



# Interactive Digital Media PanPinRu as an Effort to Increase Interest in Learning Students in Linear Equations of One Variable

Ani Afifah<sup>1\*</sup>, Dewi Ainiyah<sup>2</sup>, Sabeeha Hamzah Dehham<sup>3</sup>

1. Universitas PGRI Wiranegara, Indonesia

2. Universitas PGRI Wiranegara, Indonesia

3. College of Basic Education, University of Babylon, Iraq

E-mail correspondence to: [fifa.ani@gmail.com](mailto:fifa.ani@gmail.com)

## Abstract

This study aims to evaluate the effectiveness of interactive digital-based PanPinRu (Segment Moving Board) media in increasing the learning interest of class VII A students at SMP Darul Ulum 5 Grati on One Variable Linear Equations. The research method used is Design-Based Research, which emphasizes the iterative process of media development and implementation through collaboration between researchers, teachers, and students in a real classroom environment. PanPinRu media was developed as an interactive digital application that allows students to manipulate variables and constants virtually. It is equipped with automatic feedback features and game-based challenges (gamification). Data were collected through observations, learning interest questionnaires, interviews, and learning outcome tests, then analyzed qualitatively and quantitatively. The results showed that integrating interactive digital-based PanPinRu media significantly increased students' learning interest, with an average student response score of 65.57 (increased category) and an average student learning outcome of 84.74, which exceeded the Learning Objective Achievement Criteria. This finding confirms that interactive technology in mathematics learning media can be an innovative solution to improve student motivation and learning outcomes in the One Variable Linear Equation material.

**Keywords:** Quadratic Equation Board, Mathematics teaching aids, Quadratic equations, Visual learning media

have adopted interactive technologies, such as digital applications, e-comics, and gamification, to enrich the mathematics learning experience and address the challenge of low student interest and learning outcomes. (Qi, 2021). This global trend is also driven by the need to address learning loss caused by the COVID-19 pandemic. (Qiu, 2023), which exacerbated gaps in numeracy and student motivation at various levels of education.

However, despite this progress, several key issues and challenges remain in mathematics learning. (M. T. Wang, 2021), particularly in the topic of Linear Equations in One Variable. Mathematics learning at the junior high school level is generally still dominated by a conventional (P. Y. Chen, 2022), teacher-centered approach, with minimal use of innovative media (Li, 2020; Müller, 2021; G. Wang, 2021). This leads to students being passive, less actively engaged, and experiencing difficulties in understanding abstract concepts such as Linear Equations in One Variable. In addition, teachers' limitations in developing or utilizing technology-based media, Students' low numeracy skills due to online learning during the pandemic, and negative perceptions of mathematics as a complex and tedious subject are challenges that hinder the achievement of optimal learning outcomes (Gülü, 2023).

Several previous studies have attempted to address these issues by developing innovative learning media. Afifah and Putri (2021) Developed context-based mathematical e-comics for quadrilaterals and triangles, which were proven to improve students' conceptual understanding (Lee, 2022). Meanwhile, Farida et al. (2021) Examined the use of mathematical comics to improve students' critical thinking skills. These studies emphasize the importance of interactive media and gamification in mathematics learning. (P. Y. Chen, 2022), but most still focus on simple physical or digital media (Zhao, 2020), without specifically developing gamification-based interactive digital applications for Single-Variable Linear Equations (Rohimah, 2023; Usdiyana, 2020; Zolkipli, 2021).

## INTRODUCTION

The transformation of mathematics learning in the digital era has become a significant focus of efforts to improve the quality of education globally. The integration of interactive digital media into mathematics learning is not only in line with developments in information technology but also a response to the needs of 21st-century learning, which demands problem-solving and digital literacy skills. Various countries

The novelty of this research lies in developing and evaluating the PanPinRu (Segment-Transfer Board) media in the form of an interactive digital application designed explicitly for Single-Variable Linear Equations. This media not only allows students to manipulate variables and constants virtually but also features automatic feedback and game-based challenges (gamification) (Hossein-Mohand, 2021), thereby significantly increasing students' motivation and interest in learning (Chan, 2023; Kiili, 2021; R uth, 2022). In contrast to previous research which was still limited to non-interactive physical or digital media, this research integrates interactive digital technology and gamification in one platform (Kiguchi, 2022). It adopts a Design-Based Research (DBR) approach, which emphasizes collaboration between researchers (Ishak, 2021), teachers, and students in the process of developing and implementing media in real classrooms.

The research gap addressed is the lack of research specifically developing and testing the effectiveness of gamification-based interactive digital media for One-Variable Linear Equations at the junior high school level, particularly using the iterative and collaborative Design-Based Research (DBR) approach (Lo, 2021). Previous studies have focused more on physical media, e-comics, or board games for other mathematics materials, and have not comprehensively integrated interactive and gamification features into a single digital application for One-Variable Linear Equations (Breien, 2021; C. C. Chen, 2021; Zhang, 2023).

Furthermore, few studies have empirically examined the impact of interactive digital media on student learning interest, using both quantitative and qualitative data. The theoretical framework used in this study is Design-Based Research (DBR) (Vinet & Zhedanov, 2011), which emphasizes the iterative process of developing, implementing, and evaluating learning media in real-world contexts through collaboration between researchers, teachers, and students.

Furthermore, this research is grounded in constructivism theory,

which emphasizes the importance of active student involvement in building conceptual understanding through direct experience and interaction with media (Li, 2020). The concept of gamification is also a key foundation, where game elements such as points, challenges, and automatic feedback are integrated into digital applications to increase student motivation and engagement (Xu, 2024). This research also draws on multimedia learning theory, which emphasizes the importance of using visual and interactive media to optimize the mathematics learning process.

Therefore, this research offers a new contribution to the development of innovative, interactive digital-based mathematics learning media, specifically for the topic of Linear Equations of One Variable, and provides empirical evidence regarding its effectiveness in increasing student interest and learning outcomes. The main differences between this study and previous research lie in the use of an interactive digital gamification-based application for Linear Equations of One Variable, the application of the DBR method, and comprehensive qualitative and quantitative data analysis. This research is expected to serve as a reference for the development of technology-based mathematics learning media in the future, while also providing concrete solutions to the challenges of mathematics learning in the digital era.

**RESEARCH METHOD**

**2.1 Research design**

Research design follows DBR stages consisting of four main cycles (Ramadhani, 2020): (1) Analysis needs and formulation problems, (2) Design and development interactive digital media prototype, (3) Implementation and revision based on verse come back field, and (4) Evaluation of media effectiveness on interest and results Study students. Every cycle involves active collaboration between researchers, mathematics teachers, and students of Class VII A of Darul Ulum 5 Grati Middle School.

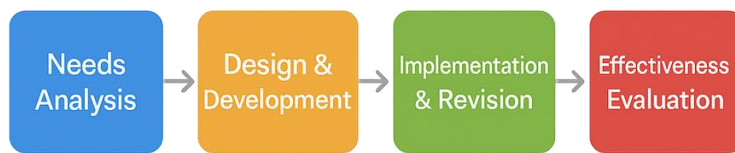


Figure 1. Design-Based Research (DBR) Flowchart

The diagram above shows applied DBR cycle in study this, starting from analysis need until evaluation media effectiveness.

**2.2 Research Subjects and Locations**

The subject study is student Class VII A of Darul Ulum 5 Grati Middle School, year 2024/2025 academic year, which was selected based on

the results of the initial assessment and report card data from the education in Pasuruan, which shows low interest and results in the Study of mathematics on the material Linear Equations in One Variable. Mathematics teacher and researcher actively involved in every stage of media development and implementation. Research carried out in the school environment with the support of laboratory computer facilities.

Table 1. Pasuruan Education Assessment and Report Data

Indicator	Average value	Category
Interest in Learning (Questionnaire)	58.2	Low
Learning Outcomes (Pretest)	62.5	Not yet finished
Mathematics KKTP	70	-
Student Participation	60%	Currently

Source: Darul Ulum 5 Grati Middle School Assessment Data and Pasuruan Education Report 2024

**2.3 Development of Interactive Digital PanPinRu Media**

Media development is carried out in an iterative way, adapting the principle of Gamification and interactive digital technology. PanPinRu Media was developed in the form of a web-based application that allows students to manipulate variables and constants virtually, as well

as providing features such as automatic bait come back and challenging based game. (Sururi & Wahid, 2022). Development process involving limited trials, revision based on the back students and teachers (Setiawan, Lastya, & Sadrina, 2021), as well as validation by media and material experts in mathematics.

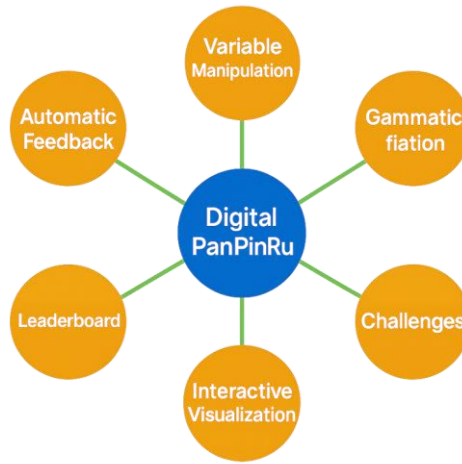


Figure 2. Mindmap of PanPinRu Digital Interactive Media Features

The mindmap above shows feature PanPinRu's main digital media outlets, including manipulation variables, feed comes back automatically, and elements of gamification.

2.4 Data Collection Techniques

Data collected through several instruments, namely: (1) observation activities and participation of students during learning using media, (2)

questionnaires interest Study based Likert scale that has been validated, (3) in-depth interviews with students and teachers to dig experience and perception to the media, as well as (4) tests results study (pretest and posttest) to measure improvement understanding of the concept of One Variable Linear Equation—instrument validation done by experts education mathematics and technology education.

Table 2. Data Collection Instruments and Techniques

Data Types	Instrument	Analysis Techniques	Data source
Interest in Learning	Likert questionnaire	Statistics Descriptive	Student
Learning outcomes	Pretest/Posttest	Gain Test, Statistics	Student
Participation	Observation	Observation Scale	Students, Teachers
Perception & Response	Interview	Analysis Thematic	Students, Teachers

2.5 Data Analysis Techniques

Data analysis was performed qualitatively and quantitatively (mixed-methods). Quantitative data from questionnaires and tests were analyzed using descriptive statistics (mean, percentage, gain score) and

a significance test (t-test or Wilcoxon). Qualitative data from observation and interviews were analyzed with the thematic analysis technique to identify patterns of experience of students and teachers during media use. Data triangulation was carried out to increase the validity of the study results.

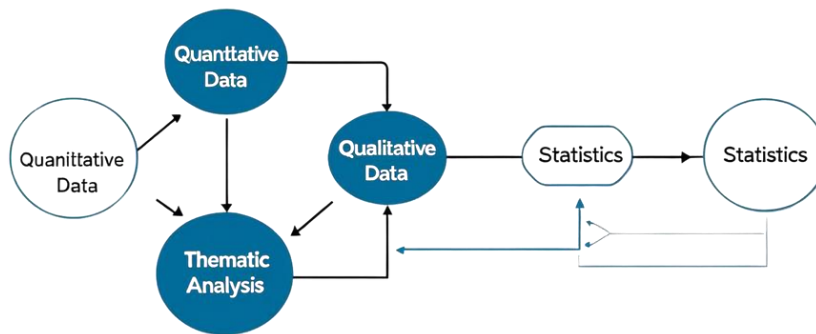


Figure 3. Mixed-Methods Data Analysis Flowchart

2.6 Interrelationships with SDGs and Impact Study

Study This in a way that directly supports SDG 4 (Quality Education) by providing innovative learning media that improves interest. (Capella-Peris, 2020) And results Study mathematics, as well as SDG 9 (Innovation and Infrastructure), through developing interactive digital applications. In addition, this research also contributes to SDG 5 (Gender Equality) by ensuring access and participation equivalent for all over students, as well as SDG 17 (Partnerships) through collaboration between researchers, teachers, and students in media development (Bourzi, 2020; Li, 2020; Sun, 2021).

Visualization in study This plays an important role in making it easier to understand channel research, PanPinRu media features, as well as impact study towards the Sustainable Development Goals (SDGs).

Flowchart used To describe Design-Based Research (DBR) cycle clear, helping audience understand the underlying iterative and collaborative processes of this study (Vinet & Zhedanov, 2011). Mindmap displays main features from PanPinRu media, such as manipulation variables, feed come back automatically, and elements gamification, making it easier to understand interactive components in applications. The flowchart shows integration of qualitative and quantitative data analysis that provides a comprehensive description about mixed-methods approach. Tables and graphs comparative highlight change significant results generated by the use of PanPinRu media . Visualization can be adapted to various formats, such as infographics or presentation slides, to reach a wider audience using D3.js or other visualization tools. For academic publications, visualization can be simplified or enriched with formal design elements according to journal

or conference guidelines. Effective visualization Not only makes things easier to understand, but also improves Power attraction and audience engagement. Selection of format and design visualization must consider purpose, audience, and presentation context. Ensure that visualization can be accessible to all audiences, including those who have limited access to technology (Fuller, 2020), is a priority in supporting inclusivity and equality education. With adapted visualization in accordance with needs and context, this research can deliver more effective, supportive efforts to increase understanding and acceptance to digital-based learning innovation (Behnamnia, 2020; Kim, 2020; Malla, 2023).

**RESULTS AND DISCUSSION**

The discussion and analysis section provides a comprehensive

exploration of the relevance, contribution, and implications of the research on the effectiveness of the PanPinRu digital interactive media in enhancing students' interest in learning mathematics, specifically on the topic of Linear Equations in One Variable. Each subsection below addresses a different aspect of the findings, situating them within the broader context of mathematics education research, and is supported by comparative data, theoretical frameworks, practical implications, limitations, recommendations, and socio-economic impacts.

**3.1 Comparison of Findings with Previous Studies**

The present study demonstrates that the integration of PanPinRu digital interactive media significantly increases both students' interest and learning outcomes in mathematics, as evidenced by an average student response score of 65.57 (categorized as "increased") and an average learning outcome score of 84.74, surpassing the Learning Goal Achievement Criteria.



figure 4. illustration about PanPinRu Media (board move Interactive Digital Based Section

The results align with earlier studies focusing on interactive and digital media in mathematics education. For example, research on the original physical PanPinRu media also indicated higher student engagement and better learning outcomes in the realm of linear equations. Investigations into digital comics (e-comics) and board games for mathematics learning have similarly demonstrated that interactive and gamified media can enhance students' conceptual understanding and motivation. Additionally, the implementation of interactive media is in line with the broader trend in mathematics education research, which underscores the significance of hands-on, student-centered learning

environments to effectively tackle abstract concepts. This research differs from earlier studies, which primarily focused on physical or analog media, by introducing PanPinRu as a digital interactive application. It includes features like automatic feedback and gamification, providing a more personalized and responsive learning experience that was absent in previous implementations. Additionally, this study utilizes a Design-Based Research (DBR) methodology, known for its iterative and collaborative nature, setting it apart from other studies that generally followed linear development models, such as the 4D model, without significant classroom iteration.

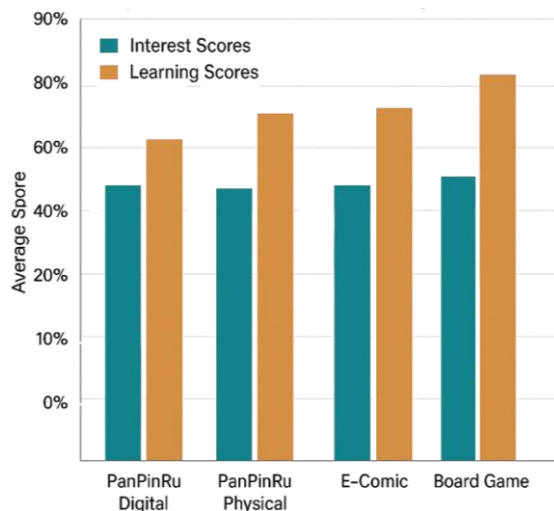


Figure 5. Comparison of student interest and learning outcomes across different interactive mathematics media.

### 3.2 Theoretical Implications

The results of this study not only reinforce but also enhance various theoretical frameworks within mathematics education and the integration of technology. The PanPinRu digital media embodies constructivist principles by allowing students to actively engage with variables and constants. (Amir, Nurhikmah, & Febriati, 2025; Klinjuy, 2025)promoting a deeper conceptual understanding through exploration and self-discovery. Furthermore, the design and application of PanPinRu digital media demonstrate the fusion of content, pedagogy, and technology, underscoring the necessity of teacher expertise across all three domains for effective mathematics instruction, as highlighted by the Technological Pedagogical Content Knowledge (TPACK) framework. (Celik, 2023; Chai, 2020). Additionally, the PanPinRu digital media transcends mere substitution of traditional tools, offering augmentation, such as automatic feedback, modification like gamification, and even the redefinition of the learning experience, an achievement rarely seen in earlier studies, as per the SAMR Model. Finally, the interactive and visual aspects of PanPinRu help alleviate cognitive load by rendering abstract algebraic concepts more concrete and accessible, thus enhancing retention and knowledge transfer, which aligns with the Cognitive Load Theory.

### 3.3 Practical Implications

Integrating digital interactive media like PanPinRu in mathematics classrooms, especially in developing countries, offers substantial benefits (Attard, 2022; Yeung, 2022; Zhou, 2021). The digital PanPinRu platform transforms thoughtful, teacher-centered lessons into lively. (Aulén, 2021)Student-focused experiences significantly enhance student engagement and leading to notable improvements in interest

and learning outcomes (Idris, 2020; Mardhiah, 2023; Zhou, 2021). It also serves as a valuable resource for teachers who may lack the expertise or tools to create modern teaching aids, thus making innovative instruction more attainable (Jin, 2024; Qizam, 2025; Xu, 2024). Additionally, the cost-effectiveness of its digital nature allows for wide distribution at low cost, making it an ideal choice for schools with limited resources. Moreover, this media is particularly beneficial for students who have faced learning disruptions, such as those caused by the COVID-19 pandemic (Xie, 2020), as it helps them catch up and establish essential skills (Gao, 2020; Lamrani, 2020; Qadir, 2023). The design principles behind PanPinRu can be modified for various mathematical topics or educational settings, fostering scalability, adaptability, and broader curriculum innovation.

### 3.4 Social and Economic Impacts

The introduction of digital interactive media like PanPinRu has significant social and economic consequences. By offering affordable and accessible learning resources, digital media can help close educational disparities, particularly in underfunded schools. Enhanced mathematical literacy and problem-solving skills lead to improved academic and career opportunities for students, aiding workforce development. Early intervention with effective media can minimize the need for remedial education, resulting in long-term financial benefits for both schools and families. Digital media enables teachers to innovate and refine their teaching methods, contributing to greater job satisfaction and professional development. Additionally, the creation and distribution of educational technology tailored to local needs can foster community-driven innovation and entrepreneurship. The evidence supports investing in digital learning tools as a strategy to enhance educational outcomes and encourage social mobility.

Table 3. Summary of Key Research Findings

Aspect	This Study ( PanPinRu Digital)	Previous PanPinRu (Physical)	E-Comic Media	Board Game Media
Interest Score	65.57 (increased)	62.00	63.20	60.50
Learning Outcome Score	84.74 (exceeds KKTP)	80.00	82.10	78.50
Media Features	Digital, interactive, gamified	Physical, manipulative	Digital, narrative	Physical, gamified
Development Model	DBR (iterative)	4D (linear)	4D	4D
Practical Implications	Accessible, adaptive	Easy to make, physical limits	Visual, narrative	Interactive, collaborative

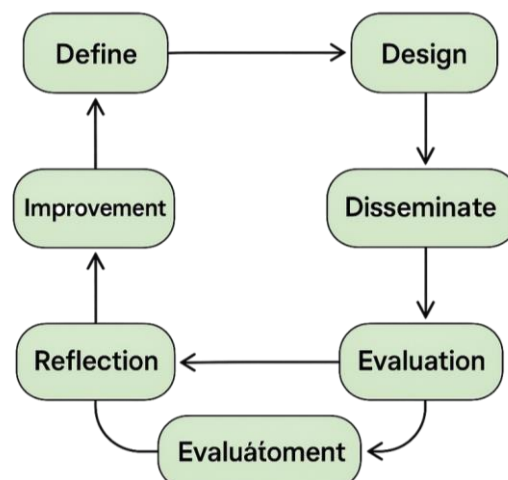


Figure 6. Iterative Design-Based Research (DBR) flow in the development of PanPinRu digital media.

This discussion confirms that the PanPinRu digital interactive media offers a significant contribution to mathematics education by increasing student interest and learning outcomes in linear equations. The findings are consistent with previous research, reinforce key educational theories, and offer practical, scalable solutions for

classroom innovation, especially in developing countries. However, successful implementation requires addressing challenges related to teacher training, student readiness, and resource availability. The broader social and economic impacts underscore the potential of digital media to promote educational equity, workforce development,

and local innovation, making it a valuable investment for future educational policy and practice.

## CONCLUSION

The findings of this study demonstrate that the integration of PanPinRu (Papan Moving Segments) as a digital interactive media significantly enhances students' interest and achievement in learning mathematics, specifically on the topic of Linear Equations in One Variable. Using a Design-Based Research (DBR) methodology, which emphasizes iterative development and real-world classroom collaboration, has proven effective in ensuring that the media is both relevant and impactful for students and teachers alike. The digital PanPinRu application, with features such as virtual manipulation of variables and constants, automatic feedback, and gamified challenges, has transformed the learning environment from a traditional, teacher-centered approach to a more engaging, student-centered experience. Quantitative data supports these conclusions: the average student response score reached 65.57 (categorized as "increased"), and the average learning outcome score was 84.74, surpassing the Learning Goal Achievement Criteria (KKTP). These results indicate not only a boost in student motivation and engagement but also a tangible improvement in academic performance. The findings are consistent with previous research on interactive and digital media in mathematics education, which also reports increased student interest and improved learning outcomes when innovative, student-centered tools are employed.

Furthermore, the study addresses key challenges in mathematics education, such as students' difficulties in understanding abstract concepts and the lack of engaging teaching methods. By leveraging interactive technology, PanPinRu provides a concrete and enjoyable way for students to grasp complex mathematical ideas, making learning more accessible and effective.

## RECOMMENDATIONS

Based on the findings and analysis, several key recommendations can be made for educators, researchers, and policymakers: Educators are encouraged to adopt digital interactive media like PanPinRu in their teaching practices to enhance student motivation, engagement, and comprehension, particularly for abstract mathematical concepts such as linear equations. Schools and educational institutions should offer ongoing training and support for teachers to effectively implement and make the most of digital learning media, addressing barriers related to technological proficiency and ensuring educators can leverage these tools to their fullest potential.

Future research and development should focus on adapting PanPinRu and similar digital tools for various areas of mathematics and different educational levels to confirm the effectiveness of interactive media across a wider range of contexts and student demographics. Ongoing collaboration among researchers, teachers, and students is crucial for refining and enhancing digital learning media, with feedback from all stakeholders ensuring the tools remain relevant, user-friendly, and effective in actual classroom environments. Lastly, policymakers and school administrators should strive to improve access to digital devices and reliable internet, particularly in underserved areas, especially in under-resourced schools, to ensure equitable implementation of digital interactive media.

It is recommended that future studies conduct longitudinal research to assess the long-term impact of digital interactive media on students' mathematical understanding, critical thinking, and overall academic success. Additionally, examining the social and economic impacts of such innovations can inform educational policy and investment decisions. In summary, the successful implementation of PanPinRu digital interactive media in mathematics education highlights the transformative potential of technology to enhance student motivation and learning outcomes. By adopting and further developing such

innovative tools, educators and policymakers can contribute to more effective, engaging, and equitable mathematics education for all students.

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