

Enhancing Student Engagement and Their Performance in Abstract Algebra Using Context Tasks

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Abstract: One of the biggest challenges in learning Abstract Algebra lies in the low level of student engagement caused by its high abstraction and lack of real-life context. This study aims to assess the effectiveness of contextual tasks in fostering students' cognitive, affective, and behavioral engagement, and its impact on academic performance. Through a qualitative case study approach with 35 students, the data were collected through observation, reflective journals, interviews, and pre-/post-tests. Thematic analysis demonstrated a substantial improvement in students' emotive and reflective engagement, as well as a critical reflection in learning abstract algebra. Students revealed their learning improvement in task focus, engagement, and a variety of problem-solving strategies, with an average increase of 27.3%. Additionally, students contended that context-based exercises enhanced their motivation, significance, and real learning experience. The findings validated that a context-based learning strategy effectively enhanced students' engagement and achievement in learning abstract algebra.

Keywords: student engagement; context tasks; abstract algebra learning, students' performance

INTRODUCTION

Student engagement has become a major focus in higher education research, given its crucial role in supporting academic achievement, retention, and long-term learning success (Miller et al., 2021; Fokkens-Bruinsma et al., 2021). Sustaining student engagement becomes a significant challenge in mathematics, particularly in esoteric disciplines such as Algebra. Emotional and cognitive detachment between pupils and abstract mathematical concepts is often a result of the subject's high level of abstraction and its limited connection to real-world contexts (Jurdak, 2016; Núñez, 2020). OECD (2023) also underscores the need for making mathematics education more meaningful through the connection between mathematical knowledge and real-world situations. Similarly, Pires et al., (2022), the failure to make connections between abstract mathematical ideas and practical experiences constitutes an important predictor of disengagement and poor conceptual knowledge among students. On the other hand, traditional Abstract Algebra teaching approaches often focus exclusively on the formal development of mathematical structures without placing sufficient emphasis on a real-world connection (Stewart et al., 2019). This issue often hinders students' ability to comprehend the relevance of their learning. as a result, students often perceive

their studies in Abstract Algebra as disconnected from professional practice and everyday social life (Kieran, 2020; Sheppard and Wieman, 2020).

The challenges in 21st-century mathematics education can be divided into two primary aspects: the necessity to develop 21st-century learning skills, such as collaboration, communication, creativity, and problem-solving, and insufficient conceptual understanding and disparities in learning achievement (Kim et al., 2019). The problems are further exacerbated by the overwhelming prevalence of traditional mathematics education methods that prioritize procedural knowledge and rote memory over the development of conceptual comprehension and critical thinking skills. The abstract nature of the material in Abstract Algebra exacerbates these issues, as it frequently lacks direct relevance to students' real-world experiences, resulting in reduced engagement and motivation to study (Barbieri and Miller-Cotto, 2021; Asada et al., 2024). Carson and Rowlands (2007) noted that the instructional failure to establish a connection between formal symbolism and conceptual meaning leads to a significant number of students solely "memorizing definitions" rather than developing a profound conceptual understanding. As a result, a new approach is necessary to establish a connection between the practical experiences of students and abstract mathematical theory. The contextual tasks approach holds significant potential as an effective instructional strategy. This approach emphasizes the execution of context-driven tasks that are significant and relevant, thereby facilitating the practical development of conceptual comprehension in students (Treagust and Duit, 2008). In this research, for Indonesian mathematics education undergraduate students, the use of a context that is culturally relevant to them, namely batik designs, provided a tangible starting point to delve into abstract notions in algebra, such as group theory and symmetry structure (Mamolo and Glynn-Adey, 2023).

Additionally, contextual task-based learning can enhance students' cognitive, affective, and behavioral engagement by emphasizing active exploration, collaborative discourse, and real-world problem-solving (Wu et al., 2015; Jurdak, 2016; Pambudi et al., 2025). This methodology is designed to meet the needs of 21st-century education, which emphasizes interactive, reflective, and sophisticated problem-solving learning experiences (Antonenko et al., 2014; Tan and Nie, 2015). While contextual task-based learning has been extensively validated in elementary and secondary mathematics education, research explicitly examining its application in Abstract Algebra at the higher education level remains limited. This gap underscores the urgent need to investigate how the contextual task approach can enhance students' multidimensional engagement and foster deeper conceptual understanding in advanced mathematics.

Referring to the gaps identified above, the following research questions are proposed:

1. How can context-based tasks enhance students' behavioral, emotional, and cognitive engagement in Abstract Algebra learning?
2. How can context-based tasks foster students' performance in Abstract Algebra learning?

Literature Review

Challenges in Learning Abstract Algebra

Abstract Algebra learning often faces fundamental challenges stemming from its high level of abstraction and lack of connection to students' real-life contexts. Many students struggle to understand structures such as groups, rings, and fields because teaching approaches tend to be formalistic and symbolic, without the support of visual representations or contextual applications (Stewart et al., 2019). This creates a gap between students' mathematical concepts and conceptual understanding, which in turn results in low motivation and active participation (Barbieri and Miller-Cotto, 2021). The disconnect between formal symbols and intuitive meanings not only hinders deep understanding but also encourages mechanistic and rote-based learning (Carson and Rowlands, 2007). Further, conventional approaches to teaching Abstract Algebra are considered inadequate to meet the pedagogical demands of the 21st century. Furthermore, these challenges are compounded by students' lack of emotional and cognitive engagement with abstract material. Data from the (OECD, 2023) shows that more than 60% of students consider advanced mathematics irrelevant to their lives, especially in abstract areas such as Algebra. When concepts are not connected to students' social, cultural, or real-world experiences, the potential for critical and reflective engagement decreases drastically (Jurdak, 2016). This has direct implications for learning outcomes, as emotional and cognitive engagement have indicated strong predictors of conceptual understanding and academic achievement (Fredricks et al., 2019). Consequently, it is important to develop learning approaches that can bridge formal abstraction and concrete experiences for students in order to increase engagement and effectiveness in learning Abstract Algebra.

Students Engagement and Its Measurement

The concept of student engagement has evolved into one of the key constructs in modern educational research. Fredricks et al. (2004) suggest that engagement is multidimensional, encompassing behavioral, emotional, and cognitive engagement. Behavioral engagement is characterized by attentiveness, attendance, social collaboration, and active participation in academic activities (Nguyen et al., 2018; Gomes et al., 2023). Emotional engagement refers to students' affective responses to learning, encompassing feelings of interest, satisfaction, and a sense of belonging within the learning community (Luo et al., 2017). Cognitive engagement refers to the intellectual commitment, application of metacognitive methods, and perseverance of students when they encounter academic challenges (Park and Yun, 2018; Pohl, 2020).

Recent study posits that cognitive engagement is the most significant feature of engagement for the advancement of deep learning and critical thinking (Sakeef et al., 2025). A study by Fredricks et al. (2019) showed that behavioral and emotional engagement serve as important motivational bases to support meaningful cognitive engagement. In other words, students who feel emotionally connected to their learning environment and are behaviorally engaged are more likely to demonstrate persistence in analytical and reflective thinking, which ultimately drives long-term academic achievement (Tas, 2016). These three dimensions of participation are interrelated within the social

environment of learning, as per Vygotsky and Cole's (1978) theory of social constructivism. Cognitive engagement is enhanced by collaborative dialogues, affective engagement is enhanced by nurturing emotional environments, and behavioral engagement is promoted by robust social interactions (Pineda-Báez et al., 2019). Research by Gillies (2019) also confirmed that productive dialogue in the classroom acts as a primary means of building deep cognitive engagement. Thus, in a contextual task-based learning approach, activity design must consciously integrate these three forms of engagement to create authentic and empowering learning experiences.

Student engagement is a multifaceted concept that includes behavioral, cognitive, and emotional dimensions (Fredricks et al., 2019). Engagement is not a singular theoretical construct that can be easily quantified with precision. Various methodologies, including self-reporting, observation, and task analysis, have been employed; nevertheless, each possesses inherent limitations. Surveys represent the predominant methodology (Bond et al., 2020), however their validity is frequently scrutinized (Hodgson et al., 2017). A triangulation strategy integrating quantitative and qualitative data is strongly advised to more correctly and comprehensively capture student participation (Phillips and O'Flaherty, 2019). Within the domain of context-based tasks the evaluation of participation is essential in the field of Abstract Algebra, despite the fact that it is not frequently investigated in current research. The majority of previous research has either focused on a single aspect of interaction or has examined it in a generalized manner without differentiation (Lo and Hew, 2021; Carmichael et al., 2017). This study adopts the classification of indicators from Fredricks et al., (2019) enriched by Cevikbas and Kaiser (2022), to examine in depth how context tasks affect student engagement in each of its dimensions—behavioral, cognitive, and emotional. Table 1 below presents the indicators of student engagement used in this study. These indicators are designed to comprehensively capture students' responses during the learning process involving contextual tasks and serve as the foundation for developing observation instruments and in-depth interview guides.

Engagement Indicator	
Behavioral	Persistence, focus on task, effort to learn, high grades, preparation before class, asking and answering questions, seeking support/teacher/friends, discussion and group work, avoiding disruptive behavior
Cognitive	Thinking aloud, planning learning, choosing challenging tasks, proving & disproving, independent working style, giving evaluation, solving problems differently, self-monitoring, becoming an expert, being aware of learning goals, searching for information, correcting mistakes, linking topics, remembering & applying knowledge
Emotional	Interest, comfort, happiness, enthusiasm, pleasure, satisfaction, willingness, sense of responsibility, self-confidence, motivation and concentration in learning

Table 1. Student engagement indicators

Context Task in Mathematics Learning

The use of context tasks in mathematics learning has developed as a pedagogical strategy designed to connect abstract concepts to real-world situations that are meaningful to students. Unlike simply presenting real-world problems, context tasks involve the construction of complex meanings between the description of the situation in the task (figurative context) and the conditions of student interaction while working on the task (interactive context). Wernet (2017) emphasizes that it is important to distinguish between the context offered by the classroom task and the personal context that students construct through that interaction. The interaction between these two dimensions significantly impacts the level of student engagement in the task. As noted by Lozano (2017), context is not fixed or universal in its interpretation. That is, not all students will engage equally with the figurative context of a task. Factors such as lack of prior experience (Liang and Moore, 2021), uninteresting context, or the expectation that context is only used to “wrap” the mathematical problem (Lester Jr and Cai, 2016) can inhibit student engagement. In fact, some students may feel compelled to quickly leave the context after identifying the mathematical aspects of the task. However, it is important to recognize that low contextual engagement does not necessarily correspond directly to poor performance, just as high engagement does not automatically guarantee improved outcomes (Shimazu et al., 2015). In this regard, context tasks present a pedagogical challenge in balancing context load with students’ cognitive load.

In contrast, environments that are structured in a pedagogical manner can serve as catalysts for significant learning experiences. Chevallard and Bosch (2020) proposed that the acquisition of mathematical knowledge should begin with contextual issues that students can authentically envision and experience, as a result of the Realistic Mathematics Education theory. Reinke and Casto (2022) substantiated this viewpoint by asserting that contextual assignments promote conceptual reinvention through exploration and social discourse, in addition to engaging students. Context functions as an epistemic framework that facilitates the development of mathematical meaning. The intricate abstraction of concepts such as groups, rings, and fields frequently presents obstacles to students’ comprehension in advanced academic subjects like Abstract Algebra. Studies by Hall-dén et al., (2013) underline that the gap between formal symbolism and conceptual intuition can be overcome through the integration of context tasks. For example, the use of symmetry contexts in art, cryptography in digital security systems, and social network structures provide more accessible conceptual starting points. This is in line with the findings of Carruthers and Worthington (2005) which show that abstract understanding can be strengthened by building mental representations of symbolized concrete experiences.

Additionally, contextual activities contribute to the improvement of cognitive flexibility and adaptive reasoning, as demonstrated by Siqu-Liu and Egner (2020). Voigt (2013) argues that effective learning occurs through the negotiation, discussion, and interaction of meaning within a social environment, as a result of a social constructivist perspective. In a context-driven Abstract Algebra course, students generate meaning through collaborative discourse that connects the actual world to formal mathematical frameworks, as well as independently. Nathan and Alibali (2021) posited that the transition from tangible experience to abstract comprehension is a dialectical process that

improves the mathematical cognition of students. The literature suggests that, despite the challenges associated with interpretative variability, cognitive load, and inconsistent engagement that contextual tasks present, this methodology has the potential to significantly improve student engagement and performance, particularly in advanced mathematical disciplines such as Abstract Algebra. As a result, the efficacy of contextual activities in higher mathematics education is contingent upon the explicit integration of context into mathematical comprehension and the pedagogical design that recognizes the diversity of students' backgrounds.

METHOD

Research Design

This study employed a qualitative exploratory case study approach, which was very suitable for exploring students' behavioral, emotional, and cognitive engagement in the context of contextual task-based Abstract Algebra learning. We employed a case study approach because it can reveal how engagement works in real life in great detail (Toogood, 2023). This perspective on engagement viewed it as a complex process influenced by social interactions, task design, and real-life learning experiences."

Participants

The participants in this study involved 35 students in the Mathematics Education study program at a state university in Indonesia. The selection of participants was carried out through a purposive sampling technique by considering several criteria, namely students who have completed elementary linear algebra courses, demonstrated readiness to participate in contextual task-based learning, and have access to basic technological devices such as smartphones or laptops to support online learning activities. The purposive sampling technique was chosen because it enabled the researchers to strategically select participants most relevant to the study's focus, who could provide rich and in-depth information (Etikan et al., 2016). Additionally, third-year students were selected because, at this stage, they had already acquired a sufficient theoretical foundation in abstract mathematics while remaining in an active phase of conceptual development, allowing for clearer observation of their responses to innovative learning interventions. Before participating in the study, all participants were provided with detailed information regarding the objectives, procedures, and their rights as subjects, and they gave their informed consent in accordance with the ethical principles governing educational research (Christenson et al., 2014).

Research Setting

This study was conducted for eight weeks at the same state university in Indonesia where the participants were enrolled. The research setting was designed to facilitate the implementation of flexible and meaningful context-based tasks. In the first two weeks, data were collected using a

pre-test and non-intervention observations of student engagement in conventional Abstract Algebra learning. Task-based learning in context took place from weeks three to six using real-life examples such as analyzing symmetry in batik and wallpaper patterns using the concept of symmetry groups. These tasks were varied based on the degree of contextualization, namely the extent to which contextual and mathematical elements are integrated with each other (Son and Goldstone, 2009; Juniati and Budayasa, 2017). In class, students worked on group discussions and assignments that were relevant to the lesson. Outside of class, they wrote daily notes to reflect on what they had learned and worked on micro projects that were also relevant to the lesson. We obtained post-intervention data in the seventh and eighth weeks through a post-test, in-depth interviews, and an examination of reflection notes to see how students' behavioral, emotional, and cognitive engagement had changed. This environment was constructed based on the concepts of social constructivism, emphasizing the necessity of collaborative contact, contextual mediation, and critical reflection in creating conceptual knowledge (Vygotsky and Cole, 2018).

Learning Procedures

The objective of this study's learning approach was to enhance student engagement and performance in grasping abstract topics by incorporating contextual assignments directly into classroom activities in the Abstract Algebra course. The learning design was divided into two primary segments: in-class activities and post-class activities. These phases were designed to establish a reflective and contextual learning cycle through collaboration. During the in-class phase, the learning activities were centered on the investigation of context-specific issues that were formulated with varying degrees of difficulty, familiarity, and contextualization—the extent to which the mathematical model and the context were interwoven. During these sessions, students worked in small groups to complete contextual assignments and engage in discussions regarding abstract algebraic structures, such as rings, fields, and groups. For example, in one assignment, students were directed to analyze symmetry patterns in geometric art in order to identify group structures (Figure 1). In another, they evaluated relationship models in social networks to understand the concept of homomorphism. The teacher functions as a scaffolder and facilitator of conceptual discourse, encouraging open discussion, the elucidation of concepts, and the contemplation of the relationship between mathematical representation and context. Through intellectual challenge, collaboration, and the exploration of personally meaningful content, this approach enhanced students' cognitive, behavioral, and affective engagement.

The post-class phase aimed to reinforce internalization of concepts and encourage metacognitive reflection. Students were requested to create digital diaries documenting their thinking processes, problem-solving strategies, and how they could interpret and relate them to the algebraic concepts. In addition, they completed context-based mini-projects that incorporated key concepts—such as building a simple encryption model based on group structures or analyzing the geometric symmetry of physical structures—to demonstrate their applied understanding. The entire procedure was designed in line with (Vygotsky and Cole, 2018) principle of the Zone of Proximal Development (ZPD), in which tasks were structured to be slightly beyond students' actual abilities but still

manageable through collaboration and social support. This context-based approach not only provided realistic cognitive challenges but also encouraged students to think flexibly, reflectively, and transformatively in relating abstract mathematics to real-world phenomena.

Task-1: Batik Frieze Design

Batik is one of Indonesia's cultural heritages that is highly valued by the community; besides being beautiful, batik also contains deep meaning and strong cultural identity. Many batik patterns are actually composed of mathematical transformations. One interesting type of pattern is the frieze pattern — a pattern of paths that repeats continuously in one direction.

In this assignment, you will explore local cultural motifs from your respective regions, such as the clove flower motif from the Tulungagung area, or the damar kurung motif from Gresik. Choose one cultural motif from your region and one mathematical object. Use the motif of your choice to design Batik, with a frieze pattern that contains symmetry operations such as translation, rotation, reflection, and glide reflection.

Choose one basic motif that has the potential for symmetry. Then, arrange the motif in the form of a repeating frieze pattern, ensuring that all patterns meet the properties of a group: closed, associative, identity, and each element has an inverse. Use the following application <http://math.hws.edu/eck/js/symmetry/frieze.html>, to help your design.

Figure 1. Context tasks- Batik Frieze Design

Instruments

This study used four different types of data gathering tools that were meant to work together to get a whole picture of how engaged students were in contextual task-based Abstract Algebra learning. First, the observation sheets were prepared based on the engagement behavior, emotion, and cognition markers as outlined in Fredricks et al., (2019), which were used to conduct non-participatory classroom observations. These observations looked at how students interacted with each other, how they participated in conversations, how they expressed their feelings, and the critical thinking skills they used while learning. Second, student diaries were collected to look at how students thought about their learning experiences, how their motivation changed, and how they saw the importance of contextual activities. This method is based on diary studies, which are good at showing how students feel and think on a daily basis (Zimmerman and Schunk, 2011). Third, a specific group of 12 students were chosen to take part in semi-structured interviews. The goal of these interviews was to have a better understanding of how students feel about their participation, working together, and how adding context might help them understand abstract ideas. The interview protocol was developed based on the principles of exploring affective and cognitive experiences in higher education (Anderson et al., 2022). Fourth, the post-test was in the form of a written test to measure changes in student performance. Each instrument was designed to meet the principles of validity and reliability, with content validity testing by three mathematics education experts and instrument trials prior to the implementation of the main study. With a combination of data from observations, written reflections, in-depth interviews, and post-tests, this study attempted to build strong source triangulation to increase credibility and confirm the findings (Cresswell, 2013).

Student Interviews

We did semi-structured interviews with stimulated recollection just after the students finished a contextual activity that used modulo arithmetic to check the legitimacy of products and analyze the symmetry of traditional batik patterns in groups. Students were asked to watch videos of the task being done along with written scripts and then redraw relevant diagrams or patterns, like verification codes or batik symmetry shapes, to show that they understood the problem and how to use the algebraic ideas that were used. The interviewer could see and hear how students' comprehension changed by using video as a stimulus. For example, they could see how students connected the congruence class structure to the digital coding system or how they recognized symmetry transformations as parts of the group structure. This process showed how well students could build meaningful conceptual understandings and actively engage with the figurative context of the task. It also tested how well the contextual approach worked to improve their engagement and performance in learning Abstract Algebra.

Data Analysis Techniques

The systematic discovery of meaning patterns within qualitative data was facilitated by the thematic analysis method established by (Braun and Clarke, 2025), which was employed in the data analysis of this study. The analytical process consisted of six stages: (1) Familiarity with the data is achieved through the iterative examination of interview transcripts, observational notes, and student reflections. (2) Preliminary codes are formulated from indicators of behavioral, emotional, and cognitive engagement. (3) Initial themes are identified from the clusters of codes. (4) Themes are evaluated to confirm internal consistency and differentiation. (5) Themes are delineated and designated to convey essential meanings. (6) An interpretive report is compiled that associates themes with the theoretical framework of student engagement. Two independent analysts participated in the data coding procedure to improve the credibility and reliability of the analysis, and Cohen's Kappa coefficient was employed to evaluate intercoder reliability. McHugh, (2012) interprets a Kappa score of 0.91 as indicating a very high degree of agreement. Additionally, source triangulation techniques (interview, diary, observation, and conceptual testing) were implemented to verify the consistency of the results across a variety of data types. Birt et al., (2016) further validated the analysis results by conducting member verification, which involved a review of the interpretation of the findings by a large number of participants to verify the veracity of the portrayal of their experiences. The exhaustive study was conducted using NVivo to systematically manage extensive data, thereby improving the efficiency of monitoring codes, themes, and interrelations among data.

RESULTS

This study aims to explore how a contextual task-based learning approach affects students' behavioral, emotional, and cognitive engagement in Abstract Algebra learning. Data were collected from four sources: classroom engagement observations, student reflection diaries, semi-structured interviews, and pre-test and post-test results of conceptual understanding. The triangulation process between data sources produced a holistic picture of changes in student engagement patterns during

the implementation of context-based tasks. In general, there was a consistent increase in all three dimensions of engagement, with variations in patterns across individuals and groups.

Enhancing Student Engagement in Abstract Algebra through Context-Based Tasks

Behavioral Engagement

The implementation of context-based learning significantly increased students' behavioral engagement in the Abstract Algebra learning process. Observation data, daily reflections, and in-depth interviews indicated that students were not only physically present, but also showed increased active participation, responsibility, and initiative in collaborative learning. At the beginning of the intervention, only 43% of students were actively involved in group discussions. However, within two weeks of the integration of contextual tasks, participation increased drastically to 82%. This involvement included the initiative to ask questions, answer questions, provide feedback, complete tasks collaboratively, and show enthusiasm in contributing ideas. One real example occurred in the "Symmetry in Traditional Batik" task session, where previously passive students began to take strategic roles in group discussions.

"S1-asked critical questions to his peers, encouraging discussion about how the symmetry pattern in batik can be modeled as a mathematical group" (Observation, Week 4).

This phenomenon marked a shift in attitude from passive presence to meaningful active involvement. Not only did participation increase, but the commitment to attendance also showed a positive trend—from 74% full attendance before the intervention to 91% during the contextual task period.

Student reflections revealed a transformation in attitudes toward attendance and learning responsibility. One student wrote,

"Usually I just come to fill in the attendance. But when the assignment about batik symmetry was given, I really wanted to come and discuss, because I felt my ideas were also important" (S2, Diary, Week 5).

In-depth interviews reinforced these findings; students felt that the context-based assignments gave them a "real reason" to engage. Most stated that this approach made learning more relevant, challenging, and encouraged equal interaction within the group. Teachers also noted that students were more proactive in asking for clarification and expressing ideas, and avoided unproductive behaviors that were previously common in traditional classes.

Behavioral Engagement Indicator	Increase		Decrease		Do not change	
	n	%	n	%	n	%
Persistence	26	74%	1	3%	8	23%
Focus on the task	27	77%	2	6%	6	17%
Learning effort	26	74%	1	3%	8	23%
High scores (indication of group assignment results)	24	69%	2	6%	9	26%
Preparation before class	25	71%	1	3%	9	26%

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Ask and answer	26	74%	3	9%	6	17%
Asking for support from teachers or friends	23	66%	3	9%	9	26%
Discussion and group work	27	77%	1	3%	7	20%
Avoiding disruptive behavior	25	71%	2	6%	8	23%

Table 2. Changes in Student Behavioral Engagement Through Context Tasks Intervention

Emotional Engagement

The results showed that context-based learning generally increased students' emotional engagement in Abstract Algebra lessons. Of the 35 participants, most students reported increased enthusiasm (n=30), enjoyment while learning (n=24), concentration in learning (n=23), and sense of responsibility for learning (n=23). This was supported by active interaction during problem solving, the use of contextual media, and group work that allowed students to learn more flexibly and meaningfully. In addition, students stated that they felt more comfortable (n=24), more confident (n=20), and more competent (n=20) in understanding abstract mathematical concepts. Activities such as real-world context exploration, group discussions, and task reflections helped them feel valued and cared for individually. As expressed by one student, "I used to be shy to ask questions, but now I feel more comfortable answering even if the answer is wrong." However, a small number of students (around 9–12%) found it difficult to adjust at first, mainly because they were used to passive lecture methods and were not ready to take full responsibility for their learning.

Emotional Engagement Indicator	Increase		Decrease		Do not change	
	n	%	n	%	n	%
Enthusiasm	30	86%	1	3%	4	11%
The joy of learning	24	69%	2	6%	9	26%
Concentration on studying	23	66%	3	9%	9	26%
Sense of responsibility for learning	23	66%	1	3%	11	31%
Happiness	22	63%	3	9%	10	29%
The spirit of learning mathematics	22	63%	3	9%	10	29%
Motivation to learn	22	63%	3	9%	12	34%
Convenience when learning mathematics	24	69%	5	14%	8	23%
Satisfaction with mathematics learning	21	60%	1	3%	13	37%
Self-confidence in mathematics	20	57%	3	9%	12	34%
Self-confidence in mathematics	20	57%	5	14%	10	29%
Interest in learning mathematics	19	54%	3	9%	13	37%

Table 3. Changes in Students' Emotional Engagement through Context Tasks Intervention

S1 – From class observation notes and student journals: "I feel more interested when learning algebra with assignments that are related to real situations. When the teacher gives questions related to transportation systems or social patterns, I understand and enjoy the learning process better. I no longer just memorize formulas, but feel like I am solving real problems. That makes me more enthusiastic about participating in discussions."

S2 – During individual interviews: "I used to be rarely active in class, afraid of making mistakes and being embarrassed. But when we worked in groups and were asked to create solutions with

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friends, I became more confident. Even though my answers were sometimes wrong, the teacher still appreciated them and my friends also helped me improve them. It felt comfortable learning like that, I was no longer afraid."

S3 – In group discussions: "I used to get bored when learning algebra because there were many difficult terms. But now it's different. When the assignments are related to real life, such as questions about asset division or encryption systems, I actually become curious. I even started to like learning mathematics, even though I used to avoid it."

S4 – From a female student interview: "In a regular class, I just listen to the teacher talk and take notes. Now, I have to be active, sometimes presenting in front of my friends. At first it was stressful, but after a while I started to like it because I could express my opinion and it turns out I can. This makes me more confident."

S5 – From a student journal: "When we were asked to make a small project from a math problem we found at the market, I felt like I was doing real research. It was fun and made me feel important. I usually don't like math, but now I look forward to algebra class."

Cognitive Engagement

Students' cognitive engagement indicated a very significant increase during the implementation of context-based Abstract Algebra learning. Data from daily reflections, classroom observations, and interviews revealed that most students actively invested their intellectual efforts to understand, evaluate, and relate abstract concepts to contextual representations. Students not only memorized definitions and repeated procedural algorithms but also began to develop higher-order thinking skills, including constructing proofs, modeling, and logically mapping relationships between concept. As many as 83% of students reported an increase in their ability to solve problems with various approaches. One student noted,

"I can solve one problem in several ways, because I learned to see the problem from different sides" (S1, reflective journal).

Prior to the intervention, their learning approach was predominantly mechanistic, characterized by memorizing axioms and algebraic properties without fostering deep understanding. However, after several weeks of engagement in contextual tasks, a marked cognitive transformation occurred. Students began to ask critical questions such as:

"If the symmetry operation in this batik satisfies the associative and identity properties, do all batik patterns necessarily form a group?" (Group Discussion, Week 5).

Another student also stated, *"I realize this concept is not just a theory. I can relate it to art and culture" (S2, group interview)*, indicating that they began to actively transfer abstract concepts into the local cultural context. This process was reinforced through mathematical visualization activities, such as the frieze symmetry design based on the clove motif. Students stated that they integrated rotations and reflections to ensure that the patterns satisfied the group axioms. In a reflective note, one student wrote,

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“I arranged the rotation and reflection sequences as part of the group, and tried to ensure that the entire batik pattern still fulfilled the associative properties and had elements of visual identity” (S5, diary).

This narrative showed that students not only understood the concept formally, but also presented it creatively and contextually.

One form of implementation of cognitive involvement could be viewed from the results of students' work in designing frieze batik patterns based on symmetry groups. In this assignment, students were asked to develop visual designs by combining local cultural elements and mathematical transformation notations. One student produced a design that contained a repeating frieze pattern, integrated rotation and reflection as elements of the group, and explained that the structure follows associative properties and had the elements of visual identity.



Figure 2. Frieze design by integrating rotation and reflection elements in symmetry groups.

Furthermore, students' creativity in linking mathematical concepts with local culture enriched their cognitive engagement. One of the prominent results was the frieze design based on the clove motif typical of the *Tulungagung* region. Students identified translation and reflection patterns in the repetition of the clove flower motif, while maintaining the nature of the group structure in their design.



Figure 3. Frieze design with clove motif from the Tulungagung (Indonesia).

Context-based learning also enhanced metacognition and self-reflection. Many students realized that true understanding was not just about memorizing, but constructing meaning.

“I thought I understood because I could answer the questions. But when I was asked to explain why the structure was a group, I had difficulty. Now I am more reflective and start to test my own understanding” (S3, class discussion).

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Another student added,

“I started to look for my own references because the assignment challenged me to understand more than just the formula” (S5, end-of-semester interview).

This is in line with the increase in indicators such as self-assessment, evaluation of ideas, and seeking additional information (each increasing by 58–70% of students). Support from teachers also strengthens this finding. The teacher stated, *“Students ask ‘why’ and ‘how’ more often than just ‘what.’ They make connections between topics independently, which I rarely see in regular classes” (G1, class observation).* Even students who were previously passive began to actively engage in group discussions and correct each other’s understanding.

“I can see how my friends solve problems, then compare it with my way. I also often help correct if there is something wrong” (S6, interview).

This approach not only built deeper cognitive understanding, but also strengthened students' collaborative and reflective skills.

Overall, 74% of students showed an increase in the use of higher-order thinking strategies, such as conceptual analysis, logical argumentation, and mapping relationships between topics. This contextual task-based learning effectively shifted students' learning orientation from a surface approach to a deep learning approach, as idealized in advanced mathematics education.

Cognitive Engagement Indicator	Positive		Negative		Do not change	
	n	%	n	%	n	%
Solving problems in a different way	29	83%	0	0%	6	17%
Thinking aloud	26	74%	3	9%	6	17%
Remembering and applying previous learning	28	80%	0	0%	7	20%
Planning learning	25	71%	3	9%	7	20%
Trying to be an expert in mathematics	25	71%	1	3%	9	26%
Proving and refuting	25	71%	1	3%	9	26%
Looking for additional information	24	69%	5	14%	6	17%
Independent working style	24	69%	5	14%	6	17%
Giving evaluation to ideas	22	63%	3	9%	10	29%
Realizing the purpose of learning	22	63%	0	0%	13	37%
Connecting between topics	22	63%	0	0%	13	37%
Monitoring and self-assessment	21	60%	0	0%	14	40%
Recognizing and correcting errors	19	54%	0	0%	16	46%
Choose challenging questions	15	43%	1	3%	19	54%

Table 4: Changes in Students' Cognitive Engagement through Context Tasks Intervention

Results of Improving Student Performance

To evaluate the development of students' conceptual understanding in Abstract Algebra material, quantitative measurements were carried out through a pre-test before the intervention and a post-

test after context-based learning tasks. The average results of students' scores on three main conceptual aspects—Symmetry Group, Frieze Group, and Dihedral Group—showed consistent and significant improvements. Details of the data are presented in Table 5 below:

Topic	Skor Pre-test (Mean ± SD)	Skor Post-test (Mean ± SD)	Improvement
Symmetry Group	48.5 ± 12.4	76.2 ± 10.3	27.4%
Freeze Group	44.7 ± 14.1	72.5 ± 11.5	27.4%
Dihedral Group	41.2 ± 13.7	68.9 ± 12.2	27.3%

Table 5. Comparison of Pre-test and Post-test Scores of Abstract Algebra

Comparative analysis between pre-test and post-test scores indicated substantial conceptual improvement across all aspects. The average improvement of $\pm 27.7\%$ reflects a profound transformation in students' understanding, which is not limited to procedural mastery or memorization of formal definitions, but includes functional meanings of algebraic structures in real-world contexts. This finding is supported by qualitative data from post-intervention interviews. Many students reported that they only “saw” the real relevance of concepts such as symmetry groups or frieze transformations after working on tasks related to cultural artifacts, architecture, and everyday visual patterns. One student stated,

“Before, I only knew the definition of a group from a book, but now I can explain why rotations and reflections in batik can form groups. This is not just mathematics, it is also art.” (S7, interview).

Furthermore, students reported that they were able to relate mathematical operations to visual structures, evaluate group properties based on axioms, and explain the relationships between different concepts (such as identity and inverse) within a local cultural context. This not only reflected deeper conceptual mastery but also demonstrated strong knowledge transferability—a key indicator of meaningful learning in higher mathematics education. Overall, both quantitative and qualitative data suggested that the integration of contextual tasks successfully improved students' academic performance and fostered a conceptual understanding that was durable, reflective, and contextually grounded. These findings confirmed that context-based learning design played a critical role in bridging the gap between mathematical abstraction and authentic, meaningful learning experiences.

Summary of Key Findings

The results indicated that context-based learning significantly increased student engagement in three main dimensions—behavioral, emotional, and cognitive—and had a direct impact on improving academic performance in the Abstract Algebra course. In terms of behavior, students showed a clear increase in attendance, discussion participation, questioning initiative, and responsibility for group assignments, with a clear transition from passive to proactive learning behavior. Emotionally, students reported increased intrinsic motivation, self-confidence, and engagement

with the material, especially due to the relevance of the task context to their experiences and cultural identities, such as in the exploration of symmetry in batik motifs. In terms of cognitive, students showed a shift from a surface learning approach to a deep approach, with increased reflective, evaluative, and conceptual thinking skills that allowed them to flexibly link abstract theories to real-world situations. These qualitative findings are supported by quantitative data in the form of an average post-test score increase of 27.7% across all aspects of the material, reflecting a clear strengthening of students' academic performance. Thus, this study confirms that the integration of context-based tasks not only expands the space for student engagement multidimensionally, but is also an effective pedagogical strategy in shaping deeper, more meaningful, and sustainable mathematical understanding and performance in higher education.

DISCUSSION

The findings of this study clearly showed that context-based learning tasks significantly contributed to increasing student engagement in Abstract Algebra learning in three main dimensions: behavioral, emotional, and cognitive. These findings strengthen existing literature, such as those expressed by Podschuweit and Bernholt, (2018); Rubel and McCloskey (2021); Juniati and Budayasa (2021); and Juniati and Budayasa (2023), that context-based learning increases relevance, motivation, and builds a strong bridge between abstract concepts and students' concrete experiences. The increase in the average post-test score of 27.3%, as well as changes in learning behavior observed and reported through reflective journals, indicate that context tasks are not only an innovative approach, but also have a direct impact on academic performance. In addition, this finding suggests that the issues associated with mathematics learning pointed out by OECD (2023), particularly the inability of students to see the practical value of mathematics in real-life scenarios, could continue to be a problem even during university studies. The transformation of students' learning approaches from procedural to conceptual, as reflected in the increase in critical thinking skills, the use of metacognitive reflection, and concept mapping, is in line with the findings of Entwistle (2023) on the importance of encouraging deep learning approaches in higher education. Students not only memorize formal definitions of groups, rings, and fields, but also begin to build flexible conceptual schemes, transfer knowledge to new situations, and evaluate mathematical structures in the context of local culture.

Cognitively, students experience a transition from simply memorizing formal definitions to being able to construct flexible conceptual structures. They demonstrated critical thinking skills, evaluating mathematical structures in the context of local culture, and transferring knowledge to new situations—achievements that align with the deep learning framework proposed by Entwistle (2023). For example, in the frieze batik design task, students not only identified rotation and reflection as group elements, but also consciously arranged them to satisfy the group axioms—a concrete demonstration of high-level cognitive engagement. This activity reinforces the principle in Coles and Sinclair (2019), that mathematics learning becomes more meaningful when rooted in students' own visual, cultural, and social representations. Emotionally, student engagement was

evident through increased self-confidence, comfort in expressing opinions, and pride in mathematics learning that is relevant to local culture. These findings indicate that contextual learning not only touches on cognitive aspects, but also creates an emotional bond to mathematical content—which was previously often considered dry and far from everyday life. In this case, the role of emotional affiliation to the task becomes a trigger for active participation, as confirmed by students in reflective notes and in-depth interviews. This dimension directly supports the expectancy-value model of Wang and Eccles (2013), which emphasizes that academic engagement is strongly influenced by an individual's perception of the value of the task and expectations of success. In terms of behavior, increased attendance, consistency in completing tasks, and increased participation in group discussions indicate a more internalized learning engagement. Students actively take responsibility for the learning process, show initiative, and develop academic persistence. These findings enrich Fredricks et al., (2019) multidimensional engagement model with empirical evidence that all three dimensions of engagement—behavioral, emotional, and cognitive—can be facilitated simultaneously through a context-based approach. In addition, this approach is in line with Vygotsky and Cole (2018) social constructivism theory, where social interaction, negotiation of meaning, and collective task-based scaffolding are important foundations for the formation of advanced conceptual understanding.

However, these positive changes were not homogeneous. Variations in students' engagement levels suggest that contextual factors such as perceived task value, clarity of learning goals, and social support in the classroom play an important role. Students who viewed the task as relevant and meaningful showed higher engagement, while students who questioned the relevance of the task showed behavioral resistance, although they still showed cognitive reflection in their diary. These findings support Wang and Eccles (2013) Expectancy-Value model, which asserts that perceived value and expectations of success jointly shape students' levels of academic motivation. From an engagement theory perspective, this study enriches Fredricks et al., (2019) multidimensional engagement model by adding empirical evidence on how contextual task-based learning can facilitate behavioral, emotional, and cognitive engagement simultaneously. Furthermore, these findings reinforce Vygotsky and Cole (2018) social constructivism principles, where social interaction, scaffolding, collective negotiation of meaning, and culturally based experiences have been shown to be important in the formation of advanced mathematical understanding. Limitations of this study include the limited scope of participants at one state university in Indonesia, which limits the generalizability of the results to other contexts. The intervention duration of only eight weeks may also not be sufficient to monitor long-term changes in learning patterns. Therefore, further research is recommended to conduct a longitudinal study based on mixed-methods design to see the dynamics of changes in student engagement over time.

CONCLUSION

This study shows that a contextual task-based learning approach can significantly increase students' behavioral, emotional, and cognitive engagement in Abstract Algebra. By connecting abstract mathematical concepts to relevant real-world contexts, such as local cultural symmetry patterns and cryptographic applications, students experienced a transformation in their learning approach, shifting from surface learning to deep learning based on critical reflection. This increased engagement was reflected not only in active class participation and pre- and post-test results, but also in assignment products that demonstrated conceptual internalization, such as a frieze design based on symmetry groups that integrated local cultural aspects. Students' reflections indicated metacognitive development, where they recognized the need to construct mathematical meaning through applying concepts in real contexts, rather than simply memorizing formal definitions. These findings add to the literature on student engagement and mathematics education, emphasizing the importance of meaningful, contextual, and flexible task design in building motivation, learning relevance, and higher-order thinking skills. Theoretically, this study provides strong support for the multidimensional engagement model (Fredricks et al., 2019) and the principles of social constructivism (Vygotsky and Cole, 2018), which posit social interaction, negotiation of meaning, and use of cultural experiences as the primary foundations of cognitive development in higher education. The practical implications of this study are the importance for educators to consciously link abstract theory to students' lived experiences, through tasks that encourage exploration, creativity, and reflection. In the context of advanced mathematics learning, contextual tasks can increase students' motivation to learn, deepen conceptual understanding, and strengthen students' academic identities as active and reflective learners. As a future direction, this study encourages further exploration of the adaptation of context-based tasks across disciplines and cultures, as well as the importance of longitudinal research to understand how student engagement develops and transforms over time. Thus, contextual task-based learning can be positioned as a transformative pedagogical strategy that not only enhances academic engagement, but also builds the foundation for continuous learning oriented towards meaning, relevance, creativity, and critical reflection in 21st century mathematics education.

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