Infinity Journal of Mathematics Education
Volume 15, No. 4, 2026
p-ISSN 2089-6867
e–ISSN 2460-9285
https://doi.org/10.22460/infinity.v15i4.p1301-1330

# Fostering students' mathematical critical thinking and learning motivation through culturally grounded ClassPoint gamification: A development study

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**Received**: Aug 26, 2026 | **Revised**: Nov 23, 2026 | **Accepted**: Nov 25, 2026 | **Published Online**: Nov 26, 2026

## Abstract

Research on the development of mathematics learning media to support 21st-century skills has been widely conducted. However, the development of gamified mathematics learning media that integrates local cultural aspects warrants additional refinement for use in daily instruction. This study is designed to develop, validate, and test the effectiveness of ClassPoint gamification learning media based on 3N (*Niteni*, *Nirokke*, *Nambahi*) to improve mathematical critical thinking skills and learning motivation of junior high school students on the material of Linear Equations and Inequalities of One Variable (PLSV/PtLSV). This study uses a 4D development model (Define, Design, Develop, Disseminate) involving eight expert validators, one mathematics teacher, and eighth-grade students in Bandung City. Content validity was analyzed using Aiken's V index, while practicality and effectiveness were tested through questionnaires, tests, and quasi-experimental designs (Non-equivalent Control Group Design). The results showed that the developed media and instruments were very valid, with Aiken's V values ranging from 0.75 to 1.00, and achieved an average practicality score of 86.33% (very practical category). Furthermore, the hypothesis test showed that students who used the developed media improved their critical thinking skills in math and their motivation to learn more than those who did not use it. This finding confirms that integrating the 3N pedagogical framework with ClassPoint gamification effectively overcomes epistemological barriers and fosters an interactive, meaningful learning environment.

**Keywords**:
3N framework, 4D model, ClassPoint gamification, Critical thinking, Learning motivation

**How to Cite**:
Resmiati, T., Hidayat, W., & Yuliani, A. (2026). Fostering students' mathematical critical thinking and learning motivation through culturally grounded ClassPoint gamification: A development study. *Infinity Journal*, *15*(4), 1301-1330. https://doi.org/10.22460/infinity.v15i4.p1301-1330

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## 1. INTRODUCTION

In the 21st century, critical thinking skills are a crucial competency for students to develop. This ability helps them understand and analyze information, assess the validity of arguments, and find logical, relevant solutions to everyday problems. In mathematics learning,

critical thinking skills not only help students solve routine problems but also serve as a foundation for logical reasoning, informed decision-making, and systematic problem-solving. However, various international assessment results still indicate that Indonesian students' mathematical critical thinking skills have not yet reached an optimal level. The results of the 2022 Programme for International Student Assessment (PISA) show that Indonesian students' mathematical literacy achievement remains below the OECD average, particularly in the aspects of reasoning, interpretation, and complex problem-solving (Wijaya et al., 2024). These findings are reinforced by the TIMSS analysis, which shows that most students still experience difficulties with problems requiring higher-order thinking skills (Kania et al., 2024).

These results indicate that mathematical critical thinking skills remain a major challenge in mathematics learning in Indonesia. Critical thinking skills not only contribute to academic success but also serve as a foundation for developing problem-solving, mathematical reasoning, mathematical communication, and decision-making skills necessary in the Society 5.0 era (Agustiani et al., 2024; OECD, 2023).

The low level of mathematical critical thinking skills is evident not only in international assessment results but also in various studies at the junior high school level in Indonesia. Hidayat et al. (2022) suggested that students still face obstacles in developing mathematical reasoning because the learning process tends to be oriented toward delivering procedures and solving routine problems. This condition is consistent with the results of a systematic study by Riastuti et al. (2023), which showed that learning obstacles in Algebra include ontogenic, didactic, and epistemological obstacles. These obstacles are not only related to students' learning readiness but are also influenced by inadequate instructional design and by students' limitations in understanding and applying algebraic concepts across contexts. Consequently, students have difficulty developing a comprehensive conceptual understanding of algebra. This condition is further exacerbated by teacher-centered learning practices, which limit students' opportunities for exploration, investigation, and mathematical reasoning, thereby hindering the development of critical thinking skills (Hidayat & Aripin, 2023).

In addition, the research results of Meika et al. (2025) show that learning designs that do not account for learning obstacles cause students to have difficulty constructing mathematical concepts independently. Therefore, innovative learning media are needed to gradually facilitate students' thinking processes and provide more meaningful learning experiences. In this context, algebraic material, specifically Linear Equations and Inequalities of One Variable (PLSV/PtLSV), was chosen as the testing context because this material is the foundation of algebraic thinking at the secondary level, where students often experience abstract transitions that trigger didactic and epistemological obstacles if not bridged by a systematic learning design.

On the other hand, the development of digital technology has changed the characteristics of students in the digital native generation. The use of technology in learning offers significant opportunities to create more interactive, adaptive, and meaningful learning experiences. However, the use of technology in schools often fails to optimize student engagement during the learning process. Device use is often directed toward non-academic activities, thus diminishing students' attention to learning. This condition results in low motivation to learn, which in turn affects the development of mathematical critical thinking

skills (Desti et al., 2020). Furthermore, various studies have shown that low motivation to learn is associated with increased math anxiety, which can lead students to feel less confident in solving math problems (Delima et al., 2024; Listiawati et al., 2025).

Learning motivation is an affective factor that is positively related to mathematical critical thinking skills. Students with high learning motivation tend to be more active in exploring various problem-solving strategies, more willing to express their opinions, and more able to defend their mathematical arguments logically (Diponegoro et al., 2024). In addition to motivation, student engagement during learning is also an important factor influencing the success of mathematics learning. Technology-based learning designed for interaction can increase students' cognitive and emotional engagement, thereby positively impacting higher-order thinking skills (Supianti et al., 2025; Widodo, Hidayat, et al., 2025).

Various technology-based learning innovations have been developed to increase student engagement, including gamification. Gamification integrates game elements such as points, rankings, badges, challenges, and feedback into learning activities, thereby increasing students' intrinsic and extrinsic motivation. Various studies report that gamification positively impacts student engagement, learning outcomes, and the learning environment (Muchuweni et al., 2025).

The use of Classroom Response Systems, such as Kahoot! and Quizizz, has also been shown to increase student participation in mathematics learning (Fadhilah et al., 2025). However, most of these studies still use gamification as a learning evaluation tool and therefore have not fully integrated it into the overall learning process (Chau & Pham, 2023). The use of technology-based learning media will have a more optimal impact if it is not only used as an evaluation tool but also integrated into learning activities designed to develop higher-order thinking skills (Sutarni et al., 2024). In addition, integrating gamification with student-centered learning strategies has been shown to increase cognitive engagement, intrinsic motivation, and mathematical problem-solving skills compared with using digital media solely as an evaluation tool.

One of the digital learning platforms that is starting to be widely used is ClassPoint, which is an application that is directly integrated with Microsoft PowerPoint, allowing teachers to insert interactive quizzes, leaderboards, awards, and various forms of real-time feedback. Querido's (2023) research shows that using ClassPoint can increase student engagement during mathematics learning. However, research on the use of ClassPoint to develop mathematical critical thinking skills remains very limited, especially at the junior high school level. Most studies measure only increased engagement or learning satisfaction, without integrating ClassPoint into a pedagogical approach grounded in a strong theoretical foundation.

In the context of learning in Indonesia, the 3N approach (*Niteni*, *Nirokke*, *Nambahi*), based on Ki Hadjar Dewantara's educational philosophy, is a relevant approach for gradually developing students' thinking processes. Theoretically, the 3N syntax is specifically designed to bridge students' epistemological and didactic barriers: The *Niteni* stage emphasizes the activity of observing and understanding concepts concretely to reduce the initial obstacle (ontogenic/didactical obstacle); *Nirokke* directs students to imitate and practice mathematical procedures in a guided manner; while *Nambahi* encourages students to develop ideas through modification, innovation, and non-routine problem solving to overcome higher-level obstacles

(epistemological obstacle) (Astuti et al., 2023). Various recent studies have shown that the 3N approach can improve students' critical and creative thinking skills (Latifah et al., 2024; Suroyaningsih et al., 2024; Widodo, Wulandari, et al., 2025). Furthermore, the development of 3N-based e-modules and worksheets has been shown to impact conceptual understanding and mathematical creativity positively and to support the integration of learning with interactive digital media (Kusumaningrum et al., 2024; Sulistyowati et al., 2026).

However, research on the 3N approach remains dominated by conventional learning media and simple digital media, such as e-modules and e-LKPD (Hidayat et al., 2025). Integration of the 3N approach with interactive gamification platforms based on ClassPoint is still very rare in the literature. This merger is not simply a random merging of two methods, but is based on the compatibility of the digital ecosystem: the interactive nature of real-time gamification in ClassPoint serves as an ideal digital environment to accommodate the gradual cognitive processes of the 3N framework. ClassPoint's live quizzes, image collection, and instant feedback features provide a precise operational platform for students as they review (*Niteni*), imitate procedures (*Nirokke*), and independently modify mathematical arguments (*Nambahi*). In fact, research by Hidayat et al. (2025) on the integration of ethno-modeling and 3N showed that combining a cultural approach with digital technology can significantly improve students' mathematical critical thinking skills. This finding opens up opportunities to develop learning media that not only utilize digital technology but also maintain Indonesian cultural values as a foundation for learning.

Based on the description, there are three research gaps that still need to be studied. First, research on the gamification of mathematics learning generally focuses only on increasing motivation and learning outcomes, without systematically developing critical thinking skills. Second, research on the 3N approach still largely relies on conventional learning media, so it has not fully optimized the potential of interactive digital technology. Third, there has been no research that theoretically or empirically integrates ClassPoint gamification with the 3N approach (*Niteni*, *Nirokke*, *Nambahi*) to bridge barriers to learning algebra through a systematic, interactive digital environment, thereby improving mathematical critical thinking skills and motivation among junior high school students.

Therefore, this study aims to develop, validate, and test the effectiveness of ClassPoint gamification learning media based on 3N (*Niteni*, *Nirokke*, *Nambahi*) on algebra material (PLSV/PtLSV). The novelty of this study lies in the synthesis of the 3N local wisdom pedagogical framework, which is expected to overcome epistemological barriers to learning, with a real-time gamification architecture on ClassPoint. This research not only offers an alternative interactive digital media format but also presents a mathematics learning model that empirically stimulates high-level critical thinking indicators while boosting students' motivation to learn.

## 2. METHOD

This study employs a research and development approach, which aims to produce a valid, practical, and effective 3N-based ClassPoint Gamification learning media (*Niteni*, *Nirokke*, *Nambahi*) in stimulating mathematical critical thinking skills and learning motivation

of junior high school students. The development model used in this study is the 4D model (Define, Design, Develop, and Disseminate) developed by Thiagarajan et al. (1974). This model was chosen because it has systematic stages in producing learning products that meet the aspects of validity, practicality, and effectiveness. These development stages have also been widely used in research on the development of mathematics learning media in recent years (Hidayat & Aripin, 2023; Hidayat et al., 2022; Kurniansyah et al., 2022).

The research was conducted at a junior high school in Bandung City during the odd semester of the 2026/2027 academic year. The subjects consisted of eight expert validators, one mathematics teacher as a user, and eighth-grade students. The trial was conducted in stages: a limited trial (developmental testing) in small groups and field trials (field testing) during the dissemination phase.

The first stage is Define. This stage aims to identify learning needs through curriculum analysis, student characteristics analysis, materials analysis, and learning obstacle analysis. The needs analysis was conducted based on the results of a preliminary study indicating low levels of mathematical critical thinking among students, low motivation to learn, and a need for digital learning media that integrate cultural and technological elements.

The second stage is Design. At this stage, an initial design (prototype I) of the ClassPoint Gamification learning media based on 3N was prepared. Activities carried out included compiling learning outcomes and learning objectives; compiling learning flows based on the stages of *Niteni*, *Nirokke*, and *Nambahi*; designing gamification activities using ClassPoint features such as quizzes, leaderboards, badges, random pickers, and interactive questions; and compiling research instruments. The research instruments developed included expert validation sheets, teacher practicality questionnaires, student response questionnaires, mathematical critical thinking ability tests, and student learning motivation questionnaires.

The third stage is Development. At this stage, comprehensive product and instrument validation is carried out by eight expert raters/validators (consisting of academics with Doctoral/Professor qualifications in the field of mathematics education) to test the validity of the content and construct. The assessment panel was divided specifically into four component focuses (4 experts per component): (1) material/substance experts for algebra and 3N syntax, (2) interactive media and gamification experts for ClassPoint, (3) critical thinking ability test instrument experts, and (4) non-test instrument experts for learning motivation scales. Aspects of material and media validity included content appropriateness, visual layout accuracy, interactivity, language, and the appropriateness of the 3N flow. Meanwhile, the validity of test and non-test instruments included the appropriateness of cognitive/affective indicators, item readability, and the appropriateness of the scoring rubric. Next, mathematics teachers conducted user validation, and readability testing was conducted on students.

Content validity analysis is calculated using the Aiken index (Aiken's V) with the formula $V = \frac{\sum s}{n(k-1)}$ to measure the level of agreement between validators. Validity criteria are referenced based on the Aiken V critical value table at a significance level of $\alpha$=0.05. The Aiken index was chosen because it is highly robust in proving inter-rater agreement on learning tool indicators (Almanasreh et al., 2019). Product improvements were made based on validation results and input from experts (validators) to refine aspects of substance, product construction, language, and presentation. Each validator's suggestion and recommendation

was systematically analyzed and then used as the basis for revising product components deemed suboptimal. This revision process aimed to ensure that the developed product had theoretical suitability, consistency between components, procedural clarity, and feasibility for implementation in learning.

After being declared valid, the media was tested with a small group (developmental testing) to assess its practicality. Practicality aspects included ease of use, clarity of display, implementation of learning syntax, ease of navigation, and the media's usefulness in helping students understand mathematics material. Practicality data were obtained through teacher and student response questionnaires using a four- to five-point Likert scale and were analyzed descriptively as percentages. After the product has been tested on a small group (developmental testing), a field trial is conducted. It aims to test the effectiveness of learning media through implementation in real classes. The school sample was determined using purposive sampling based on school accreditation criteria, availability of laboratory facilities/devices, and curriculum equivalency.

Furthermore, the intervention and comparison groups were determined using cluster random sampling from available eighth-grade classes. The Experimental Class (N=30) received learning using 3N-based ClassPoint Gamification. In contrast, the Control Class (N=30) received conventional instruction in line with the teacher's habits. The same teacher teaches classes and has equal initial mathematical abilities (prior mathematical knowledge). Both classes were administered a mathematical critical thinking ability test and a learning motivation questionnaire.

The fourth stage is dissemination. The dissemination stage aims to make the developed product available to a wider user group. The product dissemination stage is carried out to mathematics teachers through the Mathematics Subject Teachers' Conference (*MGMP*). This activity aims to introduce the product development results and provide an understanding of the conceptual basis, characteristics, syntax, and implementation procedures for mathematics learning. Dissemination is carried out through teacher training, product presentations, demonstrations of use, and discussions with teachers to gather feedback and input on its potential applications in schools. Through these activities, it is hoped that the developed product will be recognized, utilized, and adapted by mathematics teachers as an alternative innovation to improve the quality of mathematics learning.

The research instruments consisted of a mathematical critical thinking ability test (PLSV/PtLSV contextual problem-based essay questions), a learning motivation attitude scale (a 20-item questionnaire with a mix of favorable and unfavorable items), a media/material validation sheet, and a practicality response questionnaire. The cognitive test and affective scale were compiled using the standard indicators listed in Table 1.

**Table 1**. Indicators of critical thinking ability and learning motivation

| Critical Thinking Ability Indicators | Learning Motivation Indicators |
|---|---|
| Checking the truth of arguments/statements and the solution process | Having a Desire and Will to Succeed |
| Formulate questions with reasons | There is a drive and need to learn |

| Critical Thinking Ability Indicators | Learning Motivation Indicators |
|---|---|
| Identifying relevant and irrelevant data | Having Hopes and Dreams for the Future |
| Identify the assumptions underlying the solution | There is Appreciation in Learning |
| Compile answers / solve problems with reasons | There are interesting activities in learning |

The research data were analyzed both quantitatively and qualitatively. Validity data were analyzed using Aiken's V index, while practicality data were analyzed using descriptive statistics (percentages). Media effectiveness testing was conducted in sequential stages of inferential statistical analysis:

a. Analysis Prerequisite Test: The normality test for data distribution was conducted using the Shapiro-Wilk method (because the sample size was N<50), and the homogeneity test for variance was conducted using Levene's Test at a significance level of α=0.05.
b. Independent Comparative Analysis: Inter-group differences were analyzed using the Independent Samples t-test on post-test scores and the mean Normalized Gain (N-Gain).

All inferential statistical analyses were conducted using IBM SPSS Statistics version 30 at a significance level of $\alpha = 0.05$. A limitation of this model lies in the assumption of internet connectivity and student devices in the classroom. However, stringent external control procedures have been implemented to ensure other researchers can accurately replicate the study.

## 3. RESULTS AND DISCUSSION

### 3.1. Results

#### 3.1.1. Define Stage

The define stage aims to establish the requirements for developing interactive learning media to improve students' mathematical critical thinking skills and motivation to learn. The results of the initial needs analysis indicate that most students still have difficulty solving non-routine mathematical problems requiring high-level reasoning. In addition, student motivation to learn is relatively low due to a learning process that remains teacher-centered and the minimal integration of interactive digital media that can actively engage students. Analysis of the material and curriculum identified learning obstacles, both didactic and epistemological, to the independent construction of conceptual understanding. On the other hand, an analysis of the characteristics of digital-native generation students shows the need for a pleasant learning environment (joyful learning) through the integration of gamification elements.

Supported by a literature review on the effectiveness of digital gamification and the 3N approach (*Niteni*, *Nirokke*, *Nambahi*), these findings underscore the urgency of developing valid, practical, and effective 3N-based ClassPoint gamification media to stimulate mathematical critical thinking skills and increase students' motivation to learn. Furthermore, a review of previous studies on the development of ICT-based learning tools and the implementation of the 3N approach in mathematics education was conducted to inform the

compilation of product specifications (Hidayat et al., 2025; Rosita et al., 2024; Widodo et al., 2023). The results show: first, the process of developing 3N-based e-LKPD can improve students' mathematical abilities (Hidayat et al., 2025). Second, approximately 55% to 62% of students have difficulty understanding the material, indicating a need for additional electronic learning media (Hidayat & Aripin, 2023; Hidayat et al., 2025; Hidayat et al., 2022; Irfan et al., 2023; Kurniansyah et al., 2022; Pertiwi et al., 2021). Third, a preliminary meta-analysis on the impact of ICT-based learning devices on students' cognitive abilities, based on 40 relevant studies, reported an effect size of 1.281. These findings demonstrate that ICT-based learning devices positively affect students' mathematical abilities (Widodo et al., 2023).

### 3.1.2. Design Stage

The design stage aims to develop an initial prototype (prototype I) of the 3N-based ClassPoint gamification learning media, along with the necessary research instruments. The activity includes three main steps, namely: 1) Selection of media strategy, 2) Format design and evaluation, and 3) Determination of learning resources.

a. Media Strategy: The media is designed in Microsoft PowerPoint and is directly integrated with ClassPoint's interactive features to facilitate gamification activities effectively in real time. Embedded gamification features *include interactive questions (Multiple Choice, Word Cloud, Slide Drawing, Short Answer), star rewards, a leaderboard*, and a *random* pick to create a competitive, interactive, and fun learning atmosphere.
b. Format Design & Evaluation: The learning slide design is arranged systematically, referring to the 3N syntax: The *Niteni* stage presents phenomena or visual problem contexts for students to observe in order to identify important facts and concepts carefully; the *Nirokke* stage directs students to imitate, practice, and respond to concept exercises through interactive ClassPoint quizzes; the *Nambahi* stage stimulates students to modify, explore new variations of problems, and provide logical arguments through slide drawing or short answer features to train critical thinking skills.
c. Resources & Instruments: At this stage, evaluation instruments were also prepared, including validation sheets from material and media experts, questionnaires assessing the practicality of teacher and student responses, instruments for testing mathematical critical thinking skills, and a scale for student learning motivation. The interface display of the learning slides, as designed, is shown in Figure 1.

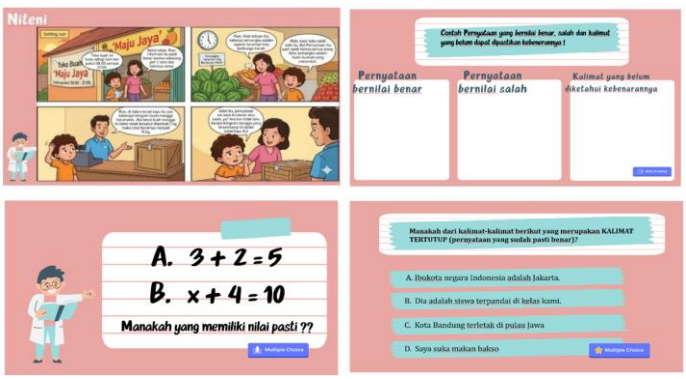



**Figure 1**. ClassPoint 3N-based gamification media display

### 3.1.3. Develop Stage

In accordance with the research stages, development activities are carried out: expert appraisal (expert validation) and development testing (small-scale trial). Expert appraisal: This is an assessment activity for ClassPoint's 3N-based gamification learning media products and research instruments, in the form of critical thinking ability tests and non-learning motivation tests, conducted by individuals considered experts in mathematics education. Expert appraisal was conducted on three research products, namely (1) 3N-based ClassPoint gamification learning media; (2) Student Critical Thinking Ability Test; and (3) Non-test Student Learning Motivation. In the expert appraisal, the 3N-based ClassPoint gamification learning media were evaluated by 4 people considered experts in mathematics education. Their expertise was demonstrated by their doctoral degree (or equivalent) in mathematics education. The 4 people who assessed the research product in the form of 3N-based ClassPoint gamification learning media consisted of media experts and material experts.

In addition, in the activities, expert appraisal was also conducted, including an assessment of the students' mathematical critical thinking ability test and the student learning motivation non-test instrument carried out by 4 people who are considered experts in the field of mathematics education. They validate the research product in terms of content, or often called content validity. This validity provides evidence of the extent to which the elements of the assessment instrument are relevant and represent the targeted constructs for specific assessment purposes (Aiken, 1980; Almanasreh et al., 2019; Polit & Beck, 2006; Polit et al., 2007). The assessment aspects on the content validation sheet of the 3N-based ClassPoint gamification learning media product were adapted from the assessment instrument for the Mathematics and Natural Sciences (*MIPA*) interest group textbook, namely: (a) the appropriateness of the content and substance of mathematics; (b) the presentation aspect based on 3N syntax; (c) the ClassPoint gamification and critical thinking aspects; and (d) the linguistic and readability aspects.

The assessment of the validation sheet for the ClassPoint gamification learning media product based on 3N includes the following aspects: (a) Visual and aesthetic design; (b) Interactive communication engineering; (c) Quality of ClassPoint feature integration; and (d) Cognitive usefulness (media effects). The validation sheet scoring generally follows a modified Likert-scale guideline, with scores ranging from 1 to 4. For content validity index (CVI) or content validity index (CVI) for ClassPoint 3N-based gamification learning media products, you can use the Lawshe method or the Aiken method. To determine whether a product (3N-based ClassPoint gamification learning media) is good or not, the content validity index (V) obtained from the calculation results is compared with Table V Aiken for the Number of Raters (n) = 4 and a scale of 4 categories (k) = 4 at a significance level of 5%. The Table value is 0.75, as reported by Aiken. It was found that for each aspect of the assessment, there were 14 items from material expert validation, 12 from media expert validation, 12 from critical thinking ability test instrument expert validation, and 11 from non-test learning motivation instrument expert validation. Based on the assessment by the material expert validator of the 3N-based ClassPoint gamification learning media, the content validity index (V) is greater than 0.75. These results indicate that the 3N-based ClassPoint gamification

learning media is very good in terms of mathematical content and substance, 3N syntax presentation, ClassPoint gamification aspects, and linguistic and readability aspects.

Based on the assessment by the material expert validator of the 3N-based ClassPoint gamification learning media, the content validity index (V) is greater than 0.75. These results indicate that the 3N-based ClassPoint gamification learning media is very good in terms of mathematical content and substance, presentation based on 3N syntax, feasibility of ClassPoint gamification aspects, as well as linguistic and readability aspects (see Table 2).

**Table 2**. The validity of the material expert for ClassPoint gamification learning media based on 3N

| Indicators | No | Aiken V-Value | Information |
|---|---|---|---|
| The appropriateness of mathematical content and substance | 1 | 1.00 | Valid |
| | 2 | 1.00 | Valid |
| | 3 | 0.92 | Valid |
| | 4 | 0.92 | Valid |
| Presentation eligibility based on 3N syntax | 5 | 0.92 | Valid |
| | 6 | 0.92 | Valid |
| | 7 | 0.83 | Valid |
| | 8 | 0.83 | Valid |
| The feasibility of ClassPoint gamification and critical thinking | 9 | 0.83 | Valid |
| | 10 | 1.00 | Valid |
| | 11 | 1.00 | Valid |
| Linguistic suitability and readability | 12 | 0.92 | Valid |
| | 13 | 1.00 | Valid |
| | 14 | 0.92 | Valid |

In addition, based on the media expert validator's assessment, the ClassPoint gamification learning media based on 3N has a content validity index of more than 0.75 (see Table 3). These results indicate that the 3N-based ClassPoint gamification learning media is very good in terms of visual and aesthetic design, interactive communication engineering, quality of ClassPoint feature integration, and cognitive usefulness (media effects). These results also indicate that the developed media can be used for the next stage.

**Table 3**. The results of the expert validity of ClassPoint gamification learning media based on 3N

| Indicators | No | Aiken V-Value | Information |
|---|---|---|---|
| Visual and aesthetic design feasibility | 1 | 1.00 | Valid |
| | 2 | 0.83 | Valid |
| | 3 | 1.00 | Valid |
| | 4 | 0.75 | Valid |
| Feasibility of interactive communication engineering | 5 | 0.92 | Valid |
| | 6 | 0.83 | Valid |
| | 7 | 0.92 | Valid |
| ClassPoint feature integration quality feasibility | 8 | 0.92 | Valid |
| | 9 | 1.00 | Valid |
| | 10 | 0.92 | Valid |

| Indicators | No | Aiken V-Value | Information |
|---|---|---|---|
| Cognitive utility feasibility (media effects) | 11 | 0.92 | Valid |
| | 12 | 0.83 | Valid |

The content validity index for the instrument assessing students' mathematical critical thinking ability was calculated using Aiken's V. The assessment aspects on the validation sheet of this test instrument include four main dimensions, namely: (a) the feasibility of the mathematical content or substance; (b) the feasibility of the construction or stimulation of critical thinking; (c) the linguistic and readability aspects; and (d) the clarity of the assessment rubric and scoring guidelines, which consist of a total of 12 statement items. The validation sheet scoring uses a Likert scale of 1 (very bad) to 4 (very good). To determine the instrument's validity, with n = 4 validators and k = 4 assessment scales, at a significance level of $\alpha = 0.05$, the calculated Aiken's V index was compared with the critical value of 0.75. The calculation results show that all items across the four assessment aspects of the mathematical critical thinking ability test had Aiken's V values above 0.75, ranging from 0.83 to 1.00 (see Table 4). These findings demonstrate that the developed mathematical critical thinking ability test instrument is highly valid in terms of content, construction, language, and evaluation rubric, and is suitable for use in the next stage of testing.

**Table 4**. The results of the expert validity of the critical thinking ability test instrument for students

| Indicators | No | Aiken V-Value | Information |
|---|---|---|---|
| Suitability of content or substance | 1 | 1.00 | Valid |
| | 2 | 0.92 | Valid |
| | 3 | 0.83 | Valid |
| Construction feasibility or critical simulation | 4 | 0.92 | Valid |
| | 5 | 0.92 | Valid |
| | 6 | 0.83 | Valid |
| Linguistic suitability and readability | 7 | 0.92 | Valid |
| | 8 | 1.00 | Valid |
| | 9 | 1.00 | Valid |
| Eligibility of assessment and evaluation rubrics | 11 | 1.00 | Valid |
| | 12 | 0.92 | Valid |

Furthermore, the content validity of the non-test instrument, the student learning motivation scale, was calculated using Aiken's V index. This non-test instrument validation sheet contains four main assessment aspects, namely: (a) content feasibility, substance, and theoretical suitability; (b) instrument construction feasibility (balance of favorable and unfavorable statements); (c) language and readability; and (d) clarity of filling instructions and scoring guidelines, with a total of 11 assessment items. Using a 1-to-4 assessment scale, each item is considered valid if it obtains a V index $\geq 0.75$. Based on the recapitulation results in Table 5, all statement items across the four assessment aspects of the non-test learning motivation instrument had Aiken's V values ranging from 0.83 to 1.00 ($> 0.75$). Thus, the student learning motivation scale is declared valid in terms of content and construct and is

ready to be used to measure students' learning motivation achievements during the implementation of learning.

**Table 5**. The results of the expert validity of the non-test instrument for student learning motivation

| Indicators | No | Aiken V-Value | Information |
|---|---|---|---|
| The feasibility of content or substance and theory | 1 | 1.00 | Valid |
| | 2 | 0.92 | Valid |
| | 3 | 0.83 | Valid |
| Feasibility of instrument construction | 4 | 0.83 | Valid |
| | 5 | 1.00 | Valid |
| | 6 | 0.83 | Valid |
| Language suitability and readability | 7 | 0.83 | Valid |
| | 8 | 0.92 | Valid |
| | 9 | 0.83 | Valid |
| Eligibility guidelines and scoring guidelines | 10 | 0.92 | Valid |
| | 11 | 1.00 | Valid |

In addition to expert appraisal, developmental testing (limited trials) was conducted during the development stage to assess the practicality of the 3N-based ClassPoint gamification learning media. The research design used in this developmental testing stage was a one-shot case study involving one class of 30 eighth-grade students at a junior high school in Bandung City, selected by purposive sampling. In this activity, all students in the limited trial group participated in mathematics learning using the 3N-based ClassPoint gamification media and were then asked to complete a response questionnaire to assess the product's practicality. Student responses in this test referred to indicators of the media's visual appearance, material presentation, attractiveness, product usefulness, and the media's potential to encourage students' mathematical critical thinking skills. Next, they responded to the 3N-based ClassPoint gamification learning media that had been used. Student responses in this test referred to indicators of the display of the results of the 3N-based ClassPoint gamification learning media, material presentation, student attractiveness, product usefulness, and the potential to encourage students' mathematical critical thinking skills.

The assessment uses a student response questionnaire with 20 statements rated on a 1–4 Likert scale. The percentage of practicality is calculated using the formula. After obtaining the final practicality value, the criteria are shown in Table 6.

**Table 6**. Practicality criteria

| Practical Criteria | Practical Level |
|---|---|
| $80\% < P \leq 100\%$ | Very Practical |
| $60\% < P \leq 80\%$ | Practical |
| $40\% < P \leq 60\%$ | Quite Practical |
| $20\% < P \leq 40\%$ | Less practical |
| $P \leq 20\%$ | Impractical |

The results of the limited trial are presented in Table 7.

**Table 7**. Recapitulation of practicality test results in limited trials

| No | Evaluation Aspects | Average (%) |
|---|---|---|
| 1 | Media Display and Visual Design | 86.67 |
| 2 | Classpoint Interactivity and Features | 88.75 |
| 3 | Presentation of Material | 88.75 |
| 4 | Attractiveness | 85.00 |
| 5 | Technical Constraints and Learning Independence | 82.50 |
| | Average | 86.33 |

Table 7 shows the average practicality percentage of 86.33%, which falls within the Very Practical category. Based on each assessment aspect, the interactivity and features of ClassPoint, as well as the presentation of the material, achieved the highest score of 88.75%, categorized as Very Practical. This indicates that integrating interactive quizzes and a leaderboard reward system can foster a more active learning atmosphere, and that the flow of contextual material presented in stages through the 3N syntax (*Niteni*, *Nirokke*, *Nambahi*) is coherent and easy to understand. Furthermore, the media display and visual design aspects achieved 86.67% (Very Practical) due to the neat slide layout, clear text readability, and visual illustrations that effectively facilitate students' initial conceptual understanding. The attractiveness aspect was also in the Very Practical category at 85.00%, indicating that the media increased students' interest and enthusiasm for learning. Meanwhile, the technical constraints and learning independence aspects achieved 82.50% (Very Practical), indicating that technical constraints could be minimized, and students could learn independently well. Overall, the results of the limited trial demonstrate that the 3N-based ClassPoint gamification media meets the criteria for very high practicality.

Several technical and pedagogical challenges encountered, such as photo upload latency in the Image Upload feature, code adaptation when joining a class, and student hesitation during independent practice, were immediately addressed by providing large QR code slides, adjusting timer allocation, and adding gradual scaffolding before moving on to the field trial phase.

Field trials aim to test the effectiveness of learning media through implementation in real classes. The experimental class, namely class VIII C (N=30), received learning using 3N-based ClassPoint Gamification, while the control class, namely class VIII B (N=30), received conventional learning according to the teacher's habits. Before conducting the comparative hypothesis test, a prerequisite test for data analysis was carried out, including tests for the normality of the data distribution (Shapiro-Wilk) and the homogeneity of variance (Levene's Test) at a significance level of $\alpha = 0.05$.

To assess the effects of the increase in mathematical critical thinking abilities in the experimental and control classes, an analysis of the N-Gain values was conducted.

**Table 8**. Results of the N-Gain normality test for critical thinking ability

| Class | Statistics (*W*) | df | Sig. |
|---|---|---|---|
| Experiment | 0.978 | 30 | 0.774 |
| Control | 0.966 | 30 | 0.426 |

Based on Table 8, the normality test results using the Shapiro-Wilk method indicate that all data distributions in both trial groups are normally distributed. In the N-Gain data, the Experimental Class obtained a value of 0.978 with a sig of 0.774 (sig > 0.05), while the Control Class obtained a value of 0.966 with a sig of 0.426 (sig > 0.05), so both are normally distributed. Because all N-Gain data are normally distributed, the next comparative test is the homogeneity test.

**Table 9**. Homogeneity test results N-Gain

| | | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| N-Gain | Based on Mean | 0.855 | 1 | 58 | 0.359 |
| | Based on Median | 0.822 | 1 | 58 | 0.368 |
| | Based on Median and with adjusted df | 0.822 | 1 | 56.344 | 0.368 |
| | Based on trimmed mean | 0.791 | 1 | 58 | 0.378 |

Based on the sig. value in Table 9, the sig. value is 0.359, which is greater than 0.05. Therefore, it can be concluded that the N-Gain data for both classes are homogeneous. Because the data for both classes are homogeneous, to determine the difference between the two average N-Gain data, a parametric statistical test (Independent Sample t-test) is used. The following is the analysis of the N-Gain test for the experimental and control classes, as shown in Table 10.

**Table 10**. Results of the independent sample t-test of N-Gain

| | | t | df | Sig.(2-tailed) | Mean difference | Std.Error Difference | 95% Confidence Interval of the Difference Lower | Upper |
|---|---|---|---|---|---|---|---|---|
| N-Gain | Equal variances assumed | 2.391 | 58 | 0.020 | 0.038 | 0.01603 | 0.00624 | 0.07043 |

Based on Table 10, the significance value is 0.02, which is < 0.05. It can be concluded that the improvement in students' mathematical critical thinking skills in the experimental class was greater than in the control class. Thus, the ClassPoint gamified learning media based on 3N is effective in improving students' mathematical critical thinking skills.

Learning motivation was measured after learning using a 20-item attitude scale questionnaire (10 positive and 10 negative) with reverse scoring maximum score = 80). The comparative results of learning motivation are presented in Table 11.

**Table 11**. Results of the normality test of learning motivation data

| Class | Statistics (*W*) | df | Sig. |
|---|---|---|---|
| Experiment | 0.984 | 30 | 0.914 |
| Control | 0.968 | 30 | 0.477 |

Based on Table 11, the results of the normality test using the Shapiro-Wilk test on the N-Gain learning motivation data show that the statistical value for the Experimental Class is 0.984 with df = 30 and a significance value (Sig.) of 0.914. Meanwhile, in the Control Class, the statistical value obtained is 0.968 with df = 30 and a sig. value of 0.477. Because the p-values for the two class groups are greater than the significance level $\alpha = 0.05$ ($p > 0.05$), the learning motivation data in the Experimental Class and the Control Class are normally distributed. The fulfillment of this normality assumption indicates that further data analysis can proceed using parametric statistical tests.

**Table 12**. Homogeneity test results learning motivation data

| | | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| Learning Motivation | Based on Mean | 0.103 | 1 | 58 | 0.749 |
| | Based on Median | 0.095 | 1 | 58 | 0.759 |
| | Based on Median and with adjusted df | 0.095 | 1 | 57.998 | 0.759 |
| | Based on trimmed mean | 0.088 | 1 | 58 | 0.768 |

Based on Table 12, the results of the homogeneity of variance test using Levene's Test on student learning motivation data show a Levene Statistic (Based on Mean) value of 0.103 with degrees of freedom df1 = 1, df2 = 58, and a significance value (Sig.) of 0.749. Because the p-value exceeds the specified significance level ($\alpha = 0.05$; Sig. = 0.749 > 0.05), it can be concluded that the variances of learning motivation data between the experimental and control classes are homogeneous (i.e., have the same variability). The fulfillment of the assumption of homogeneity of variance and normality of the data proves that the prerequisites for parametric statistical testing have been met to continue the analysis of the average difference test (Independent Sample t-test).

**Table 13**. Results of the independent sample t-test of learning motivation

| | | t | df | Sig. (2-tailed) | Mean difference | Std.Error Difference | 95% Confidence Interval of the Difference Lower | Upper |
|---|---|---|---|---|---|---|---|---|
| Learning motivation | Equal variances assumed | 2.276 | 58 | 0.027 | 1.600 | 0.703 | 0.193 | 3.007 |

Based on Table 13, the significance value (Sig. 2-tailed) is 0.027 < 0.05 (or a t-value of 2.276 with df = 58). Therefore, it can be concluded that students' motivation to learn in the experimental class is higher than in the control class. Thus, the ClassPoint gamification learning media based on 3N is effective in increasing students' motivation to learn.

### 3.1.4. Dissemination Stage

The dissemination phase is the final step of the 4D development model, which aims to disseminate the ClassPoint gamification learning media product based on 3N (*Niteni*, *Nirokke*, *Nambahi*) so that it can be utilized by a wider user group, especially junior high school educators. This dissemination activity was conducted during the Mathematics Subject Teachers' Conference (*MGMP*) forum of Junior High Schools in Bandung City (see Figure 2).



**Figure 2**. Dissemination activity of ClassPoint gamification learning media based on 3N

The dissemination was carried out through a series of main activities systematically, including: (1) Sharing Experiences and Product Socialization: Researchers together with partner teachers shared practical experiences regarding obstacles often encountered in teaching algebra materials (PLSV and PtLSV), while introducing the final prototype of ClassPoint gamification media based on 3N to the participating teachers of *MGMP*; (2) Integration of Learning Implementation Plans (*RPP*): Dissemination also included the presentation of draft Learning Implementation Plans (*RPP*) that explicitly integrate 3N syntax into the ClassPoint digital platform. Teachers were given concrete examples of how to design learning activities that combine local wisdom with real-time gamification (see Figure 3); (3) Simulation and Demonstration of Learning Practices: A live demo was conducted of the use of interactive ClassPoint features such as Word Cloud, Multiple Choice, Slide Drawing, the star rewards system, and a leaderboard that had been implemented in the research class. This directly demonstrated how a joyful learning atmosphere can be created to reduce students' math anxiety; and (4) Dissemination of Research Results and Practical Benefits: In the discussion session, empirical research results were also presented, which prove that the application of this media can significantly improve students' mathematical critical thinking skills and learning motivation. Teachers were given an understanding of the practical benefits of this media as an innovative, easy-to-use alternative that can be used directly in Microsoft PowerPoint, without requiring the installation of complicated additional software.

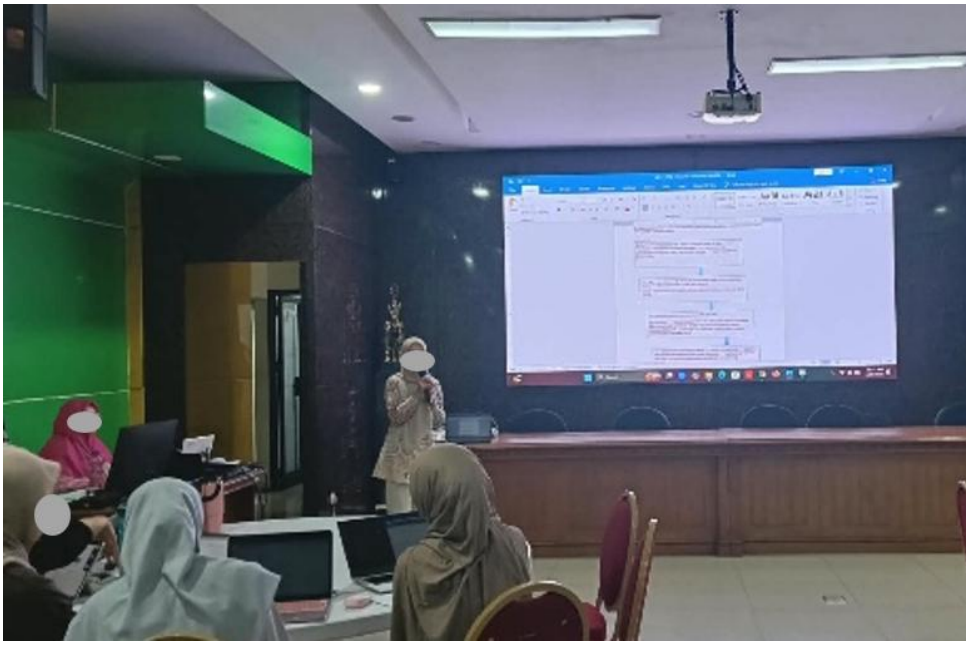


**Figure 3**. Socialization of learning tools and demonstration of ClassPoint gamification media

Through this *MGMP* activity, the developed learning media products received a very positive response and constructive feedback from fellow mathematics teachers. It is hoped that the results of this dissemination will inspire junior high school teachers in Bandung City to adopt, adapt, and replicate similar learning innovations to improve the quality of mathematics learning processes and outcomes in their respective schools.

### 3.1.5. Analysis of Students' Difficulties in Mathematical Critical Thinking Skills

Before implementing ClassPoint gamification-based learning media with the 3N approach (*Niteni*, *Nirokke*, *Nambahi*) on the One Variable Linear Equations and Inequalities (PLSV and PtLSV) material, a mapping of Prior Mathematical Ability (PAM) was conducted based on the daily mathematics test scores in the previous chapter. Student grouping was arranged with 30% in the high group, 40% in the medium group, and 30% in the low group in the experimental class of 30 students. The distribution of PAM data in the experimental class is presented in Table 14.

**Table 14**. Distribution of students' PAM data

| PAM Category | N | Mean | SD |
|---|---|---|---|
| High | 9 | 87.56 | 3.21 |
| Medium | 12 | 78.17 | 2.66 |
| Low | 9 | 67.11 | 3.37 |

Based on Table 14, the distribution of initial abilities of students in the experimental class is distributed into three proportional categories with an average score of 87.56 for the high group (SD = 3.21), 78.17 for the medium group (SD = 2.66), and 67.11 for the low group

(SD = 3.37). The difference in averages across categories indicates a clear gap in mastery of prerequisite concepts prior to the treatment.

Furthermore, to see the distribution of mathematical critical thinking ability completion after learning, the post-test score data of the experimental class (N = 30) was grouped based on the post-test score ranking into three groups, namely the high group (30%, n = 9, score range 84.31–96.08), the medium group (40%, n = 12, score range 78.43–84.31), and the low group (30%, n = 9, score range 72.55–78.43). The percentage of post-test achievement for each mathematical critical-thinking indicator by grouping is presented in Table 15.

**Table 15**. Results of post-test achievement of mathematical critical thinking ability based on PAM

| No | Mathematical Critical Thinking Indicators | High | Medium | Low | Class Average |
|---|---|---|---|---|---|
| 1 | Provides a simple explanation (elementary clarification) | 93.94% | 85.61% | 80.81% | 86.67% |
| 2 | Building basic skills (basic support) | 98.15% | 87.50% | 83.33% | 89.44% |
| 3 | To conclude (inference) | 90.60% | 79.49% | 70.09% | 80.00% |
| 4 | Provide further explanation (advanced clarification) | 90.12% | 83.33% | 83.95% | 85.56% |
| 5 | Setting strategy and tactics | 83.33% | 76.39% | 67.59% | 75.83% |
| | **Average** | **91.23%** | **82.46%** | **77.15%** | **83.50%** |

Based on Table 15, after implementing ClassPoint gamification-based learning with the 3N approach, the high group achieved an average indicator mastery percentage of 91.23%, the medium group 82.46%, and the low group 77.15%. Indicator 2 has the highest percentage of achievement across all groups (reaching 98.15% in the high group and 83.33% in the low group). In comparison, Indicator 5 is the indicator with the lowest percentage of achievement across the three groups (83.33% in the high group, 76.39% in the medium group, and 67.59% in the low group), followed by Indicator 3 in the medium group (79.49%) and the low group (70.09%).

To analyze students' difficulties in depth on mathematical critical thinking skills, six research subjects were selected representing each PAM category (two subjects from each of the high, medium, and low groups). The score achievement profiles for each indicator of the six subjects are presented in Table 16.

**Table 16**. Profile of achievement scores per indicator of mathematical critical thinking

| Subject Code | Category | PAM Score | Postest Score | Indicator | | | | | Score Total | The Most Difficult Indicator |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | | |
| S-4 | High | 93 | 96.08 | 11 | 6 | 12 | 9 | 11 | 49 | 3 & 5 |
| S-7 | High | 91 | 94.12 | 11 | 6 | 13 | 8 | 10 | 48 | 5 |
| S-13 | Medium | 82 | 84.31 | 10 | 5 | 11 | 8 | 9 | 43 | 5 |
| S-9 | Medium | 75 | 78.43 | 9 | 5 | 9 | 8 | 8 | 40 | 3 |
| S-27 | Low | 65 | 74.51 | 9 | 5 | 9 | 7 | 8 | 38 | 5 |
| S-24 | Low | 62 | 72.44 | 9 | 5 | 8 | 7 | 8 | 37 | 3 & 5 |

***Analysis of High-Level Group Subjects***

In the high group, the first subject, Student 4 (S-4), had a PAM score of 93 and achieved the highest post-test score of 96.08 (total score: 49/51). Subject S-4 perfectly mastered Indicators 1, 2, and 4, thus obtaining full points, but experienced a slight reduction in points on Indicators 3 and 5.

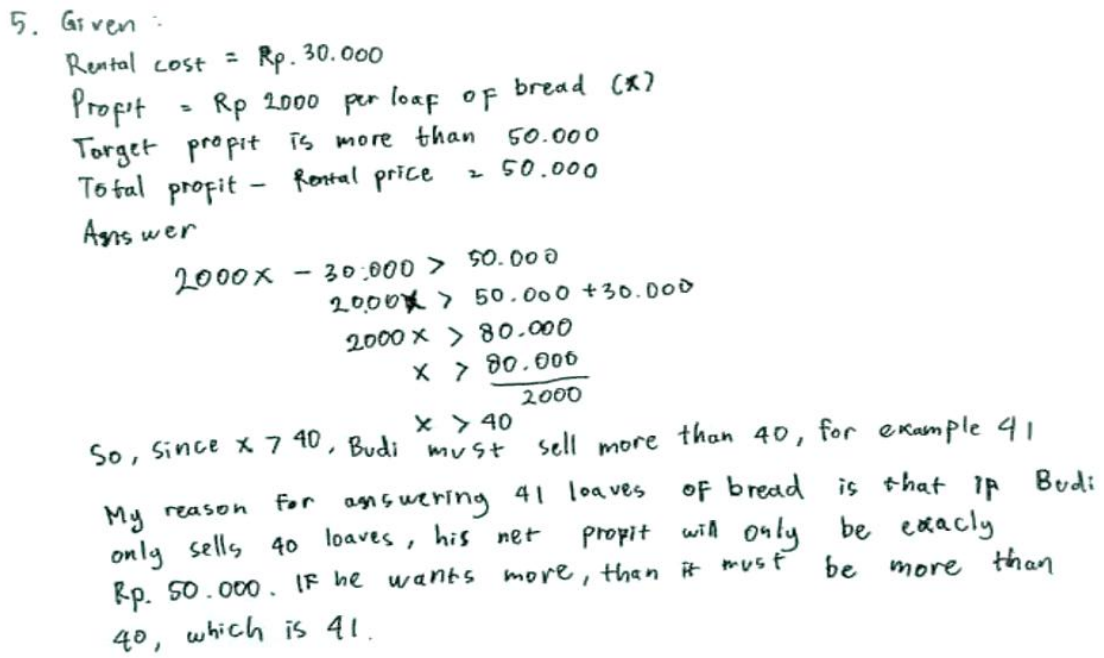



**Figure 4**. S-4 response for indicator number 5

Based on Figure 4, Subject S-4 successfully compiled the inequality model 2,000x - 30,000 > 50,000, completed the equivalence procedure to obtain x > 40, and concluded that the minimum limit was 41 loaves. However, at the stage of compiling logical reasons, Subject S-4 only explained that selling 40 loaves of bread yields a profit of exactly Rp. 50,000, so it must be more than 40, without writing the discrete integer domain condition that bread cannot be sold in fractional form. In the interview session, S-4 revealed: *"I was a bit skeptical at first about whether the table rental fee should be deducted from the total profit or added to the target, but once I remembered the net profit concept in the ClassPoint materials, I immediately corrected it."*

The second subject in the high group was Student 7 (S-7), who had a PAM score of 91 and achieved a post-test score of 94.12 (total score 48/51). Subject S-7 perfectly mastered Indicators 1, 2, and 3, and obtained 10 out of 12 points on Indicator 5, his most difficult indicator.

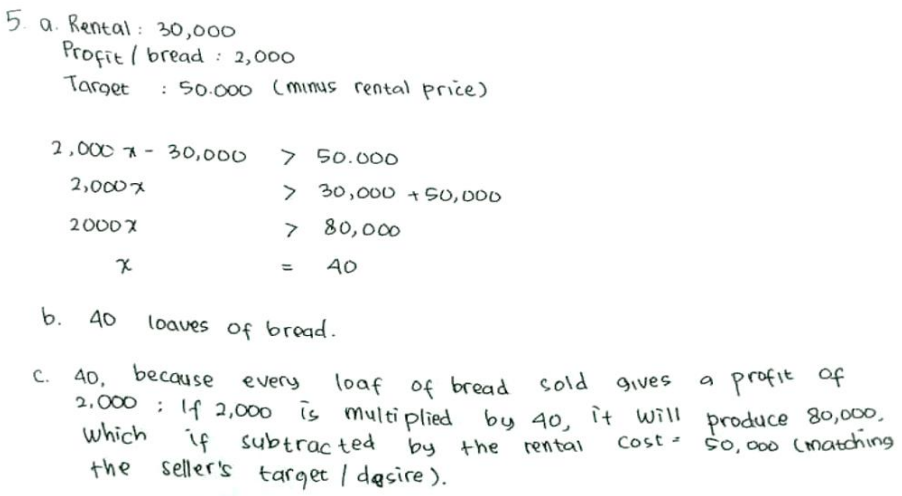



**Figure 5**. S-7 response for indicator number 5

Referring to Figure 5, Subject S-7 was able to model the inequality 2,000x - 30,000 > 50,000 accurately and complete the algebraic operations to obtain 2,000x > 80,000. However, Subject S-7 experienced a point deduction in the final stage of solving and compiling reasons because he wrote the equation notation x = 40 on the last line and outlined the proof for 40 loaves of bread (80,000 - 30,000 = 50,000) without explicitly stating why the minimum number had to be rounded to 41 loaves to exceed the target. When interviewed, S-7 stated: *"In question number 5, I immediately wrote the conclusion 41 loaves because x must be more than 40 and loaves cannot be fractions, so I thought the reason was clear without needing to write it at length."*

### *Analysis of Medium-Level Group Subjects*

In the medium group, the first subject was Student 13 (S-13) who had a PAM score of 82 and obtained a post-test score of 84.31 (total score 43/51). Subject S-13 showed good mastery of Indicator 1 (10/11 or 90.91%), Indicator 4 (8/9 or 88.89%), Indicator 3 (11/13 or 84.62%), and Indicator 2 (5/6 or 83.33%), but experienced the most significant obstacles in Indicator 5 (9/12 or 75.00%).

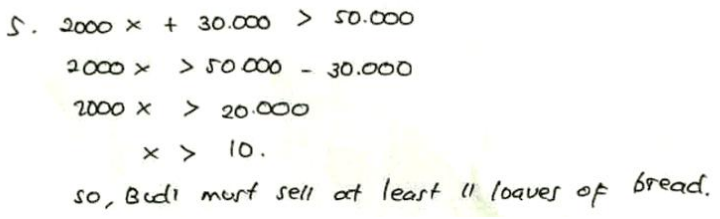



**Figure 6**. S-13 response for indicator number 5

Based on Figure 6, Subject S-13 made a mistake in the initial modeling stage by writing 2,000x + 30,000 > 50,000, which is adding the table rental costs instead of subtracting them. Although the algebraic manipulation steps and concluding the next stage were carried out consistently following the model (2,000x > 20,000, x > 10, so that a minimum of 11 loaves of bread was concluded), the final result was less accurate, so it received 4 points for the solution

and 4 points for the reason. During the interview, S-13 said, *"When I read the bazaar story, I thought the table rental fee should be added to the initial capital, so I entered the addition sign incorrectly in the inequality model."*

The second subject in the medium group was Student 9 (S-9), who had a PAM score of 75 and achieved a post-test score of 78.43 (total score 40/51). Subject S-9 obtained good scores on Indicators 4, 2, 1, and 5, while the most difficult indicator for him was Indicator 3, specifically question 3.

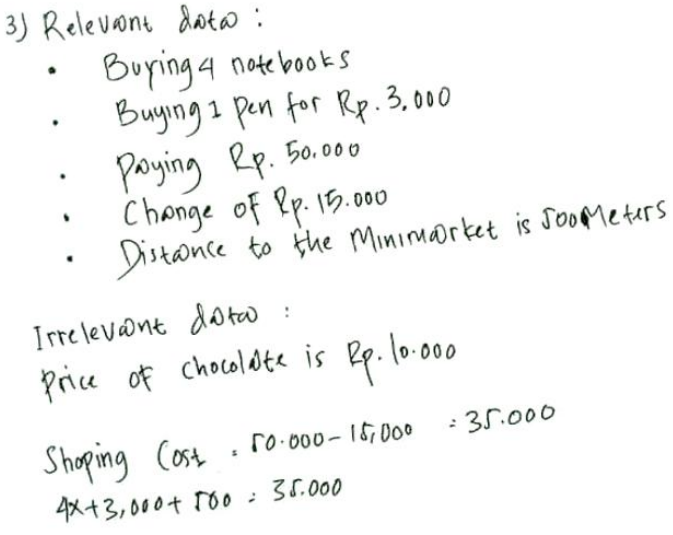



**Figure 7**. S-9 response for indicator number 3

The results of the students' answers in Figure 7 show that Subject S-9 incorrectly grouped the information "minimarket distance 500 meters" as relevant data, so he listed only the price of chocolate, Rp10,000, as irrelevant data without providing a logical reason. As a result, during the PLSV model compilation stage, Subject S-9 also added the distance element to the total shopping equation, yielding 4x + 3,000 + 500 = 35,000. In the interview, S-9 revealed: *"I thought all the numbers in the story text, including the distance of 500 meters, would be useful for calculations, so I was confused about where that distance fit in the book's equation."*

### *Analysis of Low-Level Group Subjects*

In the low group, the first subject was Student 27 (S-27), who started with a PAM score of 65 and showed a significant increase to 74.51 (total score 38/51) on the post-test. The details of Subject S-27's achievements showed scores of 5/6 on Indicator 2, 9/11 on Indicator 1, 7/9 on Indicator 4, and 9/13 on Indicator 3, with Indicator 5 being the most difficult (8/12).

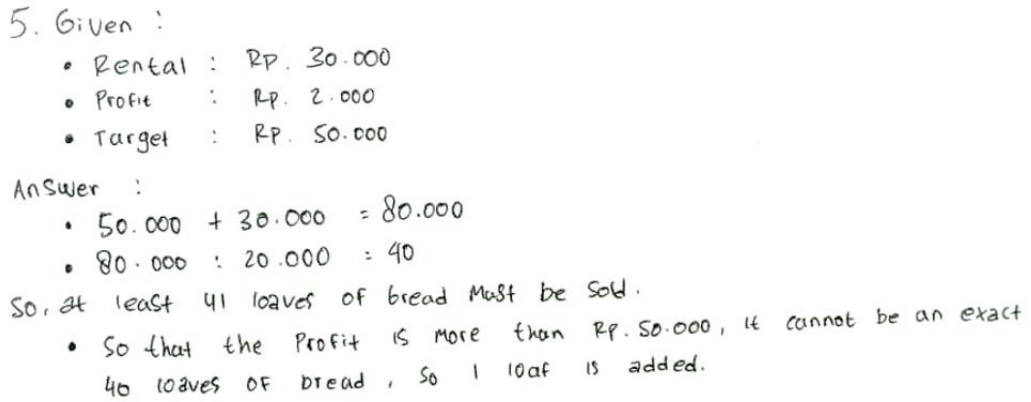



**Figure 8**. S-27 response for indicator number 5

Based on Figure 8, Subject S-27 only wrote down the known elements without formally defining the variable x or the PtLSV form. At the completion stage, Subject S-27 used backward arithmetic operations directly (50,000 + 30,000 = 80,000, then 80,000: 2,000 = 40). It concluded that at least 41 loaves of bread were sold, arguing that the profit should not be exactly Rp. 50,000, so that 1 loaf must be added. When interviewed, S-27 explained: *"I was confused about how to write the greater than (>) sign in its algebraic form, so I just calculated it using ordinary numbers like normal arithmetic, but when I learned to use ClassPoint, it was helpful to see examples of steps from my friends."*

The second subject in the low group was Student 24 (S-24), who had the lowest PAM score in the class, namely 62, and improved his achievement to 72.55 (total score: 37/51) on the post-test. Subject S-24 achieved 5/6 on Indicator 2, 9/11 on Indicator 1, and 7/9 on Indicator 4, while the main difficulties lay in Indicator 3 (8/13) and Indicator 5 (8/12).

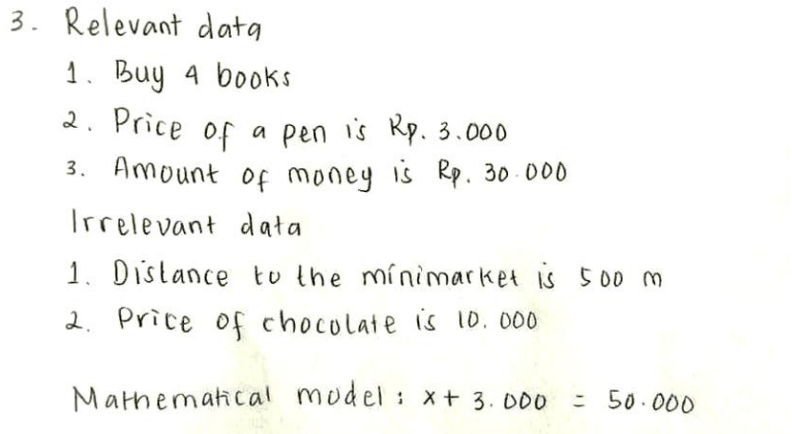



**Figure 9**. S-24 response for indicator number 3

As seen in Figure 9, Subject S-24 was able to separate irrelevant data, such as a distance of 500 meters and the price of chocolate at Rp10,000, even without a written reason (2/3 points). However, in identifying relevant data, Subject S-24 incorrectly recorded the nominal amount of Rp30,000. It omitted the change of Rp15,000, so that the PLSV model he compiled became 4x + 3,000 = 50,000 without taking into account the reduction in change. Through an interview, the student said: *"Initially, I was often afraid of making mistakes when asked to*

*work on story problems with long sentences, but because ClassPoint discusses them step by step through Slide Drawing, I now know how to differentiate between information that is used and what is just additional story."*

### 3.2. Discussion

The findings of this study indicate that the development of ClassPoint gamification media based on 3N (*Niteni*, *Nirokke*, *Nambahi*) successfully improved junior high school students' mathematical critical thinking skills and learning motivation simultaneously. This finding indicates that the effectiveness of the developed media is not only determined using digital technology, but primarily by how the technology is integrated with pedagogical stages that systematically facilitate student thinking. The integration of interactive gamification features into the learning flow has been shown to overcome learning boredom and shift interaction patterns in mathematics classes toward being more active, competitive, and meaningful. This media is designed to be fully integrated into Microsoft PowerPoint by utilizing ClassPoint features such as Interactive Quiz, Word Cloud, Slide Drawing, Short Answer, star reward system, and leaderboard.

The development of this media went through four stages of the 4D model (Define, Design, Develop, Disseminate). In the definition stage, the needs analysis revealed didactic and epistemological learning obstacles in the algebra material (PLSV and PtLSV), where students tended to memorize procedures without understanding the meaning of segment equality. In the design stage, a presentation slide flow was prepared that married the pedagogical philosophy of Ki Hadjar Dewantara (3N) with the dynamics of digital games. The development stage demonstrated that the media met the validity criteria (Aiken's V index > 0.75) and were highly practical, with an average percentage of 86.33%.

Theoretically, the integration of ClassPoint gamification and the 3N model is grounded in Vygotsky's (1978) social constructivism and Bandura's (1971) social learning theory, in which conceptual mastery is built gradually through visual modeling, guided imitation, and self-modification within a collaborative classroom climate. The conceptual synergy among the 3N syntax, ClassPoint gamification features, and the stimulation of critical-thinking indicators and learning motivation is presented in Table 17.

**Table 17**. Conceptual synergy of classpoint gamification based on 3N

| 3N Stage | ClassPoint Pedagogical Actions & Gamification Features | Deep Learning Focus | Critical Thinking Indicators & Stimulated Motivation |
|---|---|---|---|
| *Niteni* (Observe) | Observing real contextual problems (scale analysis & load capacity); initial perceptual responses via Word Cloud & Multiple Choice. | Consciousness & Contextualization | Critical Thinking: Examining arguments/statements and identifying relevant data<br>Motivation: Interest in learning and curiosity (joyful learning) |

| 3N Stage | ClassPoint Pedagogical Actions & Gamification Features | Deep Learning Focus | Critical Thinking Indicators & Stimulated Motivation |
|---|---|---|---|
| *Nirokke* (Imitate) | Imitate formal algebraic mathematical modeling and manipulation of segment equivalence through guided interactive quizzes & Slide Drawing. | Application of Essential Knowledge | Critical Thinking: Selecting logical arguments and drawing tentative conclusions.<br>Motivation: The drive and need to learn through immediate feedback. |
| *Nambahi* (Develop) | Solve open-ended challenges, modify modeling strategies, and justify arguments via Short Answer & Leaderboard. | Reflection, Innovation & Self-Regulation | Critical Thinking: Analyzing assumptions, developing creative solutions, and logical justification.<br>Motivation: Self-efficacy and desire to achieve (reward stars). |

As depicted in Table 17, the *Niteni* stage acts as a contextual reality filter. Students observe contextual phenomena such as an unbalanced orange scale or a vehicle's load capacity. Word Cloud and Multiple-Choice features guide students in identifying relevant variables and facts without feeling judged for incorrect answers. This directly reduces math anxiety and stimulates students' intrinsic motivation.

In the *Nirokke* stage, students practice the concept of linear equation equivalence through the Slide Drawing and Interactive Quiz features. This interactivity provides a digital, hands-on experience where students simulate fair algebraic procedures on both sides. Instantaneous point and star rewards during this stage maintain student focus and concentration.

In the *Nambahi* stage, students are stimulated to think more critically through non-routine questions and variations involving negative coefficients in PtLSV. The Short Answer feature gives students the freedom to write logical reasoning and modify their own mathematical models. A leaderboard displayed at the end of the session sparks enthusiasm for healthy competition and significantly increases students' self-confidence.

An analysis of students' difficulties in solving of mathematical critical thinking problems on the topic of Linear Equations and Inequalities of One Variable (PLSV and PtLSV) was reviewed based on the grouping of Prior Mathematical Ability (PAM). The results of the PAM mapping show that initial abilities vary significantly among the high, medium, and low groups. Theoretically, this mapping is crucial because the structure of the initial cognitive schema stored in long-term memory determines how students assimilate and accommodate new information in solving complex problems (Anggraini et al., 2023). Students with organized initial algebraic schemas were quicker to link the concepts of variables and similarities to the context of word problems than students whose arithmetic schemas were still fragmented. However, comparative post-test achievement data showed that the difference in average mastery between groups could be reduced, with the low group's achievement

remaining in the good category and approaching that of the medium and high groups. The high percentages in Indicator 1 and Indicator 2 across all groups indicate that the pedagogical *flow* features- Word Cloud, ClassPoint, and Nine-spotted- successfully bridged the gap in students' initial schemas. In contrast, the percentage decreases in Indicators 3 and 5, especially in the medium and low groups, indicate that the activities of filtering out distracting information (inference) and formulating strategies for solving inequalities (strategies and tactics) demand more complex, high-level coordination of reasoning.

Further investigation into the pattern of difficulties in high group shows that their consistent high performance is in line with Vygotsky's (1978) social constructivism theory regarding the self-actualization phase in Zone of Proximal Development (ZPD), where the features of Short Answer at the level add functions as a vehicle for high-level elaboration (deep learning), which encourages students to explore mathematical generalizations autonomously (Hidayat et al., 2025). However, subtle difficulties still arise when students miss the requirement for the domain of discrete integers, that the number of loaves cannot be a fraction, and are less careful in writing the equation sign $x = 40$ on the final line of the solution. These difficulties demonstrate the existence of the phenomenon of procedural schema automation (procedural fluency), which simultaneously emphasizes the importance of metacognitive reflection within the framework of cognitive load theory so that the working memory capacity of high-ability students remains directed towards explicitly articulating deductive reasoning and logical justification, rather than simply jumping to the final answer (Chen et al., 2023; Suroyaningsih et al., 2024).

Meanwhile, the analysis of difficulties in the medium group centered on the obstacles to the transition from verbal to symbolic representation. Student 13's error in translating the cost of renting a table as an addition operation ($2{,}000x + 30{,}000 > 50{,}000$) and the student's error in including misleading information in the form of a minimarket distance of 500 meters into the shopping equation ($4x + 3{,}000 + 500 = 35{,}000$) supports the theory of scaffolding by Vygotsky (1978), where syntax *Wait*. Moreover, *Nine-spotted* through activities *Slide Drawings successfully* guides algebraic manipulation procedures consistently, even at the stage. Students in the middle group still need to strengthen their semantic control in interpreting the relationship between the question sentences (Loyens et al., 2023). In addition, the inclusion of irrelevant data in the S-9 answer is theoretically explained by Cognitive Load Theory, namely the occurrence of extrinsic cognitive load due to the presence of distracting numerical information in long narrative texts on non-routine questions (Asmara et al., 2024; Chen et al., 2023; Kurniansyah et al., 2022; Oktaviyanthi et al., 2024; Santosa & Filiz, 2025), in which the feature *intervention Word Cloud at the Wait level* has proven to help train students to extract essential keywords so that the cognitive load can be reduced on other indicators.

In contrast to the previous two groups, the difficulties experienced by students in the low group stem from limitations in their arithmetic thinking schemes, which hinder the transition to formal algebraic reasoning. S-27's tendency to use a backward arithmetic strategy without inequality symbols and S-24's error in ignoring the information about the *Rp15,000* change confirm the existence of epistemological barriers in algebra learning (Riastuti et al., 2023). However, the surge in post-test scores among low-group students who surpassed their initial PAM scores demonstrates the positive impact of integrating gamification elements on

affective and cognitive outcomes. This increase in achievement aligns with empirical findings of digital gamification, where elements such as star rewards, leaderboard, and instant feedback on ClassPoint can fulfill the need for a sense of competence and reduce math anxiety in low-ability students (Muchuweni et al., 2025; Querido, 2023). Thus, the integration of pedagogical *Niteni – Nirokke – Nambahi* together with the ClassPoint gamification-based digital learning platform has been proven to be effective in reducing epistemological barriers, extrinsic cognitive load, and psychological barriers, so that students from all levels of initial ability can improve their mathematical critical thinking skills significantly (Hidayat et al., 2025; Suroyaningsih et al., 2024).

## 4. CONCLUSION

This study concludes that the development of ClassPoint gamification learning media based on 3N (*Niteni*, *Nirokke*, *Nambahi*) for the material of Linear Equations and Inequalities of One Variable (PLSV/PtLSV) has met the criteria of validity, practicality, and effectiveness. The results of expert validation confirmed that all learning media and instruments developed were in the "very valid" category, with Aiken's V indices ranging from 0.75 to 1.00. In addition, limited trials yielded an average practicality score of 86.33%, which classifies the media as "very practical" for classroom implementation.

The results of the effectiveness test showed that students' mathematical critical thinking skills improved more in classes that implemented ClassPoint 3N-based gamification media than in classes that received conventional instruction. Similarly, students' motivation to learn in classes implementing ClassPoint 3N-based gamification media was higher than in classes receiving conventional instruction. These findings indicate that integrating the 3N pedagogical approach with ClassPoint digital gamification can create a more interactive, engaging, and meaningful mathematics learning environment.

The analysis results based on prior mathematical ability (PAM) also show that the developed media can facilitate learning for students with varying levels of prior mathematical ability. However, students with lower prior mathematical ability still require further guidance, particularly in determining problem-solving strategies and providing logical justification. These findings underscore the importance of implementing gradual scaffolding and learning activities that address the diversity of student abilities in digital technology-based mathematics learning.

## Acknowledgments

The authors would like to thank the Directorate General of Research and Development, Ministry of Higher Education, Science, and Technology for the "Master's Thesis Research" scheme (*Penelitian Tesis Magister*) with contract numbers 283/C3/DT.05.00/PL-BARU/2026; 1689/LL4/PG/2026; 046/IKIP-Slw/LPPM/Lit/V/2026, which has provided funding for this research.

## Declarations

Author Contribution : TR: Data curation, Formal analysis, Investigation, Methodology, Validation, and Writing - review & editing; WH: Conceptualization, Investigation, Methodology, Supervision, Writing - original draft, and Writing - review & editing; AY: Data curation, Formal analysis, Investigation, Methodology, Validation, Supervision, and Writing - review & editing.

Funding Statement : This research was funded by the Directorate General of Research and Development, Ministry of Higher Education, Science, and Technology of the Republic of Indonesia, with contract number 283/C3/DT.05.00/PL-BARU/2026.

Conflict of Interest : The authors declare no conflict of interest.

Additional Information : Additional information is available for this paper.

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