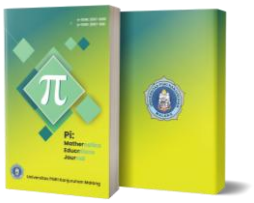
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Multidimensional Student Engagement in a Balinese Culture-Themed Mathematics Board Game

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ABSTRACT

This study examines behavioral, emotional, and cognitive student engagement during fraction learning using a Balinese culture-themed mathematics board game. The game integrates Balinese cultural representations and contextualized fraction problems through task cards. A focused qualitative approach was employed involving 48 Grade V students from two elementary schools in Tabanan, Bali. Data were collected through classroom observations, field notes, initial and follow-up interviews, student practicality questionnaires, and post-game cultural reflection sheets. The findings indicate positive student perceptions of the game's attractiveness (95.00%), ease of use (90.00%), cultural involvement (88.00%), and perceived support for understanding fractions (87.00%). These results reflect students' perceptions rather than direct measurements of engagement. Observations, field notes, and interviews documented students' participation in game activities and peer interactions, as well as positive emotional responses. Cognitive engagement was examined through students' involvement in interpreting and solving fraction problems. Overall, the findings illustrate how cultural representations, contextualized mathematical tasks, and structured gameplay can provide opportunities for interconnected behavioral, emotional, and cognitive engagement in primary mathematics learning.

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1. Introduction

Student disengagement remains a persistent challenge in primary mathematics classrooms, as it may limit students' active participation, sustained attention, and willingness to engage in learning activities. Negative perceptions of mathematics as a difficult and less appealing subject can further reduce students' motivation to participate. Previous research has associated disengagement with reduced classroom participation and lower academic persistence [1]. Perceived difficulty and low interest are also recognized as factors that may

constrain students' effort and involvement in learning [2][3][4]. Furthermore, students who experience boredom or negative emotional responses during mathematics learning may become less involved in classroom activities [5]. These conditions highlight the need for instructional approaches that not only support students' understanding of mathematical concepts but also provide meaningful opportunities for active participation and sustained involvement in the learning process.

Student engagement is a multidimensional construct encompassing behavioral, emotional, and cognitive dimensions, which reflect how students participate, feel, and think during learning activities. Behavioral engagement concerns students' participation and involvement in learning tasks, emotional engagement relates to their interest and emotional responses, while cognitive engagement involves their mental effort and investment in understanding learning materials [1][5][6][7][8]. This perspective provides a framework for examining student involvement beyond observable classroom participation. In a different but related line of research, game-based and gamified learning approaches have been discussed as ways to structure learning activities through rules, goals, challenges, and interaction [9][10]. These features may create opportunities for active participation and positive learning experiences [11], but the presence of game mechanics alone does not explain whether students also invest cognitive effort in mathematical tasks. Similarly, culturally contextualized educational approaches emphasize the relevance of local knowledge, cultural representations, and students' cultural experiences in learning [12][13][14]. However, the cited works address cultural and educational contexts such as climate change education, culturally sustaining pedagogy, and science learning, rather than the relationship between cultural elements and multidimensional engagement in primary mathematics board games. Taken together, these strands of literature provide complementary perspectives on student engagement, game-based learning, and culturally contextualized education, but leave an important question insufficiently explored: how do cultural representations, contextualized mathematical tasks, and structured gameplay relate to students' behavioral participation, emotional responses, and cognitive involvement within the same non-digital mathematics learning activity? This question is particularly relevant in primary mathematics classrooms, where students engage with mathematical concepts while interacting with familiar cultural contexts and their peers.

Addressing this gap, the present study explores how student engagement is manifested during fifth-grade students' fraction learning activities using a Balinese culture-themed snakes-and-ladders mathematics board game. The game incorporates Balinese cultural elements through its visual representations and mathematical problem contexts, including activities related to the preparation and distribution of banten, the making of jejaitan, and the traditional irrigation system of Subak. It also incorporates values associated with Tri Hita Karana through group-based activities that provide opportunities for cooperation, mutual respect, and reflection on relationships with God, other people, and the environment. Rather than focusing primarily on media development, feasibility, or learning achievement, this study emphasizes students' involvement during gameplay. Their participation in game activities, emotional responses to the learning experience, interactions with peers, and engagement with mathematical tasks are examined as observable or interpretable manifestations of behavioral, emotional, and cognitive engagement. Accordingly, the study seeks to understand how students experience and participate in mathematics learning within a culturally contextualized, non-digital game environment.

This study argues that student engagement in a culturally contextualized mathematics game may emerge through the interaction of cultural representations, meaningful mathematical tasks, and structured gameplay, rather than from the presence of cultural elements or game mechanics alone. Visual representations of familiar Balinese cultural

activities may attract students' attention and create a sense of familiarity, potentially supporting emotional interest and willingness to participate. Mathematical tasks contextualized through practices such as preparing banten, making jejaitan, and managing the Subak irrigation system may provide meaningful situations in which students can interpret problems, apply fraction concepts, and explain their reasoning, thereby creating opportunities for cognitive engagement. In addition, group-based gameplay and values associated with Tri Hita Karana may encourage students to take turns, follow shared rules, cooperate, and respect their peers, potentially supporting behavioral engagement and positive social experiences. Nevertheless, these features do not automatically ensure meaningful engagement. Students may become more focused on competitive elements, such as rolling the dice or reaching the finish, than on solving mathematical tasks. Therefore, the relationship between the cultural and pedagogical features of the game and student engagement needs to be understood through students' actual participation, emotional responses, and involvement in mathematical activities. On this basis, the present study examines how a Balinese culture-themed mathematics board game provides opportunities for interconnected behavioral, emotional, and cognitive engagement in primary mathematics learning.

2. Methods

This study employed a focused qualitative approach to examine Grade V students' engagement during fraction learning using a Balinese culture-themed snakes-and-ladders game. The study investigated classroom implementation of the game, which incorporated Balinese cultural representations, including banten, jejaitan, Subak, and the values of Tri Hita Karana, into its board design, question cards, and learning activities. Although the data originated from a broader research and development project that employed the 4D model (Define, Design, Develop, and Disseminate), the present study was independently designed around the specific analytical focus of student engagement. It examined behavioral, emotional, and cognitive engagement rather than product development, validation, or mathematics achievement effectiveness.



Figure 1. Balinese Culture-Themed Mathematics Board Game

The participants relevant to this article were 48 Grade V students from SDN 2 Dauh Peken and SDN 4 Dauh Peken, two public elementary schools in Cluster III, Tabanan District, who participated in the limited trial of the learning game. The students were selected through intact-class implementation, considering class availability and the schools' readiness to conduct the learning activities. Teachers involved in the broader practicality assessment also provided information relevant to the implementation. Student and teacher interview accounts were included according to their relevance to the use of the game and the engagement-related experiences examined in this article. The wider population of 154 Grade V students across five schools and the separate groups involved in the parent study's effectiveness test were not treated as participants in this focused analysis.

The data analyzed in this study were derived from the parent research project and comprised classroom observation records, qualitative field notes, initial and follow-up interviews with students and teachers, and student responses to the practicality questionnaire. Initial student interviews provided contextual information about students' learning experiences before the game was introduced, including their perceptions of mathematics, familiarity with snakes-and-ladders games, responses to Balinese cultural elements, and preferences for group-based and competitive learning. Follow-up interviews were used to explore students' and teachers' experiences after the game implementation, particularly students' interest, participation, responses to mathematical tasks, and interactions with peers. Classroom observation records and qualitative field notes provided information about students' engagement during the game-based fraction lessons. Student responses to the practicality questionnaire provided supplementary information about their perceptions of the game's attractiveness, ease of use, cultural relevance, and perceived support for learning fractions. These questionnaire responses were treated as supplementary evidence of students' perceptions rather than as direct measures of behavioral, emotional, or cognitive engagement. Secondary data consisted of relevant literature on student engagement, particularly its behavioral, emotional, and cognitive dimensions.

The data collection activities relevant to this article included classroom observations during the game-based fraction lessons, the recording of qualitative field notes, and interviews conducted before and after the implementation. During the lessons, observations focused on students' attention to learning activities, participation in asking and answering questions, involvement in solving fraction problems, interaction during group activities, enthusiasm, and confidence in responding to mathematical tasks. Initial interviews provided contextual information about students' learning experiences and preferences before using the game, whereas follow-up interviews explored their experiences after participating in the activities. Student responses to the practicality questionnaire were also collected to provide supplementary information about their perceptions of the game. Information from classroom observations and field notes was considered alongside relevant student and teacher interview accounts and questionnaire responses to identify points of agreement, complementary information, and differences among the data sources. Initial interview findings were treated separately as contextual information and were not used as evidence of engagement during gameplay.

Table 1. Structure of Game-Based Learning Activities

Activity Stage	Learning and Game Activities	Game Components	Observation Focus
Game orientation	The teacher explains the learning objectives, game rules, and playing procedures to the students.	Game board, playing pieces, dice, and game rules	Students' attention to the teacher's explanations
Game implementation	Students roll the dice, move their playing pieces across the board, and take turns according to the game rules.	Dice, playing pieces, and game board squares	Students' participation and enthusiasm during the game
Mathematical problem-solving	Students answer fraction-related questions presented on	Question squares and question cards	Students' involvement in solving fraction

	the game board or question cards according to the squares they land on.		problems and their confidence in answering questions
Peer interaction	Students discuss questions and exchange ideas with their peers while participating in the game.	Group-based gameplay and turn-taking rules	Students' involvement in discussions and participation in asking and answering questions

Table 1 summarizes the sequence of learning activities using the Balinese culture-themed mathematics board game, the game components involved, and the corresponding observation focuses. These activities provide the context for examining students' behavioral, emotional, and cognitive engagement during fraction learning.

The data were analyzed descriptively and interpretively using the three-dimensional framework of student engagement: behavioral, emotional, and cognitive engagement. The analysis began by reviewing classroom observation records, qualitative field notes, interview accounts, and questionnaire responses in relation to the timing and context in which each source was collected. The observation focuses presented in Table 1 served as analytical guides for examining students' engagement across the learning activities, while the three dimensions of engagement provided the main framework for organizing and interpreting the evidence. Behavioral engagement included students' attention to learning activities, participation in asking and answering questions, involvement in group discussions, and participation in game-based tasks. Emotional engagement concerned students' expressed or reported interest, enthusiasm, enjoyment, boredom, and reluctance during the learning activities. Cognitive engagement concerned students' involvement in understanding, discussing, and working through the fraction questions presented in the game. When an activity or response reflected more than one dimension, it was considered in relation to the relevant dimensions rather than assigned exclusively to one category. Interview and questionnaire information was used to contextualize and compare the observational evidence. The analysis also considered instances in which students' attention or participation was directed more toward the game mechanics than toward the mathematical tasks. This approach enabled the study to examine how the three dimensions of engagement were manifested during the learning activities without assuming that cultural elements or game mechanics automatically generated student engagement.

3. Result and Discussion

Students' responses to the practicality questionnaire indicated positive perceptions of the Balinese culture-themed snakes-and-ladders game. The questionnaire was completed by 48 Grade V students from SDN 2 Dauh Peken and SDN 4 Dauh Peken after the limited trial. As presented in Table 2, the overall mean score was 3.61, equivalent to 90.19%, and was classified as very practical. Media attractiveness received the highest mean score (3.80; 95.00%), followed by ease of understanding the game rules (3.60; 90.00%), cultural involvement (3.52; 88.00%), and perceived understanding of fraction materials (3.48; 87.00%). All four aspects were classified as very practical, indicating that students generally perceived the game as attractive, understandable, and relevant to the cultural and mathematical content presented.

Table 2. Students' Perceptions of the Learning Media

Based on the Practicality Questionnaire (n = 48)

No.	Assessment aspect	Number of items	Mean score	Percentage (%)	Category
1	Media attractiveness	3	3.80	95.00	Very practical
2	Ease of game rules	3	3.60	90.00	Very practical
3	Cultural involvement	2	3.52	88.00	Very practical
4	Perceived understanding of fraction materials	3	3.48	87.00	Very practical
	Overall	11	3.61	90.19	Very practical

The pattern of scores suggests that students perceived the game primarily as attractive and easy to follow, while its perceived support for understanding fraction materials received a slightly lower, although still positive, score. The difference between the highest and lowest percentages was eight percentage points, with all aspects remaining within the very practical category. The attractiveness score reflects students' positive perceptions of the game's visual and interactive presentation, while the score for ease of game rules indicates that the procedures were generally perceived as accessible. The cultural involvement score suggests positive perceptions of the cultural elements incorporated into the media. Meanwhile, the perceived understanding score indicates that students recognized the game as relevant to learning fractions, although this aspect received the lowest rating among the four. These results describe students' perceptions of the media after implementation and do not establish actual changes in mathematical understanding.

The questionnaire findings provide a useful starting point for examining student engagement because students' perceptions of learning materials and activities may be related to their subsequent participation and learning experiences. In the multidimensional framework, perceived attractiveness is particularly relevant to emotional engagement, while the perceived accessibility of game rules provides context for understanding opportunities for behavioral participation [15]. Similarly, students' positive perceptions of the cultural and mathematical content are relevant to examining their involvement with the learning tasks [16]. Nevertheless, these relationships should not be interpreted as direct measurements of engagement [17][18]. Behavioral, emotional, and cognitive engagement are related but distinguishable dimensions that require evidence of students' participation, emotional responses, and mental involvement during learning activities [1][5][19]. Therefore, the practicality questionnaire is treated as supplementary evidence of students' perceptions, while the analysis of engagement relies primarily on classroom observations, field notes, and relevant interview accounts.

Classroom observations, qualitative field notes, and interview accounts provided information about students' experiences during the game-based fraction lessons. The learning activities followed four stages: game orientation, game implementation, mathematical problem-solving, and peer interaction, as outlined in Table 1. The field notes described a transition from a predominantly teacher-centered learning pattern toward more active and collaborative classroom activities. During the implementation, students engaged with the game procedures, including following the rules, taking turns, moving playing pieces, and responding to fraction-related questions. The activities also provided opportunities for students to discuss questions and exchange ideas with peers. Initial interviews further showed that students had previously known snakes-and-ladders primarily

as a recreational game rather than as a mathematics learning medium. They also expressed preferences for group-based learning and competitive question-answering activities. Follow-up interviews and other qualitative accounts were used to provide additional perspectives on students' experiences after participating in the lessons.

The observed and reported experiences can be interpreted through the three dimensions of student engagement [20]. Behavioral engagement was reflected in students' participation in the learning activities, including following instructions, taking turns, participating in gameplay, and interacting with peers. Emotional engagement concerned students' expressed interest, enthusiasm, enjoyment, confidence, or reluctance during the activities. Cognitive engagement concerned students' involvement in understanding, discussing, and solving the fraction problems presented through the game. The initial interview findings provide context for these dimensions because students had expressed preferences for interactive and collaborative learning before the implementation. In particular, their expectations that learning with peers could be more enjoyable, reduce their fear of making mistakes, and facilitate understanding through discussion help explain why group-based gameplay was relevant to their prior learning preferences. However, these initial expectations are not treated as evidence that the corresponding forms of engagement necessarily occurred during implementation. The interpretation of actual engagement is therefore based on the evidence collected during and after the learning activities.

The three dimensions of engagement were considered interconnected rather than mutually exclusive. For example, participating in a group discussion about a fraction question may involve behavioral engagement through active participation, emotional engagement through interest or confidence, and cognitive engagement through interpreting the problem and considering possible answers [21][17]. At the same time, participation in the game should be distinguished from engagement with its mathematical content [22][23]. Taking turns, rolling dice, and moving playing pieces indicate participation in the game procedures, whereas discussing fraction questions and attempting to solve them provide more direct indications of cognitive involvement[1]. This distinction is important because students may participate actively in the mechanics of a game without necessarily engaging deeply with the mathematical tasks [24]. The game structure provided opportunities for participation and interaction, but the extent to which these opportunities involved sustained mathematical thinking depended on students' engagement with the fraction questions themselves.

The Balinese culture-themed game incorporated local wisdom through four dimensions: visual-symbolic representation, contextualization of fraction problems, philosophical values in game narratives, and post-game cultural reflection. The visual-symbolic dimension included the *cepuk* motif, *canang sari* illustrations, and *meru* ornaments displayed on selected board squares. The contextualization dimension was reflected in fraction problems involving cultural activities and objects, including *kue bangkit*, *banten*, and jejaitan. The game narratives also incorporated references to values associated with *Tri Hita Karana* through the rules and consequences governing movement along the snakes and ladders. In addition, the teacher's guide included a post-game cultural reflection sheet with prompts inviting students to describe collaborative values, such as *gotong royong*, and to relate fraction concepts, including one-half and one-quarter, to the practice of sharing banten. Initial interviews indicated that students were familiar with Balinese cultural symbols such as pura and traditional carvings, and that they expected cultural images to make mathematics lessons more visually appealing and less monotonous. The post-game reflection sheet provided an additional source for examining students' written interpretations of the cultural and mathematical connections presented in the activities.

The four dimensions of cultural integration served different purposes within the learning experience. Visual-symbolic representations introduced Balinese cultural references into the visual environment of the game and were relevant to students' initial expectations that cultural images could make mathematics learning more appealing [25]. Contextualized fraction problems connected mathematical content with cultural situations, providing examples through which students could interpret and discuss fraction concepts. The philosophical narratives introduced local values into the rules and consequences of gameplay [26], while the reflection activity provided an opportunity to consider collaborative experiences and relationships between mathematical concepts and cultural practices. These dimensions therefore extended cultural integration beyond the inclusion of decorative images. Cultural references were incorporated into the visual presentation, the mathematical tasks, the narratives accompanying gameplay, and the reflection activity [27]. However, the presence of these elements in the learning media does not, by itself, establish that students recognized or understood every cultural symbol or philosophical value. Students' familiarity with pura and traditional carvings, for example, indicates prior recognition of some cultural symbols but does not demonstrate their understanding of the specific meanings of *cepuk*, *canang sari*, *meru*, or *Tri Hita Karana*. Their interpretation of these elements needs to be considered in relation to their actual responses and written reflections.

The relationship between Balinese cultural integration and student engagement can be understood through the interaction of cultural representations, contextualized mathematical tasks, and structured gameplay. Visual and cultural representations provided a context relevant to students' interest in the learning materials and, consequently, to emotional engagement [21]. Fraction problems situated in cultural practices offered opportunities for cognitive engagement by inviting students to interpret mathematical situations and work with fraction concepts [27]. Meanwhile, game rules, turn-taking, and peer interaction organized students' participation and provided opportunities for behavioral engagement [28]. The post-game reflection activity extended these connections by inviting students to consider collaborative values and the use of fractions in cultural practices [1]. These components were not independent: students encountered cultural representations through the game, engaged with mathematical content through the contextualized questions, and participated in the learning process through structured gameplay. This interpretation is consistent with the multidimensional view of engagement, which recognizes the relationship between participation, emotional responses, and cognitive investment. It also supports the central argument of this study that engagement in a culturally contextualized mathematics game should be understood through the interaction of its cultural, mathematical, and game-based features rather than through the presence of cultural elements or game mechanics alone [24]. The reflection activity therefore extended the relationship between cultural representations, mathematical tasks, and structured gameplay by providing students with an opportunity to consider the meaning of their learning experiences.

4. Conclusion

The findings of this study indicate that student engagement during fraction learning with a Balinese culture-themed mathematics board game was manifested through behavioral, emotional, and cognitive dimensions. These dimensions were reflected in students' participation in game activities and peer interactions, their positive responses to the learning experience, and their involvement in mathematical tasks. However, the extent to which each dimension was evident differed across the available data, with participation and positive emotional responses more readily documented than students' cognitive involvement in mathematical problem-solving. The student practicality questionnaire also revealed positive

perceptions of the game's attractiveness (95.00%), ease of use (90.00%), cultural involvement (88.00%), and perceived support for understanding fractions (87.00%). These questionnaire results were treated as supplementary evidence of students' perceptions rather than direct measurements of engagement. Overall, the findings illustrate that student engagement in culturally contextualized game-based mathematics learning can be examined through the interconnected dimensions of behavioral, emotional, and cognitive engagement.

This study contributes empirically and methodologically to research on student engagement in primary mathematics education. Empirically, it provides a context-specific account of how Balinese cultural representations, fraction problems contextualized through local cultural practices, and structured gameplay were incorporated into learning activities that offered opportunities for multidimensional engagement. Methodologically, the study demonstrates the value of examining student engagement through complementary data sources, including classroom observations, field notes, interviews, and supplementary questionnaire responses, while distinguishing students' perceptions of media practicality from evidence of their engagement during learning activities. Rather than proposing a new theoretical sequence or causal relationship among the three dimensions, this study illustrates how the multidimensional engagement framework can be applied to examine students' learning experiences in a culturally contextualized mathematics game.

Several limitations should be considered when interpreting these findings. The study focused on the limited trial involving 48 Grade V students from two elementary schools; therefore, the findings may not represent the experiences of students in other educational contexts. In addition, cultural elements, game mechanics, and peer interaction were incorporated into the same learning experience, making it difficult to distinguish their respective contributions to student engagement. The available evidence also does not establish a temporal sequence among behavioral, emotional, and cognitive engagement. Future research could address these limitations through systematic observations across multiple learning sessions, broader participant groups, and research designs that examine the respective contributions of cultural contextualization, game mechanics, and peer interaction. Further investigation of students' mathematical reasoning during gameplay would also help clarify how participation and positive learning experiences relate to deeper cognitive engagement.

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