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The Use of Mind Maps and Educational Snakes and Ladders to Overcome Learning Difficulties in Acids and Bases

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Abstract

Low level of students' conceptual understanding and engagement in learning chemistry, particularly on acid-base topics. The purpose of this study is to analyze the effectiveness of ethnoscience-based mind map wall displays and an educational Snakes and Ladders game in improving students' conceptual understanding and motivation to learn. The study employed a qualitative classroom action research design conducted in two cycles, involving 67 eleventh-grade students at SMAN 4 Mataram, with data collected through observations, student worksheets, and learning evaluations. The results indicate a significant improvement in students' conceptual understanding, active participation, and learning outcomes, as evidenced by more than 80 percent of students achieving scores above the minimum competency criteria and an increase in the average score from 62 to 81, along with positive student responses toward a more interactive and contextual learning process. In conclusion, the integration of visual, ethnoscience-based, and gamification-oriented learning media is effective in enhancing the quality of chemistry learning, particularly on acid-base material. This study suggests that innovative, contextual, and game-based learning strategies can serve as effective alternatives for improving the quality of science education.

Keywords: acid base learning; chemistry education; ethnoscience; gamification; mind mapping

INTRODUCTION

In the 21st century, science education plays a vital role in equipping students with critical-thinking, analytical, and problem-solving skills. Chemistry, as a branch of science, contributes to the systematic explanation of natural phenomena; however, its teaching often faces challenges due to the subject's abstract and complex nature. Various studies indicate that conceptual difficulties and misconceptions in chemistry are global issues requiring more innovative and contextual learning approaches (Kumar, 2024; Islamiyah et al., 2022; Taber, 2013; Johnstone, 1991).

One of the fundamental concepts in chemistry that frequently causes difficulty is acid-base material. Empirical data indicate that students' understanding of this material remains low, as seen at SMAN 3 Padang Panjang, where 80.2% of students failed the basic acid-base test, and 46.8% fell into the high-difficulty category (Rahmadhani & Guspatni, 2023). A similar situation was also observed among 11th-grade students at SMAN 4 Mataram, who found this material difficult and boring due to the large number of formulas and theories presented in lectures. These findings indicate that difficulties with understanding acid-base concepts also occur in school settings in West Nusa Tenggara, thereby reinforcing the urgency of research in relevant local contexts.

These learning difficulties can be influenced by various factors, both internal and external (Marfu'a & Astuti, 2022). Furthermore, the concept of acids and bases requires understanding at various levels of representation (macroscopic, microscopic, and symbolic), which often leads to misconceptions among students. This is supported by research indicating that the complexity of chemical representations is the primary cause of students' low conceptual understanding (Srisawasdi & Panjaburee, 2019; Gilbert & Treagust, 2009). Yulizah's research indicates that 94.7% of students struggle to understand acid-base concepts due to a lack of visualizations in textbooks (Yulizah et al., 2015), while traditional approaches, such as lectures, have proven ineffective at enhancing student engagement (Turner, 2023; Freeman et al., 2014). Overall, these findings indicate that students require support in the form of conceptual visualizations, knowledge organization, and more contextual and interactive learning experiences to help them fully grasp the interconnections among chemical representations.

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One alternative is to implement visual, contextual, and educational game-based learning materials. Mind maps, as a visual tool, have been proven to help students organize concepts and improve retention and critical thinking skills (Rai & Naur, 2024), while concept mapping is effective in correcting misconceptions and improving students' conceptual understanding (Wu et al., 2025; Novak & Cañas, 2008). The ethoscience approach allows for the integration of local wisdom, making learning more relevant, and gamification through educational games has been shown to increase student motivation and learning outcomes (Tursyngozhayev & Kavak, 2024; Maršálek et al., 2024; Cai, 2022; Deterding et al., 2011; Hamari et al., 2014). In this study, these various approaches were focused and integrated into three main media: mind maps, local wisdom-based ethoscience bulletin boards, and the educational "Acid-Base Snakes and Ladders" game, thereby making learning more focused, contextual, and engaging for students.

Based on the above discussion, the integration of mind maps, local wisdom-based ethoscience bulletin boards, and the educational acid-base snakes-and-ladders game represents a potentially innovative approach to addressing students' learning difficulties. Therefore, this study aims to analyze the effectiveness of integrating these three media in enhancing students' conceptual understanding and motivation to learn acid-base concepts at the high school level. The novelty of this study lies in the integration of three distinct learning approaches, visual (mind maps), contextual, and based on local wisdom (ethnoscience bulletin boards), and gamification (educational Snakes and Ladders), into a single integrated learning design that has not been extensively studied in tandem within the context of high school chemistry education.

MATERIALS AND METHODS

Time and place

This study was conducted during the second semester of the 2024/2025 academic year, specifically in May 2025. The research was carried out over two instructional cycles, with each cycle consisting of two sessions, each lasting 2 × 45 minutes, for a total of four sessions. The research was conducted at SMAN 4 Mataram, West Nusa Tenggara. The selection of the location was based on initial observations indicating students' learning difficulties with acid-base material, particularly in understanding basic concepts such as pH, neutralization reactions, and acid-base indicators. Operationally, this level of difficulty was indicated by low student learning achievement, with more than 70% of students not meeting the minimum passing criteria (KKM), as well as initial evaluation results showing that misconceptions regarding basic acid-base concepts remained prevalent.

Research design

This study employs a qualitative approach using classroom action research (CAR), conducted over two cycles. Classroom action research is a form of reflective research conducted by teachers to improve the learning process and enhance student learning outcomes through specific, systematic interventions. Each cycle in this study consists of four stages: planning, action implementation, observation, and reflection.

This approach was chosen because it allows the researcher to directly identify learning problems and implement solutions in the form of innovative learning media, namely mind maps based on ethoscience and the educational game "Snakes and Ladders of Acids and Bases." Classroom action research has proven effective in improving the quality of learning through a cycle of continuous improvement (Widarti et al., 2024; Putri & Wahyuningsih, 2024; Mukhollafah et al., 2025). Furthermore, according to Kemmis & McTaggart (1988), action research is a reflective spiral process consisting of planning, action, observation, and reflection, repeated to improve teaching practices. In line with this, Mertler (2017) states that PTK plays a crucial role in improving the quality of learning and serves as a means of professional development for teachers by resolving real-world classroom problems (Siregar, 2025).

In this study, the criteria for the success of the action were established as the basis for continuing or stopping the cycle: at least 80% of students demonstrated improved conceptual understanding and active participation in learning. If these criteria were not met in Cycle I, the study would proceed to Cycle II with improvements based on the results of the previous reflection (Mukhollafah et al., 2025; Sa'diyah, 2024). This study also involves the researcher as a collaborator who works with subject teachers to design interventions, implement instruction, conduct observations, and reflect on the results of the interventions in each cycle. This collaborative role is essential to ensure the objectivity of the data and the effectiveness of the reflection process in action research (Rokhman & Yuniawan, 2021; Thamrin, 2011).

Research Population and Sample

The population of this study comprises all 11th-grade students at SMAN 4 Mataram for the 2024/2025 academic year. The study sample comprises 67 students: 35 from 11th-grade class IKL 1 and 32 from 11th-grade class IKL 3. These two classes were selected because they are parallel classes with relatively similar academic abilities; however, based on the results of the initial evaluation, they exhibited the highest level of difficulty learning acid-base material compared to other 11th-grade classes, making them representative for the implementation of remedial learning interventions.

The sampling technique used was purposive sampling, which involves selecting a sample based on specific considerations. According to Sugiyono (2019), purposive sampling is a technique for determining a sample based on specific considerations aimed at ensuring the data obtained is more representative in line with the research objectives, thereby enabling a more in-depth analysis of the learning process (Magnone & Yezierski, 2024; Hagos & Andargie, 2024). The criteria for sample selection in this study include: (1) initial evaluation results showing that more than 50% of students had not met the minimum passing grade (MPG) on acid-base material, (2) students experiencing difficulty in understanding basic concepts such as pH, acid-base properties, and indicators, and (3) recommendations from subject teachers regarding classes requiring learning intervention.

The variables in this study include independent variables such as the use of ethoscience-based mind map bulletin board learning materials and the educational "Acid-

Base Snakes and Ladders" game, as well as dependent variables such as students' conceptual understanding, active participation, and interest in learning. Conceptual understanding indicators include the ability to classify acids and bases, explain concepts in a logical sequence, and perform simple pH calculations; active participation indicators include engagement in discussions, group collaboration, and involvement in learning activities; while learning interest indicators include enthusiasm, attention during lessons, and positive responses to the use of learning media.

The data collected consisted of qualitative observations of student activities, group work results (LKPD), and documentation from the learning process. The materials and tools used in this study included mind map learning media, an ethoscience bulletin board, an educational snakes and ladders game, student worksheets (LKPD), and observation and documentation instruments to support the data collection process. The use of various data sources, such as observation and documentation, constitutes a form of triangulation commonly employed in classroom action research to enhance the validity of findings (Partanen, 2018).

Research procedure

The research procedure was carried out in accordance with the stages of classroom action research: (1) Planning phase, at this stage, instructional materials were developed, including lesson plans, worksheets, and educational media such as mind maps, an ethoscience bulletin board, and an educational Snakes and Ladders game. The prepared materials covered acid-base theory, the pH scale, indicators, and their applications in the context of local culture. (2) Action Implementation Phase: Learning is conducted by integrating mind maps and educational games. Students are divided into several groups to create mind maps that form a visual bulletin board based on ethoscience. Next, students play a "Snakes and Ladders" game on acids and bases that includes conceptual questions. This activity is designed to create an active, collaborative, and enjoyable learning environment. (3) Observation Phase: This is conducted throughout the learning process to observe student activities, engagement in discussions, group collaboration, and responses to the use of learning media. Data is collected through observation sheets and activity documentation. (4) Reflection Phase, conducted to evaluate the results of the actions in each cycle. Evaluation is carried out through class discussions, analysis of worksheet results, and feedback from students and teachers. The results of the reflection serve as a basis for improvements in the next cycle to enhance learning effectiveness.

Research data analysis

Data analysis in this study was conducted using a descriptive qualitative approach. The data analyzed included observations of student activities, student work in worksheets, and learning assessment results. The data were analyzed by reducing the data, presenting the findings, and drawing conclusions to determine improvements in students' conceptual understanding, participation, and interest in learning. Additionally, the analysis was supported by an interpretation of student learning outcomes based on achievement scores and engagement during the learning process. The integration of qualitative and quantitative data was achieved by combining observational results, worksheets, and student achievement scores into complementary descriptive narratives, thereby allowing the quantitative data to serve as supporting evidence for the qualitative findings from the learning process. This approach provides a comprehensive overview of the effectiveness of the implemented learning media. Qualitative descriptive analysis is widely used in educational research to comprehensively evaluate learning processes and outcomes (Miles et al., 2014).

To reinforce this, Miles et al. (2014) explain that qualitative data analysis is conducted through three main stages: data condensation, data display, and conclusion drawing/verification, which occur interactively. Additionally, Creswell (2014) emphasizes that qualitative analysis aims to understand phenomena in depth and within their context through systematic data interpretation. To ensure the credibility and validity of the data, this study employed source and method triangulation, which involves comparing data from observations, worksheets, and learning documentation. Furthermore, peer debriefing was conducted through discussions with collaborating teachers, and member checking was performed by confirming findings with students or teachers to ensure the consistency of data interpretation. The application of these techniques is a standard procedure in qualitative research to enhance the trustworthiness and validity of findings (Liao & Hitchcock, 2018; Ahmed, 2024; Dado et al., 2023).

RESULTS AND DISCUSSION

Result

Instructional Media Design

The following is visual documentation that includes the initial design and examples of the developed educational media, providing a clearer picture of how the designed solutions were implemented. These images show actual models of the ethnoscience bulletin board mind map and the acid-base snakes-and-ladders game board, which have been adapted to the curriculum and local cultural context. In the ethnoscience bulletin board mind map, the concepts covered include the classification of acids and bases, acid-base theories (Arrhenius and Brønsted-Lowry), the pH scale, and examples of their application in daily life, such as the use of tamarind, citrus, and betel lime, linked to local wisdom. Meanwhile, in the educational snakes and ladders game, each game square is equipped with a question card containing conceptual and applied questions, such as determining the properties of a solution, performing simple pH calculations, and identifying appropriate natural indicators, so that students can directly test their understanding through the game. It is hoped that this visualization will explain how these media are used in the learning process and help readers understand the development of these media as well as their practical application in the classroom.

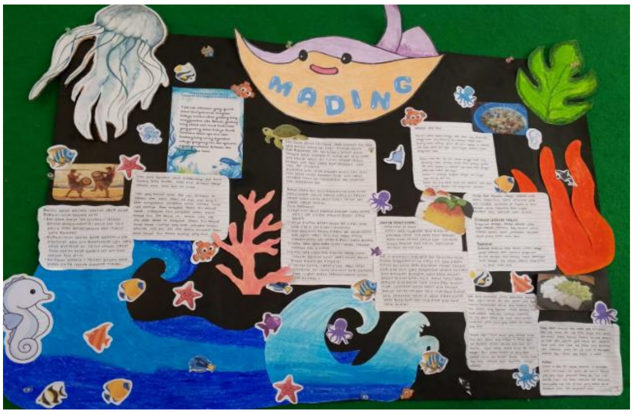

Figure 1. Mind Map Design for the Acid-Base Ethnoscience Bulletin Board

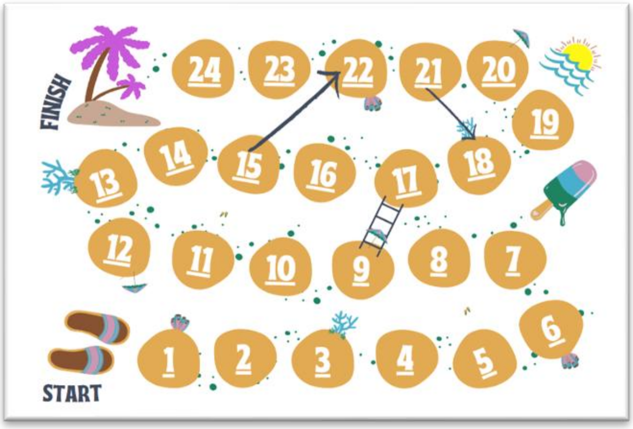

Figure 2. Design of the Educational Game "Acid-Base Snakes and Ladders"

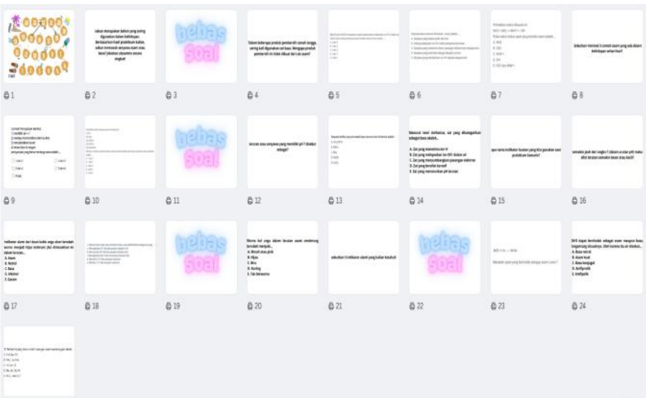

Figure 3. Example of a Question Card in the educational game Snakes and Ladders

Evaluation of Student Responses and Activities

During the learning process, students demonstrated greater engagement than in previous lessons. This engagement was observed based on several activity indicators, namely the frequency with which students asked questions, shared ideas or opinions, responded to their peers' answers, and clarified misconceptions during discussions. While working on mind maps, students appeared enthusiastic about discussing and searching for references to compile content for concept maps on local culture. They shared tasks, looked for examples of acids and bases in their surroundings, and debated the placement and relationships between subconcepts. This indicates an improvement in critical thinking and teamwork skills. The bulletin board displayed in the classroom served as a visual learning tool accessible to all students, even outside of class hours.

Compared to the situation before the intervention, student activity tended to be passive, with learning dominated by lecture-based methods and only a small number of students participating in discussions or answering the teacher's questions. After the implementation of the learning media, the number of students actively involved in group and class discussions increased, as evidenced by more equitable participation and greater interaction among students.

During the educational snakes-and-ladders game session, the learning atmosphere became more lively yet remained academically focused. Students vied to answer questions at each step of the game and supported one another within their groups. Although some students were initially shy, as the game progressed, they answered more confidently and demonstrated a better understanding of the concepts. This improvement was evident in the increasing number of students who took the initiative to answer without being called on and provided more logical, systematic explanations than before the intervention. Teachers and researchers noted that many students were able to explain the concepts of pH, the properties of acids and bases, and the use of natural indicators in their own words more accurately than before the intervention.

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Assessment of Student Understanding Based on Assignments, Worksheets, and Exams

The students' work in the worksheets demonstrated an improvement in conceptual understanding. Most students were able to correctly classify acids and bases, explain acid-base theory in the context of the questions, and accurately calculate simple pH values. In the essay questions, students began to write coherent reasons and explanations, whereas previously their answers were often just one-word responses or direct copies from the textbook. This indicates that students are beginning to understand not only "what" the answer is, but also "why."

Based on baseline data from daily test scores prior to the intervention, the average student score was 62, with only about 29.9% of students (20 out of 67) meeting the minimum passing score (≥75). Additionally, most students' answers were brief and revealed misconceptions about basic acid-base concepts. Although no structured pretest was conducted, the learning evaluation results showed improved student learning outcomes following the implementation of the mind map-based ethoscience bulletin board and the educational Snakes and Ladders game. This improvement was reflected in two main indicators: student performance on the student worksheets (LKPD) and daily test scores following the learning activities.

Most students were able to complete the worksheets with high scores, indicating that they understood the concepts of acids and bases, were able to classify substances based on their properties, explain the function of natural indicators, and apply simple formulas such as pH calculations. The students' answers in the worksheets were not only conceptually correct but also more coherent and logical than before. Some students even added contextual explanations that demonstrated applied understanding.

In addition, students' test scores after the activity were quite satisfactory. Out of a total of 67 students, 55 (82.1%) achieved learning mastery, with scores above the minimum passing grade (≥75), and the class average increased to 81. This improvement represents an average difference of 19 points from the initial condition and an increase in the mastery rate of over 50%. However, this study did not use a control class, so the comparison was conducted descriptively between the pre- and post-intervention conditions within the same class. This success indicates that the use of visual and interactive learning media can improve students' conceptual understanding and support better learning outcomes.

Student Reflections and Responses

To determine how students responded to the use of mind-map-based learning materials, an ethoscience bulletin board, and the educational game "Snakes and Ladders," their participation was observed throughout the activity. The observation was conducted using an observation sheet with indicators of student engagement, such as the frequency of asking questions, participation in group discussions, and responses to instructional prompts. Student responses were categorized into two groups: enthusiastic for students who were active, engaged, and showed interest during the lesson, and passive for students who were less engaged or showed low interest. These categories were determined based on the frequency and intensity of student engagement recorded during the learning process.

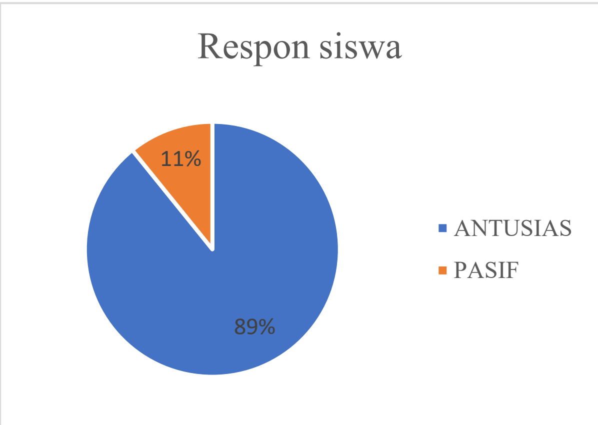

Figure 4. Student response chart

Based on Figure 4, 89% of students showed enthusiastic responses, while 11% of students were classified as passive during the learning activity. Based on oral and written reflections after the activity, students reported finding it easier to understand acid-base material when it was presented visually and in context. Most students admitted that they had only recently learned that materials such as tamarind, lime, or lemon juice could be explained through chemical concepts. They felt proud when their group's bulletin board was displayed, as they felt their work was valued. In the Snakes and Ladders game, students felt that learning became lighter and more enjoyable because it didn't feel like a test, but rather like a challenge. They also learned from other groups when questions were difficult to answer.

Discussion

As demonstrated by recent research conducted by Yulizah, 94.7% of students found the acid-base material presented in textbooks too difficult to understand, primarily due to a lack of visual aids and direct engagement in the learning process (Yulizah et al., 2015). These findings align with this study's results, which show that using visual media, such as mind maps, can help students understand concepts more effectively. However, unlike Yulizah's study, which focused on analyzing instructional material needs, this study emphasizes implementing interactive learning media, thereby providing students with a more direct and contextual learning experience. Furthermore, the chemistry textbooks currently in use fail to explain acid-base concepts comprehensively and contextually, making it difficult for students to understand their applications in daily life.

Difficulties in learning acid-base concepts are not only caused by internal student factors, such as a lack of interest and motivation, but also by external factors, such as monotonous teaching methods, a lack of innovative learning materials, and a scarcity of contextual approaches that link the material to students' culture or surrounding environment. Furthermore, the lack of visual approaches and participatory activities leads students to become passive and easily bored during the learning process, particularly with abstract topics such as acids and bases (Rosida & Muchson, 2020). The results of this study reinforce these findings and add that the simultaneous integration of visual, contextual, and gamification approaches can have a greater impact than a single approach, particularly in enhancing student engagement during learning.

This is precisely what is happening to 11th-grade students at SMAN 4 Mataram; they are experiencing significant difficulties in understanding acid-base concepts. These difficulties are driven by a combination of interacting internal and external factors. Internally, low interest and motivation to learn, limited cognitive abilities, and students' physical or psychological conditions are the primary causes (Farizal et al., 2024). Externally, a monotonous teaching approach, a lack of visual and interactive media, and textbooks that are overly theoretical and lacking in context further exacerbated learning difficulties. Unlike Farizal's study, which focused more on identifying factors contributing to learning difficulties, this study focuses on intervention efforts using innovative learning media, thereby not only identifying problems but also providing practical solutions that have been proven to improve student learning outcomes.

Given these challenges, teachers need to be creative in developing methods, models, and learning materials that are engaging and easy for students to understand. Therefore, creative interventions, such as the use of mind maps, ethnoscience bulletin boards, and the educational game "Snakes and Ladders", are crucial for addressing these challenges. The implementation of learning media in the form of ethoscience mind map bulletin boards and the educational "Snakes and Ladders" game demonstrated a significant positive impact on the learning process and outcomes for students studying acid-base concepts in Grade 11 IKL 1 and Grade 11 IKL 3 at SMAN 4 Mataram. The results of the implementation were analyzed using data from observations of student activities, student work on assignments and worksheets, post-learning reflections, general feedback on the use of the media, and learning outcomes. In the context of classroom action research, this improvement occurred gradually over two learning cycles. In Cycle I, students began to show active engagement, though some challenges in understanding the concepts remained; whereas in Cycle II, there was a more significant improvement in both participation and conceptual understanding following adjustments based on the results of the previous reflections.

Overall, the implementation of this instructional media proved effective in enhancing students' conceptual understanding, active participation, and positive attitudes toward chemistry lessons. This is supported by learning outcome data, observations during instruction, and student reflections that demonstrate deeper engagement with and understanding of acid-base concepts. This improvement also indicates that the improvement cycle in action research plays a crucial role in optimizing learning effectiveness, as each cycle provides feedback that refines learning strategies for the next phase. This learning medium can serve as an alternative solution for chemistry instruction that is more contextual, interactive, and enjoyable.

Advantages and Disadvantages of Teaching Materials

The ethnoscience-based acid–base bulletin board (mading) offers several pedagogical advantages. It helps students understand the interconnections among acid–base concepts in a visual, well-structured manner, thereby enhancing retention through spatial organization and color. Furthermore, it contextualizes chemistry content by linking it with local culture, making the learning experience more meaningful and relevant to students' lives. This approach also fosters a sense of ownership, as students' work is displayed in the classroom or school environment, and promotes teamwork and creativity in designing the bulletin board. However, this medium also presents certain limitations. Designing and constructing a mind map as a bulletin board is time-consuming; thus, teachers should divide the activity into stages, such as conceptual planning, content organization, and visual design, and provide initial templates to improve efficiency. Additionally, intensive teacher guidance is required to ensure that the information presented is accurate and not misleading. This can be addressed by providing correct examples of mind maps and simple assessment rubrics as guidance. Moreover, not all students are accustomed to or capable of constructing logical and effective concept maps. Therefore, gradual practice and scaffolding are necessary, for instance, by providing an initial conceptual framework before students work independently, as emphasized by Novak and Cañas (2008) regarding the importance of guidance in concept mapping.

Similarly, the acid–base snakes-and-ladders game demonstrates notable strengths as a gamified learning medium. It enhances students' interest and motivation through a game-based approach, encourages social interaction and collaboration, and creates an enjoyable learning atmosphere. The game also provides immediate feedback through embedded questions or challenges and is flexible in content and difficulty, making it suitable for reinforcing concepts and conducting informal assessments. This is consistent with findings by Deterding et al. (2011) and Hamari et al. (2014), which indicate that gamification significantly improves student engagement and motivation. Nevertheless, there are some drawbacks to consider. Some students may become overly focused on competition rather than the learning content; to address this, teachers can implement collaborative rules, such as group scoring systems or mandatory discussion before answering questions, to maintain conceptual focus. In addition, limited time may prevent the game from being completed. As a solution, teachers can modify the gameplay by limiting the number of rounds, applying a level-based system, or extending the activity into subsequent sessions to ensure that all students gain an optimal learning experience.

Proof of Effectiveness

This study demonstrates that the integration of educational media, specifically mind maps, ethoscience bulletin boards, and the educational game "Snakes and Ladders", is effective in enhancing students' conceptual understanding, active participation, and positive attitudes toward chemistry learning, particularly regarding acid-base concepts. Overall, the implementation of these learning media proved effective in improving students' conceptual understanding, active participation, and positive attitudes toward chemistry lessons. This is supported by learning outcome data, observations during lessons, and student reflections indicating deeper engagement and understanding of acid-base material. These media can serve as an alternative solution for more contextual, interactive, and enjoyable chemistry learning.

Nevertheless, this study has several limitations, including the absence of a control class for comparison and the limited scope of the sample, which involved only one school, thus restricting the generalizability of the results. Therefore, future research is recommended to employ a more comprehensive experimental design, include a control group, and expand the sample size and characteristics to yield stronger results that can be more broadly generalized.

CONCLUSION

Based on the research findings, it can be concluded that the use of learning media in the form of ethoscience-based mind map bulletin boards and the educational game "Snakes and Ladders: Acids and Bases" is effective in improving students' conceptual understanding, active participation, and motivation to learn regarding acid-base concepts. This improvement is evident in students' ability to classify acids and bases, explain concepts in a logical sequence, and solve problems more logically. Additionally, there was a significant improvement in learning outcomes, with over 80% of students achieving mastery, and student engagement in discussions and learning activities became more evenly distributed compared to before the intervention.

From a scientific perspective, this study demonstrates that integrating visual, context-based ethnoscience approaches and gamification can be effective strategies for more meaningful, context-based chemistry learning. However, this study has limitations, including the absence of a control group and a sample scope limited to a single school, which limits the generalizability of the findings. Therefore, future research is recommended to use a stronger experimental design, involve a comparison group, and expand the context and sample size. Additionally, the development of media variations and long-term measurement of concept retention are also important areas for further research.

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AUTHOR'S CONTRIBUTION

Seluruh penulis berkontribusi dalam setiap tahapan penelitian dan penyusunan naskah. Kontribusi meliputi konseptualisasi penelitian, kajian literatur, perancangan metodologi, pengembangan instrumen, pengumpulan dan analisis data, interpretasi hasil, serta penulisan draf awal hingga proses revisi dan penyuntingan naskah. Semua penulis telah membaca dan menyetujui versi akhir naskah untuk diajukan dalam publikasi.

Tabel Keterangan Kontribusi Penulis

Contribution Indicators	Author			
	1	2	3	4
Conceptualization	✓		✓	✓
Literature Review	✓		✓	✓
Research Design / Methodology	✓	✓		
Instrument Development		✓	✓	
Data Collection	✓			
Data Curation		✓		✓
Formal Analysis	✓	✓		
Data Interpretation	✓		✓	
Writing – Original Draft	✓		✓	✓
Writing – Review & Editing	✓	✓	✓	✓
Visualization / Tables	✓			✓
Supervision	✓	✓		

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