



## The effectiveness of using the conversion ladder on the critical thinking skills of grade III students at Elementary School 36 South Pontianak

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Article info	Abstract
Keywords: critical thinking, conversion ladder media, length measurement, elementary school	Elementary school students' critical thinking skills in learning length unit conversions remain relatively low and require concrete instructional support. This study examined the effectiveness of conversion ladder media in improving third-grade students' critical thinking skills at elementary school 36 South Pontianak. A one-group pretest–posttest design was employed with 24 students selected through purposive sampling. Data were collected using a matching test based on six critical thinking indicators proposed by Facione. The Wilcoxon test revealed a significant improvement ( $p = 0.001 < 0.05$ ), with mean scores increasing from 30.83 (pretest) to 76.46 (posttest). An effect size of 1.95 indicated a high level of effectiveness. These findings demonstrate that conversion ladder media effectively enhance elementary school students' critical thinking skills in mathematics.

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### 1. Introduction

Critical thinking is widely recognized as an essential competency for addressing complex problems in both personal and social contexts (Hakkoymaz, 2025; Karim & Normaya, 2015). It encompasses higher-order cognitive processes, including interpretation, analysis, evaluation, and self-regulation (Facione, 1990), which support creative and reflective decision-making (Norrisqa, 2021). In educational settings, critical thinking enables students to evaluate information

systematically and make sound judgments that guide effective learning actions (Catania et al., 2024). Through accurate interpretation and logical analysis, learners can select appropriate strategies and draw valid conclusions from available information (Berg et al., 2023; Kurniasih & Hakim, 2019).

Despite its importance, empirical evidence indicates that elementary school students' critical thinking skills remain relatively low. Haniva et al. (2024) reported that only 22.22% of third-grade students demonstrated adequate critical thinking ability, which they categorized as low. Similarly, Nuwa et al. (2023) attributed weak critical thinking performance to the continued dominance of conventional, teacher-centered instructional methods. Ernawati et al. (2020) further found that students' critical thinking skills in observational report writing averaged only 56. Collectively, these findings suggest that the development of critical thinking skills among elementary school students, particularly at the third-grade level, has not yet been optimized.

Mathematics is considered a subject with strong potential to foster critical thinking skills, as it requires learners to engage with abstract concepts, symbolic representations, and logical relationships among ideas (Yang et al., 2026; Zakiah & Khairi, 2019). However, mathematics is often perceived by students as difficult and unengaging, hindering meaningful learning (Gilmore, 2023; Nurbaiti & Kustin, 2022). One topic that presents particular difficulty is length unit conversion, which is frequently regarded as abstract and challenging. This perception contributes to low learning motivation and suboptimal academic outcomes (Purwaningsih & Harjono, 2023).

Students' difficulties in learning length unit conversion often stem from confusion about adding or removing zeros during the conversion process, leading to frequent computational errors. Rahmawati (2023) reported that 42.5% of students scored below the Minimum Mastery Criteria (MMC) on assessments related to this topic. These challenges are further compounded by the limited use of concrete instructional media in classroom practice (Rizqiyah et al., 2023; Susianita & Koto, 2019). Without appropriate learning media, abstract measurement concepts such as meters, centimeters, and kilometers are difficult to visualize, thereby constraining students' ability to analyze relationships among units logically (Meyra Rahma & Hima, 2023; Putra & Clara, 2020).

To address these issues, instructional innovation through interactive, concrete learning media is required (Nirwana et al., 2022). One promising approach is the use of conversion ladder media, which visually represents relationships among units of length and supports hands-on learning experiences during the conversion process (Argaruri et al., 2023; Nabilah et al., 2020; Novitasari et al., 2023). Previous studies have shown that this media enhances conceptual understanding and learning retention (Gatot Muhsetyo, 2021) while shifting learning from rote memorization toward more meaningful cognitive engagement (Hayati & Rahmawati, 2017).

Although prior research has demonstrated the effectiveness of conversion ladder media in improving general learning outcomes, studies that specifically examine its impact on the six indicators of critical thinking in the context of length unit conversion at the elementary school level remain scarce. Therefore, this study seeks to fill this gap by investigating the effectiveness of conversion ladder media in enhancing third-grade students' critical thinking skills at elementary school 36 South Pontianak.

## 2. Method

This study employed a pre-experimental design with a one-group pretest–posttest (Rukminingsih et al., 2020). The research aimed to examine the effectiveness of concrete instructional media, namely the conversion ladder, in improving students' critical thinking skills.

The sample consisted of 24 students from Class III A, selected through purposive sampling. The selection criteria included students who had not previously learned length unit conversion using concrete learning media and who demonstrated full attendance (100%) throughout the treatment period. The study was conducted in three stages: pre-test, instructional treatment, and post-test. The pre-test was administered to measure students' initial critical thinking skills. The treatment was carried out over two mathematics learning sessions, each lasting 2 × 35 minutes. During the treatment stage, learning activities were designed to be interactive and collaborative, involving students in group discussions, completion of student worksheets, and hands-on practice using the conversion ladder media to solve unit conversion problems. The teacher acted as a facilitator, guiding students in analyzing relationships among units of length and encouraging them to explain the conversion processes they performed. The final stage involved administering a post-test after all instructional activities, to identify improvements in students' critical thinking skills following the use of the conversion ladder media.

The research instrument consisted of a 12-item objective test in the form of matching questions, developed based on the six critical thinking indicators proposed by Facione (1990): interpretation, analysis, evaluation, inference, explanation, and self-regulation, with each indicator represented by two items. Although the test format was objective, each item was designed to require conceptual understanding and logical reasoning in selecting appropriate answer pairs aligned with the measured indicators.

Content validity, evaluated by three experts, indicated that the instrument was valid, with an average Aiken's V value of 0.92, classified as very high (Aiken, 1985). Item validity was examined using the Pearson Product-Moment correlation, and all items were deemed valid because the correlation coefficients exceeded 0.300 (Sugiyono, 2021). Reliability testing using Cronbach's Alpha yielded a coefficient of 0.851, which falls within the very high category, indicating that the instrument was reliable and appropriate for use. In addition, analyses of item difficulty and discrimination indices demonstrated that the test items possessed adequate characteristics for measuring students' critical thinking skills.

Pre-test and post-test data were analyzed statistically. Normality testing was conducted using the Shapiro-Wilk test, which revealed that the post-test data were not normally distributed ( $p < 0.05$ ). Consequently, hypothesis testing was performed using the Wilcoxon signed-rank test to examine differences in students' critical thinking skills before and after the treatment and to evaluate the effectiveness of the conversion ladder media.

### 3. Results

The results of the pretest and posttest analyses are presented separately by analysis type, as follows.:

Table 1. Descriptive statistics of students' critical thinking scores in pre-test and post-test

Test Stage	N	Minimum	Maximum	Mean	Std. Deviation
Pre-test	24	0	83	30.83	22.78
Post-test	24	33	100	76.46	23.26

Descriptive statistics of students' critical thinking skills before and after the treatment are presented in Table 1. The pretest mean score was 30.83 with a standard deviation of 22.78,

indicating that students' critical thinking skills were at a low level prior to the intervention. After implementing the conversion ladder instructional media, the posttest mean score increased to 76.46, with a standard deviation of 23.26. This improvement indicates a substantial development in students' critical thinking skills following instruction using the conversion ladder media.

The bar chart illustrates the comparison between the pretest and posttest mean scores of students after receiving the instructional treatment in mathematics.

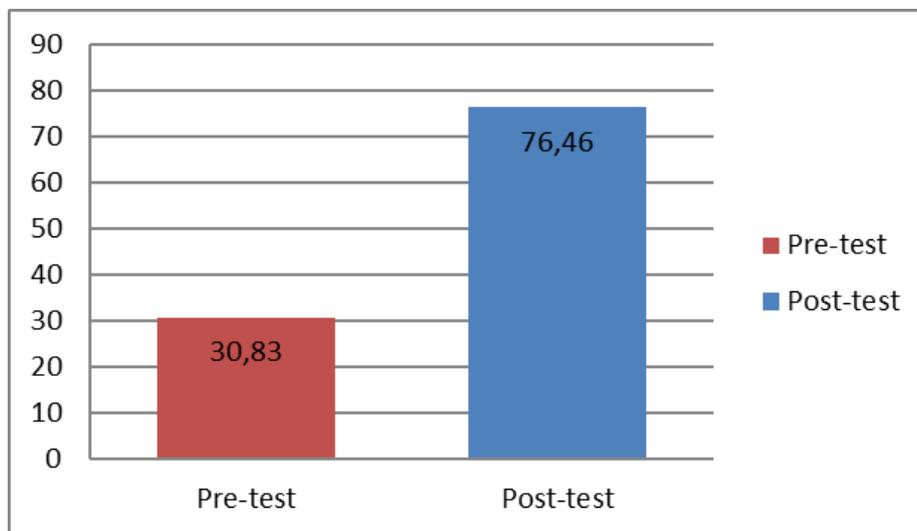


Figure 1. Comparison of average pre-test and post-test scores of students' critical thinking skills

Based on Figure 1, the average post-test score is significantly higher than the pre-test score, indicating an improvement in students' abilities after the implementation of the instructional media used in this study. Figure 2 presents a comparison of the mean pretest score, mean posttest score, and the Minimum Mastery Criteria (MMC)

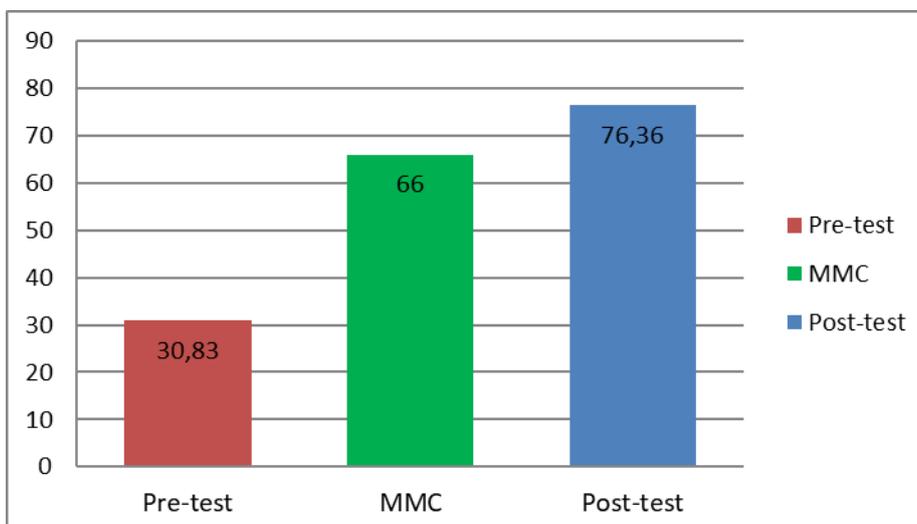


Figure 2. Comparison of average pre-test and post-test scores with the minimum mastery criterion (MMC)

As shown in Figure 1, the posttest mean was higher than the pretest mean. Furthermore, Figure 2 indicates that the mean pretest score was below the Minimum Mastery Criteria (MMC) of 66, whereas the mean posttest score exceeded the MMC. These findings demonstrate that instruction using the conversion ladder media enabled students to achieve the established mastery standard.

Figure 3 presents a comparison of correct and incorrect responses on the pretest and posttest across the six critical thinking indicators: interpretation, analysis, evaluation, inference, explanation, and self-regulation. The data were obtained from the cumulative responses of 24 students, with each indicator measured by two test items. This presentation aims to illustrate the extent of improvement in students' critical thinking skills following instructional treatment using the learning media.

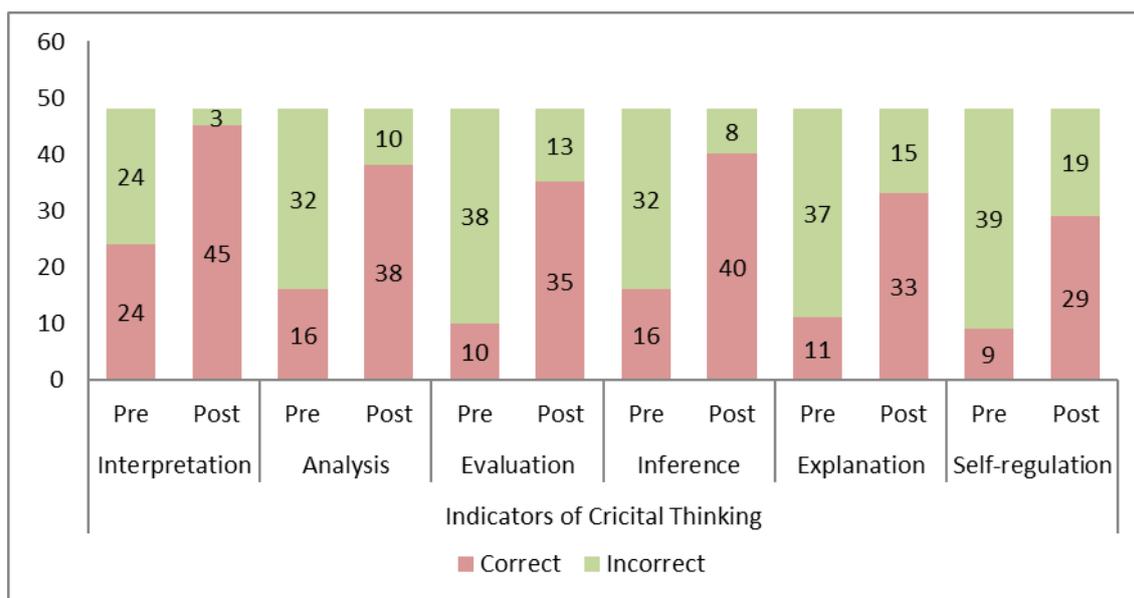


Figure 3. Recapitulation chart of correct and incorrect responses by each critical thinking indicator in the pretest and posttest

Table 2 complements Figure 3 by presenting the mean scores of students' critical thinking skills across each indicator in the pre-test and post-test.

Table 2. Mean scores of critical thinking skills by indicator

Indicators	Pretest	Posttest	Improvement
Interpretation	0.50	0.94	0.44
Analysis	0.33	0.79	0.46
Evaluation	0.21	0.73	0.52
Inference	0.33	0.83	0.50
Explanation	0.23	0.69	0.46
Self-regulation	0.19	0.60	0.41

Figure 3 illustrates the distribution of students' correct and incorrect responses across each critical thinking indicator before and after the treatment. Overall, all critical thinking indicators showed an increase in the number of correct responses in the posttest compared to the pretest. A reduction in incorrect responses was observed across all indicators, indicating improved understanding and enhanced critical thinking skills following instruction using the conversion ladder media.

To strengthen these findings, Table 2 presents the mean scores of students' critical thinking skills for each indicator. For the interpretation indicator, the mean score increased from 0.50 in the pretest to 0.94 in the posttest. Similar improvements were observed in the analysis indicator, which increased from 0.33 to 0.79, and the evaluation indicator, which rose from 0.21 to 0.73. The inference indicator showed an increase from 0.33 to 0.83, while the explanation indicator improved from 0.23 to 0.69. An improvement was also observed in the self-regulation indicator, with the mean score rising from 0.19 in the pretest to 0.60 in the posttest.

Overall, these results indicate that the use of conversion ladder instructional media not only enhanced students' critical thinking skills in general but also positively affected all critical thinking indicators, including those that were initially classified at a low level.

Table 3. Normality test results of students' critical thinking skills

	Test Stage	Statistic	Shapiro-Wilk	
			df	Sig.
Critical Thinking Skills	Pre-test	,927	24	.083
	Post-test	,834	24	.001

Prior to hypothesis testing, the pre-test and post-test data were examined for normality using the Shapiro–Wilk test. The results indicated that the pre-test data were normally distributed ( $p = 0.083 > 0.05$ ), whereas the post-test data were not normally distributed ( $p = 0.001 < 0.05$ ). Therefore, subsequent analyses were conducted using nonparametric statistical tests.

Table 4. Results of the one-sample wilcoxon test on the average critical thinking skills of students

	Null Hypothesis	Test	Sig.	Decision
1	The median of Post-test equals 66.	One-Sample Wilcoxon Signed Rank Test	.021	Reject the null hypothesis.

To determine whether students' post-treatment performance exceeded the MMC, a one-sample Wilcoxon test was conducted. The results indicated that the median posttest score was significantly higher than the MMC value of 66 ( $p = 0.021$ )

Table 5. Wilcoxon test results on students' critical thinking skills

		Posttest – Pretest
	Z	-4.209
	Asymp.sig. (2-tailed)	.001

Subsequently, the Wilcoxon signed-rank test was employed to compare the pretest and posttest scores. The analysis yielded a Z value of  $-4.209$ , with a p-value of  $< 0.001$ . These results

indicate a statistically significant difference in students' critical thinking skills before and after instruction using the conversion ladder media.

#### 4. Discussion

This study demonstrates that the use of conversion ladder media has a significant positive impact on students' critical thinking skills in mathematics, particularly in the topic of length unit conversion. Statistical analysis revealed a significant difference between the pretest and posttest scores, with a mean improvement of 45.63 and a Wilcoxon significance value of 0.001 ( $p < 0.05$ ). These findings indicate that the implemented instructional approach was effective in enhancing both the quality of the learning process and students' learning outcomes.

To ensure a clear and systematic discussion, this section is organized into several subsections. The first subsection discusses the use of conversion ladder media in teaching length measurement units. The second subsection elaborates on the strategic role of instructional media in the learning process. The third subsection examines the importance of critical thinking skills in mathematics education. The fourth subsection presents the overall conclusions derived from the discussion.

##### 4.1 Conversion ladder media in teaching length measurement units

The conversion ladder media is used as a concrete instructional aid in mathematics learning, particularly in teaching length unit conversion, to help students understand the relationships among units in a more systematic manner (Azetfika et al., 2024). This media helps concretize abstract concepts, enabling students to interpret and analyze more effectively when solving length conversion problems (Fitriyani, 2022; Sa'adah et al., 2024). By visually representing the sequential order of units, students are not merely memorizing procedures but also developing a conceptual understanding of unit transitions, which constitutes a fundamental aspect of critical thinking skills (Hayati & Rahmawati, 2017).

Conceptually, the use of conversion ladder media supports the development of all critical thinking indicators. At the interpretation stage, students interpret the position and sequence of length units displayed on the conversion ladder. During the analysis stage, they analyze the direction of unit movement (ascending or descending) and determine the appropriate mathematical operation. At the inference stage, students conclude the conversion results based on the steps undertaken. The evaluation indicator is reflected when students recheck the accuracy of their conversion outcomes, while explanation emerges when students are required to articulate the reasoning or procedures applied. Meanwhile, self-regulation develops as students recognize errors and independently revise their problem-solving strategies (Facione, 1990).

The findings of this study are consistent with those of Heimann et al. (2021) and Rongga et al. (2024), who reported that concrete instructional media are more effective than instruction without media support. Furthermore, the present study demonstrates a stronger improvement, as reflected in an effect size of 1.95, categorized as high, indicating that conversion ladder media substantially enhances students' critical thinking skills. This media facilitates students' independent exploration, conclusion drawing, and evaluation of conversion results, thereby supporting key critical thinking indicators such as interpretation, analysis, and inference (Erviana & Muslimah, 2019).

##### 4.2 The strategic role of instructional media in the learning process

Instructional media play a strategic role in supporting the teaching and learning process, particularly by bridging abstract concepts with students' concrete learning experiences (Kandia et

al., 2023). Noviyanti et al. (2020) emphasize that instructional media are an essential tool that helps teachers deliver content more effectively. In this context, media serve as a link between difficult-to-comprehend concepts and learning experiences that students can directly observe and meaningfully interpret (Mukarromah & Andriana, 2022).

The selection of appropriate instructional media that align with both the characteristics of the subject matter and students' learning needs not only enhances instructional effectiveness but also makes the learning process more engaging and meaningful (Kharissidqi & Firmansyah, 2022; Maimunah, 2016). Systematically designed media support students in understanding complex or abstract material while simultaneously fostering learning interest and motivation (Bhuttah et al., 2024; Maharani & Hidayah Putri, 2023). This view is consistent with Junaidi (2019), who asserts that instructional media encourage active participation and engagement in the learning process.

A growing body of empirical research demonstrates that the use of instructional media, particularly concrete media, is effective in improving students' conceptual understanding and learning interest. Prananda et al. (2021), for instance, reported that the use of concrete media, in the form of beads, in mathematics instruction on mixed-integer operations enhanced elementary students' conceptual understanding and interest in learning. Similar findings were reported by Wijaya et al. (2021), who found that the use of concrete media in teaching the volume of cubes and rectangular prisms increased fifth-grade students' interest in learning mathematics. The effectiveness of instructional media is also reflected in improved learning outcomes, as evidenced by an increase in mean scores from 62.58 to 79.70 following the use of instructional aids (Annisa et al., 2022). In addition, a correlational study conducted at MIN 1 Pariaman City revealed that the use of concrete media played a significant role in third-grade mathematics learning (Frasandy & Anggaraini, 2021). Collectively, these findings suggest that the use of concrete instructional media, including conversion ladder media, can substantially improve previously low learning outcomes and optimize the overall learning process.

Furthermore, the use of visually engaging and contextually relevant instructional media can create enjoyable and meaningful learning experiences, thereby contributing to students' conceptual understanding (Maulidiyah et al., 2019; Nurfadhillah et al., 2021). Instructional media also support the development of students' analytical and logical thinking skills, particularly in mathematics learning, which requires deep conceptual understanding (Moto, 2019; Nurrita, 2018). Argaruri et al. (2023) and Zhan et al. (2024) further highlight that concrete, interactive media-based learning activities promote active student engagement throughout the learning process.

In a participatory learning context, teachers serve as facilitators, guiding learning activities that enable students to interact directly with instructional media and peers (Sulistriani et al., 2021). Such interactions render learning more contextual and meaningful (Desrita, 2025). This finding is reinforced by (2023), who demonstrated that well-designed interactive instructional media enhance learning effectiveness in both content comprehension and learning motivation. Additionally, Yi et al. (2026) reported that contextually adapted instruction positively influences students' attention, self-confidence, and learning satisfaction.

### 4.3 Critical thinking skills in mathematics learning

Fundamentally, critical thinking is a complex and dynamic process shaped by students' attitudes and strategic skills to achieve specific goals (Falcó-Pegueroles et al., 2021). It is recognized as one of the essential 21st-century skills required for students to address increasingly complex global challenges (Arthi & Gandhimathi, 2025; Rahayu & Alyani, 2020). This skill is not only crucial in academic contexts but also in everyday life, as it equips students with the ability to think

reflectively, objectively, and responsibly when responding to information obtained from their environment and various media sources (Butler, 2024; Nuryanti et al., 2018; Richards et al., 2020).

Critical thinking skills develop gradually and are actively applied throughout the learning process through group discussions, problem-solving activities, experiments, and the use of instructional media designed to foster higher-order thinking skills (Wahyu Ariyani & Prasetyo, 2021). In mathematics learning, critical thinking plays a pivotal role in helping students reduce conceptual errors, develop effective problem-solving strategies, and achieve a deeper understanding of mathematical concepts (Sari & Lutfi, 2023). Therefore, critical thinking functions not merely as a supporting skill but as a central objective of mathematics education itself. Its development is strongly influenced by instructional design and the appropriate, contextual, and learner-centered use of instructional media (Nafisa & Wardono, 2019).

The observed improvement in students' critical thinking skills following the use of conversion ladder media indicates that concrete instructional media make a substantial contribution to the learning process, particularly in clarifying abstract concepts such as length measurement units. Concrete media are visual, physical, or manipulative tools that students can directly observe and use (Mahmudi et al., 2023). The use of concrete media in mathematics instruction has been shown to accelerate conceptual understanding, increase active student engagement, and promote the development of critical thinking indicators, including analysis, evaluation, and reflection (self-regulation) (Saputro et al., 2023). These findings are consistent with the study by Mudtalifah et al. (2024), which demonstrated that the use of Counting Box media in teaching fractions significantly improved third-grade students' critical thinking skills, as evidenced by a mean score increase from 30.32 in the pretest to 77.78 in the posttest. Similar results were reported by Lidiani & Indarini (2023), who found that the use of concrete instructional media in fifth-grade mathematics instruction increased students' critical thinking skills from 76% (critical category) to 88% (very critical category).

Taken together, these findings suggest that the use of concrete instructional media, such as the conversion ladder, serves not only as a visual aid but also as an effective instructional strategy for fostering students' critical thinking skills comprehensively.

## 5. Conclusion and implications

### 5.1 Conclusion

This study aimed to examine the effectiveness of using concrete instructional media in the form of a Conversion Ladder to enhance students' critical thinking skills in learning length unit conversions. The findings indicate that this objective was successfully achieved, as evidenced by a significant difference between pre-test and post-test scores and an improvement in students' learning outcomes exceeding the minimum mastery criteria (MMC). Furthermore, the large effect size suggests that the use of the Conversion Ladder media is not only statistically significant but also has a strong practical impact on improving students' cognitive processes. The most prominent improvement in critical thinking skills was observed in the interpretation indicator, where students were better able to understand and interpret relationships among length measurement units in a more systematic manner, supported by visual media.

### 5.2 Implications

From a practical perspective, these findings imply that elementary school teachers should use concrete, visual instructional media, such as the Conversion Ladder, as an alternative instructional

strategy in mathematics to enhance students' interest in learning and their critical thinking skills. From a theoretical standpoint, this study contributes to the field of mathematics education by strengthening empirical evidence that concrete instructional media play a crucial role in facilitating the development of critical thinking skills, particularly in learning abstract mathematical concepts. In terms of educational policy, the results of this study may serve as a reference for schools and policymakers to promote the integration of concrete instructional media into curricula and teacher professional development programs.

## 6. Limitation

Despite these contributions, this study has several limitations, including a one-group design without a control group, a relatively small sample size, and a limited research scope confined to a single school. Therefore, future studies are recommended to employ experimental designs with control groups, involve larger, more diverse samples, and develop more comprehensive instruments to assess critical thinking skills, thereby enhancing the generalizability of the findings.

### Credit authorship contribution statement

**First Author:** Conceptualization, Methodology, Data Collection, Formal Analysis, Writing – Original Draft. **Second Authors:** Conceptualization, Methodology, Writing–Review & Editing, Supervision. **Third Author:** Data Collection, Data Curation, Formal Analysis, Validation. **Last Author:** Validation, Supervision, Writing – Review & Editing

### Declaration of competing interest

The authors declare that there are no conflicts of interest, either financial or non-financial, that could have influenced the conduct of the research or the writing of this article.

### Data Availability Statement

The data supporting the findings of this study are original data collected and owned by the authors. The data are not publicly available and were not obtained from other parties. Access to the data may be provided by the corresponding author upon reasonable request, with due consideration given to confidentiality and the protection of participant privacy.

### Ethical Declaration

This study involved elementary school students as participants and was conducted in accordance with the principles outlined in the Declaration of Helsinki. Permission and informed consent were obtained from the classroom teacher and the school principal prior to the implementation of the study. The participants, classroom teacher, and school principal were informed about the purpose and procedures of the research, as well as the participants' right to withdraw from the study at any time without any consequences..

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### Declaration of AI statement

The authors used an artificial intelligence tool (ChatGPT) in a limited manner solely to assist with language editing, including improving grammar and clarity. All ideas, analyses, data, and the substantive content of the article are entirely the authors' own work. The entire manuscript has been reviewed, revised, and approved by the authors, who take full responsibility for the final content of the article.

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