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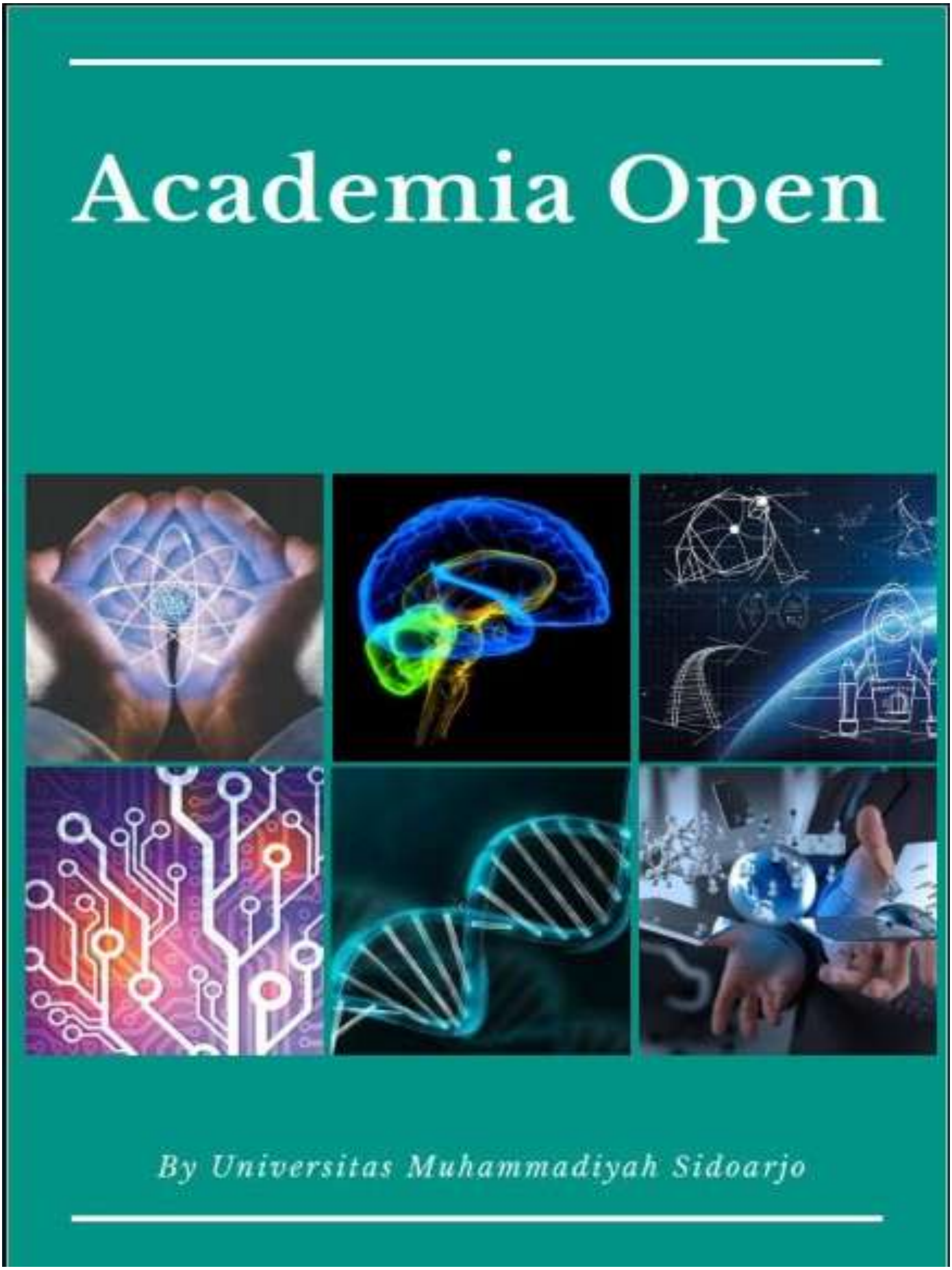

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Concrete Representational Abstract Number Boards Optimize Slow Learner Statistical Data Mastery: Papan Bilangan Konkret Representasional Abstrak Mengoptimalkan Penguasaan Data Statistik Siswa Lamban

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Abstract

General Background Inclusive secondary mathematics education requires adaptive instructional strategies accommodating diverse cognitive profiles. **Specific Background** Students at risk of slow learning often struggle with abstract concepts like measures of central tendency due to underlying arithmetic deficits in addition and division. **Knowledge Gap** Traditional instruction predominantly utilizes two-dimensional representations and symbolic calculations, failing to provide the transitional physical manipulatives necessary to reduce cognitive load for borderline learners. **Aims** This Classroom Action Research investigates the application of an integrated manipulative medium to optimize mode, median, and mean comprehension among eighth-grade students in a disadvantaged region. **Results** Following two pedagogical cycles, classical learning mastery elevated from 33 percent to 86 percent. Specifically for the twelve borderline participants, average scores progressed from a baseline of 32.50 to 65.83, with classical mastery jumping from zero to 75 percent. Observational data confirmed increased participation across tangible, visual, and symbolic mathematical stages. **Novelty** This study distinctly integrates physical unit manipulatives into a sequenced visual framework, offering a uniquely structured transition from tangible sorting to symbolic arithmetic specifically tailored for borderline intellectual capacities. **Implications** Educational practitioners must integrate sequenced manipulative media when introducing complex mathematical procedures to ensure inclusive conceptual development.

Highlights

- Sequenced physical manipulatives significantly elevate mathematical comprehension among marginalized eighth-grade cohorts.
- Average procedural performance metrics for borderline participants jumped from zero to seventy-five percent after two pedagogical cycles.
- Structured tangible-to-symbolic transitions effectively reduce cognitive load during addition and division arithmetic tasks.

Keywords

Inclusive Education; Mathematics Instruction; Tangible Manipulatives; Central Tendency; Cognitive Load

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INTRODUCTION

Teaching Mathematics in inclusive secondary schools demands teaching strategies that are suitable to the diverse learning characteristics of learners including learners at risk of being slow learners. Most students who are given the “slow learner” label have cognitive abilities slightly below the average of their peers and require more time, repetition and structured instructional help to grasp the academic concepts. They often have problems in processing information, in memory, in literacy, numeracy and abstract reasoning. This leads to lower academic achievement compared to typically developing students (Chusna, 2024). Therefore, these students receive individualized instruction, simplified learning materials, extended learning time, and instructional media to assist them in moving from concrete experience to abstract thinking. One of the mathematical topics that becomes a problem for these students is a measure of central tendency as part of the Grade VIII Mathematics Curriculum based on Indonesian Content Standards (Permendikdasmen No. 12 of 2025). Finally, measures of central tendency (mode, median and mean) require students to understand statistical concepts as well as addition, division, sequencing and logical reasoning. Though fundamental to statistical literacy, these concepts remain very abstract for students who are poor in numerical reasoning skills, especially for potentially slow learners.

Based on the classroom observation of the Grade VIII-B at SMP Negeri 2 Jenamas, it was found that some students identified as slow learners experienced difficulty in determining the mode, median, and mean because they had not yet mastered the prerequisite arithmetic operations. They could not add or divide, and therefore could not understand the underlying concepts of central tendency of data. Therefore, according to the formative assessment results, less than 50% of these students achieved the expected learning outcomes in the topic. Moreover, students exhibited low participation in mathematics lessons and low motivation to engage in individual or collaborative learning activities. These learning difficulties were closely associated with instructional practices implemented in the classroom. The teaching of Mathematics was mainly through traditional two dimensional media, most especially the whiteboard and few opportunities for students to manipulate concrete learning materials. However, prior instructional supports such as individualized assistance and pictorial media had limited success because students still struggled to connect visual representations to abstract numerical operations. For slow learners at risk it is better to gradually develop mathematical understanding through concrete experiences before abstract concepts are gradually developed towards symbolic representation.

The Concrete–Representational–Abstract (CRA) instructional approach offers an effective framework for this gradual progression. In the concrete stage students manipulate concrete objects to build conceptual understanding. Representational stage: making diagrams or visual models from real experiences; Finally, in the abstract stage, students use independently mathematical symbols and numerical procedures. This step-by-step process helps students with learning difficulties to develop concepts while decreasing cognitive load, making mathematical learning more approachable. Considering these considerations, the present study implemented a CRA-based Number Board as an instructional medium to learn measures of central tendency. The Number Board combines concrete manipulatives, visual representations, and symbolic mathematical operations into one learning medium, which allows students to learn the concepts of mode, median and mean through structured and meaningful learning experiences. It has been proven that learning media can motivate students, increase participation and engagement in classroom teaching (Tafonao, 2018). In addition, Azmidar and Putri Nur Malasari (2022) found that the Concrete–Representational–Abstract approach significantly enhanced students’ interest in mathematics compared to traditional teaching methods.

Accordingly, the classroom action research was conducted to improve the learning process and students’ understanding of measures of central tendency through the application of CRA-based Number Board to the students at risk of being slow learners in Grade VIII-B of SMP Negeri 2 Jenamas. Findings are expected to offer an effective instructional alternative for supporting inclusive mathematics education, particularly for learners who need concrete and systematic learning experiences to develop mathematical understanding

METHOD

This study was a Classroom Action Research (CAR) with the model of Kemmis and McTaggart, which consists of four cycles: planning, action, observation, and reflection. This research was conducted using a quantitative descriptive design in two action cycles to enhance students’ understanding of measures of central tendency through the implementation of a Concrete-Representational-Abstract (CRA) based Number Board. This research was conducted at SMP Negeri 2 Jenamas in Indonesia in the academic year of 2025/2026. The participants were 21 students of Grade VIII-B consisting of 12 students identified by the teacher as being at risk of slow learners and nine students without identified learning difficulties. The intervention was directed at the learning needs of students at risk of being slow learners while ensuring inclusive classroom instruction for the whole class. Each research cycle involved three teaching meetings. In the first two meetings, students learned the concepts of mode, median and mean using the Number Board based on CRA. In the concrete phase students used unit and tens sticks to physically represent data. In the representational stage, they transformed these concrete experiences into visual representations and diagrams. Finally, in the abstract phase, students solved statistical problems with mathematical symbols and numerical procedures. The written test was used to assess students’ conceptual understanding in the third meeting of each cycle. The results of the reflection from each cycle were used to enhance the next instructional cycle.

Classroom observations and achievement tests were used to collect data. The researchers assessed the performance of teachers and students’ participation in the three CRA stages using observation sheets, and they assessed students’ understanding of measures of central tendency using four essay questions on the concepts of mode, median, and mean. All research instruments and teaching media were validated by an expert before being used. The data collected were analyzed quantitatively descriptively by calculating the mean score, percentage of learning mastery, and percentage of teacher and

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student observation scores. The intervention was said to be successful if at least 70% of the students achieved the minimum learning mastery criterion and the average implementation score of the learning process reached at least 70% in each cycle.

RESULT AND DISCUSSION

This research was conducted at SMP Negeri 2 Jenamas Public Junior High School in the village of Rangga Ilung, Jenamas District, South Barito Regency, Central Kalimantan, Indonesia, one of the 3T (frontier, outermost, and disadvantaged) areas. There were 145 pupils, nine teachers and two support staff at the school in the 2025-2026 school year. The study was conducted in Grade VIII-B with 21 students (11 boys and 10 girls) out of which 12 students were found to be at risk of slow learners. The intervention was implemented in two cycles of Classroom Action Research, each cycle consisting of two teaching sessions and one evaluation session. The intervention was carried out by the mathematics teacher who was also the researcher, and the classroom teacher acted as observer to monitor the instructional process. Infrastructural challenges such as limited internet connectivity and restricted electricity availability notwithstanding, the school offered a supportive environment for the implementation of the CRA-based Number Board, a cost-effective and reusable instructional medium designed to promote students' understanding of measures of central tendency through meaningful concrete, representational and abstract learning experiences.

Initial Condition

Before the intervention an initial assessment was done to determine students' prior understanding of measures of central tendency and to establish baseline data to evaluate the effectiveness of the intervention. Prior to the assessment, students received traditional classroom instruction on the concepts of mode, median, and mean using the school's normal teaching approach. Each student was given a pre-test consisting of four essay questions: one on the mode, one on the median, and two on the mean. The assessment was designed to assess students' conceptual understanding as well as their ability to perform the arithmetic operations needed to independently determine measures of central tendency, including ordering data, addition and division. The results of the pre-test showed that the students' understanding of measures of central tendency was still relatively low. The results of the study are presented in Table 1. It shows that only 7 out of 21 students (33%) achieved the minimum mastery criterion (score ≥ 70) whereas 14 students (67%) did not achieve the expected level of achievement. The mean score in the class was just 49.00. This means that most of the students have not been able to master the basic concepts to solve statistical problems related to mode, median and mean. Most importantly, none of the twelve students who were identified as at risk of being slow learners reached the minimum mastery criterion, while only seven of the nine students who had no identified learning difficulties showed satisfactory performance. This means that the learning difficulties were significantly higher in the students with high risk of slow learners who need more instructional support than the traditional teaching method.

Table 1. *Initial Learning Outcomes on Measures of Central Tendency*

Learning Outcomes	Students at Risk of Slow Learning	Other Students	Total	Percentage	Category
Score < 70	12	2	14	67%	Not Mastered
Score ≥ 70	0	7	7	33%	Mastered
Class Mean Score			**49.00**		
Classical Mastery				**33%**	**Poor**

A closer analysis of the students' responses revealed that many of the students had difficulties in executing the procedural steps needed to find the measures of central tendency. Typical errors were to sort the numbers from smallest to largest before finding the median, to identify the mode as the most frequent value, and to correctly use addition and division when calculating the mean. Some students were able to pick out individual numerical values, but could not piece together the whole sequence of procedures needed to correctly solve the problems. The results show that students' misconceptions were not only computational mistakes but also lack of conceptual understanding of the statistical measures. The learning difficulties were more pronounced among students who were at risk of being slow learners. These students were observed in class to have a much longer processing time for the instruction, tended to be dependent on teacher assistance and were uncertain in solving problems that were presented only in symbolic mathematical notation. Their performance suggests that the traditional instruction, which emphasized abstract explanations, was not well matched to their cognitive characteristics. This resulted in students finding it difficult to relate numerical symbols to the statistical concepts they stood for, and consequently, they performed poorly on the pre-test.

Overall, the findings at this early stage suggested that students needed an instructional approach that could bridge concrete experiences to visual representation and abstract mathematical reasoning. The Concrete–Representational–Abstract (CRA)-based Number Board was therefore chosen as the main instructional medium for the intervention. The CRA approach was hypothesized to improve students' conceptual understanding, reduce cognitive load in problem solving, and ultimately improve students' learning outcomes in measures of central tendency, particularly students at risk of being slow learners, by providing students the opportunity to manipulate concrete materials, organize visual representations of data, and gradually progress to symbolic mathematical operations.

Cycle I

Cycle I was carried out to improve students' understanding of measures of central tendency through the use of the Concrete–Representational–Abstract (CRA)-based Number Board. Before the intervention, instructional materials like lesson plans, student worksheets, observation sheets, assessment instruments and the Number Board were prepared taking into

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account the learning characteristics of students at risk of being slow learners. The intervention was comprised of three instructional sessions. The first meeting was on the concepts of mode and median, the second meeting was on the concept of mean and the third meeting was on assessing students' conceptual understanding through an individual achievement test. The students, during their learning, engaged in activities that followed the three sequential stages of the CRA approach. In the Concrete stage, students used unit and tens sticks to physically represent numerical data. During the Representational stage, these concrete experiences were converted into visual representations by the systematic arrangement of data on the Number Board. In the Abstract stage, students finally determined the mode, median and mean independently using mathematical symbols and procedures. Students showed a significant improvement in comparison with the baseline condition after the first cycle of intervention. The achievement test administered at the end of Cycle I showed that the class mean score rose from 49.00 to 64.00 and the percentage of students who reached the minimum mastery criterion rose from 33% to 67%. Fourteen of the twenty-one students achieved mastery and seven students were below the expected standard. Most importantly, five of the twelve students identified as being at risk for being slow learners met the minimum mastery criterion compared to none on the initial assessment. The results indicate that the CRA-based Number Board was starting to aid the students' understanding of statistical concepts through a gradual transition from concrete experiences to symbolic mathematical reasoning, although the learning outcomes had not yet reached the predetermined success indicator.

Table 2. *Students' Learning Outcomes in Cycle I*

Learning Outcomes	Students at Risk of Slow Learning	Other Students	Total	Percentage	Category
Score < 70	7	0	7	33%	Not Mastered
Score ≥ 70	5	9	14	67%	Mastered
Class Mean Score			**64.00**		
Classical Mastery				**67%**	**Fair**

A content analysis of the students' responses showed that after manipulating the concrete materials, most students were able to identify the mode correctly. However, there were more difficulties in finding the median and especially the mean which both required multiple computational steps of ordering, addition and division. Some students understood the individual steps, but were unable to put them together in a complete problem-solving sequence. Therefore, although the procedural accuracy had been enhanced in comparison to the initial state, the conceptual understanding of the measures of central tendency had not yet been consistently developed by all students, especially by those who were at risk of being slow learners.

The classroom observations also indicated positive changes in the students' engagement in the learning activities. Students became more interested in playing with the Number Board, discussing statistical problems with their peers, and engaging in group problem solving activities. However, the level of engagement differed between the three phases of the CRA method. Table 3 showed that students' participation rate was 63% in the Concrete stage, 60% in the Representational stage, and 56% in the Abstract stage. The results suggest that students were more comfortable using concrete manipulatives than transforming visual representations into symbolic mathematical expressions. The progressive drop in participation across the CRA stages indicates that students continued to be challenged by increasing cognitive demands as learning moved from concrete experiences to abstract reasoning.

Table 3. *Observation Results of Students at Risk of Being Slow Learners in Cycle I*

CRA Stage	Percentage	Category
Concrete	63%	Fair
Representational	60%	Fair
Abstract	56%	Poor

Further classroom observations revealed several learning behaviors to explain these outcomes. During the Concrete stage most students were excited about playing with unit and tens sticks and could match physical objects with numerical quantities fairly accurately. However, some students in the Representational stage still required the teacher's assistance to correctly organize the numerical data and to transform concrete manipulations into visual representations on the Number Board. The greatest difficulties encountered during the Abstract stage when students had to do symbolic calculations on their own. Many students hesitated in applying the operations of addition and division, asked confirmation from the teacher and sometimes went back to work with the concrete materials before proceeding to the symbolic calculations. These observations suggest that students were not yet in a position to fully internalize the conceptual relationships between concrete representations and abstract mathematical procedures.

At the end of Cycle I, reflection showed that there were still several instructional challenges. Students who were at risk of being slow learners continued to have a significant difficulty during the representational and abstract stages especially in solving problems involving numbers beyond twenty. While the Number Board was effective in increasing students' motivation, participation and willingness to engage in collaborative learning, many students still relied on teacher guidance to convert concrete experiences to symbolic mathematical reasoning. Since five of the twelve students at risk of being slow learners achieved the minimum mastery criterion (the predetermined success indicator, that at least 70% of these students attain learning mastery) had not yet been met. Instructional modifications were therefore planned for Cycle II, including the simplification of numerical values, the strengthening of guided practice in the representational and abstract phases, and the provision of more intense scaffolding to support students' independent mathematical reasoning.

Cycle II

Based on the reflection results of Cycle I, several pedagogical improvements were introduced in Cycle II to tackle the remaining learning difficulties experienced by students at risk of being slow learners. The lesson plans and student

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worksheets were revised to provide more structured guidance throughout the Concrete-Representational-Abstract (CRA) learning sequence. In addition, the numerical examples used in classroom activities and assessments were simplified by limiting the values to numbers below 20, thus reducing the cognitive load of students during the addition and division operations needed to establish the mode, median, and mean. The Number Board was the primary instructional tool because it gave students an opportunity to work with physical objects and then transition to visual representations and symbolic procedures of mathematics. The intervention was composed of three meetings as in Cycle I. The first meeting was about learning the concepts of mode and median and the second meeting was about the concept of mean. In both meetings, students performed collaborative learning activities based on the CRA sequence. Students worked with unit and tens sticks on the Number Board to physically sort data in the concrete stage. In the representational stage they represented these concrete arrangements visually by ordering data and finding statistical patterns. Finally, in the abstract stage, students used mathematical symbols and numerical operations to calculate mode, median and mean and presented and discussed their solutions with classmates. The third meeting was dedicated to assessing students' conceptual knowledge through an individual achievement test.

The learning outcomes obtained in Cycle II showed a significant increase compared to Cycle I. Based on Table 4, it is known that the average score of the class in Cycle I is 64.00 and in Cycle II is 77.00. The classical learning mastery has increased from 67% to 86%. Out of the 21 students, 18 students met the minimum mastery criteria, with only three students falling below the expected score. Moreover, the nine students without any identified learning difficulties achieved mastery and the number of students at risk for being slow learners who met the mastery criterion increased from five students in Cycle I to nine students in Cycle II. The results show that the instructional changes in Cycle II were effective in improving students' understanding of measures of central tendency.

Table 4. *Students' Learning Outcomes in Cycle II*

Learning Outcomes	Students at Risk of Slow Learning	Other Students	Total	Percentage	Category
Score < 70	3	0	3	14%	Not Mastered
Score ≥ 70	9	9	18	86%	Mastered
Class Mean Score			**77.00**		
Classical Mastery				**86%**	**Good**

A closer look at the twelve students who were at risk of being slow learners showed that there was marked progress in achievement and participation in the class. The average achievement score in Cycle I was 50.83 and in Cycle II was 65.83. The percentage of students who achieved the mastery criterion was 42% and in Cycle II was 75%. Nine students attained the minimum mastery criterion, with three students performing below the expected level. While these three students continued to have difficulties in performing abstract mathematical operations, they nevertheless showed gradual improvement in comparison with their performance in the previous cycle. Classroom observations also revealed significant gains in student engagement throughout the CRA learning process. Students' confidence in manipulating concrete materials increased as they built visual representations and made symbolic calculations. As shown in Table 5, the mean observation scores were 76% for the concrete stage, 73% for the representational stage, and 70% for the abstract stage, all of which achieved the established success criterion. The most improvement was found in the abstract stage, compared to Cycle I, which means that the students would be able to transfer their concrete experience into abstract mathematical reasoning better after being exposed repeatedly to the CRA sequence.

Table 5. *Observation Results of Students at Risk of Being Slow Learners in Cycle II*

CRA Stage	Percentage	Category
Concrete	76%	Good
Representational	73%	Good
Abstract	70%	Good

The reflection at the end of Cycle II indicated that the instructional modifications were successful in overcoming most of the learning difficulties found in Cycle I. Several students who had previously failed to achieve mastery were able to perform addition, division, and data ordering procedures more accurately by simplifying numerical values and providing additional guided practice. Students also became more and more familiar with the use of the Number Board which allowed them to move more confidently to representational thinking and then to abstract problem solving from the concrete manipulative. Overall the CRA-based Number Board was effective in improving both classroom participation and conceptual understanding of measures of central tendency, although three students with more severe learning difficulties continued to require intensive support. The classroom action research was concluded after Cycle II because the success criterion that had been set was achieved, which was that at least 70% of students achieved mastery in learning.

Discussion

This classroom action research found the use of the Concrete-Representational-Abstract (CRA)-based Number Board effective in improving the learning process and students' conceptual understanding of measures of central tendency, especially for students at risk of being slow learners. This improvement was shown in the gradual increase in learning achievement in the two cycles of the intervention. The class mean score was 49.00 in the pre-cycle and increased to 77.00 in Cycle II, classical learning mastery improved significantly from 33% to 86%. Most importantly, the average score of students at risk of being slow learners increased from 32.50 to 65.83 with an increase in mastery learning from 0% to 75%. The results suggest that the CRA-based Number Board provided meaningful learning experiences that enabled students to build up statistical concepts step by step from concrete manipulation, visual representation to abstract reasoning. The use of concrete manipulatives, namely unit and tens sticks incorporated into the Number Board is the main reason for the

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improvement in the students' conceptual understanding. In the concrete phase kids moved the sticks around to represent numbers of things and then did statistics on them. The technique lessened the cognitive load of addition and division which had been a significant barrier for students at risk of being slow learners. By means of concrete learning materials, the students were able to establish meaningful associations between numerical quantities and statistical concepts before moving onto symbolic procedures. These results are consistent with the research of Pamungkas and Sriwahyuningsih (2025) which found that concrete instructional media can be effective to support students with slow learning characteristics by helping them to form concepts gradually and improving their procedural skills.

Another important finding is the function of the Number Board as a visual representational tool that connected students' concrete experiences and abstract mathematical thinking. The Number Board was not just a manipulative; it allowed students to organize numbers in an orderly way, to identify statistical trends, and to see the steps necessary to find the mode, median, and mean. This finding further reinforces the significance of developing instructional media that are adapted to the cognitive characteristics of students with intellectual learning difficulties through structured and sequential learning experiences. In this regard, Handoyo et al. (2024) emphasized that the instructional media for students with intellectual disabilities should be tailored to the learners' cognitive, motor, social, and emotional characteristics and offer clear and well-organized learning stages. The success of the intervention was also evident in the gradual improvement in all three stages of the CRA instructional sequence. At the classroom level, the students' participation in the Concrete stage increased from 74% in Cycle I to 84% in Cycle II, in the Representational stage from 72% to 82%, and in the Abstract stage from 71% to 78%. Students at risk of being slow learners also showed similar gains, suggesting that the systematic progression from concrete manipulation to abstract reasoning helped foster the gradual development of conceptual understanding. The results indicate that effective mathematics instruction for students with learning difficulties should not focus exclusively on symbolic computation but rather provide structured opportunities for students to progress through each cognitive stage in an incremental fashion.

Students' engagement and procedural understanding were especially enhanced by the Concrete stage. The data of observation showed that the students at risk of being slow learners rose their participation in this stage from 63% in Cycle I to 76% in Cycle II. There was a significant improvement for those students who had difficulty manipulating the Number Board in the first place, e.g. MRI and S, with additional guidance and repeated hands-on activities. Students explored mathematical relationships through meaningful physical experiences before they were asked to perform symbolic calculations, using unit sticks and tens sticks for direct manipulation. Our results are in agreement with Flores and Hinton (2019) who have suggested that concrete manipulatives allow students to build mathematical concepts through direct contact with real objects, prior to moving towards more abstract ways of thinking.

The Representational stage was an essential stage in the transition from concrete experiences to symbolic reasoning. The participation of students at risk of slow learners increased from 60% to 73% at this stage. Students organized numerical data, created visual patterns on the Number Board, and represented their concrete manipulations graphically during this phase before doing formal calculations. With the teacher's assistance, students who initially struggled to organize numerical data learned how to order data from smallest to largest and how to visually represent statistical relationships. This is consistent with Mudaly and Naidoo (2015) who define the representational stage as a critical point of transition in which learners internalise mathematical concepts through diagrams and visual models before moving into abstract symbolic reasoning. The most conceptual progress was in the Abstract stage when the students transferred their concrete and visual experiences into mathematical symbols and procedures. Among slow learners, the observation findings were 56 percent in Cycle I and increased to 70 percent in Cycle II. With repeated practice using the Number Board and concrete manipulatives, students like G and YN, who found addition and division challenging, were able to calculate the mode, median, and mean. This progression suggests that symbolic mathematical reasoning is better developed following concrete and representational learning experience. Hence, the findings support the argument by Hinton and Flores (2022) that students are more likely to solve mathematical problems independently at the abstract level after mastering the concepts through concrete manipulation and visual representation.

The results were positive, but some students still had learning difficulties during the intervention. Three students (AH, MI and MRA) did not achieve mastery criteria at the end of Cycle II. Classroom observations showed that these students were more interested in playing with the unit and tens sticks as objects than using them to solve mathematical problems. Thus, the focus shifted to the manipulatives themselves rather than the statistical concepts behind them. This finding supports Thompson (2016) who cautioned that manipulative materials will not improve mathematical understanding automatically without appropriate instructional guidance and continuous teacher scaffolding. But for students with more severe learning difficulties, manipulatives still need individualised support in order to function as cognitive tools and not just attractive learning objects. The findings show that the improvement of students' understanding of measures of central tendency was due to the proper integration of the three sequential stages of the Concrete–Representational–Abstract (CRA) approach. The Number Board based on CRA allowed students to start learning by manipulating concrete objects directly and then gradually translate these experiences into visual representations and finally do symbolic mathematical operations with more confidence and conceptual understanding. Hence, this study provides empirical evidence that the CRA-based Number Board is an effective instructional medium for promoting mathematics learning in inclusive classrooms especially for slow learners who need structured, sequenced and multisensory learning experiences in the development of abstract mathematical concepts.

CONCLUSION

This classroom action research proved the implementation of the Concrete-Representational-Abstract (CRA)-based Number Board was effective to improve the learning process and students' understanding of measures of central tendency among Grade VIII-B students at risk of being slow learners at SMP Negeri 2 Jenamas. The participation of students at all the stages of CRA showed an improvement. The Observation scores at Concrete stage ranged from 63% to 76%, Representational stage

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from 60% to 73% and Abstract stage from 56% to 70%. The students' conceptual understanding also improved significantly, as evidenced by the increase in the average achievement score from 32.50 in the initial condition to 50.83 in Cycle I and 65.83 in Cycle II, and mastery learning increased from 0% to 42% and finally 75%. The results reveal that the CRA-based Number Board met the predetermined success criteria and is an effective instructional medium for supporting mathematics learning for students at risk of being slow learners. The findings suggest that teachers should use the CRA-based Number Board in teaching mathematics, especially in teaching abstract concepts to students who are at risk of slow learning, because it provides meaningful learning experiences with a gradual movement from concrete manipulation to abstract reasoning. Schools are required to provide adequate learning resources and facilities that facilitate inclusive teaching practices that support the application of innovative instructional media. Further investigations are suggested to test the effectiveness of the CRA-based Number Board in different mathematical topics, educational levels, and larger groups of participants to further strengthen the empirical evidence of its application for inclusive mathematics education.

References

1. Abdur Rahman As'ari, Tohir, M., Valentino, E., Imron, Z., & Taufiq, I. (2017). Matematika SMP/MTs Kelas VIII (2nd ed.). Pusat Kurikulum dan Perbukuan, Balitbang, Kementerian Pendidikan dan Kebudayaan.
2. Arianti, D., et al. (2019). Pembelajaran matematika berbasis kompetensi. Kencana.
3. Arikunto, S., Suhardjono, & Supardi. (2017). Penelitian tindakan kelas. Bumi Aksara.
4. Ariyanti, I. D. (2019). Pengaruh model pembelajaran kontekstual dengan media papan bilangan terhadap hasil belajar matematika.
5. Arsyad, A. (2017). Media pembelajaran. RajaGrafindo Persada.
6. Astuti, F. (2021). Analisis ranah kognitif Taksonomi Bloom revisi. Piwulang Journal. https://journal.unnes.ac.id/sju/piwulang/article/view/47031
7. Azmi, M. P. (2016). Penerapan pendekatan Concrete–Representational–Abstract (CRA). Jurnal Pengajaran Matematika. https://ejournal.upi.edu/index.php/jpmipa/article/view/36249
8. Chasanah, N. A., Sisworo, & Dwiyana, D. (2019). Meningkatkan penalaran matematis siswa pada materi ukuran pemusatan data melalui pendekatan problem posing (Doctoral dissertation, Universitas Negeri Malang).
9. Cui, L., & Liu, Z. (2021). Synergy between research on ensemble perception, data visualization, and statistics education: A tutorial review. Attention, Perception, & Psychophysics, 83(3), 1290–1311. https://doi.org/10.3758/s13414-020-02212-x
10. Daryati, M. E., Suryadi, D., & Indrawati, I. (2026). CRA method to improve problem solving. Aulad. https://www.aulad.org/index.php/aulad/article/view/1370
11. Dian, F. A. (2024). Analisis kemampuan representasi matematis siswa dalam menyelesaikan soal kontekstual pada materi statistika.
12. Fadilah, A., Nurzakiyah, K. R., Kanya, N. A., Hidayat, S. P., & Setiawan, U. (2023). Pengertian media, tujuan, fungsi, manfaat dan urgensi media pembelajaran. Journal of Student Research, 1(2), 1–17.
13. Flores, M. M., & Hinton, V. (2020). Teaching fraction concepts using the concrete–representational–abstract sequence. Remedial and Special Education. https://doi.org/10.1177/0741932518795477
14. Gunawan, S. (2018). Pembelajaran terstruktur untuk anak berkebutuhan khusus. Rosda.
15. Hamid, H. (2020). Pendekatan terhadap anak dengan hambatan belajar: Strategi pembelajaran yang efektif. RajaGrafindo Persada.
16. Handoyo, R. R., Ishartiwi, & Taqiyah, D. B. (2024). Analisis kebutuhan alat peraga edukatif di Sekolah Luar Biasa. Literal: Disability Studies Journal, 2(2), 87–96.
17. Hidayati, N. (2019). Pendekatan terhadap anak dengan hambatan belajar. Remaja Rosdakarya.
18. Huda, A. (2021). Pemanfaatan teknologi untuk anak dengan hambatan belajar. Jurnal Teknologi Pendidikan.
19. Ipindi, R., Zurfadly, A., Prawinata, M. G., Putra, M. A., & Alfassa, A. I. (2025). Mengenal ukuran pemusatan data dalam ilmu statistika dasar. ALPHA: Journal of Statistics Demography and Engineering, 1(1), 49–54.
20. Irdamurni. (2019). Faktor penyebab lamban belajar siswa kelas VIII A di SMPN 25 Jambi (Master's thesis, Universitas Jambi).
21. Isnaeni, N., Sessu, A., & Hadi, W. (2020). Pengaruh pendekatan Concrete Representational Abstract (CRA) berbantu alat peraga terhadap kemampuan representasi matematis siswa. Edumatica: Jurnal Pendidikan Matematika.
22. Jihad, A., & Haris, A. (2022). Evaluasi pembelajaran. Bumi Aksara.
23. Juhanda, A. (2016). Analisis soal berdasarkan Taksonomi Bloom revisi. JPMIPA. https://ejournal.upi.edu/index.php/jpmipa/article/view/36258
24. Kemmis, S., & McTaggart, R. (2014). The action research planner: Doing critical participatory action research. Springer. https://doi.org/10.1007/978-981-4560-67-2
25. Kusnadi, S. (2020). Psikologi anak dengan kebutuhan khusus. Bumi Aksara.
26. Latifah, H. (2020). Strategi pembelajaran individual untuk anak berkebutuhan khusus. Rajawali Press.
27. Lomibao, L. S., et al. (2016). Kemampuan komunikasi matematis dalam menyelesaikan masalah. Prosiding Universitas Negeri Semarang.
28. Lyytinen, K., Topi, H., & Tang, J. (2023). MaCuDE IS Task Force Phase II report: Views of industry leaders on big data analytics and AI. Communications of the Association for Information Systems, 52, 429–464. https://doi.org/10.17705/1CAIS.05217
29. Martias, L. D. (2021). Statistika deskriptif sebagai kumpulan informasi. Fihris: Jurnal Ilmu Perpustakaan dan Informasi, 16(1), 40–59.
30. Marta, M. A., & Purnomo, D. (2025). Konsep Taksonomi Bloom dalam desain pembelajaran. Lencana Journal. https://ejurnal.politeknikpratama.ac.id/index.php/Lencana/article/view/4572
31. Maulana, R. (2022). Analisis capaian pembelajaran berbasis Taksonomi Bloom revisi. Jurnal PTK dan Pendidikan. https://jurnal.uin-antasari.ac.id/index.php/ptkpend/article/view/7621

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32. Monte, J. L. (2024). An exploration of manipulatives in math education. https://www.academia.edu/download/112030589/viewcontent.pdf
33. Muhammad, I., & Ariani, S. (2021). Kognisi Taksonomi Bloom dan penerapannya. Jurnal Mudarrisuna. https://jurnal.ar-raniry.ac.id/index.php/mudarrisuna/article/view/6303
34. Muliawati, N. E. (2020). Kemampuan pemecahan masalah siswa melalui pendekatan Concrete Representational Abstract (CRA). Jurnal Pendidikan dan Pembelajaran Matematika.
35. Nasir, F., Nurhidayah, S., & Anindiyah, S. (2019). Students' mathematical representation ability in learning fractions through a Concrete–Representational–Abstract approach. Jurnal Pendidikan Guru Sekolah Dasar.
36. Nasution, R. P., & Amir, A. (2025). Peran ukuran pemusatan dan penyebaran data dalam analisis statistika. Pendas: Jurnal Ilmiah Pendidikan Dasar, 10(4), 332–350.
37. Nugroho, R. (2021). Pentingnya kolaborasi antara guru, orang tua, dan profesional dalam pembelajaran anak berkebutuhan khusus. Jurnal Pendidikan Inklusif.
38. Nursyamsi, M., & Wulandari, D. (2021). Penguatan positif dalam pembelajaran anak berkebutuhan khusus. Bumi Aksara.
39. Nuryati, & Darsinah. (2021). Implementasi teori perkembangan kognitif Jean Piaget. JPAPEDA.
40. Okoth, O. P. (2021). Exploring the use of concrete materials in teaching and learning of fractions in Grade Three (Master's thesis, Aga Khan University). https://ecommons.aku.edu/theses_dissertations/2005/
41. Özdemir, R. (2017). The investigation of virtual concrete-representational-abstract model to teach one-digit multiplication word problem (Doctoral dissertation). ProQuest.
42. Pamungkas, B., & Sriwahyuningsih, Y. (2025). (Lengkapi sesuai artikel yang digunakan dalam sitasi). ← Referensi ini perlu dilengkapi jika digunakan di pembahasan.
43. Permendikdasmen Nomor 12 Tahun 2025.
44. Pramudyasti, S. (2017). Pengaruh media papan telur terhadap kemampuan pengenalan konsep bilangan. https://repositori.unimma.ac.id/427/
45. Riduwan. (2016). Skala pengukuran variabel-variabel penelitian. Alfabeta.
46. Rifki, A., Rahimah, S., Arianto, A., & Zulpan, Z. (2026). Ukuran pemusatan dan penyebaran data. Educational Journal, 1(3), 798–804.
47. Rizki, I., & Mulyani, S. (2022). Hambatan belajar pada anak dan dampaknya terhadap prestasi akademik di sekolah. Jurnal Psikologi Pendidikan.
48. Rusman. (2018). Model-model pembelajaran: Mengembangkan profesionalisme guru. Rajawali Pers.
49. Santoso, R. (2024). Peran pendidik dalam penanganan anak dengan hambatan belajar. Jurnal Pendidikan Inklusif Indonesia.
50. Sriwahyuningsih, Y., & Pamungkas, B. (2025). Parenting programs supporting parents' skills for children with special needs. Indonesian Journal of Innovation Studies, 26(4). https://doi.org/10.21070/ijins.v26i4
51. Sudijono, A. (2018). Pengantar statistik pendidikan. Rajawali Pers.
52. Sugiyono. (2019). Metode penelitian kuantitatif, kualitatif, dan R&D. Alfabeta.
53. Sutaryo. (2022). Pendekatan pendidikan untuk anak dengan hambatan belajar: Teori dan praktik. Kencana.
54. Thompson, T. (2016). The effects of concrete, virtual, and multimodal tangram manipulatives on elementary students' mathematics achievement (Doctoral dissertation, Oklahoma State University). https://openresearch.okstate.edu/bitstreams/5f23e39e-abf7-4484-b2b2-03f536b6b9d1/download
55. Waseso, I. (2018). Psikologi pendidikan. Kencana.
56. Widodo, B. (2023). Mengadaptasi pembelajaran untuk anak dengan gangguan belajar. Jurnal Pendidikan Anak Berkebutuhan Khusus.
57. Winkel, W. S. (2018). Psikologi pendidikan dan pembelajaran. Gramedia.
58. Wulandari, A. (2022). Pengembangan media papan dalam pembelajaran matematika. https://repository.stkippacitan.ac.id/id/eprint/922/
59. Yulianto, T. (2020). Strategi fleksibel dalam pembelajaran anak dengan gangguan perhatian. Jurnal Psikologi Pendidikan.
60. Zulfakri, Z., Ikhsan, M., & Yusrizal. (2019). Improving mathematical representation through the Concrete–Representational–Abstract approach. International Journal for Educational and Vocational Studies. https://ojs.unimal.ac.id/ijevs/article/view/1585

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