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Development of design thinking-based interactive digital media integrating kahoot! and heyzine flipbook to enhance students' mathematical numeracy literacy through differentiated learning

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Abstract

Background: Mathematical numeracy literacy remains a major challenge in senior high school mathematics learning, particularly in interpreting data, analyzing probability events, and solving contextual problems. This issue is exacerbated by the limited availability of interactive digital learning media that support differentiated instruction and diverse learning needs.
Aims: This study aimed to develop and evaluate the feasibility of Design Thinking-based interactive digital media integrating Kahoot! and Heyzine Flipbook to enhance students' mathematical numeracy literacy in probability learning.
Method: This study employed a Research and Development (R&D) approach using the Design Thinking framework consisting of empathize, define, ideate, and prototype stages. The participants were 30 senior high school students selected through purposive sampling. Data were collected through observations, interviews, and validation questionnaires, then analyzed descriptively using qualitative and quantitative techniques.
Results: The developed media successfully integrated gamified evaluation and interactive visual materials within differentiated learning environments. Validation results showed highly feasible categories, with scores of 90% from media experts and 92% from material experts. The media effectively supported probability learning, increased student engagement, and strengthened mathematical numeracy literacy.
Conclusion: The developed interactive digital media have strong potential to support differentiated mathematics instruction and technology-enhanced numeracy learning in probability topics.

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INTRODUCTION

The rapid advancement of information technology has significantly transformed various aspects of education, particularly the learning process in schools. The integration of digital technology into classroom instruction provides opportunities for teachers to create more interactive, engaging, and meaningful learning experiences for students. Technology-enhanced learning environments also enable students to access information more flexibly and develop higher-order thinking skills through interactive activities (Kim et al., 2020; Letchumanan et al., 2023; Lu et al., 2025; Vu, 2025). However, mathematics learning at the senior high school level is still frequently dominated by conventional teacher-centered approaches that position students as passive recipients of information (Woods & Copur-Gencturk, 2024). This condition limits students' opportunities to actively participate in the learning process and reduces their engagement in constructing

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mathematical understanding independently. As a result, many students experience difficulties in understanding abstract mathematical concepts and applying them in contextual situations. One of the competencies that remains relatively low among students is mathematical numeracy literacy. Mathematical numeracy literacy is considered an essential competency in twenty-first-century education because it involves the ability to interpret quantitative information, analyze mathematical representations, and solve practical problems logically and critically (Geiger & Schmid, 2024; Szabo et al., 2020). Numeracy literacy also supports students in making evidence-based decisions in various real-life contexts through mathematical reasoning processes. Therefore, improving students' mathematical numeracy literacy has become an important challenge that requires innovative and adaptive learning strategies in mathematics education.

The low level of students' mathematical numeracy literacy is reflected in national and international educational assessments, which indicate that many students still struggle to analyze mathematical information and solve contextual problems effectively. This issue becomes more prominent in probability learning because probability concepts require logical reasoning, analytical thinking, and the ability to interpret uncertain situations mathematically (Elbehary, n.d.; Kazak & Pratt, 2021; Sari et al., 2024; Zorzos & Avgerinos, 2023). Many students perceive probability as one of the most difficult mathematics topics due to its abstract nature and complex conceptual structures. In many classrooms, students tend to memorize formulas procedurally without fully understanding probabilistic concepts and their applications in everyday situations. Such conditions indicate that mathematics learning has not yet optimally facilitated conceptual understanding and contextual reasoning processes. One of the contributing factors is the limited use of interactive learning media that can accommodate students' diverse learning characteristics and learning needs. Learning media that rely heavily on text-based explanations often fail to stimulate students' active participation and conceptual exploration (Mohammadi Zenouzagh et al., 2023). Consequently, students become less motivated and less engaged during mathematics learning activities. Innovative digital learning media are therefore needed to support more contextual, visual, and student-centered mathematics instruction (Ginting et al., 2024; Meryansumayeka et al., 2022). The integration of interactive digital platforms into probability learning is expected to improve students' understanding, participation, and mathematical numeracy literacy simultaneously.

One of the promising approaches for improving students' mathematical numeracy literacy is the integration of interactive digital learning media with differentiated learning strategies. Differentiated learning emphasizes the adaptation of instructional content, learning activities, assessments, and learning processes according to students' readiness levels, interests, and learning profiles (Gheyssens et al., 2022; Goyibova et al., 2025; Wong et al., 2023). Through differentiated instruction, students are provided with learning experiences that are more relevant to their individual needs and abilities. This approach also allows teachers to provide adaptive support and tiered learning tasks that accommodate differences in students' learning capacities. In the context of digital learning, platforms such as Kahoot! and Heyzine Flipbook offer opportunities to create more interactive and engaging mathematics learning environments. Kahoot! provides gamified evaluation activities that encourage students' participation, competitiveness, and motivation through interactive quizzes and immediate feedback systems (Cadet, 2023; Donkin & Rasmussen, 2021; Kalleny, 2020; Zainuddin et al., 2020). Meanwhile, Heyzine Flipbook enables teachers to present learning materials visually and interactively through digital book formats containing illustrations, animations, and contextual examples. The combination of these two digital platforms has the potential to create adaptive and enjoyable mathematics learning experiences that support differentiated instruction. Nevertheless, previous studies generally examined differentiated learning, gamification, and interactive digital media separately rather than integrating them into a unified mathematics learning ecosystem (Lee et al., 2023; Maswadi et al., 2026; Niyazova et al., 2026).

Furthermore, limited studies have specifically developed Design Thinking-based interactive mathematics learning media integrating Kahoot! and Heyzine Flipbook to enhance students' mathematical numeracy literacy in probability learning at the senior high school level.

Previous studies have extensively examined mathematical numeracy literacy, differentiated instruction, interactive digital learning media, gamification, and Design Thinking in educational contexts. Research has shown that numeracy literacy plays an important role in improving students' mathematical reasoning and academic achievement (I. Chang, 2023; Grotlüschen et al., 2020; Nurcahyo et al., 2024), while differentiated instruction has been reported to enhance students' motivation, self-efficacy, and mathematics learning outcomes by accommodating diverse learning needs and profiles (Lai et al., 2020; Russo et al., 2021). In addition, previous studies highlighted that interactive digital media and gamified learning platforms such as Kahoot! can increase students' engagement, participation, and achievement in mathematics learning environments (Jarrah et al., 2024; Pellas, 2024), whereas interactive multimedia and digital feedback systems were found to support conceptual understanding and active learning processes in mathematics education (Barana et al., 2021; Irmawan et al., 2022). Furthermore, Design Thinking has increasingly been recognized as an innovative framework for educational problem-solving and technology-enhanced learning development (Baltador et al., 2024; Lin et al., 2025; McLaughlin et al., 2022). However, despite these growing research trends, limited studies have integrated differentiated learning, gamified digital media, and Design Thinking into a unified interactive mathematics learning ecosystem specifically designed to enhance students' mathematical numeracy literacy in probability learning at the senior high school level. Existing studies generally investigate these variables separately, and research combining Kahoot! and Heyzine Flipbook within differentiated mathematics instruction remains scarce, particularly in supporting contextual probability learning and numeracy literacy development.

This study aimed to develop and evaluate the feasibility of Design Thinking-based interactive digital learning media integrating Kahoot! and Heyzine Flipbook to enhance students' mathematical numeracy literacy in probability learning through differentiated learning approaches. The study focused on designing digital learning media capable of accommodating students' diverse learning characteristics, including differences in readiness, interests, and learning styles. The developed media integrated Kahoot! as a gamified evaluation platform and Heyzine Flipbook as an interactive visual learning material platform to support contextual mathematics learning experiences. In addition, this study applied the Design Thinking framework to ensure that the developed learning media were designed based on students' actual learning needs and classroom challenges. The Design Thinking process emphasized human-centered problem solving through empathize, define, ideate, and prototype stages. Through differentiated learning approaches, the media were expected to provide adaptive learning activities and tiered numeracy tasks suitable for students with varying levels of mathematical understanding. The study also aimed to examine the feasibility of the developed media in terms of content quality, visual design, and interactivity through expert validation processes. Furthermore, this research attempted to contribute to technology-enhanced mathematics education by integrating gamification, differentiated instruction, and interactive digital learning media into a comprehensive learning ecosystem. The integration of Kahoot! and Heyzine Flipbook was expected to create more meaningful, engaging, and student-centered mathematics learning experiences in probability topics. Therefore, the findings of this study are expected to contribute theoretically and practically to the development of innovative digital mathematics learning media in contemporary educational contexts.

LITERATURE REVIEW

Mathematical numeracy literacy is widely recognized as an essential competency in contemporary education because it enables students to interpret quantitative information, analyze mathematical relationships, and solve contextual problems effectively. Numeracy literacy extends beyond computational skills and involves reasoning, critical thinking, and decision-making abilities in various real-life situations (Ogunsola & Adigun, 2025; Sakurai & Goos, 2023). In mathematics education, numeracy literacy supports students in understanding abstract concepts through meaningful contextualization and analytical interpretation (Manfreda Kolar & Hodnik, 2021; Rubel & McCloskey, 2021). Students with strong numeracy literacy are generally more capable of connecting mathematical concepts with authentic problems encountered in everyday life. Numeracy literacy also contributes to the development of higher-order thinking skills, including problem-solving, logical reasoning, and data interpretation. In the context of probability learning, numeracy literacy becomes particularly important because probability concepts require students to analyze uncertain situations and evaluate possible outcomes systematically (Reyna & Brainerd, 2023; Sharna et al., 2021). However, many students still experience difficulties in interpreting probability concepts because mathematics instruction often emphasizes procedural calculations rather than conceptual understanding. This condition causes students to rely heavily on memorization without understanding the underlying mathematical reasoning processes. Consequently, innovative learning approaches are needed to support students in developing numeracy literacy through more interactive and contextual mathematics learning experiences. Therefore, the improvement of mathematical numeracy literacy has become one of the primary objectives of modern mathematics education.

The integration of digital technology into mathematics education has significantly influenced the development of interactive and student-centered learning environments. Digital learning media provide opportunities for teachers to present mathematical concepts more visually, contextually, and engagingly through multimedia elements such as animations, simulations, and interactive exercises (Odekeye & Jita, 2025). Interactive digital learning environments are considered effective in supporting conceptual understanding because students can actively explore learning materials through dynamic representations and immediate feedback systems (Abrahamson & Abdu, 2021; Cirkony et al., 2022; Conceição, 2021; Zhou, 2025). In addition, technology-enhanced learning environments increase students' engagement and motivation by creating more enjoyable and flexible learning experiences. The implementation of interactive digital media in mathematics learning also enables students to learn independently and collaboratively through various digital platforms. In probability learning, digital media can help students visualize probabilistic concepts and interpret mathematical data more effectively through contextual simulations and graphical representations (Kazak & Pratt, 2021; Zorzos & Avgerinos, 2023). One of the interactive digital platforms widely used in mathematics education is Kahoot!, which integrates gamification elements into classroom learning activities. Gamification-based learning platforms encourage students' active participation through competitive quizzes, scores, rewards, and immediate feedback mechanisms. Such features can improve students' motivation, concentration, and classroom interaction during mathematics learning activities. Therefore, the integration of interactive digital media and gamified learning platforms has become increasingly important in supporting effective mathematics instruction in digital education environments.

Kahoot! is recognized as one of the most popular gamified learning platforms because it combines assessment activities with engaging game-like learning experiences. The platform allows teachers to create interactive quizzes that can be accessed through digital devices during classroom learning activities. Kahoot! encourages students to participate actively in mathematics learning through competitive and collaborative learning environments. The immediate feedback system provided by Kahoot! also enables students to identify mistakes and improve their understanding

directly during the learning process. In mathematics education, Kahoot! has been widely used to increase students' engagement, participation, and learning motivation (Jarrah et al., 2024; Lashari et al., 2024; Licorish & Lötter, 2022). Gamified learning activities supported by Kahoot! can reduce students' anxiety toward mathematics learning because the learning process becomes more enjoyable and interactive. In addition, Kahoot! supports formative assessment practices by enabling teachers to monitor students' understanding and learning progress in real time. Alongside gamified evaluation platforms, digital flipbook media such as Heyzine Flipbook provide visual-interactive learning materials that support students' conceptual understanding. Heyzine Flipbook allows teachers to present learning materials through digital books containing multimedia elements such as images, videos, hyperlinks, and animations. The combination of Kahoot! and Heyzine Flipbook therefore has strong potential to create interactive mathematics learning environments that support both conceptual understanding and students' engagement simultaneously.

Differentiated learning is an instructional approach designed to accommodate students' diverse learning needs, readiness levels, interests, and learning profiles. This approach emphasizes that students learn differently and therefore require adaptive learning experiences to achieve optimal learning outcomes. Differentiated instruction allows teachers to modify learning content, activities, instructional processes, and assessments according to students' characteristics and learning capacities (Grecu, 2023; Pozas et al., 2020; Smets et al., 2022). Through differentiated learning, students with higher readiness levels can receive enrichment activities, while students requiring additional support can receive scaffolding and adaptive guidance. Such instructional flexibility helps create more inclusive and equitable learning environments in mathematics classrooms. In mathematics education, differentiated learning is considered effective in improving students' participation, motivation, and conceptual understanding because students receive learning experiences aligned with their individual needs (Lai et al., 2020). Furthermore, differentiated instruction encourages students to become more active and independent learners by allowing them to engage with learning materials in various ways. The implementation of differentiated learning also supports the development of numeracy literacy because students can learn mathematical concepts through adaptive and contextual activities. In probability learning, differentiated learning enables teachers to provide tiered probability tasks and contextual problem-solving activities suitable for students with varying levels of understanding. Therefore, differentiated learning has become an important pedagogical approach for supporting student-centered mathematics instruction in diverse classroom environments.

Design Thinking has emerged as an innovative framework for developing educational solutions through human-centered and problem-solving-oriented approaches. The Design Thinking framework focuses on understanding users' needs and designing solutions that address authentic educational challenges systematically and creatively. In educational contexts, Design Thinking is often implemented through several stages, including empathize, define, ideate, prototype, and testing processes. The empathize stage emphasizes understanding students' learning difficulties, classroom challenges, and educational needs through observations and interactions. The define stage focuses on identifying and formulating the core learning problems that need to be addressed through instructional innovation. Meanwhile, the ideate stage encourages the generation of creative ideas and alternative learning solutions based on identified educational challenges. The prototype stage involves developing initial forms of learning products or instructional media that can be evaluated and improved continuously. In mathematics education, Design Thinking supports the development of innovative learning media that are relevant to students' actual learning experiences and classroom needs. The integration of Design Thinking, differentiated learning, gamified platforms, and interactive digital media can create adaptive and meaningful mathematics learning environments that strengthen students' mathematical numeracy literacy. Therefore, the application of Design

Thinking in developing Kahoot! and Heyzine Flipbook-based interactive digital media is expected to provide innovative contributions to technology-enhanced mathematics education.

METHOD

Research Design

This study employed a Research and Development (R&D) method adapted from the Borg and Gall development model to develop interactive digital learning media integrating Kahoot! and Heyzine Flipbook in probability learning. The Borg and Gall model was modified according to the research needs and time limitations without reducing the essential stages of product development. The purpose of this study was to produce interactive learning media that combine Kahoot! as a gamified evaluation platform and Heyzine Flipbook as an interactive learning material platform within differentiated learning environments. The developed media were designed to accommodate students' diverse learning readiness, interests, and learning styles through adaptive instructional activities. In developing the learning media, this study integrated the Design Thinking approach as the primary instructional design framework. The Design Thinking framework emphasized human-centered problem solving and innovation development based on students' actual learning needs and classroom conditions. The framework consisted of several stages, namely empathize, define, ideate, and prototype. The empathize stage focused on identifying students' learning difficulties and instructional challenges related to probability learning and mathematical numeracy literacy. The define stage aimed to formulate the main instructional problems and determine the objectives of media development. Meanwhile, the ideate and prototype stages focused on designing and developing the initial version of the interactive digital learning media integrated with differentiated learning approaches.

Participants

The population of this study consisted of tenth-grade students at SMA N 1 Bawen. The sample involved 30 students selected using purposive sampling techniques based on classroom learning conditions and students' participation in mathematics learning activities. The selected participants represented students with diverse learning characteristics, including differences in learning readiness, learning interests, and learning styles. Such diversity was considered important because the developed media were specifically designed using differentiated learning principles. In addition to students, mathematics teachers were also involved during the preliminary observation and interview stages to provide information regarding classroom learning challenges and instructional needs. The students participating in this study had previously experienced mathematics instruction dominated by conventional teacher-centered learning approaches. Consequently, many students showed low participation and engagement during mathematics learning activities, particularly in probability topics. The selected participants were expected to provide meaningful information regarding the effectiveness and feasibility of the developed interactive digital learning media. All participants voluntarily participated throughout the research and media implementation processes. The participant selection process aimed to ensure that the developed learning media were relevant to authentic classroom learning situations and students' actual educational needs.

Instruments

This study employed several instruments to collect qualitative and quantitative data throughout the research process. Observation sheets were used to identify classroom learning conditions, students' participation, and students' needs regarding digital learning media in mathematics instruction. Observations were conducted during the initial stages of the study to obtain information about instructional practices and learning difficulties encountered by students during probability learning activities. Interview guidelines were also utilized to collect deeper information

from mathematics teachers and several students regarding learning obstacles, instructional limitations, and expectations toward interactive digital learning media. In addition, questionnaires were administered in two forms, namely expert validation questionnaires and student response questionnaires. The expert validation questionnaires were used to evaluate the feasibility of the developed learning media in terms of content quality, instructional suitability, visual appearance, and interactivity. Meanwhile, student response questionnaires were used to identify students' perceptions regarding the attractiveness, accessibility, ease of use, and usefulness of the developed media during learning activities. The questionnaires applied a Likert-scale format with scores ranging from 1 to 5, where score 1 represented "very inappropriate" and score 5 represented "very appropriate." Data collection activities were conducted systematically during each stage of the Design Thinking framework to ensure that the developed media reflected students' actual learning needs and classroom conditions. The use of multiple instruments enabled researchers to obtain comprehensive information regarding the quality and feasibility of the interactive digital learning media.

Data Analysis

The collected data were analyzed using descriptive qualitative and descriptive quantitative analysis techniques. Qualitative data were obtained from observations, interviews, and suggestions provided by expert validators during the validation process. These data were analyzed through several stages, including data reduction, data presentation, interpretation, and conclusion drawing. The qualitative findings were subsequently used as the basis for revising and improving the developed learning media prototype. Meanwhile, quantitative data were obtained from expert validation questionnaires and student response questionnaires administered during the implementation stage. The quantitative data were analyzed using Likert-scale-based descriptive statistics. Each score obtained from the questionnaires was calculated into an average score and then converted into percentage form using the following formula:

$$\mathrm{P} = \frac{Obtained\ Score}{Maximum\ Score}\ x\ 100\%$$

The percentage results were then interpreted based on media feasibility criteria consisting of very feasible, feasible, moderately feasible, less feasible, and not feasible categories. These criteria were used to determine the feasibility level of the developed learning media and to support decision-making regarding whether the media could be implemented, revised, or further developed. The quantitative analysis results from media experts and material experts were used to assess the validity and instructional quality of the developed media. Student response data were also analyzed descriptively to evaluate students' engagement and perceptions regarding the implementation of Kahoot! and Heyzine Flipbook in mathematics learning. The integration of qualitative and quantitative analysis techniques enabled comprehensive evaluation of the developed media from pedagogical and technological perspectives.

Procedure

The research procedure followed the stages of the Design Thinking framework consisting of empathize, define, ideate, and prototype stages. During the empathize stage, researchers conducted classroom observations and interviews with teachers and students to identify learning difficulties, classroom instructional limitations, and students' needs related to probability learning and mathematical numeracy literacy. The findings obtained during this stage indicated that students experienced difficulties in understanding probability concepts and showed low engagement during mathematics learning activities. The define stage was then conducted to formulate the main instructional problems and determine the objectives of developing interactive digital learning media.

Based on the identified problems, the ideate stage focused on generating ideas and designing differentiated learning activities integrated with Kahoot! and Heyzine Flipbook platforms. During this stage, researchers designed learning materials, contextual numeracy tasks, gamified quizzes, and adaptive instructional activities suitable for students with different learning characteristics. The prototype stage involved developing the initial version of the interactive digital learning media based on the designed instructional framework. The developed prototype was subsequently validated by media experts and material experts using validation questionnaires to evaluate its feasibility and instructional quality. Suggestions and recommendations obtained from the validation process were used to revise and improve the developed media before implementation. After the revision process, the prototype was introduced to students to identify their responses regarding the attractiveness, usability, and usefulness of the developed learning media during probability learning activities. Overall, the research procedure emphasized iterative development processes to ensure that the developed interactive digital media were adaptive, relevant, and capable of supporting differentiated mathematics learning and mathematical numeracy literacy development.

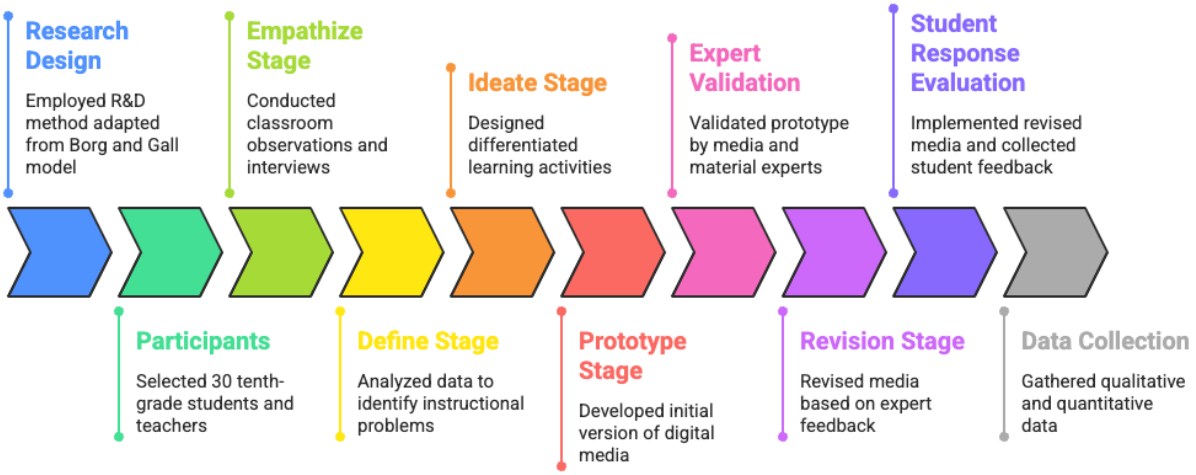

Figure 1. Research Method Flow

RESULTS AND DISCUSSION

Results

Development of Interactive Digital Learning Media

The development of interactive digital learning media in this study was conducted using the Design Thinking framework consisting of empathize, define, ideate, and prototype stages. The development process focused on creating adaptive mathematics learning media integrating Kahoot! and Heyzine Flipbook to support differentiated learning and strengthen students' mathematical numeracy literacy in probability learning. The developed media were designed based on students' actual learning needs identified during classroom observations and interviews with teachers and students. The findings from the preliminary analysis revealed that students experienced difficulties in understanding probability concepts, particularly in interpreting probabilistic data, analyzing compound events, and solving contextual mathematical problems. In addition, students demonstrated diverse learning characteristics, including differences in learning readiness, learning styles, and learning preferences. The classroom learning process was also found to be dominated by conventional teacher-centered instruction, resulting in low student engagement and limited opportunities for contextual mathematical exploration. Therefore, the developed media were specifically designed to provide interactive, visual, contextual, and adaptive learning experiences suitable for differentiated instruction. The integration of Kahoot! and Heyzine Flipbook was intended

to support both formative assessment and conceptual understanding within a technology-enhanced learning environment. Kahoot! was developed as a gamified evaluation platform, while Heyzine Flipbook functioned as an interactive digital learning material platform. The overall development process emphasized student-centered instructional design to improve students' participation and mathematical numeracy literacy in probability learning.

Results of the Empathize Stage

The empathize stage aimed to identify students' learning difficulties, classroom instructional conditions, and students' needs regarding digital learning media in mathematics learning. Classroom observations and interviews indicated that probability learning was perceived as one of the most difficult mathematics topics due to its abstract characteristics and analytical reasoning demands. Many students experienced difficulties in understanding probabilistic concepts because learning activities primarily emphasized procedural calculations rather than contextual reasoning and interpretation. Students also demonstrated limited ability to interpret tables, diagrams, and probability-based contextual problems. Furthermore, observations showed that students possessed diverse learning profiles, including visual, auditory, and kinesthetic learning preferences. Several students demonstrated fast conceptual understanding, while others required additional explanations, contextual examples, and visual representations to understand abstract probability concepts effectively. Teachers also explained that the existing learning media had not yet optimally supported differentiated learning implementation in mathematics classrooms. Limited use of interactive learning media contributed to low student participation and engagement during classroom activities. These findings indicated the need for interactive digital learning media capable of accommodating students' diverse learning needs and supporting differentiated instruction. Therefore, the empathize stage provided the foundation for designing adaptive and contextual digital learning media suitable for probability learning.

Table 1. Findings from the Empathize Stage

Identified Problems	Description
Low numeracy literacy	Students experienced difficulties in interpreting probabilistic data and contextual mathematical problems
Abstract probability concepts	Students tended to memorize formulas procedurally without conceptual understanding
Diverse learning characteristics	Students demonstrated visual, auditory, and kinesthetic learning styles
Limited interactive media	Existing learning media did not adequately support differentiated learning
Low student engagement	Students showed passive participation during mathematics learning activities

Results of the Define Stage

Based on the findings obtained during the empathize stage, researchers formulated several core instructional problems requiring immediate educational intervention. The identified problems included limited use of interactive digital learning media, insufficient implementation of differentiated learning approaches, and low support for students' mathematical numeracy literacy development in probability learning. Researchers also identified that mathematics learning activities frequently lacked contextual learning experiences capable of connecting probability concepts with real-life situations. These findings indicated that the learning problems were not only related to instructional content but also associated with learning strategies and media utilization. Consequently, researchers determined the need to develop interactive digital learning media integrating differentiated instructional activities and contextual probability learning tasks. The define stage also focused on formulating instructional objectives related to mathematical numeracy

literacy indicators. Researchers determined that the developed media should support students' abilities in interpreting probabilistic information, analyzing probability events, and solving contextual mathematical problems logically and critically. In addition, the developed media needed to accommodate students' diverse learning readiness and learning preferences through adaptive instructional activities. Therefore, the define stage became an essential foundation for designing relevant and student-centered digital mathematics learning environments.

Results of the Ideate Stage

During the ideate stage, researchers generated instructional ideas and designed interactive digital learning media integrating Kahoot! and Heyzine Flipbook within differentiated learning environments. The primary instructional idea was to combine visual-interactive learning materials with gamified evaluation activities to create more engaging and adaptive probability learning experiences. Heyzine Flipbook was designed as a digital learning material platform containing contextual probability explanations, visual illustrations, simulations, diagrams, and numeracy literacy exercises. The learning materials were organized systematically to support gradual conceptual understanding from basic probability concepts to contextual problem-solving activities. Meanwhile, Kahoot! was designed as a gamified evaluation platform containing interactive quizzes with varying levels of difficulty. The quiz activities included immediate feedback systems, scores, and competitive learning elements to improve students' motivation and participation during mathematics learning activities. Researchers also integrated differentiated learning principles by developing tiered probability exercises and adaptive learning activities suitable for students with varying levels of mathematical understanding. Storyboards, learning flows, visual layouts, and instructional structures were also prepared during this stage to ensure the integration of differentiated learning and numeracy literacy indicators within the developed media. The ideate stage therefore produced a comprehensive instructional framework for developing interactive digital mathematics learning media. The designed media emphasized contextual learning experiences, active participation, and adaptive instructional activities to strengthen students' mathematical numeracy literacy.

Results of the Prototype Stage

The prototype stage resulted in the development of the initial version of the interactive digital learning media integrating Kahoot! and Heyzine Flipbook. The Heyzine Flipbook prototype contained probability learning materials presented systematically through interactive visual explanations, contextual examples, probability simulations, and numeracy literacy exercises. The flipbook also included multimedia elements such as diagrams, illustrations, and interactive navigation systems to support students' conceptual understanding and learning engagement. Meanwhile, the Kahoot! prototype consisted of 25 interactive quiz questions related to mathematical numeracy literacy indicators in probability learning. The quiz activities were designed using differentiated learning principles by providing tiered levels of difficulty and adaptive learning feedback mechanisms. The developed prototype was subsequently evaluated by media experts and material experts to assess its instructional quality, interactivity, visual appearance, and content suitability. The validation results indicated that the developed media achieved highly feasible categories in both media and material evaluations. Media experts provided a feasibility score of 90%, while material experts provided a score of 92%. These findings indicated that the developed media successfully fulfilled pedagogical, technological, and instructional quality standards for mathematics learning. The prototype was therefore considered suitable for supporting differentiated probability learning and strengthening students' mathematical numeracy literacy. Overall, the prototype stage demonstrated that integrating Kahoot! and Heyzine Flipbook within differentiated learning environments could create adaptive and engaging digital mathematics learning experiences.

Table 2. Expert Validation Results

Validation Aspect	Percentage	Category
Media Expert Validation	90%	Very Feasible
Material Expert Validation	92%	Very Feasible

Overall Results of Media Development

Overall, the development of Kahoot! and Heyzine Flipbook-based interactive digital learning media demonstrated positive results in supporting differentiated mathematics learning and mathematical numeracy literacy enhancement. The developed media successfully integrated gamified evaluation activities, visual-interactive learning materials, and contextual probability learning tasks within adaptive instructional environments. The Design Thinking framework enabled researchers to develop instructional solutions based on students' actual learning difficulties and classroom needs. Furthermore, the developed media accommodated students' diverse learning characteristics through differentiated learning activities and tiered probability exercises. The integration of multimedia elements, contextual explanations, and gamified quizzes also contributed to increasing students' engagement and participation during learning activities. Expert validation results confirmed that the developed media fulfilled instructional quality standards in terms of pedagogical suitability, visual design, interactivity, and probability content relevance. The findings also indicated that the combination of Kahoot! and Heyzine Flipbook has strong potential to support technology-enhanced mathematics instruction in probability learning contexts. The developed media therefore represent an innovative instructional alternative capable of supporting student-centered and adaptive mathematics learning environments. Consequently, the findings suggest that interactive digital learning media integrating differentiated learning approaches can contribute positively to strengthening students' mathematical numeracy literacy in contemporary mathematics education contexts.

Discussion

The findings of this study demonstrate that the development of Design Thinking-based interactive digital learning media integrating Kahoot! and Heyzine Flipbook successfully addressed several instructional challenges identified during probability learning activities. The developed media were able to support differentiated mathematics instruction by accommodating students' diverse learning readiness, learning styles, and learning preferences through adaptive and contextual learning activities (Setambah et al., 2025). The implementation of interactive digital learning environments also contributed to improving students' engagement and participation during probability learning processes. These findings indicate that technology-enhanced learning environments can create more meaningful and student-centered mathematics instruction compared to conventional teacher-centered approaches. The effectiveness of the developed media is closely related to the application of human-centered instructional design principles emphasized in the Design Thinking framework. Through the empathize stage, researchers were able to identify authentic classroom problems and students' actual learning needs before designing the learning media. This finding supports the argument that educational innovations become more effective when instructional products are developed based on users' experiences and educational contexts (Castro & Zermeño, 2020; Kwangmuang et al., 2021). The results of this study are consistent with previous research reporting that Design Thinking can facilitate the development of adaptive and innovative educational solutions that improve instructional relevance and learning engagement. Previous studies also emphasized that human-centered educational design contributes positively to the quality of digital learning environments and students' learning experiences. Therefore, the

findings confirm that the integration of Design Thinking principles into mathematics learning media development can support the creation of relevant and context-sensitive instructional innovations.

The results obtained during the empathize stage revealed that probability learning remains one of the most challenging mathematics topics for students because it requires strong mathematical numeracy literacy, analytical reasoning, and contextual interpretation abilities. Students experienced difficulties in interpreting probability data, analyzing compound events, and connecting probabilistic concepts with real-life situations (Díaz Palencia & Ordoñez Ontiveros, 2024; He & Xin, 2025). Such findings are consistent with previous studies indicating that probability learning is often perceived as abstract and cognitively demanding due to its reliance on logical reasoning and data interpretation processes (Dasgupta et al., 2020; Szollosi et al., 2023). In many mathematics classrooms, students still tend to rely on procedural memorization instead of conceptual understanding and contextual reasoning (Barumbun & Kharisma, 2022; May, n.d.). This condition frequently causes students to struggle when solving contextual probability problems that require analytical interpretation and decision-making skills. The findings also showed that students demonstrated diverse learning profiles, including visual, auditory, and kinesthetic learning preferences, which influenced their understanding of mathematical concepts. This result supports previous studies emphasizing that students' learning diversity should be accommodated through adaptive instructional strategies and flexible learning environments. The implementation of differentiated learning in this study therefore became an important pedagogical strategy for addressing students' diverse learning characteristics. Through differentiated learning activities, students were able to access contextual probability tasks and learning materials suited to their individual capacities and learning preferences. Consequently, the findings strengthen the argument that differentiated learning can support more inclusive and effective mathematics instruction, particularly in topics requiring strong numeracy literacy and contextual reasoning abilities.

The integration of Kahoot! and Heyzine Flipbook within differentiated learning environments also demonstrated positive instructional contributions to students' engagement and conceptual understanding. Kahoot! functioned effectively as a gamified evaluation platform capable of increasing students' motivation, classroom participation, and learning interaction through competitive quizzes and immediate feedback mechanisms. This finding aligns with previous research reporting that gamification elements such as scores, rankings, rewards, and interactive feedback can significantly improve students' learning motivation and cognitive engagement in mathematics education (Algburi et al., 2026; Alghadari et al., 2020; Lo & Hew, 2020; Pan et al., 2026). The implementation of Kahoot! also created more enjoyable learning experiences, reducing students' anxiety toward probability learning activities. In addition, the immediate feedback provided by Kahoot! enabled students to identify misconceptions and improve their understanding directly during learning activities. Meanwhile, Heyzine Flipbook contributed positively to students' conceptual understanding by presenting probability materials visually and interactively through contextual illustrations, diagrams, and multimedia elements. The visual-interactive characteristics of the flipbook supported students in understanding abstract probability concepts more effectively. These findings are consistent with previous studies indicating that multimedia learning environments can improve conceptual understanding by integrating visual representations and contextual instructional explanations (Çeken & Taşkın, 2022; Noetel et al., 2022; Rau, 2020). The combination of Kahoot! and Heyzine Flipbook therefore

created complementary instructional functions in which one platform supported assessment and engagement, while the other supported conceptual understanding and contextual exploration. Consequently, the integration of gamified evaluation and visual-interactive learning materials appears to be highly relevant for supporting mathematical numeracy literacy development in contemporary digital learning environments.

Another important finding of this study is related to the role of differentiated learning in supporting adaptive and student-centered mathematics instruction. The developed learning media integrated differentiated instructional principles through tiered probability tasks, adaptive learning activities, and contextual instructional materials designed according to students' diverse learning capacities. This approach enabled students with higher readiness levels to engage in enrichment activities while allowing students requiring additional support to receive scaffolding and guided learning experiences. Such instructional flexibility contributed positively to students' engagement and participation because learning activities became more relevant to students' individual learning needs. The findings support previous studies reporting that differentiated learning improves students' self-efficacy, learning motivation, and academic performance by providing personalized instructional experiences (C.-Y. Chang et al., 2020; Lai et al., 2020; Salar & Turgut, 2021; Zhao et al., 2021). In mathematics learning, differentiated instruction is particularly important because students often demonstrate significant differences in conceptual understanding, reasoning abilities, and learning preferences. The integration of differentiated learning into digital learning environments therefore creates opportunities for more inclusive and equitable instructional practices. In addition, differentiated learning supports students' mathematical numeracy literacy because students can learn through contextual tasks adjusted to their cognitive capacities and learning progress. The implementation of differentiated learning within interactive digital media also strengthens students' independent learning and problem-solving skills through adaptive learning experiences. Therefore, the findings indicate that differentiated instruction should be considered an essential component of technology-enhanced mathematics learning environments designed to strengthen students' mathematical numeracy literacy.

The prototype validation results further demonstrated that the developed interactive digital learning media fulfilled pedagogical, technological, and instructional quality standards required for mathematics learning implementation. The media expert validation score of 90% and material expert validation score of 92% indicated that the developed media were categorized as highly feasible in terms of visual appearance, interactivity, instructional suitability, and probability content quality. These results suggest that integrating Design Thinking, differentiated learning, and interactive digital media can produce high-quality educational products capable of supporting effective mathematics instruction. The validation findings are consistent with previous studies indicating that interactive digital learning media developed through systematic instructional design processes generally demonstrate higher levels of usability, instructional relevance, and learning effectiveness. The iterative development process implemented through the Design Thinking framework also contributed significantly to improving the quality of the developed learning media because revisions were continuously conducted based on users' needs and expert feedback. Furthermore, the developed media provided contextual and adaptive learning experiences that supported students' active participation during probability learning activities. The integration of visual-interactive materials, gamified quizzes, and differentiated instructional tasks created more meaningful and engaging learning environments compared to conventional instructional approaches. The findings also suggest that the developed media have strong potential to support

technology-enhanced mathematics instruction in various educational contexts beyond probability learning. Nevertheless, this study was limited to prototype development and feasibility evaluation stages, meaning that broader implementation and effectiveness testing remain necessary for future research. Therefore, future studies are recommended to examine the long-term effects of integrating differentiated digital learning media on students' mathematical numeracy literacy, problem-solving skills, and academic achievement across different mathematics topics and educational settings.

Implications

The findings of this study provide several important implications for mathematics education, particularly in the development of technology-enhanced and differentiated learning environments. The successful integration of Kahoot! and Heyzine Flipbook demonstrates that interactive digital learning media can support more engaging, adaptive, and student-centered mathematics instruction. The implementation of differentiated learning within digital learning environments also indicates that instructional activities can be adjusted according to students' diverse readiness levels, learning styles, and learning preferences. This implication is particularly important because many mathematics classrooms still rely heavily on conventional teacher-centered instruction that does not adequately accommodate students' individual learning needs. The developed media also illustrate that probability learning can become more contextual and meaningful when supported by visual-interactive explanations, gamified evaluation systems, and adaptive instructional tasks. In addition, the findings suggest that the integration of gamification and multimedia learning can increase students' engagement, motivation, and participation during mathematics learning activities. From a pedagogical perspective, the study highlights the importance of combining differentiated instruction with interactive digital media to strengthen students' mathematical numeracy literacy and contextual reasoning abilities. The application of the Design Thinking framework further implies that educational innovation should be developed based on students' authentic learning experiences, classroom challenges, and instructional needs. This study also contributes theoretically by expanding the application of Design Thinking within mathematics education and technology-integrated learning development. From a practical perspective, the developed media may serve as an alternative instructional model for teachers seeking to implement adaptive and technology-enhanced mathematics learning in secondary education contexts. Furthermore, the integration of Kahoot! and Heyzine Flipbook provides opportunities for schools to optimize digital technology utilization in supporting meaningful mathematics learning experiences. Therefore, the findings imply that the combination of differentiated learning, gamified assessment, and interactive multimedia has strong potential to support the transformation of mathematics learning toward more inclusive, innovative, and student-oriented educational practices.

Limitations and Suggestions for Future Research

This study has several limitations that should be considered when interpreting the findings and implementing the developed interactive digital learning media in broader educational contexts. First, the study was limited to the prototype development and feasibility evaluation stages, meaning that the long-term effectiveness of the developed media in improving students' mathematical numeracy literacy was not comprehensively examined. Second, the research participants consisted of only 30 tenth-grade students from a single senior high school, which may limit the generalizability of the findings to other educational settings and student populations. Third, the implementation of the developed media was conducted only in probability learning contexts, so the applicability of the media to other mathematics topics remains unexplored. In addition, the study primarily focused on students' engagement, media feasibility, and instructional suitability without conducting extensive

experimental comparisons with conventional instructional approaches. The differentiated learning activities integrated into the media were also limited to several adaptive tasks and contextual exercises, which may not fully represent the complexity of differentiated instruction in diverse classroom environments. Furthermore, the study relied mainly on descriptive qualitative and descriptive quantitative analyses without employing advanced statistical testing to measure the direct impact of the developed media on students' academic achievement and numeracy literacy improvement. Technical limitations related to internet access, digital device availability, and students' technological familiarity may also influence the implementation effectiveness of the developed media in different educational contexts. Despite these limitations, the findings provide valuable insights into the integration of Design Thinking, differentiated learning, gamification, and interactive multimedia in mathematics education. Therefore, future studies are recommended to conduct experimental or quasi-experimental research designs involving larger and more diverse participant groups to examine the effectiveness of the developed media more comprehensively. Future research is also encouraged to investigate the long-term impact of interactive digital learning media on students' mathematical reasoning, problem-solving skills, self-efficacy, and academic performance across various mathematics topics. In addition, researchers may further develop more advanced differentiated learning systems by integrating artificial intelligence, adaptive learning analytics, or personalized feedback mechanisms into digital mathematics learning environments. Consequently, broader and more comprehensive investigations are needed to strengthen the empirical evidence regarding the effectiveness of technology-enhanced differentiated learning in improving students' mathematical numeracy literacy in contemporary educational settings.

CONCLUSION

This study successfully developed Design Thinking-based interactive digital learning media integrating Kahoot! and Heyzine Flipbook to support differentiated mathematics instruction and enhance students' mathematical numeracy literacy in probability learning. The development process, which followed the empathize, define, ideate, and prototype stages, enabled the researchers to design learning media based on students' actual learning needs, classroom challenges, and diverse learning characteristics. The findings revealed that students experienced difficulties in understanding probability concepts, particularly in interpreting probabilistic data, analyzing compound events, and solving contextual mathematical problems related to numeracy literacy. The integration of differentiated learning approaches within the developed media allowed instructional activities to accommodate students' varying readiness levels, learning styles, and learning preferences. Kahoot! functioned effectively as a gamified evaluation platform that increased students' engagement, participation, and learning motivation through interactive quizzes and immediate feedback systems. Meanwhile, Heyzine Flipbook supported conceptual understanding by presenting probability materials through visual-interactive explanations, contextual examples, and multimedia elements. The expert validation results demonstrated that the developed media achieved highly feasible categories, with a score of 90% from media experts and 92% from material experts, indicating strong pedagogical, visual, and technological quality. These findings suggest that the integration of gamification, interactive multimedia, and differentiated instruction can create more meaningful and student-centered mathematics learning environments. Furthermore, the application of the Design Thinking framework contributed positively to the development of adaptive and context-sensitive instructional innovations in mathematics education. The study also highlights the importance of technology-enhanced learning environments in supporting students' mathematical numeracy literacy and contextual reasoning abilities in contemporary education. In addition, the developed media provide practical contributions for teachers seeking innovative instructional

alternatives capable of increasing students' engagement and participation during probability learning activities. Therefore, the findings confirm that the integration of Kahoot!, Heyzine Flipbook, differentiated learning, and Design Thinking has strong potential to support the transformation of mathematics learning toward more adaptive, interactive, and student-oriented educational practices.

AUTHOR CONTRIBUTIONS STATEMENT

Salma Millenia Utami was responsible for the research conceptualization, development of the interactive digital learning media, data collection, implementation of the differentiated learning activities, data analysis, and manuscript drafting. Aryo Andri Nugroho contributed to the research supervision, methodological validation, instructional design evaluation, interpretation of the research findings, and critical revision of the manuscript. Supandi contributed to the development of the theoretical framework, validation of the research instruments and learning media, refinement of the research design, and final manuscript review. All authors participated in the discussion of the findings, approved the final version of the manuscript, and agreed to be accountable for all aspects of the research.

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