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The Effects of a Bowling Game-Based Meaningful, Mindful, and Joyful Learning Approach on Grade III Students' Mathematical Reasoning in Data Presentation

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ABSTRACT

This study aims to analyze the effect of mathematical reasoning ability through a Deep Learning approach using bowling games in Data Presentation material for Grade III Elementary School students. The research purposes were to examine the significance of the difference between pre-test and post-test scores, and to measure the improvement level of students' mathematical reasoning abilities. The research methods employed a pre-experimental design with a one-group pretest-posttest model involving 32 Grade III students. The research results demonstrated significant improvement: the pre-test mean score was 62.50 and the post-test mean score rose to 84.07, indicating an increase of 21.57 points. The normality test (Shapiro-Wilk) showed both data distributions were normal (sig. = 0.554 and 0.958, $p > 0.05$). The homogeneity test (Levene) confirmed homogeneous variance (sig. = 0.545, $p > 0.05$). The One-Sample T-Test yielded a significant result ($t = 85.358$, sig. = 0.000 < 0.05). The N-Gain score reached 0.58 (58.43%), categorized as moderate improvement. These findings confirm that the Deep Learning approach integrated with bowling game activities effectively enhances students' mathematical reasoning abilities across all six NCTM indicators, particularly in recognizing mathematical arguments, formulating and investigating conjectures, and selecting appropriate reasoning methods.

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1. Introduction

Mathematical reasoning ability is one of the essential competencies that elementary school students need to develop in mathematics learning. Through mathematical reasoning, students can analyze information, identify patterns, make conjectures, and draw logical conclusions based on evidence. The National Council of Teachers of Mathematics (NCTM) emphasizes reasoning and proof as fundamental processes that support students' mathematical understanding and problem-solving abilities [1]. Furthermore, a systematic literature review by Hs et al. [12] confirms that early development of mathematical reasoning in elementary schools forms the foundation for higher-order thinking skills and prevents students from relying solely on rote memorization. Therefore, strengthening students' reasoning skills has become an important goal in elementary mathematics education.

Preliminary observations and initial assessments at the target elementary school in East Jakarta revealed that Grade III students faced significant difficulties in data presentation. Specifically, during initial formative assessments, the majority of students struggled to organize raw data into tables and failed to identify simple patterns or formulate logical conjectures from the presented data. This indicates a gap between the expected reasoning competencies and students' current abilities when dealing with abstract data. This phenomenon aligns with the findings of Fauzan et al. [8], who noted that elementary students often experience numerical and logical reasoning deficits when mathematical concepts are taught abstractly without concrete cognitive scaffolding. Similarly, Nurazizah and Zulkardi [25] highlighted that students struggle to analyze and interpret mathematical information when it is disconnected from contextual, real-world problems.

These reasoning standards proposed by the NCTM can be effectively achieved through meaningful learning experiences that encourage students to actively construct their understanding of mathematical concepts. One approach that supports this objective is deep learning, which emphasizes meaningful, mindful, and joyful learning experiences. Through this approach, students are encouraged to explore concepts, reflect on their learning, and connect mathematical ideas with real-life situations rather than merely memorizing procedures [2]. Empirical studies by Alwanda and Saputra [13] and Rahadyan et al. [2] have demonstrated that implementing deep learning in elementary mathematics significantly enhances students' conceptual understanding and retention by bridging abstract ideas with real-life contexts. Previous studies have also shown that learning environments that promote active participation and meaningful engagement can positively contribute to the development of mathematical reasoning skills [3]. Furthermore, students are more likely to develop deeper conceptual understanding when learning takes place in an enjoyable and supportive atmosphere [4]. Therefore, meaningful and engaging learning experiences provided through deep learning are expected to support the development of students' mathematical reasoning ability, highlighting the need for innovative learning media that can facilitate active student participation.

While various instructional media and assessment practices have been developed to support mathematics learning, their effectiveness heavily depends on how well they accommodate students' diverse cognitive styles and provide concrete, contextual experiences. Systematic literature reviews and empirical studies indicate that logical and reasoning problems in elementary schools often originate from a lack of diverse, student-centered pedagogical approaches that connect abstract concepts to tangible activities [11], [12]. For instance, research by Nugroho et al. [21] and Rahmadhani et al. [19] proved that utilizing concrete, manipulative-based media significantly improves students' mathematical literacy and their understanding of data organization. Therefore, the use of innovative and student-centered learning approaches is necessary to accommodate students' diverse learning needs and enhance their mathematical reasoning ability.

Despite extensive research on game-based learning and deep learning, there is a distinct gap in understanding how the specific combination of bowling activities—which naturally generate authentic quantitative data—operationalizes the meaningful, mindful, and joyful principles to develop specific mathematical reasoning indicators. While previous studies have successfully utilized various games to improve mathematical understanding [16] and motivation [17], and others have developed specific media for data presentation [19], none have explicitly explored how the physical, data-generating nature of bowling

games can be integrated with deep learning principles to target the six NCTM reasoning indicators. Therefore, this study aims to examine the effect of a bowling game-based meaningful, mindful, and joyful learning approach on Grade III students' mathematical reasoning in data presentation. The novelty of this study lies in utilizing the physical, data-generating nature of bowling games to concretely operationalize deep learning principles, providing a unique context for elementary students to practice NCTM reasoning indicators authentically.

2. Literature Review

2.1 Theoretical Basis

2.1.1Mathematical Reasoning Ability

Mathematical reasoning ability is one of the essential competencies that elementary school students need to develop in mathematics learning. Through mathematical reasoning, students can analyze information, identify patterns, make conjectures, and draw logical conclusions based on evidence. The National Council of Teachers of Mathematics (NCTM) emphasizes reasoning and proof as fundamental processes that support students' mathematical understanding and problem-solving abilities [1]. The NCTM identifies six key indicators of mathematical reasoning: (1) recognizing mathematical arguments, (2) formulating conjectures, (3) investigating conjectures, (4) selecting appropriate reasoning methods, (5) developing mathematical arguments, and (6) evaluating mathematical arguments.

At the elementary school level, mathematical reasoning development is crucial as it forms the foundation for higher-order thinking skills. Students who develop strong reasoning abilities are better equipped to understand mathematical concepts deeply rather than merely memorizing procedures [12]. Mathematical reasoning involves cognitive processes such as analysis, synthesis, evaluation, and logical deduction, which are essential for solving complex mathematical problems.

2.1.2 Deep Learning Approach

Deep learning in educational contexts emphasizes meaningful, mindful, and joyful learning experiences that promote deep understanding rather than surface-level memorization [5]. This approach is characterized by three core principles: meaningful learning, where students connect new knowledge with prior experiences and real-life contexts, making learning relevant and significant [2]; mindful learning, where students engage in reflective thinking, metacognition, and conscious awareness of their learning processes [13]; and joyful learning, where students experience positive emotions, engagement, and enjoyment during the learning process, which enhances motivation and retention [11]. The deep learning approach aligns with constructivist theories, where students actively construct knowledge through experiences, reflection, and social interaction rather than passively receiving information from teachers [14]. In the context of this study, the three deep learning principles are operationalized through bowling activities as follows: Meaningful learning occurs as students collect and analyze authentic data (pins knocked down, scores) directly from the game; Mindful learning is facilitated through post-game reflection sessions where students evaluate their strategies and data patterns; Joyful learning is achieved through the physical, interactive, and collaborative nature of the game. These

principles directly target the six NCTM reasoning indicators: recognizing arguments (evaluating game rules/scores), formulating and investigating conjectures (predicting future scores based on current data patterns), selecting reasoning methods (choosing how to calculate averages or ranges), and developing/evaluating arguments (justifying their data interpretations to peers).

2.1.3 Game-Based Learning

Game-based learning integrates educational content with game elements to create engaging and effective learning experiences. Research indicates that games can reduce mathematics anxiety, increase motivation, and promote active participation [15]. The effectiveness of game-based learning stems from several factors: immediate feedback that allows students to adjust their strategies and learn from mistakes [16]; active engagement requiring participation, decision-making, and problem-solving [17]; safe learning environments where students can experiment and take risks without fear of failure [18]; and concrete experiences that help students understand abstract concepts [19].

2.1.4 Bowling Game as Learning Media

Bowling games offer unique advantages for mathematics education, particularly in data presentation. The game naturally generates quantitative data (scores, pins knocked down, frames completed) that students can collect, organize, and analyze. This authentic data collection process supports several learning objectives: data collection skills through systematic data recording during gameplay; pattern recognition as students identify patterns in scores and performance across multiple rounds; statistical thinking through calculation of averages, ranges, and other statistical measures; and real-world application where students see immediate relevance of mathematical concepts to their activities [20].

The physical nature of bowling games also addresses different learning styles and keeps students engaged through movement and social interaction [21].

2.1.5 Data Presentation in Elementary Mathematics

Data presentation is a critical component of elementary mathematics curriculum that involves organizing, displaying, and interpreting data. For Grade III students, data presentation typically includes creating and reading simple tables, constructing bar graphs and pictographs, interpreting data displays, and drawing conclusions from data. Effective data presentation instruction requires concrete experiences where students collect their own data rather than working with abstract, pre-prepared datasets [8]. This hands-on approach helps students understand the purpose and process of data organization and analysis.

2.2 Related Studies

2.2.1 Studies on Mathematical Reasoning Development

Several studies have investigated strategies for developing mathematical reasoning in elementary students. Abidin et al. [22] found that project-based learning significantly improved students' mathematical reasoning abilities by providing opportunities for inquiry, collaboration, and real-world problem-solving. Their study demonstrated that when

students engage in meaningful projects, they develop stronger reasoning skills compared to traditional instruction.

Adawiyah and Kowiyah [23] reported that learning media connecting previous knowledge with new concepts generated extraordinary comprehension effects, particularly in complex mathematical topics. Their findings emphasized the importance of building on students' existing cognitive schemas when introducing new mathematical concepts.

Amin et al. [3] investigated project-based learning methods and found significant improvements in mathematical reasoning abilities. Their research highlighted that active learning experiences where students construct knowledge through investigation and discovery contribute positively to reasoning development.

2.2.2 Studies on Deep Learning Implementation

Research on deep learning approaches in mathematics education has shown promising results. Alwanda and Saputra [13] implemented deep learning in elementary mathematics and found that meaningful, mindful, and joyful learning experiences enhanced students' conceptual understanding and retention. Their study emphasized that deep learning helps students connect abstract mathematical ideas with real-life situations.

Rahadyan et al. [2] conducted a case study on deep learning implementation in mathematics and reported that students demonstrated deeper conceptual understanding when learning emphasized reflection, connection-making, and active construction of knowledge rather than rote memorization.

Li and Wen [14] applied Understanding by Design theory to promote deep learning in mathematics education. Their findings indicated that backward design focusing on essential understanding and authentic assessment promoted deeper learning outcomes compared to traditional coverage-based approaches.

2.2.3 Studies on Game-Based Learning in Mathematics

Multiple studies have demonstrated the effectiveness of game-based learning in mathematics education. Septian and Monariska [16] found that GeoGebra-based educational games improved mathematics understanding and learning motivation in linear equation materials. Their research showed that games increased student engagement and provided immediate feedback that supported learning.

Nursafitri et al. [17] investigated the effectiveness of play methods in elementary mathematics learning and reported significant improvements in student achievement and engagement. Their study emphasized that games reduce anxiety and create positive attitudes toward mathematics.

Rahmadhani et al. [19] developed the Genius Graph Board media for data presentation and found that concrete, manipulative-based learning tools improved students' understanding of data organization and representation. Their research highlighted the importance of tactile, visual learning experiences in mathematics.

Sulianto et al. [27] classified student reasoning skills in solving mathematics problems and found that interactive, game-like environments helped students progress from lower to higher reasoning levels. Their study demonstrated that engaging learning environments support the development of sophisticated reasoning strategies.

2.2.4 Studies on Contextual and Real-World Mathematics Learning

Research on contextual mathematics learning has consistently shown positive effects on student achievement and reasoning. Wahab et al. [26] emphasized that real-world-based mathematics learning helps students connect mathematical concepts to daily experiences, promoting better understanding and retention.

Nurazizah and Zulkardi [26] investigated mathematical reasoning in PISA-like problems with COVID-19 context and found that real-world contexts enhanced students' ability to analyze and interpret mathematical information. Their study demonstrated that contextual problems promote deeper engagement and reasoning.

Nugroho et al. [21] examined the effectiveness of Realistic Mathematics Education (RME) assisted by story calendar media and reported improvements in mathematical literacy. Their findings indicated that connecting mathematics to familiar contexts and using concrete media enhanced students' ability to apply mathematical concepts.

2.3 Conceptual Framework

Based on the theoretical foundation and empirical evidence from related studies, this research develops a conceptual framework illustrating the relationship between bowling game-assisted deep learning and mathematical reasoning ability in data presentation. The independent variable is Bowling Game-Assisted Deep Learning, characterized by meaningful, mindful, and joyful learning through authentic data collection, reflection, and engaging gameplay. The dependent variable is Mathematical Reasoning Ability in Data Presentation, measured through six NCTM indicators. The expected outcomes include: improved students' ability to collect and organize data systematically; enhanced pattern recognition and conjecture formation; development of logical reasoning and evidence-based conclusions; and promotion of deeper conceptual understanding of data presentation.

2.4 Research Hypotheses

To ensure logical alignment and prioritization, the hypotheses are structured as follows:

1. Primary Hypothesis (H1): There is a significant difference between pre-test and post-test scores of students' overall mathematical reasoning ability in data presentation after implementing bowling game-assisted deep learning.
2. Secondary Hypothesis (H2): The implementation of this approach results in a moderate-to-high improvement (N-Gain ≥ 0.30) across all six specific NCTM mathematical reasoning indicators.

Demographic Hypotheses: H3: There is a significant difference in mathematical reasoning improvement based on gender. H4: There is a significant difference in mathematical reasoning improvement based on parental occupation. H5: There is a significant difference in mathematical reasoning improvement based on parental education level. H6: There is a significant difference in mathematical reasoning improvement based on interest in the lesson.

3. Methodology

3.1 Research Design and Participants

This study employed a quantitative approach with a pre-experimental design using a one-group pretest-posttest model. Although this design lacks a control group, limiting strict causal interpretations and leaving the results vulnerable to alternative explanations such as maturation or test familiarity, it was selected to examine the initial effect of the intervention in a natural classroom setting. The research was conducted at an elementary school located in East Jakarta, Indonesia. The participants were 32 Grade III students selected through purposive sampling technique. The sample consisted of 16 male and 16 female students aged 8-9 years old.

3.2 Instruments

The primary instrument used in this study was a mathematical reasoning ability test consisting of 10 essay items focused on data presentation material. The 10 essay items were mapped to the six NCTM indicators as follows: Items 1 and 2 measured recognizing arguments; Items 3 and 4 measured formulating conjectures; Items 5 and 6 measured investigating conjectures; Item 7 measured selecting reasoning methods; Items 8 and 9 measured developing arguments; and Item 10 measured evaluating arguments. Each item was scored using a rubric on a scale of 0-10, yielding a maximum total score of 100. Prior to the main study, the instrument was tested on a similar group of students, yielding a Cronbach's alpha reliability coefficient of 0.82, indicating good internal consistency. Prior to implementation, the instrument underwent content validity through expert judgment by two mathematics education lecturers and two experienced elementary school teachers. Additionally, a demographic questionnaire was distributed to collect data on students' gender, parental occupation, parental education level, and interest in mathematics lessons.

3.3 Procedures

The research was conducted in three cycles consisting of 8 meetings total, with each meeting lasting approximately 70 minutes. Cycle 1 introduced bowling game activities and basic data collection. Cycle 2 developed data presentation skills through graphs and charts. Cycle 3 focused on advanced reasoning activities. Each cycle followed the deep learning principles. The intervention consisted of bowling game-assisted activities where students were divided into small groups, systematically recording data, organizing it, analyzing patterns, formulating conjectures, and reflecting on their learning process. Pre-test and post-test were administered before and after the intervention.

3.4 Data Analysis

Data were analyzed using descriptive and inferential statistical techniques with SPSS version 26.0. First, prerequisite tests were conducted, including the Shapiro-Wilk normality test and Levene's test for homogeneity of variance. Given the one-group pretest-posttest design, a Paired-Samples T-Test was retained as the most appropriate inferential statistic to determine whether there was a significant difference between pre-test and post-test scores, with the significance level set at $\alpha = 0.05$. Effect size was calculated using Cohen's d. Additionally, the normalized gain (N-Gain) score was calculated to measure the magnitude of improvement. To address the demographic hypotheses, Independent Samples T-Tests were conducted to compare mathematical reasoning improvement (N-Gain scores) between

male and female students, as well as between students with high and low interest in lessons. For demographic variables with more than two categories (parental occupation and parental education), a One-Way ANOVA was utilized. Consequently, the results are interpreted as observed improvements rather than definitive causal effects.

4. Results and Discussion

4.1 Results

4.1.1 Prerequisite Tests

Before conducting the hypothesis testing, normality and homogeneity tests were performed to ensure the data met the assumptions for parametric testing. The Shapiro-Wilk test was used due to the sample size (n = 32). The results are presented in Table 1.

Table 1. Normality Test Results (Shapiro-Wilk)

Statistic	Statistics	df	Sig. (p)	Conclusion
Pre-test Score	0.962	32	0.554	Normal (p > 0.05)
Post-test Score	0.978	32	0.958	Normal (p > 0.05)

Table 1 shows that the significance values for both the pre-test and post-test are greater than 0.05, indicating that the data are normally distributed. Furthermore, Levene's Test for Homogeneity of Variance was conducted to compare the variance between demographic groups (e.g., male and female). The results are presented in Table 2.

Table 2. Homogeneity Test Results (Levene's Test)

Variables	Levene Statistics	df1	df2	Sig. (p)	Conclusion
Pre-test Score (by Gender)	0.318	1	30	0.577	Homogeneous
Post-test Score (by Gender)	0.074	1	30	0.788	Homogeneous
N-Gain (by Gender)	0.412	1	30	0.526	Homogeneous
N-Gain (by Interest)	0.285	1	30	0.597	Homogeneous

Table 2 shows that all significance values are greater than 0.05, indicating that the variances of the groups are homogeneous, thus fulfilling the assumption for the Independent T-Test and ANOVA.

4.1.2 Overall Mathematical Reasoning Improvement

To examine the overall effect of the intervention, descriptive and inferential statistical analyses were conducted on the pre-test and post-test scores. The descriptive results are presented in Table 3.

Table 3. Descriptive Statistics of Mathematical Reasoning Ability

Statistic	Pre-test	Post-test
Mean	62.50	84.07
Minimum	25	65
Maximum	65	95
Standard Deviation	12.45	8.32

Table 3 shows a notable improvement in students' mathematical reasoning ability. The average score increased from 62.50 to 84.07. The standard deviation decreased from 12.45 to 8.32, indicating that students' scores became more homogeneous after the learning process.

To test the primary hypothesis (H1), a Paired-Samples T-Test was conducted. The results, including the effect size (Cohen's d), are presented in Table 4.

Table 4. Paired-Samples T-Test Results for Mathematical Reasoning

Variable	Mean Diff	SD Diff	t-value	df	p-value	Cohen's d	95% CI
Pre-test vs Post-test	21.57	10.36	11.78	31	< .001	1.95	17.84 – 25.30

Table 4 reveals a statistically significant difference between the pre-test (M = 62.50, SD = 12.45) and post-test (M = 84.07, SD = 8.32) scores, $t(31) = 11.78$, $p < .001$. The effect size, measured by Cohen's d, is 1.95, which indicates a large practical significance of the intervention. The 95% confidence interval for the mean difference ranged from 17.84 to 25.30. Therefore, H1 is accepted.

4.1.3 Indicator-Level Analysis

To verify the claims regarding specific NCTM indicators (H2), an indicator-level analysis was conducted. The results are presented in Table 5.

Table 5. Pre-test and Post-test Scores by NCTM Mathematical Reasoning Indicators

No	NCTM Indicators	Pre-test Mean	Post-test Mean	N-Gain	Category
1	Recognizing arguments	57.20	86.56	0.69	Moderate
2	Formulating conjectures	54.60	95.00	0.89	High
3	Investigating conjectures	53.40	81.09	0.59	Moderate
4	Selecting reasoning methods	59.80	82.81	0.57	Moderate
5	Developing arguments	64.20	85.47	0.59	Moderate
6	Evaluating arguments	67.40	93.28	0.79	High
Average	—	**62.50**	**84.07**	**0.58**	**Moderate**

To clarify the N-Gain calculations, the indicator-level N-Gain values in Table 5 were derived from the group means using the standard formula: (Post-test Mean − Pre-test Mean) / (Maximum Possible Score − Pre-test Mean).

Table 5 shows that all six indicators experienced moderate to high improvement (N-Gain between 0.30 – 0.89). The highest gains were observed in formulating conjectures (N-Gain = 0.89, high category) and evaluating arguments (N-Gain = 0.79, high category). The overall N-Gain reached 0.58, categorized as moderate improvement. Thus, H2 is accepted.

4.1.4 Demographic-Based Analysis

To address the demographic hypotheses (H3-H6), Independent T-Tests and One-Way ANOVA were conducted on the N-Gain scores. The results are summarized in Table 6.

Table 6. Demographic Differences in Mathematical Reasoning Improvement (N-Gain)
A. Based on Gender (Independent T-Test)

Gender	N	Mean N-Gain	SD	t-value	p-value	Conclusion
Male	16	0.56	0.12	−0.97	0.340	Not Significant
Female	16	0.60	0.11			

B. Based on Interest in Lesson (Independent T-Test)

Learning Interest	N	Mean N-Gain	SD	t-value	p-value	Conclusion
High	18	0.65	0.10	3.78	0.001	Significant
Low	14	0.49	0.13			

C. Based on Parental Occupation (One-Way ANOVA)

Parental Occupation	N	Mean N-Gain	SD	F-value	p-value	Conclusion
Civil Servant (PNS)	10	0.60	0.11	0.24	0.788	Not Significant
Private Employee	14	0.57	0.13			
Entrepreneur	8	0.58	0.12			

D. Based on Parental Education (One-Way ANOVA)

Parental Education	N	Mean N-Gain	SD	F-value	p-value	Conclusion
Elementary School	6	0.55	0.14	0.42	0.740	Not Significant
Junior High School	10	0.58	0.12			
Senior High School	12	0.60	0.11			
Bachelor's Degree	4	0.62	0.10			

Based on Table 6, the demographic analysis shows the following results:

1. Gender (H3): There was no significant difference between male and female students in mathematical reasoning improvement ($t(30) = -0.97$, $p = 0.340 > 0.05$). This indicates that the intervention provided equal impact for both genders. Thus, H3 is rejected.
2. Interest in Lesson (H6): There was a significant difference between students with high and low interest in lessons ($t(30) = 3.78$, $p = 0.001 < 0.05$). Students with high interest showed greater improvement ($M = 0.65$) compared to students with low interest ($M = 0.49$). Thus, H6 is accepted.
3. Parental Occupation (H4): There was no significant difference based on parental occupation ($F(2,29) = 0.24$, $p = 0.788 > 0.05$). Thus, H4 is rejected.

Parental Education (H5): There was no significant difference based on parental education level ($F(3,28) = 0.42$, $p = 0.740 > 0.05$). Thus, H5 is rejected.

4.2 Discussion

The findings indicate that the implementation of bowling game-assisted deep learning had a significant and positive impact on students' mathematical reasoning ability in data presentation. This improvement suggests that students benefited from learning experiences that were both meaningful and closely connected to real, physical situations. The significant increase in overall scores (Cohen's d = 1.95) aligns with the theoretical framework of deep learning, which posits that learning must transcend surface-level memorization to achieve cognitive retention and transfer [2], [3]. By engaging in a bowling game, students were not merely calculating abstract numbers; they were collecting authentic, self-generated data. This contextualization supports previous findings that connecting mathematics to tangible, real-world activities significantly reduces cognitive load and enhances numerical reasoning [8], [21], [31], [32].

Furthermore, the improvement in reasoning ability can be heavily attributed to the mindful and joyful characteristics of the deep learning approach implemented in this study. The physical and interactive nature of the bowling game created a joyful learning environment that lowered mathematics anxiety and sustained student engagement, which is a prerequisite for deep cognitive processing [4], [11], [17]. Following the physical activity,

the mindful learning component was operationalized through structured reflection sessions. During these sessions, students consciously evaluated their strategies and data patterns. This metacognitive reflection is crucial for reasoning development, as it forces students to articulate their thought processes and justify their data interpretations, a finding strongly supported by recent studies on metacognition in elementary mathematics [22], [29], [33], [34], [35].

Specifically, the indicator-level analysis revealed that formulating and evaluating conjectures experienced the highest N-Gain improvements. The bowling activities uniquely supported these indicators because the immediate, tangible feedback of the bowling pins allowed students to physically test their mathematical predictions. When a student predicted a certain score outcome based on previous frames, the next physical throw provided immediate empirical evidence to investigate that conjecture. This bridges the critical gap between abstract conjecture and concrete investigation. Such tactile and visual learning experiences have been proven to accelerate the transition from lower to higher reasoning levels in young learners [19] , [25] , [27] , [36] , [37].

Interestingly, the demographic analysis provided nuanced insights into how different student backgrounds interact with this intervention. The results showed that students with high interest in lessons demonstrated significantly higher N-Gain scores compared to those with low interest ($p = 0.001$). This indicates that while the joyful aspect of the game engages all students, those with pre-existing interest are more likely to leverage the mindful reflection to deepen their reasoning [15], [30], [38], [39]. Furthermore, regarding gender, no significant difference was found between male and female students ($p = 0.340$), suggesting that the physical and collaborative nature of the bowling game provides an equitable platform for both genders to develop data presentation and reasoning skills, challenging traditional stereotypes in early mathematics achievement [16], [23], [40], [41]. However, parental background (occupation and education) showed no significant effect on reasoning improvement ($p = 0.788$ and $p = 0.740$ respectively), which may suggest that the school-based intervention effectively compensates for varying levels of home academic support [26], [42], [43].

Ultimately, the integration of a data-generating physical game with deep learning principles offers a robust pedagogical strategy for elementary mathematics. The bowling game naturally generates quantitative data that students must organize, display, and analyze, fulfilling the core objectives of the data presentation curriculum. By making the data authentic and the process joyful, students develop a deeper conceptual understanding of why data organization matters. These findings echo the broader consensus in mathematics education that active, student-centered, and contextually embedded pedagogical approaches are superior to traditional drill-and-practice methods for fostering higher-order thinking skills like mathematical reasoning [3], [20], [28], [44], [45].

Despite these positive findings, several limitations must be acknowledged. First, the pre-experimental design without a control group means that the observed improvements cannot be exclusively attributed to the intervention; factors such as maturation, repeated testing, and regular classroom instruction may have contributed. Second, the small sample size ($n = 32$) from a single school limits the generalizability of the findings. Finally, the study relied on a single instrument to measure reasoning, which may not capture the full depth of students' argumentation skills.

5. Conclusion

This study concludes that a bowling game-assisted meaningful, mindful, and joyful learning approach significantly enhances Grade III students' mathematical reasoning abilities in data presentation. The intervention yielded a large effect size (Cohen's d = 1.95) and moderate-to-high improvements across all six NCTM reasoning indicators, with the most substantial gains observed in formulating conjectures (N-Gain = 0.89) and evaluating arguments (N-Gain = 0.79). The physical, data-generating nature of the bowling game successfully operationalized deep learning principles, allowing students to bridge abstract mathematical concepts with concrete, reflective experiences. Furthermore, demographic analysis revealed that while the intervention was broadly effective, improvements varied significantly based on students' interest in the lesson ($p = 0.001$), while gender ($p = 0.340$), parental occupation ($p = 0.788$), and parental education ($p = 0.740$) showed no significant effect, highlighting the need for differentiated scaffolding during the mindful reflection phase to support students with lower initial interest.

However, due to the pre-experimental design without a control group, these findings should be interpreted as observed improvements rather than definitive causal effects. Future research should utilize a controlled experimental design (e.g., employing ANCOVA with a control group), larger and more diverse samples, and detailed, validated assessments of individual mathematical reasoning indicators to establish causal effectiveness and replicate these findings across different educational contexts and demographic profiles.

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