Examining the Interplay of Situational Engagement and Need for Cognitive Closure During Engineering Problem Solving

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Abstract

This empirical full paper examines the differences in situational engagement among students with low and high levels of need for cognitive closure (NFCC) during problem-solving activities. Problem-solving in engineering requires not only conceptual understanding but also sustained cognitive engagement when tackling challenging tasks. Individual differences in motivational dispositions, such as NFCC, may influence students' ability to maintain attention, manage uncertainty, and remain engaged during complex problem-solving activities. This study is guided by one major research question: How does the need for cognitive closure impact students' situational engagement, including their skill, interest, and perceived challenge during problem-solving activity?

To investigate the impact of NFCC on situational engagement during problem solving, the researchers adopted a sequential mixed-method approach. In the first phase, they collected quantitative data from engineering students at a land grant public university in the western United States using a validated NFCC survey. A total of 103 undergraduate engineering students participated during the first phase of data collection. Based on survey responses, two distinct NFCC groups (high and low) were identified, and eight students were purposefully selected for in-depth qualitative analysis. During the qualitative phase, each participant completed a complex engineering problem. The situational engagement questionnaire was used to measure their skill, interest, and perceived challenge at four time points. Participants were also interviewed with the same situational engagement questionnaire to understand the problem-solvers' subjective cognitive engagement experiences after the problem-solving activity.

Quantitative data were analyzed using descriptive and inferential statistics. Situational engagement data were further analyzed to examine group differences and identify patterns across NFCC levels. Qualitative responses from the post-problem interviews were coded thematically to identify engagement patterns and cognitive alignment. The comparative analysis of quantitative trends and qualitative narratives revealed that high-NFCC participants tended to maintain consistent engagement when task structure was clear, whereas low-NFCC participants demonstrated more adaptive engagement during the emergence of ambiguity or uncertainty.

Findings highlight the importance of incorporating individual difference variables with real-time engagement measures to design adaptive instructions in engineering education. These findings contribute to a better understanding of the cognitive-motivational mechanisms underlying engineering problem solving. The findings also imply that recognizing and responding to students' differing levels of NFCC can help instructors design adaptive problem-solving environments and enhance learning outcomes in engineering education.

Keywords: Need for cognitive closure, problem solving, situational engagement

1. Introduction and Background

Engagement has commonly been conceptualized in terms of quality of cognitive processing, i.e., deep versus shallow engagement [1]. Deep engagement is characterized by meaningful processing, such as connecting ideas, integrating prior knowledge, and striving for understanding. In contrast, shallow engagement emphasizes surface-level strategies, such as rote capture or minimal efforts in task interpretation, monitoring, and evaluation [2], [3]. Engineering students' cognitive engagement during problem solving has emerged as a critical component for academic achievement [4]. However, the students vary in their cognitive orientations and the extent to which they are inclined to engage deeply in problem-solving situations. Several studies have explored individual cognitive factors, such as the need for cognitive closure (NFCC), that affect students' engagement during problem-solving. Moreover, the epistemic motivation or the desire for mastery of content also influences a subject's beliefs (beliefs about the nature of knowledge and knowing), learning, reasoning, problem-solving, and decision-making in their academic pursuit [7], [8]. The NFCC measures a subset of epistemic motivations, which refers to an individual's desire for a firm answer to a question and a tendency to avoid ambiguity [7]. Building on this definition, Kruglanski and Webster [8] describe the need for cognitive closure (NFCC) as the extent to which individuals prefer knowledge that is clear, unambiguous, and stable rather than open to revision. NFCC is a motivated tendency in cognitive processing. Individuals with high NFCC tend to seek rapid closure by seizing on the first plausible judgment and maintaining it throughout a goal-oriented task, especially in uncertain situations. High NFCC is associated with discomfort with ambiguity, preference for stability, and resistance to alternative perspectives [9], [10]. NFCC was initially conceptualized as a general individual difference, often examined along a continuum from low to high need for closure. As this cognitive construct developed, Webster and Kruglanski [11] further conceptualized the NFCC construct into five facets: preference for order, preference for predictability, decisiveness, discomfort with ambiguity, and closed-mindedness. This research focused on low and high NFCC dimensions and can be extended further in the future across the five facets of NFCC.

NFCC can vary among individuals and due to situational orientations; some situations may heighten an individual's desire for a clear problem structure while others motivate them to avoid closure [10]. Several studies explored the impact of NFCC on cognitive engagement and learning during problem solving. Faber and Benson [12] explored the influence of engineering students' NFCC on their motivation during complex problem solving. They analyzed epistemic motivation in terms of closed-mindedness, discomfort with ambiguity, and epistemic aims focused on certainty, efficiency, and completion. Participants in their study prioritized task completion, reflecting "seizing" and "freezing" behavior, which maps directly onto high NFCC tendencies. Ma and Rapee [13] investigated the relationship between NFCC and mathematical performance and creativity, highlighting how closure-oriented tendencies respond to the structured versus open-ended task demands. Abideen et al. [4] also explored the relation between engineering students' NFCC (Low/High) and their cognitive engagement during a problem-solving activity. Low NFCC participants were engaged actively and constructively, which served as a bridge to their deep reasoning. Their procedural engagement was based on conceptual understanding, not on solving problems systematically. High NFCC participants exhibited low constructive and high passive engagement. Their discomfort with ambiguity limited the span of in-depth engagement. Abideen et al. [14] also examined the relationship between task complexity and engagement of students with different NFCC profiles. A consistent pattern was observed, i.e., as the task complexity increases, students with high NFCC tend to prioritize rapid problem resolution, often at the expense of creativity, whereas students with low NFCC remain engaged with complex tasks, explore multiple solution paths, and sustain creative thinking.

Existing NFCC research has primarily examined engagement and problem-solving through broad cognitive or outcome-based lenses. For example, engagement has often been described as deep versus shallow cognitive processing, linking NFCC to general tendencies in learning strategies rather than to task-embedded fluctuations. Abideen [10] has examined NFCC through epistemic cognition during problem solving, highlighting closure-related behaviors such as seizing on early solutions and freezing on initial judgments, or through performance outcomes such as efficiency versus creativity under increasing task complexity. These studies provide limited insight into how students with different NFCC profiles experience engagement as problem-solving unfolds. In contrast, this study conceptualizes engagement as situational and dynamic, focusing on students' situational experiences of interest, perceived skill, and perceived challenge during a problem-solving task. Schneider and colleagues conceptualize such experiences as "optimal learning moments" when students experience higher-than-average interest, skill, and perceived challenge during a learning activity [5]. Interest refers to learners' immediate curiosity or enjoyment of the task, perceived skill reflects their sense of competence in meeting task demands, and perceived challenge captures how demanding the task feels at a given moment. Although general engagement and situational engagement are related, their association is not always consistent, underscoring the need to distinguish between them [15].

2. Purpose of Study

The purpose of this study is to examine the role of NFCC in shaping situational engagement during problem solving, operationalized through students' experiences of interest, skill, and perceived challenge during engineering problem-solving. By focusing on situational engagement, this research extends prior work on NFCC and cognitive engagement and provides a more nuanced understanding of how epistemic motives influence students' engagement during complex learning tasks. The following research question guides this study: How does the need for cognitive closure impact students' situational engagement, including their skill, interest, and perceived challenge during and after problem-solving activity?

3. Methodology

This study adopted a sequential mixed-method design with a quantitative phase followed by the qualitative phase [16]. In the quantitative phase, participants of this study completed a validated survey designed for the Need for Cognitive Closure questionnaire to identify their low and high NFCC profiles. Based on these profiles, eight students (four from each group) were purposefully selected to participate in an electronics circuits problem-solving activity. During the activity, situational engagement was assessed at four different timepoints. Following the task, semi-structured interviews were conducted after problem-solving activity sessions to examine the participants' situational engagement throughout their problem-solving process.

3.1. Participants and Data Collection

Data were collected in two phases. In the first phase, 103 sophomore undergraduate engineering students, majoring in electrical, computer, and aeronautical engineering, enrolled in a Fundamental Electronics for Engineers course at a land-grant public university in the western United States, and completed a validated Need for Closure Scale (NFCS) developed by webster and kruglanski and updated by roets and hiel [11], [17]. The NFCS demonstrated acceptable internal consistency in the present study (Cronbach's $\alpha > 0.70$). Descriptive statistical analysis was performed to observe a general overview of the collected data, with an overall mean NFCC score of $M = 3.90$ and $SD = 0.60$. To support comparative analysis, the students were categorized into low NFCC and high NFCC groups based on their scale scores. Specifically, participants scoring below (M − 0.5 SD) were classified as low NFCC, whereas those scoring above (M + 0.5 SD) were classified as high NFCC. This classification of low and high NFC was adapted as mentioned in the foundational study of Webster and Kruglanski

[11]. Based on these quantitative results, eight participants (four from each group) were selected for the second phase of solving an engineering problem. During that phase, participants' situational engagement was measured using Schneider et al.'s [5] conceptualization of situational engagement in terms of interest, skill, and perceived challenge at four times throughout the activity. Each situational engagement dimension was measured with a Likert-type item scored from 1 to 4, allowing the analysis of dynamic engagement patterns across the four time points during problem-solving. Qualitative data were collected through a semi-structured interview conducted immediately after the problem-solving activity. During the post-problem-solving interview, participants were asked to reflect on the same situational engagement dimensions assessed during solving the task.

3.2. Data Analysis

The quantitative data from NFCS and situational engagement were analyzed using descriptive and inferential statistics. The transcribed data from the interviews were coded deductively and inductively for analysis. Deductive codes were developed from the three dimensions of situational engagement (interest, skill, and perceived challenge), followed by the inductive coding adapted from the work of Saldana [18], through the iterative process of coding, categorizing, and theming. Two researchers independently coded the data using MAXQDA software and refined it collaboratively for the themes, with the inter-rater reliability of more than 90% through the peer debriefing process [19]. Finally, quantitative and qualitative findings were integrated using methodological triangulation to examine the relationship between students' need for cognitive closure and their situational engagement during problem solving.

4. Findings

Data collected from the NFC scale were used for the classification of the participants into low and high need for cognitive closure groups. Then, the situational engagement of participants was analyzed at four different times during the problem-solving activity through the descriptives (means and standard deviations) and inferential statistics obtained from the situational engagement questionnaire using SPSS, as shown in Table 1.

Table 1

Descriptives of Three Dimensions of Situational Engagement for Low and High NFCC at 4 Time Points(N=8)

Time Point	Situational Engagement	Low NFCC		High NFCC		Overall NFCC	
		Mean	S. D	Mean	S. D	Mean	S. D
Timepoint 1	Q1-Interest	3	0.82	2.50	1.00	2.75	0.88
	Q2-Skills	2.50	1.00	2.50	0.58	2.5	0.76
	Q3-Challenge	3	0.82	3.25	0.96	3.125	0.83
Timepoint 2	Q1-Interest	3.50	0.58	2.50	1.00	3	0.92
	Q2-Skills	3	0.82	2.25	0.50	2.625	0.74
	Q3-Challenge	3	0.82	3.75	0.50	3.375	0.74

	Q1-Interest	3	0.82	2.50	0.58	2.75	0.70
Timepoint 3	Q2-Skills	3.25	0.96	2.75	0.50	3	0.75
	Q3-Challenge	2.75	0.50	3.75	0.50	3.25	0.70
	Q1-Interest	2.75	0.96	2.75	0.50	2.75	0.70
Timepoint 4	Q2-Skills	2.75	0.50	2.75	0.50	2.75	0.46
	Q3-Challenge	3.50	0.58	3.50	0.58	3.50	0.53

To identify the significant differences across four time points, a Friedman test was conducted for both low and high NFCC participants on each engagement dimension (interest, skill, and perceived challenge). Repeated measures analyses revealed no statistically significant differences across the four time points for any dimension of situational engagement, as shown in Table 2. However, examination of descriptive statistics revealed meaningful fluctuations in students' reported levels of interest, skill, and perceived challenge over time, as shown in Figure 1.

Table 2

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

Engagement Dimension	Need for Cognitive Closure (NFCC) Groups	Chi-square (X^2)	p-value
Interest	Low NFCC	6.33	0.096
	High NFCC	1.28	0.733
	Overall NFCC	2.25	0.522
Skills	Low NFCC	4.14	0.246
	High NFCC	2.53	0.468
	Overall NFCC	3.51	0.319
Challenge	Low NFCC	4.00	0.261
	High NFCC	3.66	0.300
	Overall NFCC	2.20	0.532

As a result of qualitative analysis, three major themes were developed for each case of low NFCC and high NFCC participants, representing their situational engagement during problem-solving. The following section presents the thematic findings of the two cases.

Case 1: Low NFCC Students

Three major themes were developed that represent the situational engagement of low NFCC students during problem solving.

Theme 1: Interest Emerges Through Sustained Exploration

Low NFCC participants' situational interest was not driven by quick solution paths, but by engaging in sense-making and analysis through exploration. For instance, John (pseudonym) described the task as engaging because it was "more of a problem solve as opposed to a plug and chug" showing his interest was rooted in reasoning rather than routine calculation. Similarly, Eric echoed this orientation as "very interested in solving it out…not super interested in electronics," which indicates the emergence of interest during problem-solving.

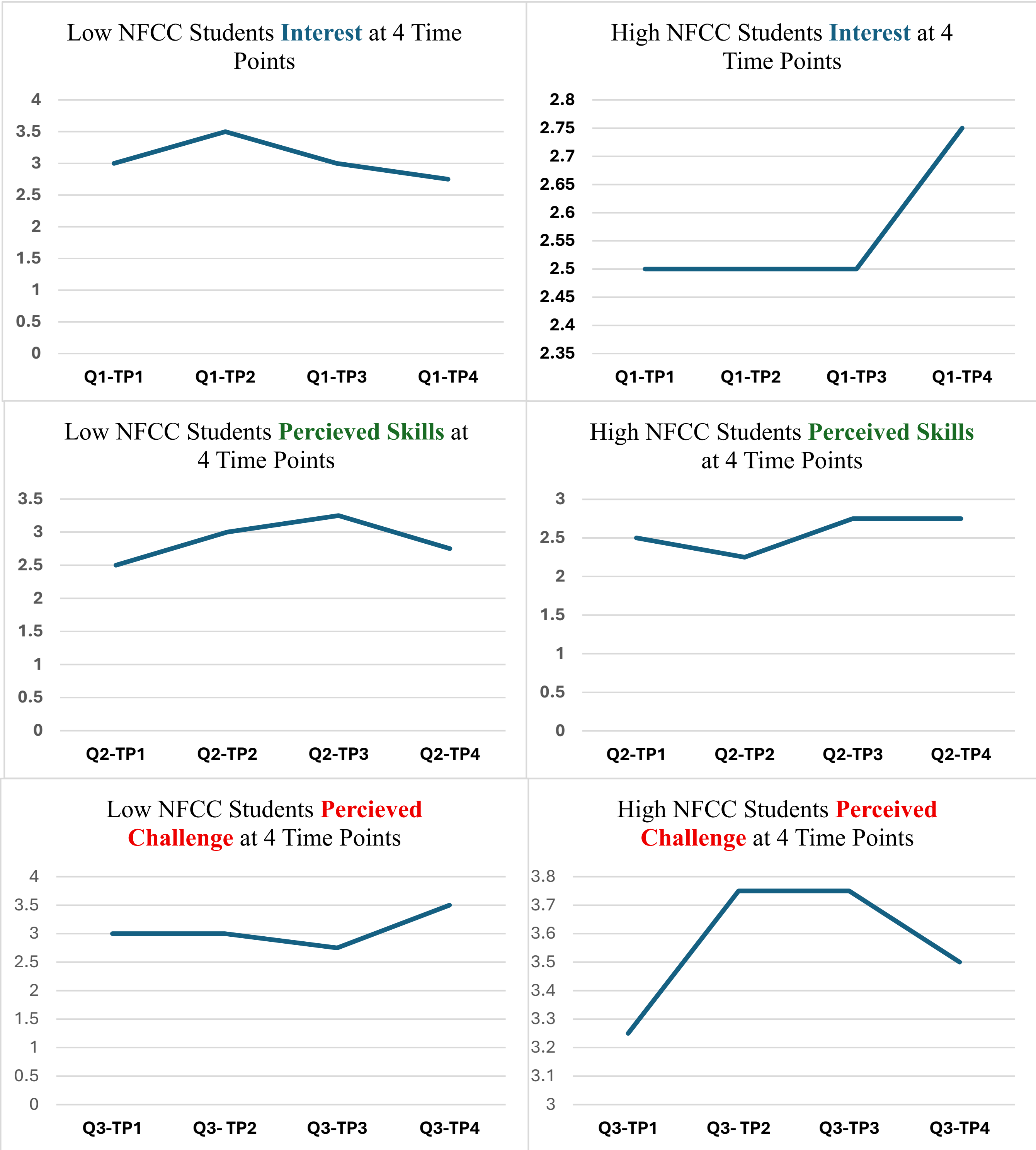

Figure 1: *Situational Engagement Trajectories Across Four Timepoints*

Even though Eric did not find the domain attractive, the cognitive effort needed to solve the problem instigates their internal motivations and interests.

The persistence of low NFCC participants despite complexity describes their interest in problem-solving, as mentioned by John, “There were a lot of complex elements, it didn’t feel tedious”. Similarly, Sally explained interest as developing over time, stating, “As I felt more confident, I was more interested but not inherently interested,” indicating the situational interest grew through continued engagement with the problem-solving tasks. Taking together these patterns, low NFCC participants experienced situational interest as dynamic, which develops through meaningful involvement rather than immediate task closure.

Theme 2: Skill is Experienced as Developable and Constructed through Engagement

Low NFCC participants’ skill in problem solving was emergent, not fixed, developing through interaction with the problem. Initial uncertainty did not lead to disengagement; instead, the ambiguity in the problem component led the participants to analyze the task in-depth, recall relevant knowledge, and adjust their approaches. For example, John stated that “Initially, no, as I started to actually analyze the circuit, maybe I am kind of skilled,” illustrating that problem complexity did not evoke discomfort during the initial stage of the problem-solving process. The participants also did not seek early closure, even though they initially perceived themselves as unskilled. Similarly, Sally reported feeling “quite skilled” during numerical problem-solving, while also acknowledging less confidence in recalling information from memory. This shows that skill was context-dependent and also depends on the characteristics of the task. Max reflected on the problem-solving process as “I felt like I knew what I was doing… I went on the wrong path… but got where I needed to be,” demonstrating the capacity to revise their approach and return to productive problem solving rather than quitting. Collectively, these accounts suggest that low NFCC participants’ skill as an ongoing problem-solving skill-development process by working through uncertainty and ambiguity. They rely on internal cognitive and logical development and iterative reasoning to develop competence.

Theme 3: Challenge is Tolerated as Conceptual Exploration

Low NFCC participants consistently approached the challenge as an opportunity for conceptual exploration, tolerating ambiguity and resisting the urge to rush to a conclusion. Across multiple cases, challenges were associated with thinking deeply, restructuring the problem, and reflecting on reasoning, rather than with time pressure or discomfort. Multiple participants described the challenge in terms of moving beyond the surface features of the task. For example, when John was asked, “Did you feel challenged while solving the problem?”, he stated, “I think the most challenging thing was for me was moving past just what the circuit looked like,” indicating the challenge or difficulty in interpreting the system behavior beyond what was being given. Echoing this, Eric talked about the difficulty of the circuit as, “Breaking down the circuit into a normal looking one was really weird.” But these challenges were manageable and motivating for them rather than discouraging. As Sally said explicitly, “Yes. It was a challenging problem, it means. Yeah, like definitely have to be thoughtful about it but Again, not impossible. Just have to be thoughtful.” distinguishing effort from frustration. This suggests that Low NFCC students' situational engagement is supported by tolerance for ambiguity, delayed closure, and sustained engagement with conceptual challenge during problem solving. This finding also indicates a key characteristic of students with Low NFCC: the greater the challenge, the more eager they are to solve the problem.

Case 2: High NFCC Students

Three major themes were developed that represent the situational engagement of high NFCC students during problem solving.

Theme 1: Interest is Contingent on Clear Directions and Problem Structure

High NFCC participants' interest was dependent on a clear problem structure and directions. Interest increased once they understood the problem, identified a clear solution path, or began to see the progress towards completion. Lack of clear directions or ambiguity often coincides with little initial interest, which only increases with clarity. Several participants described this transition when asked, "were you interested in what you were doing?" Faber responded, "I wasn't interested at all, but once I started was in the problem thinking about it, it became a little bit more interesting". Similarly, Wayne's interest was tied to the understanding of the problem as "how the two voltages would play with each other". For Zack, interest was framed less around the topic and more around the problem-solving process.

In addition, high NFCC participants often grounded interest in the utility and task value. For example, Harry described the problem as interesting: "I thought that this problem was very applicable to what I've been learning," indicating that their interest is governed by the relevance and the usefulness of the task. Overall, these patterns suggest that high NFCC students' interests are regulated by the mental clarity and usefulness of the task rather than by ambiguity or complexity that appears in task components or structure.

Theme 2: Skill is Experienced as the Correct Application of Tools and Procedures

The perceived skill of high NFCC participants was associated with having the necessary tools for problem-solving and applying them correctly in the problem-solving process. They mostly perceive skill as procedural correctness rather than a developmental process through exploration. Participants frequently emphasized correctness, validation, and accuracy rather than rationalizing, meaning-making, and logical progression. Once they felt that there was sufficient structure or understanding of problem-components, they felt skilled enough to complete the task accurately. Several participants described feeling unskilled at the start but reported increased confidence only after making progress or gaining clarity. When Faber was asked, "Did you feel skilled at what you were doing during this problem-solving activity?", he responded, "At the beginning, no. But once I started making progress, I felt more skilled". Similarly, Wayne stated, "Yeah, I did. Not at first. But I think now, I'm kind of understanding what it was asking for," showing perceived skill increased as understanding improved.

Procedural uncertainty was exhibited by some participants while talking about their skills. For instance, Harry said, "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". Zack also emphasized this orientation by stating, "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 suggests that high NFCC students experienced skill as conditional on validation and correctness rather than as an evolving cognitive capacity.

Theme 3: Challenge is Experienced as Unfamiliarity and Uncertainty

The uncertainty about task correctness emerged as the biggest challenge for high NFCC participants. Difficulty was most salient when students were unsure whether they were applying the correct equations, interpreting the problem accurately, or progressing toward a valid solution. Participants felt challenged early in the task before understanding was established. When the participants were asked, "Did you feel challenged?", most of them responded that it was a challenging problem, but the challenge stemmed primarily from uncertainty about the correctness and appropriate solution paths rather than from conceptual difficulty itself. High NFCC participants demonstrate comparatively less eagerness to explore the problem-solving process through exploration, because the challenge in problem-statement cognitively impedes them from looking for a possible problem-solving path. Wayne talked about the challenge in terms of the "new problem," although "I've seen similar problems", described the challenge as emerging when a problem deviated from familiar structures or expectations. Zack also talked about the challenge as:

> *"I would say the main challenge is just being able to conceptualize in this problem specifically the how the different elements and states interact with one another because I know, especially I feel like the steady states are easier to analyze because it's more straightforward, but it's when things change that being able to conceptualize what happens immediately after the change is more challenging."*

This suggests that the challenge was experienced most strongly when familiar and stable structures were disrupted, requiring students to reason under uncertainty. These participants frequently felt challenged due to unfamiliarity and uncertainty about the procedural correctness. For example, Harry explained that the task was challenging because "I just didn't know exactly which equations to use, and kind of I had to figure out the step-by-step process. So that was challenging. And I don't necessarily know if I did the problem right," emphasizing difficulty in establishing a clear procedural structure. Notably, the challenge was closely tied to uncertainty about correctness. These patterns indicate that High-NFCC students perceived challenge as an obstacle linked to uncertainty. They are motivated by the efforts to reduce ambiguity and reach a correct solution with little exploration to follow different problem-solving paths.

5. Discussion and Conclusion

This study aims to explore how students with different profiles of epistemic motivation, i.e., low and high NFCC, exhibit situational engagement operationalized as interest, skill, and perceived challenge, during an engineering problem-solving task. The quantitative analysis revealed no statistically significant differences in students' situational engagement across four time points for either low or high NFCC participants. This finding could suggest relative stability in engagement; however, the descriptive statistical analysis and qualitative findings provide a more nuanced and in-depth interpretation of problem-solvers' subjective experience. Importantly, the descriptive trends (Figure 1) revealed meaningful fluctuations in all the dimensions of situational engagement for both low and high NFCC participants. Low NFCC participants demonstrated engagement patterns characterized by stabilized interest, emergent perceived skill, and sustained engagement while facing challenge in the problem-solving process. This result aligned with the profile of low NFCC participants in earlier research in terms of tolerance of ambiguity and continued exploration in the face of uncertainty during problem solving [8], [10]. High NFCC participants' situational engagement was regulated by clear problem structure and the clarity in task completion procedures; perceived skill was closely tied to procedural correctness and validation, and perceived challenge was driven by uncertainty about correctness, unfamiliarity within problem structures, and ambiguity in solution paths. Kruglanski and Webster [8] also mentioned in their findings about the preference for a structured approach by high NFCC participants, which leads to their decreased persistence in open-ended problems. Moreover, some external factors can heighten the dynamic interactions between NFCC and situational engagement, including task laboriousness [20], time constraint [21], noise, or fatigue [11].

The present findings align with prior research distinguishing low and high NFCC students' engagement during problem solving. Importantly, examining engagement situationally allowed these established NFCC patterns to be observed as dynamic engagement processes rather than static tendencies. By measuring interest, perceived skill, and perceived challenge at four distinct time points, this study reveals how NFCC shapes students' engagement as problem-solving unfolds. Rather than manifesting uniformly, differences between low and high NFCC students emerged at specific moments of uncertainty, sense-making, and resolution, highlighting engagement as a temporally situated experience. This approach reveals when engagement increased or diminished and how students regulated their engagement in response to task demands. For example, low NFCC students exhibited relatively stable perceptions of challenge across time, suggesting sustained tolerance for ambiguity and conceptual difficulty, whereas high NFCC students experienced pronounced fluctuations in challenge, particularly during periods of uncertainty and unfamiliarity. These temporal patterns show when engagement increases, stabilizes, or fluctuates for low and high NFCC students, differences that are obscured when engagement is examined only at an aggregate level. These research findings suggest that instructional design should balance structure and ambiguity to support students with differing closure needs. A key limitation of this study is the small sample size, which limits the generalizability to broader student populations. Moreover, this research also provides grounding for further research on how NFCC interacts with problems that vary in structure and ambiguity. Future studies should explore the instructional supports or strategies that can stabilize students' engagement, especially for students with high NFCC who showed fluctuations in engagement during uncertain moments.

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