

Teachers' perceptions of student learning during educational role-playing game instruction: A phenomenographic study of grades 7–9 mathematics teachers

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Abstract

Educational role-playing games (RPGs) have been increasingly adopted in mathematics education because of their potential to support students' cognitive, affective, and social learning. However, previous studies have predominantly examined their effectiveness from the perspective of student outcomes, while relatively little is known about how teachers experience and interpret student learning during educational RPG instruction. This study aimed to explore the qualitatively different ways Grades 7–9 mathematics teachers experienced student learning in educational role-playing game environments using a phenomenographic approach. Thirty mathematics teachers participated in the broader educational RPG implementation program, from which five teachers representing diverse teaching experiences were purposively selected for in-depth phenomenographic interviews. Classroom observations, teacher reflection sheets, and student activity sheets were used to contextualize and support the interpretation of interview data. Data were analysed through iterative phenomenographic procedures to construct categories of description and an outcome space. The findings identified four qualitatively different ways teachers experienced student learning: (1) engagement and emotional involvement, (2) strategy use and procedural engagement, (3) conceptual understanding of algebra, and (4) integrated cognitive, emotional, and social development. These categories formed an outcome space representing increasing inclusiveness in teachers' ways of experiencing student learning. The study contributes to educational game research by demonstrating that the pedagogical value of educational RPGs depends not only on game design or student performance but also on how teachers recognise and interpret learning within classroom practice.

Keywords:

Educational role-playing games, Mathematics education, Phenomenography, Student learning, Teacher experience

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1. INTRODUCTION

The rapid advancement of digital technology has significantly transformed educational practices, particularly in lower secondary education. One prominent development is the growing integration of digital games as instructional tools, commonly referred to as game-based learning. Educational games are no longer perceived merely as supplementary media or sources of entertainment; rather, they are increasingly recognized as structured learning environments that can support students' cognitive, affective, and social development. Foundational scholarship has emphasized the capacity of well-designed games to promote engagement, meaningful interaction, problem-solving, and conceptual learning (Gee, 2003; Mandala et al., 2025; Plass et al., 2015). More recent reviews and meta-analyses have further demonstrated that digital game-based learning can positively influence students' academic achievement across educational levels and STEM disciplines, including mathematics, although its effectiveness depends on pedagogical design, instructional integration, and the characteristics of the learning context (Pan et al., 2022; Wang et al., 2022).

Among various types of educational games, role-playing games (RPGs) offer distinctive pedagogical affordances. RPG-based learning environments place learners within narrative and problem-oriented contexts in which they assume roles, make decisions, interact with challenges, and experience the consequences of their actions. These characteristics can encourage active participation, exploration, reflection, and sustained engagement, allowing learners to construct knowledge through interaction rather than passive reception. Recent studies indicate that educational RPG environments can support learning by enabling students to test knowledge, revise decisions, and reflect on the effects of their choices, while appropriately designed RPGs may also facilitate learning performance and cognitive processing (Zhong, 2022). Role-playing has further been used to make abstract disciplinary processes and mathematical representations more accessible to K–12 learners by allowing them to enact and examine relationships among data, rules, representations, and outcomes (Kajiwarra et al., 2023). In mathematics education, earlier studies by Pramuditya et al. (2018) similarly demonstrated the potential of educational RPGs to situate mathematical ideas within interactive and problem-based learning experiences.

Previous studies have demonstrated that educational RPGs can support a wide range of learning outcomes. For instance, Pramuditya et al. (2022) found that students engaged in open-ended virtual reality game-based learning exhibited diverse characteristics of mathematical problem-solving abilities, highlighting the potential of game environments to accommodate varied learning strategies. Similarly, differentiated educational games have been shown to enhance students' understanding of complex topics such as three-dimensional geometry by allowing learners to progress at different cognitive levels (Pramuditya et al., 2025). Beyond cognitive outcomes, educational games have also been found to promote mathematical literacy, communication skills, and reflective thinking by fostering interactive and student-centered learning environments (Hamidah et al., 2025; Pramuditya et al., 2021). Collectively, these studies demonstrate that educational RPGs consistently support diverse dimensions of mathematics learning.

However, despite the growing body of research demonstrating the educational benefits of role-playing games, considerably less attention has been devoted to understanding how

teachers experience and interpret student learning during educational RPG-based instruction. Existing studies have predominantly examined learning from the perspective of students' outcomes, instructional effectiveness, or game design, whereas teachers are frequently positioned as facilitators who implement instructional innovations rather than as individuals who actively interpret learning as it unfolds in classroom practice.

In educational RPG environments, teachers continuously observe students' participation, interactions, problem-solving processes, and reflections, while simultaneously constructing meanings about what constitutes learning. These interpretations influence how teachers respond to students, organize subsequent learning activities, and evaluate learning progress. Consequently, understanding teachers' experiences of student learning becomes essential for explaining how educational RPGs are pedagogically enacted within authentic classroom settings.

To address this gap, a research approach capable of revealing variations in how teachers experience and interpret student learning is required. Phenomenography provides an appropriate methodological framework because it is specifically concerned with identifying the qualitatively different ways individuals experience, understand, or conceptualize a shared phenomenon (Marton, 1986). Rather than seeking objective descriptions of educational role-playing games or measuring their instructional effectiveness, phenomenography focuses on the variation in teachers' experiences of student learning, making it particularly suitable for the purpose of this study.

In phenomenographic research, learning is understood as a relational phenomenon emerging from the interaction between individuals and the world in which they participate (Marton & Booth, 1997). Accordingly, phenomenography adopts a second-order perspective by investigating how a phenomenon is experienced by individuals rather than describing the phenomenon itself. Within educational role-playing game environments, this perspective enables researchers to explore how teachers experience and interpret students' learning during gameplay instead of evaluating the educational game as an instructional intervention.

Previous phenomenographic studies have demonstrated the value of this approach for revealing qualitative variation in conceptions of learning, teaching, technology use, and educational practice (Åkerlind, 2018; Han & Ellis, 2019). More recent phenomenographic research has continued to employ this methodology to investigate how educators experience teaching, learning, and educational change across diverse educational settings, confirming its continuing relevance for contemporary educational research. Collectively, these studies illustrate that phenomenography is particularly valuable when the research objective is to understand variation in experience rather than to evaluate effectiveness or establish causal relationships. Building on this methodological tradition, the present study applies phenomenography to explore the qualitatively different ways lower secondary school teachers experience and interpret student learning during educational role-playing game instruction.

Although previous research has demonstrated the educational potential of role-playing games and phenomenographic research has provided valuable insights into variations in educational experiences, these two lines of inquiry have rarely been integrated. Existing studies have predominantly focused on students' learning outcomes, instructional effectiveness, or game development, whereas phenomenographic studies have generally

explored educational experiences in broader learning contexts rather than within educational role-playing game environments. Consequently, there remains limited understanding of the qualitatively different ways teachers experience and interpret student learning during educational RPG instruction. Addressing this gap is significant because teachers' interpretations influence how learning is recognised, supported, and translated into pedagogical decisions, ultimately shaping the educational value of game-based learning in classroom practice.

Accordingly, this study addresses the following research question: How do lower secondary school teachers qualitatively experience and interpret student learning during educational role-playing game instruction? To answer this question, the study aims to identify and describe the qualitatively different ways teachers experience student learning through a phenomenographic approach, thereby revealing the variation in teachers' experiences across multiple educational contexts.

The expected outcome of this study is an empirically grounded outcome space that illustrates the structural relationships among qualitatively different ways teachers experience student learning in educational role-playing game environments. Theoretically, the findings extend the application of phenomenography to educational role-playing games by positioning teachers' experiences as the primary unit of analysis. Practically, the study provides insights for teachers, educational game designers, and curriculum developers in designing and implementing educational RPGs that better support meaningful student learning through informed pedagogical interpretation.

Building on the phenomenographic perspective described, [Figure 1](#) illustrates the conceptual relationship between teachers, educational RPG environments, and student learning. Rather than treating learning as a direct consequence of game features, the framework emphasizes that student learning is understood through teachers' interpretive processes during classroom interaction.

[Figure 1](#) presents a phenomenographic framework that conceptualizes the interaction among teachers, educational RPG environments, and student learning. The framework emphasizes that student learning is understood through teachers' interpretive processes, rather than as a direct outcome of game features. It illustrates how different ways of experiencing learning emerge through the interplay between what teachers attend to, how they interpret student activity, and the opportunities for action and meaning-making offered by the game environment.

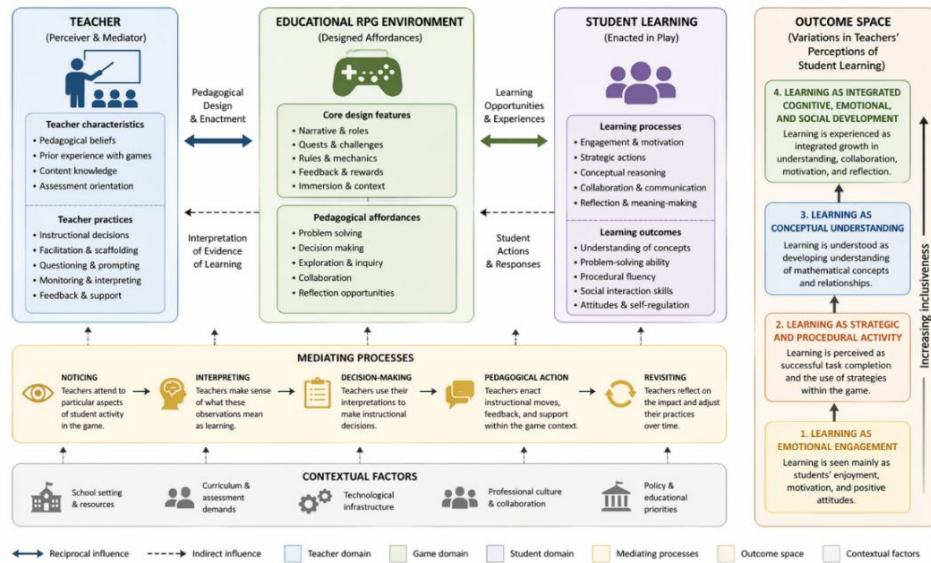


Figure 1. Phenomenographic framework of teacher–game–learning interaction

Guided by this conceptual framework, the following section describes the research design and methodological procedures used to explore the qualitatively different ways teachers experience student learning in educational RPG environments.

2. METHOD

Building on the phenomenographic framework presented in the preceding section, this study was designed to explore the qualitatively different ways lower secondary school teachers experience and interpret student learning during educational role-playing game (RPG) instruction. Consistent with the second-order perspective of phenomenography, the methodological procedures were developed to capture variation in teachers' experiences rather than to evaluate the effectiveness of the educational game itself. The following sections describe the research design, participants, data collection procedures, and phenomenographic data analysis employed to construct the outcome space representing teachers' perceptions of student learning.

2.1. Research Design

This study employed a phenomenographic research approach to explore teachers' perceptions of student learning when educational role-playing games (RPGs) were used in lower secondary school classrooms. Phenomenography is a qualitative research methodology that aims to identify the qualitatively different ways individuals experience, understand, or conceptualize a particular phenomenon (Åkerlind, 2018; Marton, 1986). This approach was selected because the purpose of the study was not to describe the essence of teachers' lived experiences or to generate explanatory theory, but rather to identify the qualitatively different ways teachers experience and interpret student learning during educational role-playing game instruction. Accordingly, phenomenography provides an appropriate methodological framework for revealing variations in teachers' conceptions of the same educational phenomenon across different classroom contexts.

Adopting a second-order perspective, phenomenographic research does not seek to describe the phenomenon itself, but rather focuses on how the phenomenon is experienced by individuals. Accordingly, the unit of analysis in this study was not the educational role-playing game itself nor students' observable learning outcomes, but teachers' different ways of experiencing and interpreting student learning as it occurred within RPG-supported classroom activities.

From a phenomenographic standpoint, learning is understood as a relational phenomenon that emerges through the interaction between individuals and their learning environment (Marton & Booth, 1997). This orientation makes phenomenography particularly suitable for examining teachers' perceptions of student learning in game-based contexts, where learning processes are complex, non-linear, and often interpreted differently by teachers observing the same instructional situation.

The outcome of phenomenographic analysis is a set of categories of description that represent variations in experience, together with an outcome space that illustrates the logical relationships among these categories (Åkerlind, 2018). In this study, phenomenography was used to reveal variations in how teachers perceive students' learning processes during educational RPG-based instruction. Consequently, phenomenographic analysis enabled the study to address the research question by identifying the categories of description and the outcome space representing the structural relationships among teachers' qualitatively different ways of experiencing student learning.

2.2. Research Context and Participants

The study was conducted in five Indonesian lower secondary schools (equivalent to Grades 7–9). These schools were purposively selected to provide variation in educational settings while maintaining comparable curricular requirements for lower secondary mathematics. Such variation was considered important in phenomenographic research because it increases the likelihood of capturing qualitatively different ways teachers experience the same educational phenomenon. Participants were selected using purposeful sampling, a strategy commonly employed in phenomenographic research to ensure that participants have direct experience with the phenomenon under investigation and that variation in experiences can be captured (Han & Ellis, 2019; Marton, 1986). A total of 30 lower secondary school mathematics teachers participated in the broader educational RPG implementation program. All participants were involved in designing, implementing, or observing educational role-playing games during mathematics instruction, ensuring that each teacher possessed direct experience with the phenomenon under investigation.

Following completion of the program, five teachers were purposively selected for the phenomenographic study because they had successfully completed the entire implementation process, including instructional planning, educational RPG development, classroom deployment, and post-implementation reflection. These teachers therefore possessed comprehensive experience of the phenomenon under investigation and were able to provide rich descriptions of how they experienced and interpreted student learning during educational RPG instruction.

2.3. Data Collection

Data were collected from the five purposively selected teachers through four complementary sources: semi-structured interviews, classroom observations, teacher reflection sheets, and student activity sheets. Semi-structured interviews served as the primary source of phenomenographic data, whereas classroom observations and documentary artefacts were used to contextualize and clarify teachers' experiential accounts.

Semi-structured interviews were conducted with the five purposively selected teachers following completion of the educational RPG implementation. The interviews were designed to elicit the qualitatively different ways teachers experienced and interpreted student learning during educational RPG instruction. Rather than evaluating the effectiveness of the educational game, participants were encouraged to describe what they noticed, how they interpreted students' learning, and how these interpretations informed their pedagogical understanding.

The principal interview prompts and their phenomenographic purposes are summarized in [Table 1](#). Follow-up questions were used flexibly to clarify meanings, elicit concrete examples, and encourage participants to elaborate on differences in how they experienced student learning.

Table 1. Semi-structured interview protocol

Interview prompt	Phenomenographic purpose
How do you experience student learning when educational role-playing games are used in your classroom?	Eliciting teachers' overall ways of experiencing the phenomenon
What aspects of student learning become most visible to you during RPG-based activities?	Identifying the focus of teachers' attention
What student actions or responses do you interpret as indications that learning is occurring?	Revealing the meanings teachers attribute to observable classroom events
In what ways do you experience student learning in RPG-based lessons as different from conventional classroom learning?	Exploring contrasts that clarify variation in experience
Can you describe a particular classroom event that influenced your understanding of student learning during the game?	Obtaining concrete experiential accounts rather than general opinions
How did your observations of students influence your instructional decisions during or after gameplay?	Exploring relationships between interpretation and pedagogical action

Follow-up questions were used to encourage clarification and elaboration, allowing teachers to describe their experiences in their own terms and to provide specific classroom examples. Each interview lasted approximately 45–60 minutes, was audio-recorded with participants' consent, and was transcribed verbatim prior to analysis. Identifying information was removed from the transcripts, and each participant was assigned a teacher code for reporting purposes.

Classroom observations were conducted during educational RPG lessons implemented by the five focal teachers. The observations documented classroom events that could later assist in interpreting teachers' interview accounts, including student participation, emotional

responses, problem-solving activity, peer interaction, mathematical explanation, and teacher facilitation. Field notes recorded the instructional sequence, relevant student actions, teacher responses, and contextual conditions surrounding salient learning events. The observation focus was descriptive and open-ended; it was not organized according to predetermined categories of learning. Observation records were subsequently examined in relation to teachers' interview accounts to clarify the classroom situations to which participants referred.

Teacher reflection sheets were completed following RPG-based classroom activities. These reflections invited teachers to record the learning events they considered most significant, the student responses that attracted their attention, and the meanings they attributed to those responses. The reflection sheets provided contemporaneous accounts that complemented the retrospective interview data and helped identify classroom experiences requiring further exploration during the interviews.

Student activity sheets were examined only as contextual artefacts associated with the focal teachers' accounts. The sheets included students' written responses, solution attempts, and reflections produced during or after gameplay. They were not independently assessed to determine students' achievement or conceptual mastery. Instead, they were used to understand the artefacts to which teachers referred when explaining why they interpreted particular student actions or responses as indications of learning. The four sources of data and their respective functions in the phenomenographic analysis are summarized in [Table 2](#).

Table 2. Data sources and their functions in the study

Data source	Participants/materials	Main focus	Function in the analysis
Semi-structured interviews	5 teachers	Teachers' experiences and interpretations of student learning	Primary phenomenographic data
Classroom observations	Five focal teachers' classrooms	Student activity, classroom interaction, and teacher facilitation	Contextualizing teachers' accounts
Teacher reflection sheets	Five focal teachers	Significant learning events and teachers' immediate interpretations	Complementing interview accounts
Student activity sheets	Student artefacts associated with the focal classrooms	Written responses, solution attempts, and reflections	Clarifying artefacts referenced by teachers; not measuring achievement

2.4. Data Analysis

Data analysis followed established phenomenographic procedures with the aim of identifying the qualitatively different ways teachers experienced and interpreted student learning during educational RPG instruction. Analysis focused on variation in teachers' experiences rather than on the frequency of particular responses or the evaluation of instructional effectiveness (Marton, 1986; Marton & Booth, 1997). Throughout the analysis, interviews served as the primary source of phenomenographic data, while classroom observations, teacher reflection sheets, and student activity sheets were used to clarify and contextualize participants' experiential accounts. The overall analytical procedure adopted in this study is illustrated in [Figure 2](#).

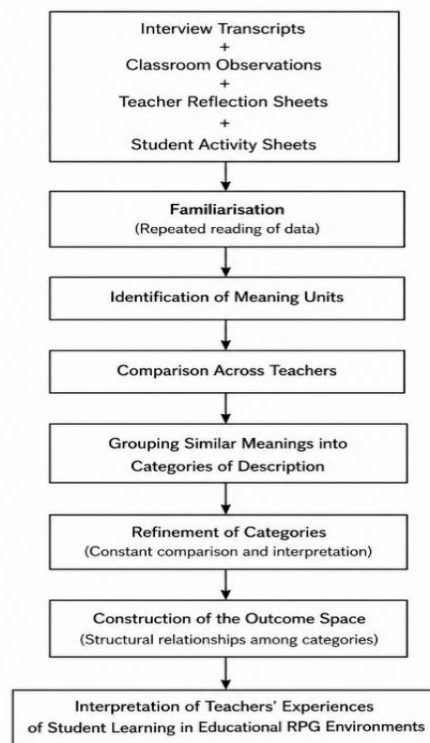


Figure 2. Phenomenographic data analysis procedure adapted from the analytical principles of Marton (1986), Marton and Booth (1997), and Åkerlind (2018)

The analysis proceeded iteratively through several stages. First, interview transcripts were read repeatedly to develop familiarity with participants' accounts. Second, statements describing teachers' experiences of student learning were identified and compared across participants. Third, conceptually similar meanings were grouped into preliminary categories through constant comparison. Fourth, the relationships among categories were examined to refine category boundaries and establish their structural relationships. Finally, an outcome space was constructed to represent the logical relationships among the qualitatively different categories of description (Åkerlind, 2018; Marton & Booth, 1997).

Categories of description were developed inductively from teachers' accounts rather than being predetermined before analysis. Each category represented a qualitatively distinct way teachers experienced student learning within educational RPG environments. Throughout the analytical process, categories were continuously refined until each represented a logically coherent and empirically supported way of experiencing the phenomenon (Åkerlind, 2018; Marton, 1986).

The final outcome space represented the structural relationships among the categories of description. Rather than ranking teachers according to ability or instructional quality, the outcome space illustrated how different ways of experiencing student learning were logically related within the collective experience of the participants (Marton & Booth, 1997).

Classroom observations, teacher reflection sheets, and student activity sheets were analysed alongside interview data to provide contextual understanding of the classroom situations described by participants. These supplementary data sources were not coded

independently to generate categories of description but were used to clarify meanings, verify interpretations, and strengthen the credibility of the phenomenographic analysis.

2.5. Trustworthiness

To enhance the trustworthiness of the findings, several strategies were employed throughout the study. First, methodological triangulation was achieved by integrating evidence from semi-structured interviews, classroom observations, teacher reflection sheets, and student activity sheets. Second, the iterative nature of phenomenographic analysis required repeated comparison of participants' accounts to ensure that each category of description represented a distinct way of experiencing the phenomenon. Third, the emerging interpretations and category boundaries were continuously reviewed among the research team until consensus was reached regarding the logical structure of the outcome space. Finally, an audit trail documenting analytical decisions and category refinement was maintained throughout the study to enhance the transparency and dependability of the analytical process.

3. RESULTS AND DISCUSSION

3.1. Results

Phenomenographic analysis identified four qualitatively different ways in which lower secondary mathematics teachers experienced and interpreted student learning during educational role-playing game (RPG) instruction. These categories of description represent collective variations in teachers' experiences rather than classifications of individual participants. Together, the categories constitute the outcome space that illustrates the structural relationships among different ways of experiencing student learning in educational RPG environments. The findings are presented sequentially, beginning with each category of description and concluding with the overall outcome space that integrates the relationships among the categories.

Category 1: Student Learning as Engagement and Emotional Involvement

Teachers in this category primarily recognised student learning through visible engagement and emotional participation during gameplay. Rather than initially referring to students' mathematical performance, they described learning in terms of students' enthusiasm, willingness to participate, and positive emotional responses while interacting with the educational game. From this perspective, active participation was regarded as the first indication that meaningful learning was taking place. As one teacher reflected:

"The students were happy and felt challenged while learning through the game." (T4)

For these teachers, students' emotional engagement was interpreted as an important indicator that the game had created a supportive learning environment, encouraging students to participate actively before demonstrating deeper mathematical understanding.

Category 2: Student Learning as Strategy Use and Procedural Engagement

In the second category, teachers experienced student learning through the ways students approached mathematical tasks during gameplay. Rather than emphasising students'

emotional engagement, these teachers focused on how students selected procedures, responded to challenges, and completed mathematical missions embedded within the educational RPG. Learning was recognised through students' efforts to apply solution strategies rather than merely reaching the correct answer.

Teachers paid particular attention to students' procedural actions while completing the missions, including how they interpreted questions, selected mathematical operations, and adjusted their approaches when encountering difficulties. During implementation, teachers frequently provided guidance when students experienced obstacles, while continuing to observe how students attempted to solve the tasks independently.

Student activity sheets reinforced these observations. Rather than simply recording correct answers, many students described the procedures they used to overcome mathematical challenges, for example by explaining that they solved a mission "*by answering the questions*" or by identifying the use of "*letters or variables*" when working with algebraic expressions. One teacher reflected:

"I paid particular attention to students' strategies and procedures in solving the game missions, while providing guidance when they encountered difficulties." (T3)

For teachers in this category, successful learning was indicated by students' ability to engage with mathematical procedures embedded within the game. Although conceptual understanding remained important, their primary attention was directed toward how students selected and applied solution strategies while progressing through the learning tasks. This category therefore represents a procedural conception of learning, in which learning is understood as the effective use of mathematical strategies within the game environment.

Category 3: Student Learning as Conceptual Understanding of Algebra

In the third category, teachers experienced student learning as students' developing conceptual understanding of algebraic ideas. Rather than emphasising successful completion of game missions, these teachers focused on how students demonstrated understanding of mathematical concepts through their written work, classroom discussions, and explanations during gameplay. Learning was recognised when students began to express mathematical meaning using algebraic language, even if their explanations remained informal.

Teachers paid particular attention to students' written responses after completing the game. They interpreted references to variables, algebraic expressions, and the relationships among mathematical quantities as evidence that students were beginning to construct conceptual understanding rather than merely following procedural steps. Classroom observations complemented these interpretations by documenting occasions when students asked conceptual questions or explained mathematical ideas while interacting with peers.

Students' written reflections further reinforced these observations. When asked what they had learned from the game, several students referred explicitly to algebraic concepts, including "*variables*", "*algebraic operations*", and "*elements of algebra*". Others explained that algebra involves the use of letters to represent unknown quantities. Although these explanations were expressed in simple language, teachers interpreted them as evidence that students were beginning to construct conceptual meaning. One teacher's observation reflected this orientation toward conceptual understanding:

"I focused on students' conceptual understanding while observing how they learned through the game." (T2)

For teachers in this category, meaningful learning was indicated by students' ability to communicate mathematical ideas, however informally, rather than by simply producing correct answers. From this perspective, educational gameplay became a context through which students gradually developed conceptual understanding of algebraic ideas. This category therefore represents a meaning-oriented conception of learning, in which teachers recognised learning through students' construction and communication of mathematical meaning.

Category 4: Student Learning as Integrated Cognitive, Emotional, and Social Development

The fourth category represents the most inclusive way teachers experienced student learning during educational RPG implementation. In this category, learning was understood not merely as students' successful completion of mathematical tasks, but as a dynamic classroom process shaped by interactions among students, the educational game, and the teacher's ongoing pedagogical decisions. Teachers experienced meaningful learning as emerging through classroom participation, peer interaction, and continuous instructional adaptation in response to students' learning needs.

Unlike the previous categories, teachers in this category did not focus exclusively on students' engagement, procedural performance, or conceptual understanding. Instead, they interpreted learning as a process that evolved throughout classroom implementation, requiring continuous observation, facilitation, and reflection. Classroom observations documented students interacting with peers, discussing mathematical tasks, and seeking assistance while progressing through the game, whereas teacher observation sheets showed that teachers simultaneously monitored conceptual understanding, learning strategies, motivation, and social interaction during gameplay. One teacher reflected:

"The students enjoyed the game, although some still required additional explanation. In future lessons, this educational game could also be developed for other mathematics topics." (T4)

This reflection illustrates that the teacher experienced student learning as an evolving instructional process rather than as a fixed outcome of gameplay. Instead of evaluating learning solely through students' mathematical performance, the teacher reflected on how students' classroom responses informed subsequent instructional decisions, including the need to provide additional explanations and to further develop the educational game for future learning contexts.

Overall, this category represents the most comprehensive way teachers experienced student learning during educational RPG instruction. Teachers viewed learning as a situated, collaborative, and adaptive classroom process in which conceptual understanding, student participation, social interaction, and pedagogical reflection continuously informed one another. Within this way of experiencing the phenomenon, meaningful learning extended beyond individual task completion to encompass collective meaning-making and ongoing instructional improvement. Within this most inclusive way of experiencing the phenomenon, teachers simultaneously attended to students' engagement, strategic activity, conceptual understanding, and the ongoing adaptation of classroom instruction, integrating these dimensions into a coherent interpretation of student learning.

The four categories of description presented above are not independent findings but are structurally related within an outcome space. In phenomenography, an outcome space represents the logical relationships among the qualitatively different ways participants experience a common phenomenon (Marton & Booth, 1997). Figure 3 illustrates the outcome space derived from the present study.

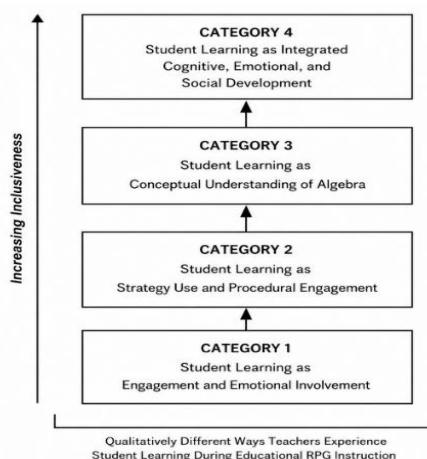


Figure 3. Outcome space of teachers' perceptions of student learning during educational RPG instruction

The outcome space demonstrates increasing inclusiveness in teachers' ways of experiencing student learning during educational RPG instruction. Teachers who experienced learning as integrated cognitive, emotional, and social development also recognised the dimensions represented in the preceding categories, but interpreted them as interconnected components of a broader learning process. Conversely, teachers whose experiences were centred on engagement or procedural activity tended to focus primarily on those aspects without explicitly integrating conceptual or collaborative dimensions of learning.

Collectively, the outcome space illustrates that variation in teachers' experiences does not reflect differences in teaching quality or professional competence. Rather, it represents qualitatively different ways of recognising and interpreting student learning within the same educational RPG environment. As teachers' awareness became increasingly inclusive, their interpretations expanded from observable engagement to procedural activity, conceptual understanding, and finally the integration of cognitive, emotional, and social dimensions of learning. This structural relationship provides the principal phenomenographic outcome of the present study and forms the basis for the following discussion.

3.2. Discussion

The findings of this study demonstrate that the educational value of role-playing games (RPGs) cannot be understood solely through students' observable performance or the instructional characteristics of the game itself. Instead, learning is pedagogically constituted through teachers' interpretations of students' classroom experiences. By identifying qualitatively different ways teachers experienced student learning, this study extends existing game-based learning research from evaluating instructional outcomes toward understanding how learning is recognised within authentic classroom practice.

This perspective both complements and extends previous research on educational game-based learning. Numerous studies have reported that educational games enhance students' motivation, engagement, and academic achievement (Pan et al., 2022; Plass et al., 2015; Wang et al., 2022). However, these studies have generally conceptualised learning as an observable outcome of instructional intervention. The present study adopts a different perspective by demonstrating that the same classroom events may be interpreted differently by teachers depending on the aspects of learning to which they attend. Consequently, variation exists not only in students' learning outcomes but also in teachers' ways of recognising and interpreting those outcomes.

The outcome space developed in this study further suggests that teachers' perceptions are characterised by increasing inclusiveness rather than by differences in teaching competence. Teachers who experienced learning in more inclusive ways recognised emotional engagement, strategic participation, conceptual understanding, and collaborative meaning-making as interconnected dimensions of the same learning process. Conversely, more limited ways of experiencing tended to emphasise only particular aspects of learning. This structural relationship represents the principal contribution of the present phenomenographic study and provides a foundation for interpreting each category discussed.

The findings of this study demonstrate that teachers play a central interpretive role in recognising student learning during educational role-playing game (RPG) instruction. Rather than functioning as passive observers of students' performance, teachers actively construct meanings about learning by attending to different aspects of classroom interactions. This finding extends previous research on educational game-based learning, which has predominantly focused on student outcomes, engagement, or instructional design (Pan et al., 2022; Plass et al., 2015; Wang et al., 2022). The present study shifts this perspective by positioning teachers' experiences as the primary analytical focus through a phenomenographic lens.

The findings further indicate that even when teachers implement the same educational RPG, they may experience and interpret student learning in qualitatively different ways. This variation helps explain why educational games do not produce uniform instructional experiences across classrooms. While numerous studies have reported positive educational effects of digital game-based learning (Pan et al., 2022; Wang et al., 2022), meta-analytic evidence suggests that learning outcomes are strongly influenced by pedagogical implementation, teacher facilitation, and instructional alignment rather than by the game itself (Clark et al., 2016). From a phenomenographic perspective, these differences are not viewed as inconsistencies but as legitimate variations in how teachers experience the same educational phenomenon.

The first category suggests that teachers initially recognised learning through students' emotional engagement before attending to more explicit indicators of mathematical understanding. Rather than interpreting enthusiasm, curiosity, and enjoyment merely as positive classroom behaviours, teachers viewed these responses as meaningful signs that students were becoming cognitively receptive to learning. This finding extends previous research showing that educational games foster motivation and engagement by demonstrating

that emotional responses also function as interpretive cues through which teachers recognise learning during classroom practice (Pan et al., 2022; Plass et al., 2015; Wang et al., 2022).

However, previous research also indicates that emotional engagement alone is insufficient to ensure meaningful learning. A meta-analysis by Clark et al. (2016) concluded that improvements associated with digital game-based learning are strongly influenced by instructional design, teacher facilitation, and the integration of learning activities rather than by students' enjoyment alone. Similarly, Wouters et al. (2013) reported that serious games produce stronger educational outcomes when gameplay is accompanied by instructional guidance and opportunities for reflection. These findings complement the present study by suggesting that emotional engagement represents an important entry point for learning but should not be interpreted as direct evidence of conceptual understanding.

From a phenomenographic perspective, this category illustrates one qualitatively distinct way teachers experienced student learning during educational RPG implementation. Teachers' attention was primarily directed toward students' emotional involvement because this was the most immediately observable aspect of classroom interaction. Rather than representing an incomplete or less effective way of teaching, this category reflects one legitimate way of experiencing the same educational phenomenon. The outcome space further demonstrates that this way of experiencing becomes increasingly inclusive as teachers begin to recognise additional dimensions of learning, including strategic participation, conceptual understanding, and collaborative meaning-making.

The second category reflects a broader way of experiencing student learning in which teachers interpreted learning through students' strategic participation and procedural engagement during gameplay. Rather than focusing primarily on emotional responses, teachers attended to how students selected strategies, tested alternative solutions, and justified procedural decisions while solving mathematical tasks. These observations suggest that learning became visible through students' active involvement in mathematical problem-solving rather than through participation alone. This interpretation is consistent with previous studies reporting that educational games can promote active learning, problem-solving, and strategic thinking by encouraging learners to make decisions within meaningful contexts (Qian & Clark, 2016; Zhong, 2022).

Nevertheless, active participation should not automatically be equated with meaningful mathematical understanding. Research in mathematics education has shown that students may successfully complete procedures without developing robust conceptual knowledge, particularly when instructional activities emphasise task completion over conceptual explanation (Rittle-Johnson et al., 2015). Similarly, educational games may encourage productive behavioural engagement without necessarily promoting deeper reasoning unless gameplay is accompanied by opportunities for explanation, discussion, and teacher-guided reflection (Clark et al., 2016). These perspectives reinforce the present findings by suggesting that teachers in this category recognised learning primarily through observable strategic actions rather than through students' underlying conceptual understanding.

From a phenomenographic perspective, the second category represents a more inclusive way of experiencing student learning than the first because teachers' attention expanded beyond emotional engagement to include students' strategic actions and procedural

reasoning. However, learning was still interpreted mainly through what students did rather than through how they conceptualised mathematical ideas. As illustrated in the outcome space, this category provides an important transition toward the more conceptually oriented ways of experiencing student learning identified in the subsequent categories.

The third category represents a further expansion in teachers' ways of experiencing student learning by emphasising students' conceptual understanding of algebraic ideas. Rather than focusing primarily on participation or procedural performance, teachers interpreted learning through students' ability to explain variables, describe relationships between quantities, and express mathematical meaning in their own words. This finding is consistent with research demonstrating that meaningful mathematics learning depends on students' ability to construct conceptual understanding rather than merely perform procedures (Hiebert & Grouws, 2007; Rittle-Johnson et al., 2015). Within educational RPG environments, teachers therefore recognised conceptual explanations as stronger evidence of learning than successful task completion alone.

At the same time, previous studies have shown that conceptual understanding does not automatically emerge from active participation in game-based learning. While educational games provide authentic contexts for exploration and experimentation, students often require structured reflection, discussion, and teacher guidance to connect gameplay experiences with formal mathematical concepts (Clark et al., 2016; Qian & Clark, 2016). This perspective complements the present findings by suggesting that teachers' attention to students' explanations and written reflections played an essential role in recognising conceptual learning beyond observable gameplay behaviours.

From a phenomenographic perspective, this category represents a more inclusive way of experiencing student learning because teachers no longer interpreted learning solely through students' observable actions but also through the meaning students constructed from those actions. The emphasis shifted from what students did during gameplay to how they understood the mathematical ideas embedded within the learning activities. As reflected in the outcome space, this category bridges procedural engagement and the integrated understanding of learning discussed in the final category, illustrating the progressive expansion of teachers' awareness of student learning.

The fourth category represents the most inclusive way teachers experienced student learning during educational RPG instruction. At this level, learning was no longer interpreted through a single dimension such as engagement, procedural performance, or conceptual understanding alone. Instead, teachers experienced learning as an integrated process in which cognitive development, emotional engagement, and collaborative interaction mutually reinforced one another. Students' discussions, peer support, shared problem-solving, and reflective dialogue were interpreted as interconnected expressions of meaningful mathematical learning rather than as separate classroom activities.

This interpretation is consistent with contemporary perspectives that view learning as a socially situated process in which knowledge is constructed through interaction, dialogue, and shared participation (Mercer & Howe, 2012; Vygotsky, 1978). Research on collaborative learning similarly suggests that meaningful mathematical understanding develops when students explain ideas, negotiate different perspectives, and jointly construct solutions rather

than working in isolation (Webb et al., 2014). Within educational RPG environments, these forms of interaction become particularly visible because gameplay naturally encourages communication, negotiation, and collective decision-making.

Nevertheless, collaborative interaction does not automatically result in productive learning. Previous studies have shown that group activities may remain superficial when students simply divide tasks or rely on dominant group members without engaging in genuine mathematical discussion (Barron, 2003). Consequently, teachers' pedagogical decisions remain essential for transforming collaborative gameplay into opportunities for meaningful learning. The present findings reinforce this perspective by demonstrating that teachers in the most inclusive category continuously reflected on their instructional strategies, adjusted classroom interactions, and modified learning activities in response to students' emerging needs rather than relying solely on the game environment itself.

From a phenomenographic perspective, this category represents the broadest awareness of student learning identified in the outcome space. Teachers simultaneously recognised emotional engagement, strategic participation, conceptual understanding, and collaborative meaning-making as inseparable dimensions of the same educational experience. Rather than replacing the previous categories, this way of experiencing encompasses them within a more comprehensive interpretation of learning. This progression illustrates the phenomenographic principle of increasing inclusiveness and highlights that variation among teachers lies in the breadth of awareness through which student learning is interpreted, rather than in differences in instructional competence.

Taken together, the outcome space demonstrates that teachers' experiences of student learning during educational RPG instruction differed not in instructional competence but in the breadth of awareness through which learning was interpreted. As teachers' ways of experiencing became increasingly inclusive, their attention expanded from students' emotional engagement to strategic participation, conceptual understanding, and ultimately the integration of cognitive, emotional, and social dimensions of learning. These categories therefore represent structurally related ways of experiencing the same educational phenomenon rather than isolated or sequential stages.

This phenomenographic outcome contributes to educational game research by showing that the educational value of RPG-based learning is not determined solely by the design of the game or students' observable performance, but also by how teachers interpret evidence of learning within classroom practice. Consequently, strengthening teachers' capacity to recognise multiple dimensions of student learning may be as important as improving the instructional design of educational games themselves.

4. CONCLUSION

This study identified four qualitatively different ways lower secondary mathematics teachers experienced student learning during educational role-playing game (RPG) instruction. Through a phenomenographic analysis, teachers experienced learning as (1) engagement and emotional involvement; (2) strategy use and procedural engagement; (3) conceptual understanding of algebra; and (4) integrated cognitive, emotional, and social development. These categories were structurally related within an outcome space demonstrating increasing

inclusiveness in teachers' ways of experiencing student learning. Rather than evaluating the effectiveness of educational RPGs, this study contributes by revealing how teachers interpret evidence of student learning during classroom practice, thereby extending current research on educational game-based learning through a phenomenographic perspective.

This study has several limitations. The phenomenographic analysis was based on the experiences of five mathematics teachers implementing educational RPGs within a specific instructional context, and therefore the findings are not intended for statistical generalisation. As with phenomenographic research more broadly, the aim was to reveal variation in experience rather than represent the prevalence of particular perspectives. In addition, the study focused on teachers' interpretations of student learning and did not examine how these experiences may evolve over time or across different mathematical topics and educational settings.

The findings provide implications for both educational research and classroom practice. Future studies may investigate how teachers' ways of experiencing student learning develop through sustained professional development, different mathematical topics, or alternative educational game environments. Extending phenomenographic inquiry to other educational contexts may further deepen understanding of how teachers recognise and support meaningful learning. Practically, the outcome space developed in this study may inform the design of teacher professional learning, educational RPG implementation, and reflective instructional practices that enable teachers to recognise the multiple dimensions of student learning beyond observable academic performance alone.

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Declarations

Author Contribution	: SAP: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Writing - original draft, and Writing - review & editing; IH: Data curation, Investigation, Visualization, Writing - original draft, and Writing - review & editing.
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REFERENCES

- Åkerlind, G. S. (2018). What future for phenomenographic research? On continuity and development in the phenomenography and variation theory research tradition. *Scandinavian Journal of Educational Research*, 62(6), 949–958. <https://doi.org/10.1080/00313831.2017.1324899>
- Barron, B. (2003). When smart groups fail. *Journal of the Learning Sciences*, 12(3), 307–359. https://doi.org/10.1207/s15327809jls1203_1
- Clark, D. B., Tanner-Smith, E. E., & Killingsworth, S. S. (2016). Digital games, design, and learning. *Review of Educational Research*, 86(1), 79–122. <https://doi.org/10.3102/0034654315582065>
- Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in Entertainment*, 1(1), 20. <https://doi.org/10.1145/950566.950595>
- Hamidah, I., Zulkardi, Z., Putri, R. I. I., & Pramuditya, S. A. (2025). Developing a mathematical literacy learning environment for students through educational game assistance. *Jurnal Pendidikan Matematika*, 19(1), 141–162. <https://doi.org/10.22342/jpm.v19i1.pp141-162>
- Han, F., & Ellis, R. A. (2019). Using phenomenography to tackle key challenges in science education. *Frontiers in psychology*, 10, 01414. <https://doi.org/10.3389/fpsyg.2019.01414>
- Hiebert, J., & Grouws, D. A. (2007). The effects of classroom mathematics teaching. In F. K. Lester Jr. (Ed.), *Second handbook of research on mathematics teaching and learning: A project of the national council of teachers of mathematics* (pp. 371–404). Information Age Publishing.
- Kajiwarra, Y., Matsuoka, A., & Shinbo, F. (2023). Machine learning role playing game: Instructional design of AI education for age-appropriate in K-12 and beyond. *Computers and Education: Artificial Intelligence*, 5, 100162. <https://doi.org/10.1016/j.caeai.2023.100162>
- Mandala, A. S., Anwar, L., Sa'dijah, C., & Zulnaidi, H. (2025). Development of mobile augmented reality-based geometry learning games to facilitate spatial reasoning. *Infinity Journal*, 14(2), 323–348. <https://doi.org/10.22460/infinity.v14i2.p323-348>
- Marton, F. (1986). Phenomenography—A research approach to investigating different understandings of reality. *Journal of thought*, 21(3), 28–49. <https://www.jstor.org/stable/42589189>
- Marton, F., & Booth, S. (1997). *Learning and awareness*. Lawrence Erlbaum Associates.
- Mercer, N., & Howe, C. (2012). Explaining the dialogic processes of teaching and learning: The value and potential of sociocultural theory. *Learning, Culture and Social Interaction*, 1(1), 12–21. <https://doi.org/10.1016/j.lcsi.2012.03.001>
- Pan, Y., Ke, F., & Xu, X. (2022). A systematic review of the role of learning games in fostering mathematics education in K-12 settings. *Educational Research Review*, 36, 100448. <https://doi.org/10.1016/j.edurev.2022.100448>
- Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of game-based learning. *Educational Psychologist*, 50(4), 258–283. <https://doi.org/10.1080/00461520.2015.1122533>

- Pramuditya, S. A., Noto, M. S., & Azzumar, F. (2022). Characteristics of students' mathematical problem solving abilities in open-ended-based virtual reality game learning. *Infinity Journal*, 11(2), 255–272. <https://doi.org/10.22460/infinity.v11i2.p255-272>
- Pramuditya, S. A., Noto, M. S., & Handayani, V. D. (2021). Desain didaktis konteks fabel berbasis pemahaman matematis siswa pada materi aljabar [Didactic design of fable context based on students' mathematical understanding of algebra material]. *Jurnal Elemen*, 7(1), 68–83. <https://doi.org/10.29408/jel.v7i1.2730>
- Pramuditya, S. A., Noto, M. S., & Syaefullah, D. (2018). The educational game design on relation and function materials. *Journal of Physics: Conference Series*, 1013, 012138. <https://doi.org/10.1088/1742-6596/1013/1/012138>
- Pramuditya, S. A., Widiyadari, R., & Fitriadi, P. (2025). Enhancing 3D geometry learning: A differentiated educational game approach. *Infinity Journal*, 14(4), 1043–1064. <https://doi.org/10.22460/infinity.v14i4.p1043-1064>
- Qian, M., & Clark, K. R. (2016). Game-based Learning and 21st century skills: A review of recent research. *Computers in human Behavior*, 63, 50–58. <https://doi.org/10.1016/j.chb.2016.05.023>
- Rittle-Johnson, B., Schneider, M., & Star, J. R. (2015). Not a one-way street: Bidirectional relations between procedural and conceptual knowledge of mathematics. *Educational Psychology Review*, 27(4), 587–597. <https://doi.org/10.1007/s10648-015-9302-x>
- Vygotsky, L. S. (1978). *Mind in society: Development of higher psychological processes*. Harvard university press.
- Wang, L.-H., Chen, B., Hwang, G.-J., Guan, J.-Q., & Wang, Y.-Q. (2022). Effects of digital game-based STEM education on students' learning achievement: a meta-analysis. *International journal of STEM education*, 9(1), 26. <https://doi.org/10.1186/s40594-022-00344-0>
- Webb, N. M., Franke, M. L., Ing, M., Wong, J., Fernandez, C. H., Shin, N., & Turrou, A. C. (2014). Engaging with others' mathematical ideas: Interrelationships among student participation, teachers' instructional practices, and learning. *International Journal of Educational Research*, 63, 79–93. <https://doi.org/10.1016/j.ijer.2013.02.001>
- Wouters, P., van Nimwegen, C., van Oostendorp, H., & van der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of educational psychology*, 105(2), 249–265. <https://doi.org/10.1037/a0031311>
- Zhong, L. (2022). Incorporating personalized learning in a role-playing game environment via SID model: A pilot study of impact on learning performance and cognitive load. *Smart learning environments*, 9(1), 36. <https://doi.org/10.1186/s40561-022-00219-5>