastery-approach score exceeded their performance-approach score were categorized as MGO, whereas those with higher performance-approach scores were categorized as PGO. The descriptives (means and standard deviations) of MGO and PGO participants were computed at four different time points of a problem-solving activity using the situational engagement questionnaire, as shown in Table 1.

Table 1

Descriptives of Three Dimensions of Situational Engagement for MGO and PGO at 4 Time Points

Time Point	Situational Engagement	MGO		PGO		AGO	
		Mean	S. D	Mean	S. D	Mean	S. D
Timepoint 1	Q1-Interest	2.75	1.25	2.75	0.50	2.75	0.89
	Q2-Skills	2.75	0.95	2.25	0.50	2.5	0.76
	Q3-Challenge	3	1.15	3.25	0.50	3.125	0.83
Timepoint 2	Q1-Interest	3	1.41	3	0	3	0.92
	Q2-Skills	2.75	0.95	2.5	0.58	2.63	0.74
	Q3-Challenge	3.25	0.95	3.5	0.58	3.38	0.74
Timepoint 3	Q1-Interest	2.75	0.95	2.75	0.50	2.75	0.71
	Q2-Skills	3.5	0.57	2.5	0.58	3	0.76
	Q3-Challenge	3	0.82	3.5	0.58	3.25	0.71
Timepoint 4	Q1-Interest	3	0.82	2.5	0.58	2.75	0.71
	Q2-Skills	3	0	2.5	0.58	2.75	0.46
	Q3-Challenge	3.5	0.58	3.5	0.58	3.5	0.53

To identify statistically significant differences, a non-parametric Friedman test was conducted separately for both MGO and PGO participants for each situational engagement dimension (interest, skill, and perceived challenge) as shown in Table 2. For mastery-oriented students, none of the engagement dimensions showed statistically significant differences across four time points. Similarly, performance-oriented students did not exhibit significant time-based differences in any engagement dimension. These non-parametric test results indicate that situational engagement remained relatively stable across the problem-solving phases for both groups. However, descriptive patterns suggest meaningful quantitative fluctuations, as shown in Figure 1. Given the absence of significant within-group changes, no post hoc pairwise comparisons or between-group analyses were performed, consistent with nonparametric analysis procedures and to avoid unnecessary type I error inflation. Interpretation focused on the descriptive patterns and line plots, which offered insight into how engagement fluctuated during the problem-solving activity despite the lack of statistically significant differences.

Table 2

Friedman Test Results for Situational Engagement Across Four Time Points by Goal Orientation Groups

Engagement Dimension	Goal Orientation Groups	Chi-square (X^2)	p-value
Interest	MGO	1.20	0.753
	PGO	4.00	0.261
	AGO	2.25	0.522
Skills	MGO	3.82	0.281
	PGO	1.00	0.801
	AGO	3.51	0.319
Challenge	MGO	1.00	0.801
	PGO	2.20	0.532
	AGO	2.20	0.532

Post problem-solving interview data were analyzed using thematic analysis. The transcribed data from the interviews were coded deductively and inductively for analysis. Schneider et al.'s [10] situational engagement dimensions (interest, skill, and perceived challenge) were used to guide the deductive coding process, followed by the inductive coding adapted from the work of Saldana [19]. The analysis was done through the iterative process of coding, categorizing, and theming. A codebook was maintained for compiling the codes that evolved during the analysis. Two researchers independently reviewed the coded data and collaboratively refined the themes to ensure accuracy and to establish a shared, consensus-based understanding.

Three major themes were developed for each case of MGO and PGO based on three deductive codes of situational engagement: situational interest during problem solving, skill, and perceived challenge. The following section presents the thematic analysis of two cases of MGO and PGO students.

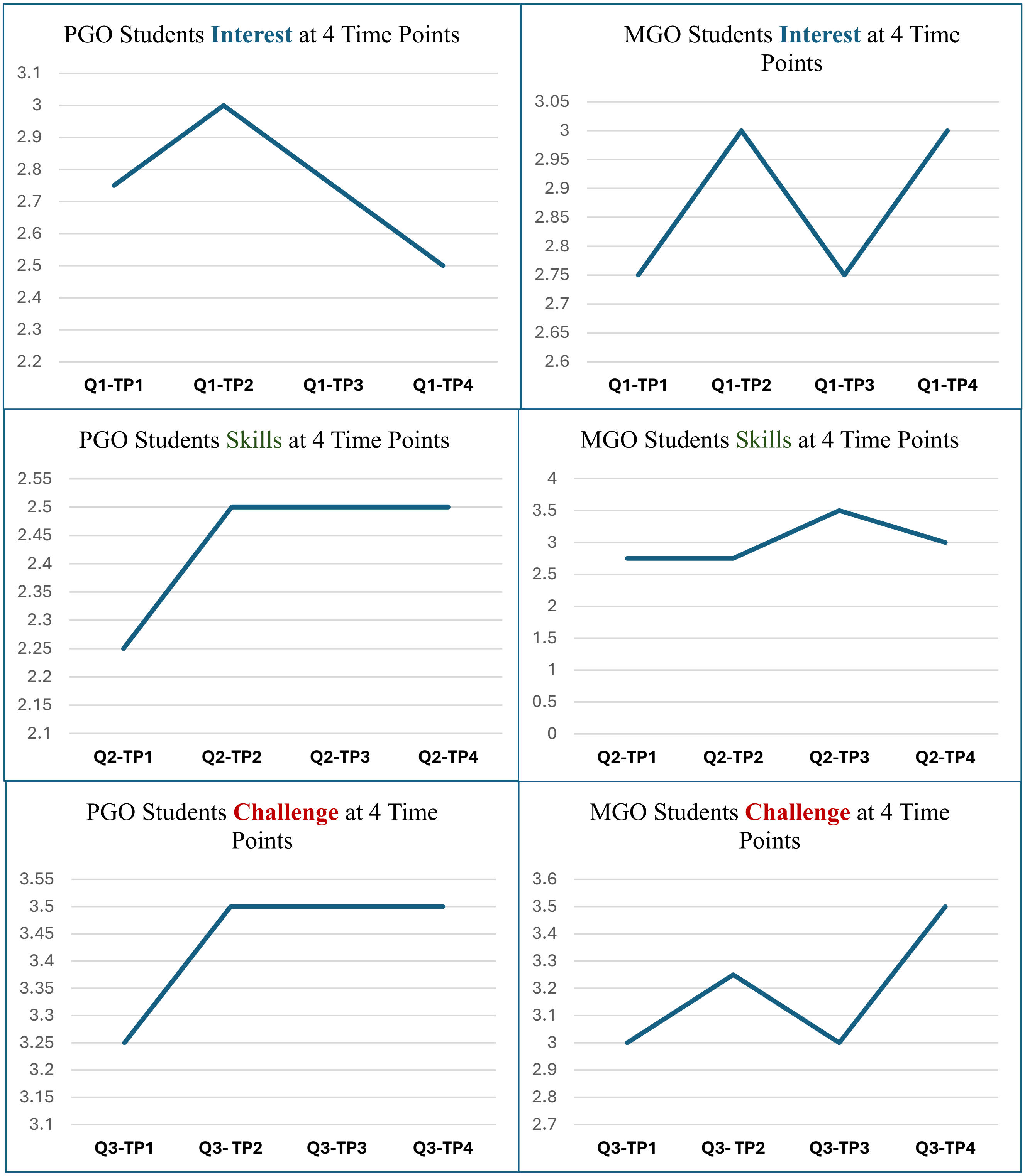

Figure1: Situational Engagement Trajectories Across Four Timepoints

Case 1: Mastery Goal-Oriented (MGO) Students

Three major themes were developed, representing the situational engagement of MGO students during the problem-solving activity.

Theme 1: Interest as Cognitive Investment During Problem Solving

Interest emerged as a cognitive investment that developed through active engagement with the task. Students' interest was driven by analyzing the problem initially, struggling with complexity, and then progressing towards understanding the task. Students emphasized conceptual engagement with the task rather than procedural execution by saying:

> *"I would say that the problem itself was pretty interesting. Just because there were a lot of kind of complex elements, but they weren't it wasn't like some of the homework can sometimes feel really tedious and it didn't feel like that. It was like more of a problem solve as opposed to a plug and chug"*

This reflects that the MGO students' interest was rooted in cognitive challenge rather than the ease of the task. Across participants, interest was associated with cognitive effort and sustained focus. One participant explicitly described a shift from disinterest to engagement once he started thinking about the problem. This reflects that their learning unfolds through interaction with the task, and interest functioned as an outcome of engagement. Similarly, another MGO participant acknowledged the problem-solving process of electronics as "I do appreciate the problem-solving process and being able to analyze the circuit." Indicating the interest stemmed from cognitive engagement with the task. Although students showed initial uncertainty, they remained engaged and were persistent in their interests as they began to understand the problem rather than being dependent on immediate success or task simplicity.

Theme 2: Recalibrating Skill During Problem Solving

MGO students entered the task with initial uncertainty about whether they possessed the necessary skills required for solving the problem. For example, one of the participants stated that **"**At the beginning, no. But once I started making progress, I felt more skilled," characterizing their competence as developing rather than fixed. This view was further echoed by another participant through their description of the problem-solving experience as "So when you are solving the world, you will feel scared. I felt like I had the tools necessary to solve the problem. It was just a matter of making sure I apply them correctly." This reflection was closely tied to progressive sense-making and strategic processes, which were consistently observed among MGO profiles. Rather than expressing overconfidence, MGO participants relied more on becoming aware of the task's conceptual demand without being disengaged. This recalibration reflected metacognitive awareness and understanding that competence evolves through continued engagement. Overall, MGO participants framed skill as constructed and adjusted through interaction with the problem components and associated operators, and reinforcing its view that the skill was developed through effortful problem solving.

Theme 3: Challenge as a Catalyst for Sense-making

For MGO participants, the challenge of solving a problem emerged as a catalyst for deeper sense-making rather than as an indicator of failure. Students valued challenges when they were prompted to abstract and refinement of understanding. They consistently described challenge as moving beyond the surface features, as stated by one of the participants, "I think the most challenging thing was for me was moving past just what the circuit looked like." This emphasis on the underlying principle illustrates challenge as productive cognitive work, not an obstruction. Similarly, another participant identified a challenge as "being able to conceptualize how the different elements and states interact with one another," noting that in electric circuits, steady states were more straightforward, but changes in terms of state transitions are more challenging. This was further reiterated by another participant that the problem was "definitely not trivial", emphasizing that it required thinking of aspects "that weren't just there,". These findings indicate that for MGO participants, perceived challenge functioned as an engine for learning, initially complex, then stabilized with understanding.

Case 2: Performance Goal-Oriented (PGO) Students

Three major themes were developed, representing the situational engagement of PGO students during the problem-solving activity.

Theme 1: Interest Driven by Outcome-Contingent Engagement

For PGO students, interest was closely tied to observable outcomes rather than to sustained engagement with the problem-solving process itself. Several students explicitly framed interest as dependent on confidence rather than internal curiosity. For example, one of the participants stated, " As I felt more confident, I was more interested but not inherently interested." This clearly distinguished interest is a by-product of outcomes and perceived competence. Similarly, another participant described, "I was very interested in solving it out and seeing what the values might be just because I thought that might be interesting. as the topic as a whole, I'm not super interested in electronics though," suggesting the interest was driven by the prospect of getting the results. As the participants progressed in the problem-solving activity, interest declined due to increased uncertainty and doubts about correctness. For example, one participant felt less skilled because "did not get the right answer," which undermined their deteriorating interests during the problem-solving activity. Similarly, another participant expressed concern about the correctness of the equations, indicating the interest was contingent on successful execution rather than cognitive investment in the given tasks. Across these accounts, interest was not intrinsic but outcome dependent.

Theme 2: Skill is Framed as Procedural Correctness Rather than Conceptual Growth

PGO participants consistently framed skill as the ability to correctly solve the highly conditional problem. When the students were uncertain about the correctness, their confidence in their skills declined. Some students connected the skill to remembering equations as "I understand the concept, but I don't know if the equations are right because I was told not to memorize them, and so I don't have them memorized.”, positioning skill as acquisitions of maximum possible mathematical rules and contingent on external support. Another participant echoed this as:

> *“But I also was not super confident or didn't feel super skilled because I knew I was messing up some of the equations. Because I didn't have them in front of me. And so I couldn't go back to confirm whether I was doing it right”*

This overreliance on procedural verifications through mathematical rules also illustrates a view of skill as dependent on correct execution. These participants showed discomfort when correctness could not be confirmed. Likewise, another participant reported feeling “quite skilled in my assumptions” but simultaneously shared reduced confidence about the corrections of their assumptions. Collectively, these patterns suggest that for PGO participants, perceived skills function as performance validation. They perceive skills as strong when answers appeared correct or verifiable, and as weak when uncertainty arose, consistent with performance-oriented goal structures.

Theme 3: Challenge is Experienced as a Risk to Correctness

PGO students considered challenge as a risk to correctness rather than an opportunity for exploration and conceptual growth. They discussed challenges in terms of choosing the wrong equation, misapplying procedures, and misinterpreting the problem. For instance, one student described feeling challenged because he “*didn’t know exactly which equations to use*”. Furthermore, the challenge was also linked to uncertainty in dealing with unfamiliar problems, particularly when problems deviated from a familiar context. One participant described difficulty in “breaking down the circuit into a normal looking one,” while another noted that encountering an RL problem with “two voltage sources” introduced novelty that “threw a challenge.” These excerpts show the challenge was a threat to successful execution due to uncertainty in structural representation and the risk of applying incorrect procedures. This aligns with performance-oriented students’ tendency to interpret challenge as a threat to accurate performance rather than as a productive opportunity for learning.

V. Discussion and Conclusion

This study examined how students with different goal orientations exhibit situational engagement operationalized as interest, perceived skill, and perceived challenge during an engineering problem-solving activity. Although the quantitative results did not reveal statistically significant differences in situational engagement of both MGO and PGO participants across four different timepoints during the problem-solving activity, the situational engagement trajectories shown in Figure 1 and qualitative themes offer insight into the differences in engagement fluctuation.

The descriptive patterns of MGO participants show moderate fluctuations but overall stable levels of interest, skill, and challenge across time points. The non-linear trajectory of interest is explained by the MGO student’s description of interest as a cognitive investment, including moments of reduced interest due to heightened cognitive demand, and then re-engagement as students made sense of the problem. This fluctuation represented productive struggle, not disengagement during problem solving. Similarly, a perceived skill trajectory represents growing competence through analysis, while a slight decline reflects students' recalibration of their metacognition, as previous studies also aligned mastery orientation with metacognitive strategies [20]–[21]. This aligns with MGO participants' responses to their perceived skills as developmental and reflective. Finally, the perceived challenge among MGO participants increased at the end of the problem-solving, but participants experienced this challenge as a core motivator for learning. MGO participants did not feel challenged in generating new information beyond what is given in the problem, as also mentioned by Chi and Wylie [22], the constructive engagement during problem solving. All three dimensions co-occurred in ways consistent with Schneider et al [10] optimal learning moments when interest, skill, and challenge were elevated simultaneously.

The descriptive patterns of PGO participants showed that participants' interest increased early in the task but steadily declined across later timepoints. Thematic analysis further explained this pattern by showing that the interest was outcome contingent and decreased when correctness became harder to verify, indicating that engagement was tied to performance validation rather than cognitive engagement. Then, the quantitative patterns illustrate an early increase in perceived skill and challenge, followed by a plateau. PGO participants framed skill as procedural correctness, emphasizing remembering equations, following known steps, and confirming answers. Their discomfort regarding correctness, despite having a conceptual understanding, reflected a conditional sense of competence. Regarding perceived challenges as a threat to the correct execution of mathematical and domain-specific rules and were concerned about making mistakes. The combination of persistently high challenge and declining interest suggests that challenge was not balanced by the perceived skill. For performance-oriented students, challenges often outweighed perceived skill, limiting sustained engagement and, in turn, exploration and creativity [23].

These findings emphasized the importance of examining the situational engagement that fluctuates meaningfully across time and is shaped by the interaction between individual characteristics and contextual demands as described in SCT [24]– [25]. The present findings are consistent with Wolters' [26] work showing that mastery goal orientation is associated with deeper cognitive engagement, whereas performance goal orientation is linked to more surface-level or outcome-focused engagement. Abideen et al. [23] also explored the impact of goal orientation on students' cognitive engagement during problem-solving through the lens of ICAP levels (Interactive, constructive, active, and passive). While these findings characterize what types of engagement students demonstrate, the current study advances this line of inquiry by revealing how these engagement patterns are experienced and sustained situationally during problem solving.

VI. Implications and Limitations

The integration of situational engagement measurements with AGO profiles has implications for creating adaptive instructional tools as well as insight into the dynamic nature of learning processes in engineering problem solving. The findings of this research suggest that instructors should balance structure and ambiguity to support students with differing motivational profiles. The study is limited by its relatively small sample size, which may limit the generalizability of the findings. Future mixed-method research studies with larger and more diverse samples are needed to more rigorously test quantitative patterns observed here and to further validate and refine the qualitative themes identified in this study.

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