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ORIGINAL

Mathematical Concepts, Logical Reasoning, and Socio-Emotional Skills through Board Games

Conceptos Matemáticos, Razonamiento Lógico y Habilidades Socioemocionales con Juegos de Mesa

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ABSTRACT

Introduction: the pedagogical use of board games has gained attention as a strategy to foster mathematical reasoning and socio-emotional competencies in higher education.
Objective: this study analyzes the use of three board games—Qwixx, Sequence, and Scotland Yard—to promote mathematical logic and socio-emotional skills among undergraduate Mathematics Teaching students.
Method: a qualitative exploratory design was implemented with 32 undergraduate Mathematics Teaching students at Universidad Pedagógica Nacional Francisco Morazán (Honduras). The intervention consisted of six three-hour gameplay sessions, with data collected through observation and surveys.
Results: gameplay supported the development of mental calculation, number sequencing, probability estimation, pattern recognition, geometric reasoning, and logical inference. It also fostered decision-making, problem-solving, communication, teamwork, adaptability, and negotiation. Participants highlighted that gameplay provided authentic contexts for applying mathematical reasoning.
Conclusions: the findings indicate that these board games constitute viable pedagogical resources for integrating mathematical logic and socio-emotional skill development, with potential applications in mathematics education curricula.

Keywords: Mathematics Education; Soft Skills; Logical Thinking; Game-Based Learning; Critical Thinking.

RESUMEN

Introducción: el uso pedagógico de los juegos de mesa ha ganado atención como estrategia para fomentar el razonamiento matemático y las competencias socioemocionales en la educación superior.
Objetivo: este estudio analiza el uso de tres juegos de mesa—Qwixx, Sequence y Scotland Yard—para promover la lógica matemática y las habilidades socioemocionales en estudiantes de la carrera de Profesorado en Matemáticas.
Método: se implementó un diseño cualitativo exploratorio con 32 estudiantes de la carrera de Profesorado en Matemáticas de la Universidad Pedagógica Nacional Francisco Morazán (Honduras). La intervención consistió en seis sesiones de juego de tres horas cada una, con recolección de datos mediante observación y encuestas.
Resultados: la dinámica de juego favoreció el desarrollo del cálculo mental, la secuenciación numérica, la estimación de probabilidades, el reconocimiento de patrones, el razonamiento geométrico y la inferencia lógica. Asimismo, promovió la toma de decisiones, la resolución de problemas, la comunicación, el trabajo en equipo, la adaptabilidad y la negociación. Los participantes destacaron que el juego proporcionó contextos auténticos para la aplicación del razonamiento matemático.
Conclusiones: los hallazgos indican que estos juegos de mesa constituyen recursos pedagógicos viables para integrar la lógica matemática y el desarrollo de habilidades socioemocionales, con potenciales aplicaciones en los planes de estudio de educación matemática.

Palabras clave: Educación Matemática; Habilidades Blandas; Pensamiento Lógico; Aprendizaje Basado en Juegos; Pensamiento Crítico.

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INTRODUCTION

This research is based on the theory of gamification, exploring its potential to enhance learning. Gamification is defined as the incorporation of game design elements in non-game contexts to foster engagement and learning, highlighting its capacity to strengthen cognitive skills and socio-emotional abilities.[1] Board games, as part of gamification, provide a concrete means to develop these competencies.

In mathematics education, students often struggle to apply logical reasoning, communicate arguments clearly, and formalize solutions, particularly in proof-based tasks. Teachers also face challenges in selecting appropriate topics and pedagogical strategies for teaching reasoning and proof. Board games thus emerge as a valuable resource to support logical reasoning and mathematical logic across topics in arithmetic, algebra, and geometry. In this regard, an analysis is presented of how board games develop core educational skills and concepts that lead to academic achievement.[2]

Board games can develop students' interest in learning mathematics. In this direction, evidence shows that board games not only contribute to students' learning achievements in specific algebraic concepts, but also improve motivation and attitudes toward mathematics, positively influencing traditional learning environments.[3] Additionally, the design and implementation of board games aimed at strengthening logical reasoning have demonstrated positive results, including increased student motivation, collaborative work, and the development of soft skills such as teamwork, problem solving, analytical thinking, and autonomy.[4] Furthermore, systematic evidence indicates that board games have positive effects on promoting mathematics learning and increasing participants' motivation.[5]

Studies show that board games can be used as a strategy for teaching topics related to mathematics and logic. For instance, the didactical value of board games to introduce and consolidate concepts related to mathematical thinking has been highlighted, showing that they facilitate students' learning processes and foster the development of reasoning skills.[6] Additionally, a framework has been proposed to support teachers in guiding students during board game activities, concluding that board games can contribute to the development of basic cognitive skills of the curriculum, particularly reasoning, critical thinking, and communication.[7] Furthermore, research focused on strategy games has shown that students progress through processes such as conjecturing, interpreting, deciding, concluding facts, justifying, reflecting, and explaining strategies, all of which are essential skills for logical reasoning and argumentation.[8]

Studies have examined specific board games to assess their benefits in mathematics teaching. Evidence indicates that games such as Othello can enhance students' mathematical reasoning, as they require constant explanation and justification of moves and conclusions.[9] Similarly, research has shown that students who played games such as Settlers of Catan developed basic probability concepts more effectively than peers who engaged only with traditional problem-solving activities.[10] Positive effects have also been reported for classic games such as chess, with findings showing a strong association between playing chess and higher mathematics grades in young students.[11] In addition, replacing a weekly mathematics lesson with chess instruction has been associated with increased mathematics test scores, suggesting that chess can be an effective tool for improving mathematical skills at early educational levels.[12]

Positive effects of using board games to teach mathematics can be observed from early educational stages. Systematic evidence indicates that board games are associated with mathematical understanding and numerical abilities in prekindergarten and kindergarten children, with improvements reported in a substantial proportion of mathematics tasks when comparing pre- and post-assessments.[13] In addition, meta-analytic findings have shown a strong and positive relationship between chess abilities and key cognitive skills, including fluid reasoning, comprehension-knowledge, short-term memory, and processing speed.[14] Furthermore, classroom-based implementations of commercial board games have made it possible to examine how children use and develop different forms of reasoning, such as inductive, deductive, analogic, and informal reasoning, demonstrating growth in students' reasoning abilities through gameplay.[8]

Multiple implementations have demonstrated the benefits of gamification in mathematics. Evidence shows that problem-based gamification activities enhance student motivation more effectively than non–problem-based game-based learning approaches, even when implemented with large student samples.[15] In addition, curated game-based activities with detailed implementation guidelines have been reported as suitable for a wide range of college-level mathematics courses.[16] Furthermore, incorporating games into mathematics lessons has been associated with improved student attitudes toward the subject, largely due to the collaborative interactions and peer feedback fostered during gameplay.[17]

Taken together, these studies consistently report positive cognitive and motivational outcomes associated with board game implementation. However, much of the literature emphasizes either isolated cognitive gains or the use of a single game, without articulating an integrated perspective that simultaneously addresses mathematical logic and socio-emotional competencies. Moreover, relatively limited attention has been given to how such experiences may influence the professional preparation of future mathematics teachers.

For this research study, physical game boards are considered due to the social and emotional benefits they may provide to participants. Evidence indicates that the requirement to follow specific rules and alternate turns may contribute to the development of self-management skills, while board games inherently offer opportunities for social interaction and practice in turn taking, communication, negotiation, conflict resolution, and empathy.[18]

Although contemporary educational environments increasingly incorporate digital tools and augmented reality experiences aimed at enhancing interaction and engagement, the decision to employ physical board games was grounded in their tangible and face-to-face interaction dynamics. These characteristics enable direct observation of negotiation, communication, and collaborative reasoning processes within authentic classroom settings.

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Because various socio-emotional skills are stimulated during the experience of playing board games, it is necessary to take into account social and emotional learning (SEL), which is based on five core competencies: self-awareness, self-management, social awareness, relationship skills, and responsible decision-making.[19]

Incorporating board games into educational settings is consistent with active learning approaches such as Project-Based Learning (PBL) and the STEAM model. These approaches emphasize interdisciplinary connections, critical thinking, creativity, and collaborative problem-solving.[20,21]

Although there is research demonstrating that board games can support the teaching and learning of mathematics and the development of logical reasoning skills, such approaches remain scarcely explored in the Honduran educational context, particularly within higher education programs in mathematics. In Mathematics Teaching programs, the use of board games not only affects students' own learning processes but may also contribute to the development of didactic awareness. Experiencing these dynamics as learners allows future teachers to reflect on how structured gameplay can mobilize mathematical content, foster reasoning processes, and generate meaningful instructional situations transferable to school practice. Specifically, in the Universidad Pedagógica Nacional Francisco Morazán, no study exists that considers board games as a possible teaching instrument in courses including logic, not even other easier mathematics concepts.

The selection of Qwixx, Sequence, and Scotland Yard was intentional and based on criteria of mathematical and procedural complementarity. Qwixx engages mental calculation, number sequencing, and probabilistic estimation; Sequence promotes pattern recognition, spatial relationships, and strategic thinking; while Scotland Yard requires logical inference, planning, and decision-making under conditions of partial information. Together, these games allow for addressing a broad range of mathematical processes and interaction dynamics in an integrated manner.

Within this context, the present study addresses the following research question: What potential developments in mathematical concepts, logical reasoning, and socio-emotional skills do participants perceive can result from the use of selected board games in mathematics education? To address this question, the study aims to: identify the mathematical concepts and logic laws applied during gameplay; explore students' perceptions of the cognitive and socio-emotional skills fostered through these activities; and gather participants' ideas and recommendations regarding the educational use of the selected board games. In addition, the study proposes specific mathematical contents and curricular moments at different educational levels where the tested board games can be integrated as pedagogical resources.

METHOD

The research methodology adopted for this research study is an exploratory and descriptive qualitative research approach, using observations and surveys to collect data. This methodology aims to provide a detailed and comprehensive account of a phenomenon or experience, focusing on the perspectives and experiences of the participants.[22] The data was described in terms of the mathematical concepts and socio-emotional skills that participants reported as being positively stimulated during the game sessions.

Given its exploratory nature, the study did not seek statistical generalization but rather an in-depth understanding of how participants perceived the didactic and socio-emotional potential of board games within their academic formation.

The research was conducted at Universidad Pedagógica Nacional Francisco Morazán (UPNFM), Honduras, with students in the third and fourth year of the undergraduate degree in the Teaching of Mathematics. The participants were students aged 18–30, with a mix of genders and ethnicities. The inclusion criteria included being enrolled in or having approved the course Language of Mathematics of the study plan. Participants were invited to workshops or meetings to play board games. The resulting sample was therefore based on convenience and voluntary participation, as students who met the criterion and were available chose to attend the sessions.

Six sessions were held during May and June 2024, lasting between 2 and 3 hours each. A total of 32 students attended at least one of the six sessions, and on average, each session had 18 participants. This implies that the group composition varied across sessions rather than constituting a fully stable cohort. Data were collected from all participants who attended at least one session, and all 32 students completed the survey instrument, ensuring that the full sample contributed to the analysis. For confidentiality purposes, participants are identified in the article as P01 to P32. Three board games were mainly played: Qwixx, Sequence, and Scotland Yard.

Observation was used to directly document behaviors, interactions, opinions, and practices during the playing sessions. A participant observation approach was adopted, as the researcher facilitated and was actively present during the workshops while simultaneously documenting the interactions that emerged throughout gameplay. Attention was paid to evidence of mathematical reasoning processes and socio-emotional interactions, including strategic decision-making, argumentation, collaboration, negotiation, and communication among participants. Field notes were taken during and/or immediately after each session. These notes included descriptions of interactions, verbal exchanges, strategic decisions, and observable behaviors related to logical reasoning, communication, negotiation, and collaboration.

Two gameplay rounds of each board game were video recorded. These recordings were used to support the field notes and to review specific interaction episodes in greater detail, particularly those related to mathematical reasoning and socio-emotional exchanges observed during the sessions.

The observation process was open-ended during the workshops, without the use of a predefined observation guide. Categories and thematic groupings were subsequently organized during the data analysis phase, based on recurring patterns identified in the field notes, video reviews, and participants' survey responses.

A survey was conducted among participants to gain deeper insight into their specific experiences and opinions regarding gameplay.

The questionnaire combined closed-ended and open-ended questions. The open-ended questions invited participants to describe the mathematical concepts applied and the socio-emotional skills they perceived as stimulated during gameplay. In addition, closed-ended items included a Likert-type scale ranging from 1 (very low) to 5 (very high), which was used to obtain participants' ratings on different aspects of the board games. The inclusion of this scale aimed to complement qualitative descriptions with a descriptive quantitative overview of participants' perceptions, allowing comparison across evaluated aspects.

The questionnaire was reviewed and validated by a panel of three colleagues, including two mathematics professors and one psychologist, to ensure clarity, relevance, and appropriateness of the items. This review process contributed to reducing potential bias and avoiding leading or suggestive wording in the questions.

Participants were invited to workshops or meetings in which they played board games in small groups. During the workshops, participants engaged in gameplay and interaction, discussing strategies and reflecting on decisions made during the sessions. Through interaction and discussions, researcher gathered participants' insights, ideas, and perspectives about the experience. After gameplay, participants completed the survey.

After collecting the data from surveys, summarizing observations made during workshops, and joining the descriptions of the interactions and behaviors observed, the perceptions of the participants about the didactic benefits in teaching mathematics and the socio-emotional skills that emerged while playing board games were presented and described.

In line with the exploratory and descriptive nature of the study, the data were summarized to highlight the mathematical concepts and socio-emotional skills identified by participants as being stimulated through gameplay.

The qualitative data (open-ended responses, field notes, and observation summaries) were organized and coded using MAXQDA 2024 software for data organization and retrieval.[23]

An inductive coding approach was employed, allowing categories to emerge from participants' responses and observed interactions rather than being predefined by an external framework. Codes were generated iteratively through repeated reading and comparison of the data, identifying recurring references to mathematical concepts and socio-emotional skills stimulated during gameplay.

Categories were defined based on recurring references to mathematical concepts (e.g., probability, sequencing, logical inference) and socio-emotional skills (e.g., teamwork, decision-making, negotiation).

Quantitative data derived from the Likert-scale items were summarized descriptively by calculating average ratings for each evaluated aspect, as shown in Figure 6. These numerical summaries were used to complement, not replace, qualitative interpretations.

In this study, the confidentiality of the participants was preserved. Participants were informed about the purpose of the research and agreed to the use of their opinions, interactions, and experiences during the workshops and surveys for research purposes. The study received approval from the ethics committee of the university where it was conducted.

RESULTS

In this section, we present the empirical outcomes that show the multifaceted benefits of integrating board games into educational settings to enhance learning in mathematics, reasoning skills, and social-emotional development. First, the data obtained from the survey is described, and then, expressions and comments from the observations are presented.

The 32 participants were asked if they had played board games before in the last year, in a five-option question: never, seldom, occasionally, almost every day, and every day. The distribution of the answers to this question is presented in figure 1. Around 53 % of the participants play board games occasionally or almost every day before this experience. No participant plays board games every day.

The board games that the participants play, not including the ones proposed in the sessions of this study, are UNO, Jenga, Connect Four, Domino, Classic Sorry (Parchís), Catan, Monopoly and Checkers. A really short list of options, that for example, does not include some classic ones, such as Sudoku and Chess. Concerning the Classic Sorry game, participants mentioned that it could be used for developing strategies of counting and adding/subtracting small integer numbers. Regarding the Domino game, some participants indicated that it includes some math concepts such as counting, operations, double, commutative property of addition, more than, and less than.

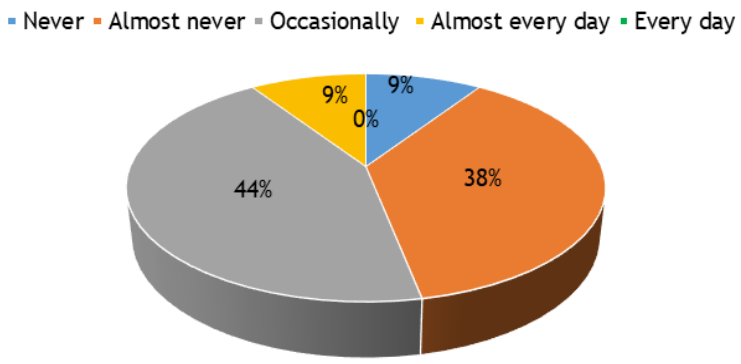

Figure 1. Frequency of participants' interaction with board games in the last year

Three board games were mainly played during the sessions, Qwixx, Sequence, and Scotland Yard. First, Qwixx is a fast-paced, roll-and-write dice game that combines simplicity with strategic depth. Designed for 2 to 5 players, it involves rolling colored dice and choosing combinations to mark off numbers on personal score sheets. Players aim to complete rows of numbers while managing risks to maximize their scores. Each turn offers different choices, as players must balance the desire to score points with the need to prevent opponents from gaining an advantage. Game instructions are available.[24] Figure 2 shows a moment of the participants playing Qwixx. For its part, Sequence is a strategic board game that combines elements of card play and board strategy. Players aim to create a sequence of five connected markers on the board, which features a 10x10 grid displaying different playing cards. Each player uses a hand of cards to place their chips in corresponding spaces on the board. Players take turns drawing cards, placing their chips, and blocking opponents while trying to form their own sequences. The first player or team to achieve the required number of sequences wins the game. It's suitable for 2 to 12 players and is great for families and friends, offering a mix of luck and strategic thinking. More details about the game and its rules are available.[25] The development of a Sequence match is seen in figure 3.

Finally, Scotland Yard is a classic board game that combines strategy, deduction, and teamwork. Set in London, players take on the roles of either detectives or the elusive criminal known as Mr. X. The detectives work together to track down Mr. X as he moves secretly across the board using various modes of transportation, while Mr. X tries to evade capture and reach specific destinations. The game involves careful planning, strategic movement, and the use of limited public transport tickets, making each round a thrilling chase. The combination of hidden movement and cooperative gameplay creates an engaging experience for players. A version of the game contextualized in Italy was also used. A more detailed description and game instructionsis available.[26] Figure 4 and figure 5 shows participants playing Scotland Yard (London version and Italian version, respectively) in a turn almost near the end of the game.

Figure 2. Participants playing Qwixx

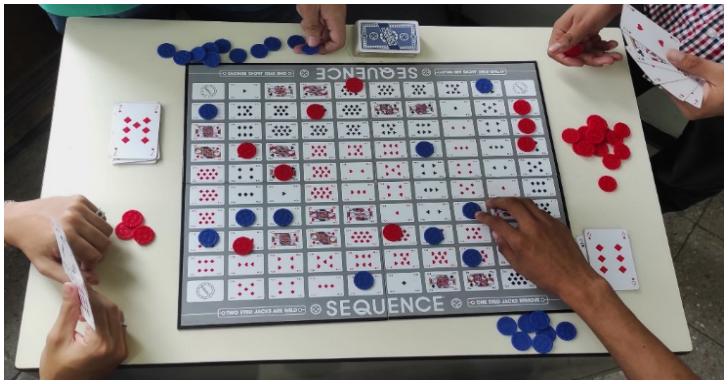

Figure 3. Development of a Sequence match

Figure 4. Participants playing Scotland Yard (London version)

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Figure 5. Participants playing Scotland Yard (Italian version)

Figure 6 presents participants' evaluations of the three board games on a scale from 1 (very low) to 5 (very high). The evaluated aspects included materials and rules, difficulty, enjoyment, willingness to play again, relationship with mathematics, relationship with prior knowledge, perceived learning, and interaction with other players. Participants considered that materials and difficulty increased progressively from Qwixx to Sequence and then to Scotland Yard. They responded positively regarding enjoyment and willingness to play again. Concerning the relationship with mathematics, prior knowledge, and perceived learning, all three games were rated similarly, around 4/5. Interaction with other players received ratings close to 5 in all cases.

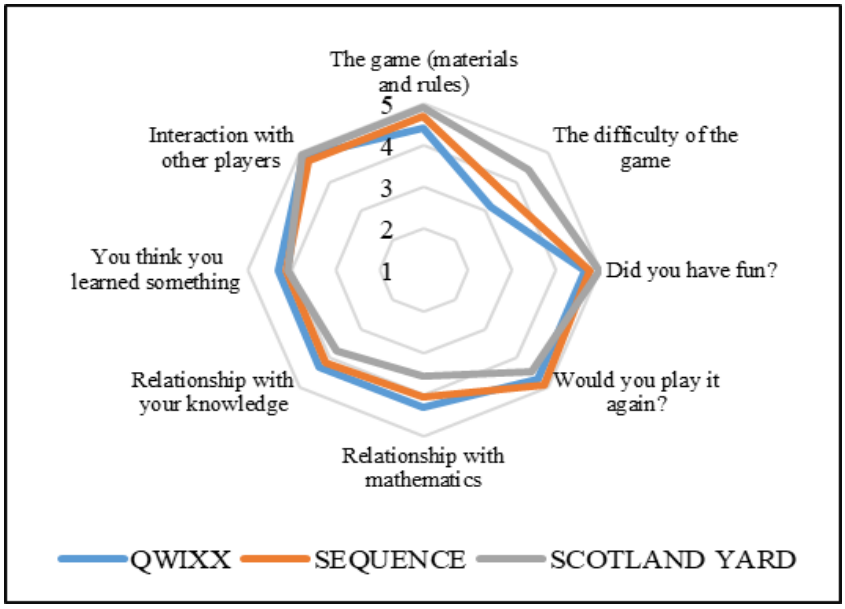
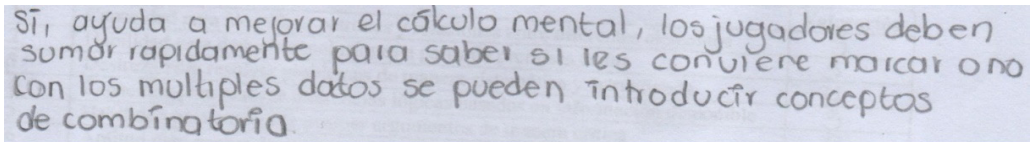


Figure 6. Perception of participant's interaction about some aspects while playing the board games proposed during the sessions

Some key math concepts and reasoning abilities that players identified they can develop while playing Qwixx include number recognition, counting, addition, basic arithmetic, probability, strategic thinking, planning, patterns, sequences, critical thinking, and goal setting. For instance, regarding counting and addition, players add the numbers shown on the dice to determine which numbers they can mark off on their score sheet, and this requires mental addition and encourages players to quickly assess the possible outcomes of their rolls, reinforcing addition skills, a comment in this direction was made by participant P11 who states that "Yes, it helps to improve mental calculation, players must add quickly to know if it is convenient for them to score or not. With multiple dice you can introduce combinatorial concepts", see figure 7. Hence, players must evaluate various options, exactly nine sums, after each roll and decide the best course of action, and this fosters their critical thinking.



Yes, it helps to improve mental calculation, players must add quickly to know if it is convenient for them to score or not. With multiple dice you can introduce combinatorial concepts.

Figure 7. Comment of participant P11 about math concepts enhanced while playing Qwixx

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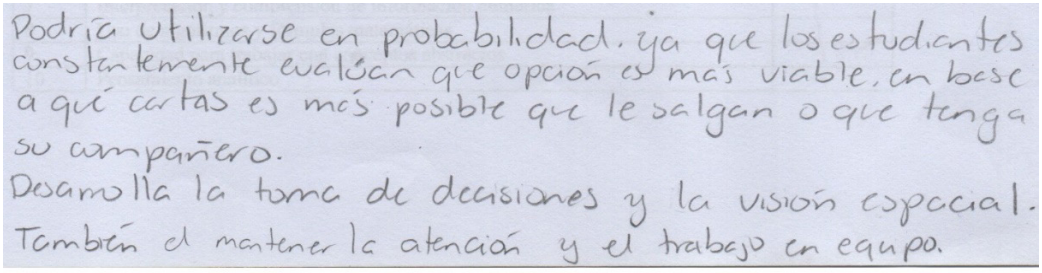
Players also identified probability in the board game Qwixx, since they must evaluate the likelihood of rolling certain combinations of numbers and decide whether to take risks by marking off numbers.

Additionally, players developed strategic thinking, since they foresaw and planed their move to maximize their points while minimizing risks, enhancing their strategic decision-making skills, an interesting comment in this direction was given by participant P16, mentioning that "players must evaluate the likelihood of rolling certain combinations of numbers and decide whether to take risks by marking off numbers". Finally, participant P28, as registered while playing, identifies the sequence with which the final sum of the points is made, in which, according to the number of marks on the marking card, for each row, the sum of the first natural numbers is obtained until reaching that number of marks.

While playing the board game Sequence, participants mentioned that they can enhance various math concepts and reasoning skills in several ways. For example, strategic thinking, pattern recognition, spatial reasoning, critical thinking, probability and geometry. For instance, participant P03 mentioned that "It could be used in probability, since players constantly evaluate which option is most viable, based on what cards are most likely to be drawn or that their teammate has. Develops decision making and spatial vision. It also requires maintaining attention and teamwork", see figure 8, and this is evidence in the fact that players often need to estimate the likelihood of drawing certain cards or completing a sequence based on the cards already played. This requires an understanding of basic probability concepts.

While observing participants playing Sequence, it was noted that they often think ahead about their moves and anticipate the consequences. They frequently comment on evaluating different potential sequences and their outcomes, which demonstrates logical reasoning and decision-making. Additionally, they must recognize how pieces can connect to form sequences, which is a key aspect of geometric reasoning. For instance, participant P08 mentions that "Sequence can be used as a teaching tool to reinforce basic geometry concepts, such as diagonal, horizontal, vertical, parallel, and perpendicular lines. It also includes geometric figures like triangles, squares, and rhombuses."



It could be used in probability, since players constantly evaluate which option is most viable, based on what cards are most likely to be drawn or that their teammate has. Develops decision making and spatial vision. It also requires maintaining attention and teamwork.

Figure 8. Comment of participant P03 about probability concepts appearing while playing Sequence

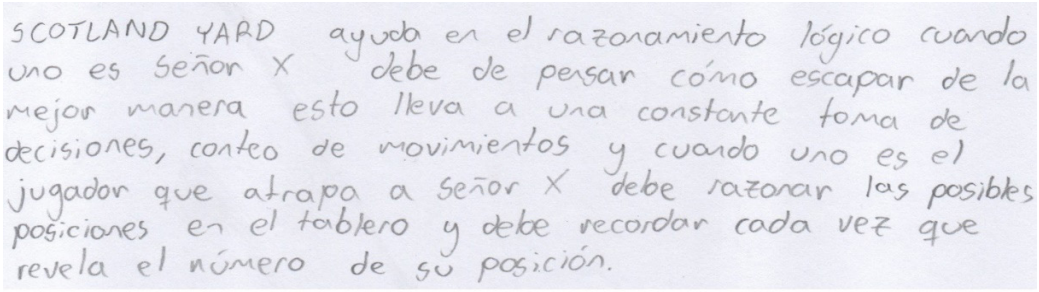
Furthermore, participants noted that as the game progresses, they must adapt their strategies based on new information, which fosters flexible thinking and the ability to modify plans. Phrases like "I cannot make that move anymore" or "I can no longer form that sequence" are common. Lastly, participant P08 suggests that when choosing between two possible positions for a card, it is better to play the position closer to the center of the board, as "there are more possibilities of forming sequences in the center than on the sides or corners." The need to anticipate moves, justify decisions, and articulate strategies during Sequence aligns with findings from research on the strategic board game Othello, where players' mathematical reasoning was reinforced through ongoing explanations and justifications in gameplay.[9]

Participants concluded that Scotland Yard can enhance various mathematical concepts and reasoning skills, particularly in areas like graph theory, probability, strategic thinking, and logical reasoning. For instance, during the game, participant P05 remarked, "The map is like a graph where locations on the board represent nodes, and the connections between them represent edges, with the game involving movement through this graph." The game also introduces elements of chance, especially in how Mr. X moves and how the detectives attempt to guess his location.

While playing, it is common for participants to devise strategies to either capture Mr. X (as detectives) or evade capture (as Mr. X). This process involves planning several moves ahead, anticipating opponents' actions, and adapting strategies based on the changing game state. Additionally, players often optimize their movements; in this regard, participant P32 noted, "At certain moments in the game, it's necessary to ask yourself, what is the optimal way, spending the least amount of moves together with the other detectives, to quickly reach nearby nodes to Mr. X."

Scotland Yard also involves significant logical reasoning, as the game requires players to use logical deduction to determine Mr. X's potential locations based on the available information (e.g., the transport tickets used). This enhances logical reasoning skills as players make inferences and deductions based on the game's rules. For example, participant P01 mentioned, "Scotland Yard helps with logical reasoning. When you are Mr. X, you must think about how to escape in the best way, leading to constant decision-making and counting of moves. As a detective, you must reason about Mr. X's possible positions on the board and remember each time his position is revealed" (figure 9). Players face numerous decisions throughout the game, such as where to move or when to use special tickets, fostering critical thinking and decision-making skills.

Most participants agreed that while playing, you must continually make guesses, pose scenarios, and decide on the most convenient option, all of which require evaluating premises and engaging in deductive reasoning. Various laws of logic are applied during gameplay, such as transitivity, modus ponens, modus tollens, disjunctive syllogism, and reduction to the absurd. Participants have identified the use of these logical principles when playing board games, particularly when drawing conclusions from a set of premises.



Scotland Yard helps with logical reasoning. When you are Mr. X, you must think about how to escape in the best way, leading to constant decision-making and counting of moves. As a detective, you must reason about Mr. X's possible positions on the board and remember each time his position is revealed.

Figure 9. Comment of participant P01 arguing the need for logical reasoning to find Mr. X's while playing Scotland Yard

For example, in the games Qwixx and Sequence, transitivity is frequently applied, as each move is planned based on previous ones. Participant P19 explains, "In the game Sequence, if I have a certain card, I play it in a specific position. If, in the next turn, I've already executed the previous idea, I play another move adjacent to the previous card, thereby forming a sequence. In this way, the transitivity of logical propositions is constantly applied."

While observing participants playing Scotland Yard, it was noted that they frequently use modus ponens and modus tollens, as they constantly pose hypotheses and scenarios to deduce conclusions. For example, in the case of modus ponens: if Mr. X moves by taxi, then he will be in a particular position. After Mr. X reveals himself and it turns out that he did indeed move by taxi, the players' hypothesis is confirmed. Modus tollens, on the other hand, appears in situations like the following: Mr. X plays a hidden move, and the detectives hypothesize that if Mr. X moved by bus, he would be in a certain position. When Mr. X is revealed and is not in the position the detectives suggested, they deduce that Mr. X did not previously travel by bus.

Disjunctive syllogism was identified by participant P28, when Scotland Yard is played, "near the end of the game, and the detectives know that Mr. X can only be in two positions, and one of them occupies one of those positions, if Mr. X is still alive, it means that he is in the other position. This is p or q, and if q does not hold, then p is deduced". This law of logic is quite recursive in this game. The requirement to anticipate opponents' moves reflects the higher-order thinking skills emphasized in the STEAM framework, integrating mathematics with strategic design and creative problem-solving.[21] The cycle of conjecturing, verifying, and adjusting strategies observed—for example, formulating hypotheses about Mr. X's route and refuting them with new information—replicates reasoning trajectories identified in game-based contexts, where students progress through conjecturing, interpreting, deciding, concluding, and justifying.[8]

A transversal aspect across the three games is their connection to logical reasoning. In Qwixx, students use conditional statements when they predict outcomes: "if I choose to mark this number, then my probability of success increases; if not, I may lose the chance later." In Sequence, players construct arguments based on premises and conclusions, such as "if I block this position, then the opponent cannot complete a diagonal; therefore, my move prevents their win." In Scotland Yard, deductive structures appear when detectives reason: "if Mr. X used a taxi ticket and cannot be in station A, then he must be in station B or C." These examples show how these board games provide concrete situations where formal logic rules (modus ponens, modus tollens, disjunctive syllogism) can be practiced in accessible ways.

The participants were asked about the logical reasoning skills that are stimulated by the experience of playing board games during the sessions developed, and the most valued aspects, in this order, include:

- Make rational and informed decisions.
- Organize information logically and sequentially.
- Deduce conclusions from given premises.
- Analyze and evaluate arguments critically.
- Identify relationships between different elements.

In addition, the participants mention the socio-emotional skills that are stimulated during the experience of playing board games, the first five are listed below in the order of assessment:

- Decision making.
- Teamwork.
- Critical thinking.
- Effective communication.
- Negotiation skills.

Participant P02's reflections on the experience of playing board games during the sessions provide valuable insights into the cognitive and socio-emotional skills cultivated through these activities. P02 highlights that playing board games is not merely a fun and engaging educational activity but also offers a multifaceted experience that can impact various areas. Specifically, board games stimulate cognitive development by fostering critical thinking and strategic decision-making skills. They also enhance social skills by facilitating interaction, whether through collaboration or competition, and contribute to emotion management, as players learn to navigate their emotions in the face of both victories and defeats (figure 10). These observations underscore the potential of board games as tools for holistic development, integrating cognitive, social, and emotional learning experiences.

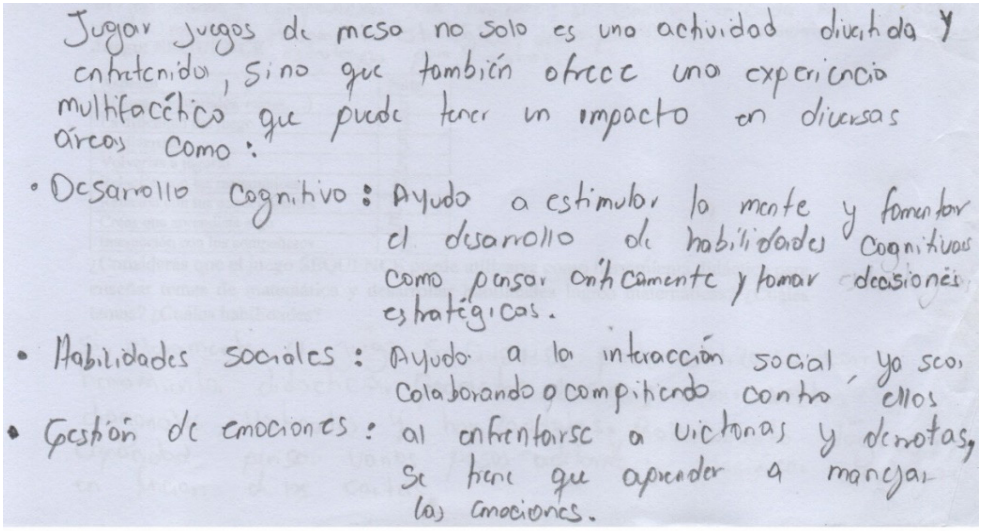


Figure 10. Comment of participant P02 about the experience of playing board games

Finally, figure 11 presents a word cloud that compiles the general reactions of the participants when interacting with the board games, when they are asked to comment on the experience during the sessions. It is emphasized that the words that appear most are decision-making, teamwork, deductive analysis, problem-solving, and communication. Many of these resulting words coincide with the capabilities included within the 5 competencies on social and emotional learning (SEL).[19]

Figure 11. Word cloud generated with the comments of the participants to the activity of sessions to play board games

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DISCUSSION

The findings presented in the Results section invite deeper interpretation beyond descriptive reporting. A distinctive feature of this study is that the participants were future mathematics teachers rather than secondary school students. This characteristic likely influenced the depth and explicitness of the mathematical connections identified during gameplay, including references to formal logical laws and graph-theoretical reasoning. Therefore, the results should be interpreted within the framework of teacher education, where participants' prior disciplinary knowledge shapes how they perceive and articulate the didactic potential of board games.

The quantitative perceptions displayed in Figure 6 merit closer examination. Although Qwixx, Sequence, and Scotland Yard differ substantially in mechanics and cognitive demands, participants rated the "relationship with mathematics" similarly (around 4/5) across all three games. This convergence suggests that mathematical engagement may be perceived less as a function of formal complexity and more as a consequence of structured decision-making, rule-based reasoning, and pattern recognition embedded in gameplay. The consistently high ratings in "interaction with other players" (close to 5 in all cases) further indicate that social dynamics may reinforce how mathematical relevance is experienced. The positive evaluations of enjoyment and willingness to play again also suggest a possible relationship between affective engagement and perceived learning, although no inferential statistical analysis was conducted to establish correlations between these dimensions.

Several of the empirical patterns observed are consistent with prior research. The probabilistic reasoning identified in Qwixx corresponds with findings indicating that probability-based board games can strengthen arithmetic fluency and strategic decision-making.[10] The geometric and spatial reasoning reported in Sequence aligns with analyses of logic and strategy games as didactic tools for introducing and consolidating mathematical concepts.[6] Similarly, the deductive reasoning processes observed in Scotland Yard reflect reasoning trajectories identified in game-based contexts, where students engage in conjecturing, interpreting, deciding, concluding, and justifying strategies.[8] The broader cognitive and interpersonal benefits described by participants are also consistent with systematic reviews reporting that board game interventions can enhance content understanding, motivation, and the quality of interpersonal interactions among learners.[4,5]

However, beyond alignment with existing literature, this study contributes a complementary perspective by examining three board games simultaneously rather than focusing on a single case. The analysis highlights how different mechanics activate distinct mathematical domains—arithmetic in Qwixx, geometric reasoning in Sequence, and graph theory and formal logic in Scotland Yard—within a unified pedagogical experience. This multi-game approach allows for a broader integration of mathematical concepts and reasoning processes than studies centered on one specific game.

The Honduran higher education context also provides an additional contribution. Much of the literature on game-based mathematics learning has been produced in European and North American settings. By examining the perceptions of mathematics teacher candidates in a Central American university, this study expands the geographical scope of existing evidence and offers insight into how gamified approaches are interpreted in contexts where such methodologies are not yet systematically embedded in mathematics curricula.

Summarizing, these board games can be used in the classroom as tools to approach mathematical content in progressive ways, while also providing opportunities to discuss and practice logical reasoning. Board games can be systematically integrated into classroom practice to support the teaching of academic concepts and engage students in active participation. In table 1, we present examples where Qwixx, Sequence, and Scotland Yard can be integrated into lessons at different levels of mathematics teaching.[2]

In Qwixx, rolling and combining dice is an immediate context for practicing addition of integers. At a basic level, teachers can ask students to record all possible sums of two dice and identify which sums appear more frequently in play. This leads to the construction of the distribution of sums from 2 to 12. At an intermediate level, the game can be linked to probability: students compare the theoretical frequency of a 7 with the actual outcomes observed in their games. They can discuss why some results deviate from expectation. At a more advanced level, the scoring rows of Qwixx can be connected to arithmetic sequences. Students calculate how many points are obtained from n consecutive marks, recognize triangular numbers in the scoring system, and justify why the formula $T_n=(n(n+1))/2$ emerges from the game's mechanics.

Sequence offers a visual context that can be directly connected to geometry. At a basic level, the formation of horizontal, vertical, and diagonal lines on the grid allows students to identify parallel and perpendicular lines, as well as angles formed at intersections. Teachers can pause the game and ask players to describe the line they are building using geometric terms. At an intermediate stage, the probability of completing a sequence given the cards in hand can be studied. Students calculate the chance of drawing a needed card, compare outcomes, and discuss how knowledge of the deck influences decision-making. At a more advanced level, the strategic decisions in Sequence can be used to practice constructing arguments. Students justify why a move is optimal, why blocking an opponent is more effective than advancing, or why one sequence has greater potential than another. These justifications can be written in the form of short argument structures resembling mathematical proofs.

Scotland Yard introduces students to graphs and networks. At a basic level, the board can be redrawn as a graph where stations are nodes and connections are edges. Students locate the shortest path between two stations and verify it by playing moves. At an intermediate level, the deductive process of locating Mr. X with limited information provides a context to test hypotheses. Detectives formulate possibilities, eliminate inconsistent options, and use available data to narrow Mr. X's location. At a more advanced stage, Scotland Yard can be linked to optimization problems. Students analyze the cost of strategies based on limited tickets, compare alternatives, and determine which path minimizes resource use while maximizing efficiency.

Taken together, these findings support broader evidence that game-based activities can serve as inclusive pedagogical tools, consistent with gamification principles, by engaging diverse learners in authentic, interactive tasks that promote both academic and social-emotional growth.[1,17]

Table 1. Classroom themes by level and board game

Level	Qwixx	Sequence	Scotland Yard
Basic	Addition with two dice; listing sums 2–12; comparing frequencies	Identifying parallel, perpendicular, and diagonal lines; describing angles	Representing the board as a graph; identifying nodes and edges; shortest path between two stations
Intermediate	Theoretical vs. empirical probability of dice outcomes; comparison of expected and observed results	Calculating probability of drawing specific cards; estimating likelihood of completing a sequence	Hypothesis testing about Mr. X's location; eliminating inconsistent possibilities based on ticket use
Advanced	Arithmetic sequences and triangular numbers from scoring rows; deriving formula $T_n=(n(n+1))/2$	Constructing strategic arguments for moves; blocking strategies; writing justifications in proof-like form	Optimization under constraints; comparing strategies with limited tickets; resource allocation problems

Several limitations should be acknowledged. The sample was based on convenience and voluntary participation, which limits generalizability. Attendance varied across sessions, and the group was not fully stable throughout the intervention. Participants were future mathematics teachers, whose prior knowledge may have influenced the depth of the mathematical interpretations identified. The study relied primarily on self-reported perceptions and qualitative observations rather than objective performance measures. Additionally, the Likert-scale data presented in figure 6 were analyzed descriptively and do not constitute inferential statistical evidence.

Future studies could replicate this design with secondary school students to examine whether similar mathematical connections emerge in populations with different levels of prior knowledge. Experimental or quasi-experimental designs could explore measurable learning gains and analyze possible relationships between enjoyment, interaction, and perceived mathematical relevance in greater depth.

CONCLUSIONS

Engaging in board games such as Qwixx, Sequence, and Scotland Yard provides more than an entertaining classroom activity. The findings indicate that structured gameplay can create meaningful contexts for mathematical reasoning, strategic thinking, and the articulation of formal logic. Each game activates distinct mathematical domains—arithmetic and probability in Qwixx, geometric reasoning and argument construction in Sequence, and deductive logic and graph structures in Scotland Yard—demonstrating that commercial board games can function as cognitively rich pedagogical environments.

Beyond cognitive development, participants consistently identified socio-emotional growth as an integral part of the experience. Decision-making, teamwork, communication, negotiation, and emotional regulation emerged not as secondary effects but as embedded features of gameplay. This suggests that the integration of board games into mathematics education may simultaneously address academic and socio-emotional dimensions of learning, rather than treating them as separate instructional goals.

From the perspective of gamification theory, the study reinforces the idea that meaningful learning does not depend solely on digital environments or reward systems. Instead, rule-based interaction, uncertainty, strategic choice, and social negotiation—core elements of game design—can generate sustained cognitive engagement in physical board game settings. The findings therefore contribute to discussions on gamification by illustrating how structured, non-digital games can operationalize theoretical principles such as active participation, immediate feedback, and situated problem-solving.

The implications for teacher education are particularly relevant. Because participants were future mathematics teachers, gameplay functioned not only as a learning experience but also as a didactic reflection opportunity. Participants were able to identify explicit mathematical structures within the games and propose curricular connections across educational levels. This suggests that incorporating board games into teacher training programs may support the development of pedagogical content knowledge, enabling future teachers to recognize and design learning situations grounded in interactive problem-solving contexts.

At the curricular level, board games can be integrated into secondary and higher education mathematics courses as complementary tools within active learning methodologies. Their use may support arithmetic, algebra, probability, geometry, discrete mathematics, and logical reasoning topics, while fostering engagement and collaborative inquiry.

However, several methodological limitations must be acknowledged. The study relied on a convenience and voluntary participation sample, and the group composition varied across sessions. No control group was used, and the findings are based largely on self-reported perceptions and qualitative observations rather than objective measures of learning gains. Additionally, because participants were students in a teacher education program, their responses may reflect prior disciplinary knowledge and possible social desirability effects. While the accessibility of commercial games can pose practical constraints, the primary limitations concern the exploratory design and the perceptual nature of the data.

Future research should examine the implementation of similar game-based strategies with secondary school students and incorporate objective assessments of learning outcomes. Comparative or quasi-experimental designs could further clarify the extent to which gameplay contributes to measurable gains in mathematical reasoning and socio-emotional development.

In sum, this study suggests that structured board game experiences, when intentionally integrated into mathematics education and teacher training, can serve as pedagogically meaningful environments that connect formal reasoning, social interaction, and reflective practice.

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