

Mathematics Learning with Concrete Manipulatives among Second-Grade Students at SDN Tridadi: A Perspective on the Concrete Operational Stage

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Abstract

Mathematics learning in elementary schools needs to consider students' cognitive development, particularly among second-grade students who are beginning to develop logical thinking while still relying on concrete experiences. Although Jean Piaget's theory of cognitive development has been widely discussed in relation to elementary mathematics education, empirical evidence of how characteristics of the concrete operational stage are manifested in actual classroom learning remains limited. This study aims to examine the characteristics of the concrete operational stage in mathematics learning among second-grade students and to explore the role of concrete manipulatives in supporting their understanding of mathematical concepts. A descriptive qualitative approach was employed involving 15 second-grade students at SDN Tridadi selected through purposive sampling. Data were collected through structured classroom observations and clinical interviews, while source and method triangulation were used to strengthen the credibility of the findings. The data were analyzed using an interactive qualitative analysis model consisting of data reduction, descriptive data presentation, and conclusion drawing. The findings indicate that the students demonstrated characteristics of the early concrete operational stage. Classification and number conservation were observed during mathematics learning, while reversibility was still developing and required support through concrete objects. The use of concrete manipulatives provided opportunities for students to directly manipulate, compare, and represent mathematical quantities when solving addition and subtraction problems. Clinical interviews further showed that students' reasoning was closely related to their ability to visualize and manipulate concrete quantities. The study concludes that empirical observation of second-grade students provides important insight into the manifestation of the concrete operational stage in actual mathematics learning. Mathematics instruction that considers students' cognitive developmental characteristics and incorporates concrete manipulatives can provide learning experiences that connect mathematical concepts with concrete and observable experiences.

Keywords: Cognitive Development; Concrete Manipulatives; Concrete Operational Stage; Mathematics Learning; Second-Grade Students

INTRODUCTION

Cognitive development plays an important role in how children understand and respond to learning experiences. In elementary education, differences in cognitive development are particularly relevant because students do not acquire mathematical concepts only through memorization but also through processes of reasoning, representation, and problem solving (Saputra & Suryandi, 2020). Each developmental stage is associated with particular ways of processing information; therefore, instructional activities need to provide learning experiences that correspond to students' cognitive characteristics (Fadila et al., 2026). This consideration is especially important in mathematics, where students are expected to move from understanding

observable quantities and situations toward increasingly symbolic and abstract representations.

Jean Piaget's theory of cognitive development provides an important framework for understanding this transition. Children in the concrete operational stage begin to demonstrate logical reasoning, particularly when dealing with objects, quantities, and situations that can be directly observed or manipulated. At this stage, abilities such as classification, conservation, reversibility, and decentration gradually develop. However, logical reasoning is still closely associated with concrete experiences, making tangible objects and representations relevant to the learning of mathematical concepts (Rukayah & Fuady, 2026; Rizqiyati et al., 2023). For mathematics learning, this characteristic means that students may require opportunities to work with concrete representations before they can consistently understand corresponding abstract symbols and procedures.

This issue is particularly relevant for second-grade students, who are at an early phase of the concrete operational stage. At this level, students encounter mathematical operations such as addition and subtraction that require them to understand numerical relationships rather than merely reproduce written procedures. The use of concrete manipulatives can provide direct experiences through which students can count, compare, combine, separate, and represent quantities. Such activities allow researchers and teachers to observe not only whether students obtain correct answers but also how they reason when solving mathematical problems. In this context, concepts such as conservation and reversibility become useful indicators for examining students' developing mathematical reasoning.

The relevance of developmentally appropriate mathematics learning is also consistent with the orientation of the Merdeka Curriculum, which emphasizes learning that considers students' needs, characteristics, and learning development. Within this orientation, teachers are expected to understand students' learning conditions and provide learning experiences that support meaningful understanding rather than relying solely on the delivery of information. For young learners, concrete learning experiences can therefore serve as one way of connecting students' existing experiences with mathematical representations. The use of concrete manipulatives is particularly relevant when students are still developing the cognitive structures needed to interpret abstract mathematical symbols.

Nevertheless, understanding the relationship between cognitive development and mathematics learning requires more than a general application of Piaget's theoretical stages. Existing discussions have extensively explained the characteristics of the concrete operational stage and its relevance to elementary education, but theoretical explanations do not necessarily describe how these characteristics appear in students' actual classroom behavior. In particular, there is a need for classroom-based evidence showing how second-grade students demonstrate classification, conservation, and reversibility while interacting with concrete mathematical objects and how their reasoning can be understood through direct observation and follow-up interviews. Empirical observation is important because students' observable actions and verbal explanations may reveal aspects of their reasoning that cannot be adequately captured through theoretical descriptions alone.

The present study addresses this gap by examining the cognitive characteristics of 15 second-grade students at SDN Tridadi during mathematics learning involving concrete manipulatives. Rather than attempting to evaluate Piaget's theory as a whole or generalize the findings to elementary school students in general, this study focuses on a specific classroom context and explores how characteristics of the concrete operational stage are manifested during mathematical activities. The novelty of the study lies in connecting Piaget's concrete operational perspective with direct classroom evidence from second-grade students, particularly through the combination of structured observations and clinical interviews. This approach enables the study to examine students' mathematical actions together with the reasoning they provide when explaining those actions.

Based on this focus, the study aims to describe the manifestation of the concrete

operational stage among second-grade students during mathematics learning with concrete manipulatives and to examine how students' observed behaviors and explanations reflect developing mathematical reasoning. The study is limited to the classroom context of SDN Tridadi and does not seek to establish a statistical effect or generalize the findings to all elementary school students. The study is guided by the following (RQs) Research Questions:

1. How are the characteristics of the concrete operational stage manifested in second-grade students during mathematics learning at SDN Tridadi?
2. How do second-grade students demonstrate classification, number conservation, and reversibility when solving mathematics problems using concrete manipulatives?
3. How do students' classroom behaviors and clinical interview responses describe their mathematical reasoning during the learning activities?

LITERATURE REVIEW

Jean Piaget's Cognitive Development Theory

Jean Piaget conceptualized cognitive development as an active process through which children construct and reorganize knowledge through interaction with their environment. From this perspective, children are not passive recipients of information but actively construct understanding based on their experiences. Cognitive development therefore involves qualitative changes in the ways children organize, interpret, and reason about information.

A central concept in Piaget's theory is the schema, which refers to an organized structure of knowledge that individuals use to interpret experiences. As children encounter new experiences, existing schemas may be expanded or modified through the processes of assimilation and accommodation. Assimilation occurs when new experiences are incorporated into an existing schema, whereas accommodation occurs when existing schemas are modified because they cannot adequately explain a new experience. The interaction between these processes contributes to equilibration, through which children gradually develop more organized cognitive structures.

These mechanisms are relevant to mathematics learning because students continuously encounter new numerical relationships and problem-solving situations. Students may initially use an existing schema to interpret a mathematical problem. When new information is consistent with that schema, assimilation may occur. When the existing schema is insufficient to explain the new situation, accommodation may be required. Mathematics learning can therefore involve the construction and reorganization of knowledge rather than the simple memorization of procedures.

The Concrete Operational Stage

The concrete operational stage is characterized by an increasing ability to use logical reasoning when dealing with concrete objects and situations. During this stage, children develop cognitive abilities such as classification, conservation, reversibility, and decentration. However, their reasoning remains closely related to experiences and objects that can be directly observed or manipulated.

The concrete operational stage is particularly relevant to the present study because the participants are second-grade students who are developing mathematical reasoning through direct interaction with quantities and objects. Rather than assuming that all students demonstrate these abilities at the same level, classroom observation provides an opportunity to examine how such characteristics are expressed in actual learning activities.

Three characteristics are central to this study. Classification refers to the ability to group objects according to common characteristics. Conservation refers to understanding that a quantity remains unchanged despite changes in physical arrangement. Reversibility refers to the ability to understand that an action or operation can be mentally reversed. These characteristics

are particularly relevant to elementary mathematics because students encounter activities involving grouping, comparing, combining, separating, and relating numerical quantities.

Cognitive Characteristics Relevant to Mathematics Learning

Table 1. Cognitive Characteristics Relevant to Mathematics Learning in the Concrete Operational Stage

Cognitive characteristic	Definition	Relevance to mathematics learning
Classification	Ability to group objects according to shared characteristics	Grouping and organizing mathematical quantities or objects
Conservation	Understanding that quantity remains unchanged despite changes in arrangement	Understanding numerical quantity and comparing groups of objects
Reversibility	Ability to understand that an operation or action can be mentally reversed	Understanding the relationship between addition and subtraction

The characteristics presented in Table 1 provide specific indicators for interpreting the empirical data in this study. Classification can be observed when students organize concrete objects according to quantity or other characteristics. Conservation can be examined when students determine whether the quantity of objects remains the same after the objects are rearranged. Reversibility can be observed when students recognize relationships between operations, such as understanding that a subtraction operation can reverse an addition process. These characteristics should not be interpreted as isolated abilities. Students' cognitive development is dynamic, and their performance may vary according to the type of task, representation, and learning context. Consequently, the present study examines both students' observable actions and their explanations obtained through clinical interviews.

Concrete Manipulatives in Mathematics Learning

Concrete manipulatives are physical objects that students can directly handle, arrange, compare, and transform during learning activities. Examples include counting blocks, counters, sticks, number cards, and other objects that represent mathematical quantities. These materials can help students connect physical experiences with mathematical representations. The use of concrete manipulatives is relevant to students whose reasoning is still closely associated with concrete experiences. In addition and subtraction activities, for example, students can physically combine or separate objects to represent mathematical operations. Through these activities, students can observe changes in quantity and relate those changes to numerical symbols and operations.

Concrete manipulatives also provide an opportunity to observe students' mathematical reasoning. Their actions may indicate how they classify objects, compare quantities, recognize conservation, and establish relationships between mathematical operations. However, manipulation of objects alone does not necessarily demonstrate conceptual understanding. Students' actions therefore need to be considered together with their verbal explanations. This consideration provides a rationale for combining classroom observation with clinical interviews in the present study.

Theoretical Position of the Present Study

The present study positions Piaget's concrete operational stage as a theoretical lens for interpreting students' mathematical behaviors and reasoning, rather than as a framework for evaluating the entire theory of cognitive development. Mathematics learning provides the empirical context, while concrete manipulatives provide opportunities for students to interact directly with mathematical quantities. The relationship among the main concepts can be described as follows:

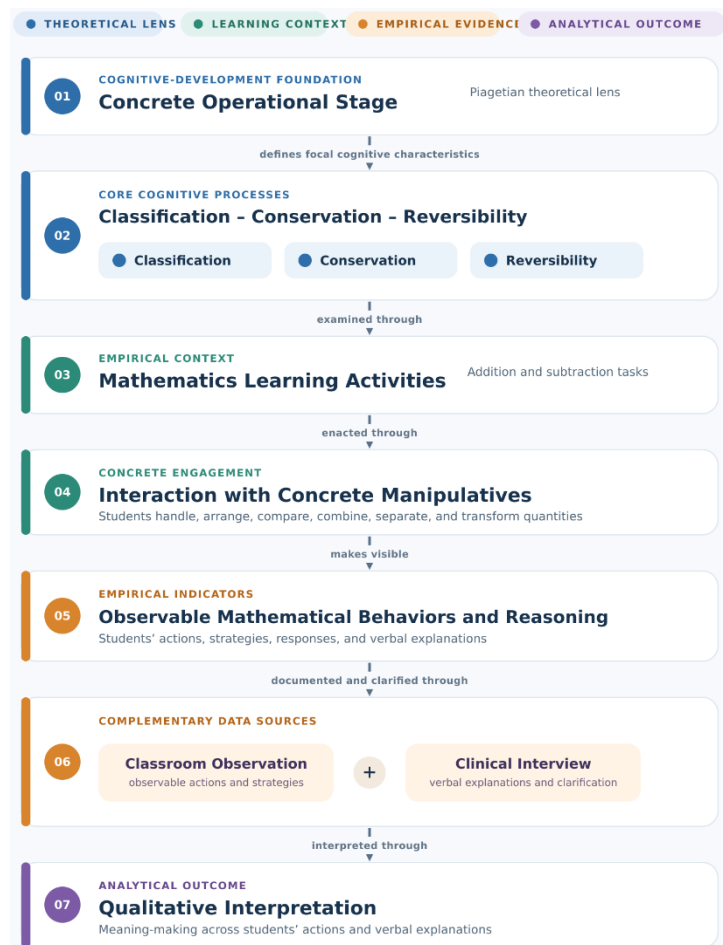


Figure 1. Conceptual and Analytical Framework of the Study

METHODS

Research Design and Setting

This study employed a descriptive qualitative research design to obtain an in-depth description of the cognitive characteristics demonstrated by second-grade students during mathematics learning involving concrete manipulatives. The descriptive qualitative approach was selected because the study focused on describing students' observable behaviors, reasoning processes, and verbal explanations rather than statistically measuring the effect of an instructional treatment. The analysis was guided by Jean Piaget's theory of cognitive development, particularly the characteristics of the concrete operational stage and the processes of assimilation, accommodation, and equilibration.

The study was conducted in a second-grade classroom at SDN Tridadi. The mathematics learning activities focused on basic numerical operations, particularly addition and subtraction, using concrete manipulatives. These activities provided students with opportunities to count, combine, separate, compare, and rearrange concrete quantities. Such activities were considered appropriate contexts for observing characteristics associated with the concrete operational stage, particularly classification, conservation, and reversibility.

Participants and Sampling

The participants consisted of 15 second-grade students at SDN Tridadi. The participants were selected using purposive sampling based on the focus and objectives of the study. Second-grade students were selected because they are generally developing characteristics associated with the concrete operational stage, in which logical reasoning begins to develop while reasoning remains closely related to concrete objects and observable situations (Nabilah et al., 2024).

The inclusion criteria were that participants were officially enrolled as second-grade

students at SDN Tridadi, participated in the mathematics learning activities involving concrete manipulatives, and were available for the classroom observation and follow-up clinical interview procedures. The selection was therefore based on the relevance of the participants' developmental characteristics to the phenomenon being investigated rather than on statistical representativeness.

All 15 students were involved in the classroom learning activities and were observed during the research process. The clinical interviews were conducted following the learning activities to obtain additional information regarding students' reasoning and to clarify their observable responses.

Research Procedure

The research procedure consisted of three stages: planning, mathematics learning and observation, and follow-up clinical interviews. In the planning stage, the researcher prepared mathematics learning activities supported by concrete manipulatives. The activities were designed to provide students with direct experiences in representing and solving addition and subtraction problems. The researcher also prepared structured observation guidelines and clinical interview prompts based on the cognitive characteristics relevant to the concrete operational stage.

During the mathematics learning stage, students interacted directly with concrete objects to solve mathematical problems. The researcher conducted structured classroom observations and documented students' actions, responses, strategies, and explanations. Particular attention was given to students' abilities to classify objects, recognize the conservation of quantity, understand reversible relationships between mathematical operations, and connect concrete representations with mathematical ideas.

The observation process did not focus solely on whether students obtained correct answers. It also examined how students manipulated concrete objects, how they responded when the arrangement of objects changed, how they explained their solutions, and how they related physical actions to numerical operations. These observations provided the primary empirical basis for interpreting students' developing cognitive characteristics. After the learning activities, individual clinical interviews were conducted to explore the reasoning underlying selected classroom behaviors. The interviews were used to clarify students' responses and to determine whether their observable actions were accompanied by corresponding conceptual explanations.

Observation Instrument

The primary observation instrument was a structured observation sheet developed based on the characteristics of the concrete operational stage and the objectives of the mathematics learning activities. The instrument focused on observable behaviors and verbal responses demonstrated while students interacted with concrete mathematical objects.

Table 2. The observation indicators

Cognitive aspect	Observation indicator	Observable evidence
Classification	Ability to group or organize concrete objects according to relevant characteristics	Students group objects based on quantity, type, or other relevant characteristics
Conservation	Understanding that quantity remains unchanged despite changes in physical arrangement	Students recognize or explain that the number of objects remains the same after rearrangement
Reversibility	Understanding that an action or mathematical operation can be reversed	Students recognize relationships between addition and subtraction or explain how a quantity can return to its initial condition
Decentration	Ability to consider more than one relevant aspect of a situation	Students consider quantity and arrangement when comparing groups of objects rather than relying on

		only one physical characteristic
Abstraction	Ability to connect concrete representations with mathematical symbols or procedures	Students use concrete objects to explain or represent a corresponding numerical operation

The observation sheet was supplemented by field notes containing relevant classroom interactions, students’ spontaneous statements, problem-solving strategies, and contextual conditions that could help explain their responses. The indicators functioned as qualitative analytical categories rather than numerical scores.

Clinical Interview Procedure

The clinical interviews were conducted individually after the mathematics learning activities. The interview procedure used prepared prompts while allowing follow-up questions to be adjusted according to each student’s responses. This format enabled the researcher to explore the reasoning behind students’ observable actions rather than simply recording whether their answers were correct or incorrect. The interview prompts addressed the main cognitive indicators examined in the study. Examples included questions such as:

- Classification: *“Why did you put these objects into the same group?”*
- Conservation: *“If these objects are moved farther apart, do you think the number of objects is still the same? Why?”*
- Reversibility: *“If these objects are combined and then some are taken away, what happens? Can you explain how you know?”*
- Mathematical reasoning: *“Can you show me how you got this answer using the objects?”*
- Concrete-symbolic connection: *“How does what you did with these objects relate to the number sentence?”*

Follow-up questions were used when students provided unclear or incomplete explanations. The interviews were intended to obtain a deeper understanding of students’ reasoning and to provide additional evidence for interpreting the observation findings. The students’ interview responses were documented and used together with the classroom observation records during the analysis process. Thus, the clinical interviews functioned as a complementary source of evidence for understanding the cognitive processes reflected in students’ classroom behavior.

Data Triangulation

Triangulation was conducted by comparing classroom observation data with clinical interview data. The observation data provided evidence of students’ actual behaviors during mathematics learning, while the interview data provided information about the reasoning students used to explain those behaviors.

The triangulation process involved three steps. First, the researcher identified relevant behaviors from the observation records, particularly those related to classification, conservation, reversibility, decentration, and abstraction. Second, the researcher compared these observations with students’ explanations obtained through clinical interviews. Third, the researcher examined whether the two forms of evidence supported, clarified, or contradicted the initial interpretation.

When observation and interview data were consistent, the two sources were considered complementary evidence supporting the interpretation. When discrepancies occurred, the researcher returned to the original observation records and interview responses and reconsidered the context in which the behavior and explanation occurred. The final interpretation was therefore based on the convergence of available evidence rather than on a single observation or statement. The triangulation procedure in this study was primarily method triangulation, as classroom observation and clinical interviews were used to examine the same cognitive phenomena from complementary perspectives.

Data Analysis

The collected data were analyzed using an interactive qualitative data analysis process consisting of data reduction, data presentation, and conclusion drawing (Kartika et al., [2023](#)). The analysis was conducted systematically by moving between the observation records, interview data, coding categories, and emerging interpretations.

First, the researcher organized the observation sheets, field notes, and clinical interview records. The data were read repeatedly to identify information relevant to the research questions. During data reduction, information unrelated to students' cognitive characteristics and mathematical reasoning was excluded from the main analysis, while observations and statements relevant to the research focus were retained.

Second, the researcher conducted initial coding of relevant data segments. The initial codes were developed based on the theoretical framework and the patterns emerging from the empirical data. The deductive codes included classification, conservation, reversibility, decentration, abstraction, assimilation, accommodation, and equilibration. Additional descriptive codes were used when students demonstrated behaviors or explanations that were not adequately represented by the initial categories. Third, related codes were grouped into broader categories. For example, students' recognition that the quantity of objects remained unchanged after rearrangement, together with explanations supporting that recognition, was categorized as evidence related to conservation. Similarly, students' understanding of the relationship between combining and separating quantities was categorized as evidence related to reversibility.

Fourth, the categories were compared across classroom observation and clinical interview data. Recurring patterns, supporting evidence, and discrepancies were identified. The researcher then developed themes describing how characteristics of the concrete operational stage were manifested during mathematics learning with concrete manipulatives. Finally, the researcher reviewed the coded data, categories, and themes in relation to the research questions and Piaget's theoretical framework. Conclusions were drawn from patterns supported by the collected evidence. The analysis was interpretive and descriptive and was not intended to establish statistical effectiveness or causal relationships.

Trustworthiness

The credibility of the findings was strengthened through the comparison of classroom observation data and clinical interview data. The two methods provided complementary evidence regarding students' observable behaviors and their underlying explanations.

The researcher also maintained a systematic record of the data collection and analysis process, including observation records, interview documentation, coding results, category development, and analytical decisions. These records provided an **audit trail** that enabled the progression from the original data to the final interpretation to be traced.

In addition, the researcher repeatedly reviewed the observation and interview data during the coding and interpretation process. Particular attention was given to cases in which students' observable actions and verbal explanations did not initially appear consistent. Such cases were reconsidered in relation to the learning context before being included in the final interpretation.

Ethical Considerations

Because the participants were elementary school students, ethical considerations were applied throughout the research process. Permission to conduct the research was obtained from the relevant school authority before data collection. The research activities were conducted within the regular mathematics learning context and were designed to avoid physical or psychological harm to the students.

The identities of the participants were protected during data processing and reporting. Student names were not used in the presentation of the findings; instead, participant codes were

used where individual responses needed to be identified. The collected observation and interview data were used solely for research purposes and were handled confidentially. Participation in the research activities was conducted with the appropriate permission from the school. Students were informed about the activities in language appropriate to their age, and their participation in interviews was conducted in a manner that did not place pressure on them to provide particular answers.

RESULT AND DISCUSSION

Result

Overview of Students' Cognitive Characteristics

The findings were obtained from classroom observations of 15 second-grade students at SDN Tridadi and follow-up clinical interviews conducted to clarify students' reasoning during mathematics learning activities involving concrete manipulatives. The analysis focused on the cognitive characteristics relevant to the concrete operational stage, particularly classification, conservation, reversibility, decentration, and the connection between concrete representations and mathematical symbols.

The observations indicated that the students demonstrated characteristics associated with the early concrete operational stage, although these characteristics were not manifested uniformly across all students or all learning situations. Students generally showed greater confidence when mathematical quantities could be directly represented and manipulated using concrete objects. In contrast, when students were required to explain the same mathematical relationship without direct manipulation of objects, their reasoning was sometimes less consistent and required additional explanation or representation. The qualitative findings are summarized in Table 3.

Table 3. Thematic Summary of Students' Cognitive Characteristics

Cognitive indicator	Observation evidence	Clinical interview evidence	Interpretation
Classification	Students grouped and organized concrete objects according to quantity or other relevant characteristics during mathematics activities	Students were able to explain why objects were placed in the same group	Students demonstrated developing classification ability
Conservation	Students recognized that the number of objects remained unchanged when their arrangement was modified	Students explained that rearranging the objects did not necessarily change their quantity	Students demonstrated an emerging understanding of number conservation
Reversibility	Students used concrete objects to combine and separate quantities, but some required additional visual support to explain the reverse relationship	Students could explain the relationship between addition and subtraction when supported by concrete or pictorial representations	Reversibility was developing and was not equally stable across learning situations
Decentration	Students considered quantity and arrangement when comparing concrete objects in selected learning activities	Some students were able to provide explanations that considered more than one aspect of the situation	Decentration was beginning to emerge in students' mathematical reasoning
Abstraction	Students connected concrete objects with numerical operations, although some relied on objects or visual representations when explaining the operation	Students more readily explained solutions when they could refer to the concrete representation	The transition from concrete representation to symbolic representation was still developing

Classification and Number Conservation

Classification was observed when students organized concrete objects according to relevant characteristics during mathematics activities. Students were able to group objects and

use the resulting groups to represent mathematical quantities. Their responses suggested that they could identify similarities and differences among objects and use these characteristics when completing mathematical tasks.

Number conservation was also observed during activities in which the arrangement of concrete objects was changed. Students were able to recognize that changing the distance or arrangement of objects did not necessarily change the number of objects. However, the consistency of this reasoning varied among students and depended on the representation used in the task.

For example, when students were asked to compare two groups containing the same number of objects after one group had been rearranged, several students maintained that the quantities were still equal. Their explanations generally referred to the number of objects that had been counted rather than only to the physical length or spread of the arrangement. This observation was further explored through clinical interviews, in which students were asked to explain why the quantity remained the same after the objects were rearranged. These findings indicate that number conservation was present in the students' mathematical reasoning, although its manifestation was not identical across all students and situations.

Reversibility in Addition and Subtraction

Reversibility emerged as another important characteristic during the mathematics learning activities. Students were able to use concrete objects to represent addition by combining quantities and subtraction by separating quantities. The concrete representation helped students visualize the relationship between the two operations.

However, when the concrete objects were removed and students were asked to reason using numerical representations alone, some students required additional time or visual support before explaining the relationship between the operations. Their responses became more consistent when they were allowed to refer again to the concrete representation. Clinical interviews provided additional evidence regarding this pattern. When students were asked to demonstrate how a quantity could return to its initial condition after an operation, they were generally able to explain the process more clearly when they could manipulate or visualize the objects. This suggests that reversibility was developing but was still closely associated with concrete representations.

The findings therefore indicate that students' difficulty with symbolic representations should be understood in relation to the form of the mathematical task. The data do not indicate a general inability to reason logically; rather, they suggest that logical reasoning was more readily expressed when students could connect the problem to concrete quantities.

Assimilation and Accommodation During Mathematics Learning

The observation and interview data also showed indications of assimilation and accommodation during mathematics learning. Students appeared to use existing experiences with quantities to interpret new mathematical situations. For example, subtraction problems involving the removal or loss of objects could be related to familiar experiences of having fewer objects after some objects were taken away.

During clinical interviews, students sometimes explained mathematical operations using everyday situations. One participant, identified as AN, explained a subtraction situation by relating it to a familiar context involving animals:

"Yesterday, when we were learning about caring for animals, I imagined having five chickens, then two died, so there were three chickens left in the coop."

This response illustrates how the student connected a mathematical operation with an existing experiential schema. The response can be interpreted as an example of assimilation because the student related the mathematical concept of subtraction to a familiar situation.

In contrast, accommodation was observed when students encountered mathematical relationships that could not be explained adequately using their initial strategies. In these situations, students sometimes required concrete objects, visual representations, or additional questioning to reorganize their understanding. The evidence suggests that students were developing new mathematical schemas through interaction between their existing knowledge and the learning situations provided.

Connection Between Concrete and Symbolic Representations

A recurring pattern in the data was the difference between students' responses when concrete objects were available and their responses when mathematical information was presented symbolically. During activities involving seeds, sticks, or other concrete objects, students were able to demonstrate mathematical operations through direct manipulation. They could count, combine, separate, and compare quantities.

When the same relationships were represented primarily through numerical symbols, some students required additional visual support or questioning. Their explanations were often clearer after the researcher connected the numerical expression to the concrete objects previously used in the activity.

This pattern was also reflected in the clinical interviews. Students were generally able to explain their solutions more readily when they could refer to the objects or mentally reconstruct the concrete situation. The findings suggest that the transition from concrete mathematical experiences toward symbolic abstraction was still developing among the participants.

Summary of the Empirical Findings

Overall, the observations and clinical interviews showed three main patterns. First, students demonstrated developing abilities in classification and number conservation when working with concrete mathematical objects. Second, reversibility was emerging but was more readily demonstrated when students could manipulate or visualize concrete quantities. Third, the transition from concrete representations to symbolic mathematical representations was not equally stable across students. The findings therefore suggest that the 15 second-grade students demonstrated characteristics associated with the early concrete operational stage, but these characteristics varied according to the cognitive demand and representation used in the mathematics activities.

Discussion

Manifestation of the Concrete Operational Stage in Mathematics Learning

The findings indicate that the mathematical reasoning of the second-grade students was closely related to concrete experiences. Students demonstrated classification and number conservation when they were provided with objects that could be directly grouped, counted, compared, and rearranged. This pattern is consistent with the characteristics of Piaget's concrete operational stage, in which logical reasoning develops through situations that remain connected to concrete objects and observable relationships.

The findings should not, however, be interpreted as conclusive confirmation of Piaget's theory. The study involved only 15 students in one classroom and used a qualitative approach. Instead, the findings are consistent with Piagetian descriptions of children's developing logical reasoning and provide classroom-based illustrations of how these characteristics may appear during mathematics learning.

The results also show why cognitive development needs to be considered in the presentation of mathematical concepts. When students were able to manipulate concrete quantities, they could demonstrate mathematical relationships through observable actions. This supports the argument that mathematical learning for young students can benefit from representations that connect abstract numerical ideas with experiences that students can directly observe and manipulate (Jusniani et al., [2023](#)).

Conservation, Classification, and Mathematical Reasoning

The development of classification and conservation observed in this study is relevant to elementary mathematics because both abilities support students' understanding of quantity and relationships among mathematical objects. Students' ability to maintain the idea of quantity after an arrangement was changed indicates that their reasoning was not based solely on the physical appearance of the objects.

At the same time, variation among students suggests that cognitive development should not be treated as a uniform process. Students may demonstrate a particular cognitive characteristic in one task but require support in another task with a greater level of abstraction. This finding is important for teachers because observing students' responses can provide information about which representations and explanations are most appropriate for a particular learning situation.

Reversibility and the Relationship Between Addition and Subtraction

The findings concerning reversibility are also consistent with the role of reversible thinking in the concrete operational stage. Students could represent addition and subtraction through concrete manipulation and gradually recognize the relationship between the two operations. However, their reasoning became less stable when the concrete representation was removed.

This finding suggests that the relationship between addition and subtraction should not be introduced only as a symbolic rule. Concrete activities can allow students to experience the inverse relationship directly. For example, students can combine two groups of objects and subsequently remove one group to reconstruct the original quantity. Such experiences provide an observable basis for understanding the relationship between the two operations.

This interpretation is consistent with previous research emphasizing the importance of concrete representations in supporting elementary students' mathematical understanding (Siregar, 2023). In the context of the present study, concrete manipulatives were not interpreted as independently producing cognitive development. Rather, they provided a learning context in which students could express and explore mathematical relationships that were relevant to their developing cognitive structures.

Assimilation, Accommodation, and Students' Everyday Experiences

The interview data also illustrate how students used familiar experiences when explaining mathematical concepts. AN's explanation of subtraction through the example of chickens demonstrates how a mathematical operation could be connected with an existing experiential schema. This pattern can be interpreted through Piaget's concept of assimilation, in which new information is incorporated into an existing cognitive structure.

Accommodation becomes relevant when students encounter situations that cannot be adequately explained through their existing schemas. In the present study, students who initially relied on direct counting or addition strategies sometimes required concrete representations and additional questioning when dealing with new mathematical relationships. These observations suggest that mathematics learning can involve a process of reorganizing existing understanding rather than simply adding new information.

The findings are therefore consistent with the view that meaningful learning occurs when new mathematical experiences are connected with students' existing knowledge and experiences (Diana et al., 2022). However, because the study did not experimentally examine cognitive mechanisms, assimilation and accommodation are treated as interpretive concepts rather than directly measurable psychological processes.

The Role of Concrete Manipulatives

The findings provide classroom-based evidence that concrete manipulatives created

opportunities for students to directly represent mathematical quantities. Students could count, combine, separate, and compare objects before relating these actions to numerical representations. This was particularly relevant for addition and subtraction activities.

The use of manipulatives should therefore be understood as a supporting instructional representation, rather than as proof that concrete materials are universally effective. The qualitative data show that students' explanations were often clearer when they could refer to concrete quantities, but the study did not measure learning gains statistically.

This distinction is important because the present study was designed to describe students' cognitive characteristics rather than to test the effectiveness of a particular instructional medium. The findings suggest that teachers may use concrete manipulatives as one strategy for making mathematical relationships observable and discussable, particularly when students have difficulty connecting numerical symbols with quantities.

Implications for Mathematics Teachers

The findings have several practical implications for mathematics teachers working with second-grade students. First, teachers can begin mathematical activities with concrete representations before gradually introducing more abstract numerical representations. Second, teachers can observe not only students' final answers but also the strategies they use to reach those answers. Third, when students experience difficulty with symbolic operations, teachers can return to concrete or pictorial representations and ask students to explain the relationship between the representation and the mathematical expression.

Teachers can also use questions that encourage students to explain their reasoning, such as asking why the quantity remains unchanged after objects are rearranged or how subtraction can reverse an addition process. Such questions can provide information about students' developing classification, conservation, and reversibility abilities.

These implications are consistent with the broader principle that mathematics instruction should consider students' developmental characteristics and provide opportunities for active engagement with mathematical concepts. However, the findings should be applied as contextual instructional considerations rather than generalized prescriptions for all elementary students.

Limitations of the Study

This study has several limitations. First, the participants consisted of only 15 second-grade students from one school, namely SDN Tridadi, which limits the transferability of the findings to other educational contexts. Second, the study used a descriptive qualitative design, so the findings cannot be used to establish statistical effects or causal relationships between concrete manipulatives and students' mathematical achievement. Third, the observation period was limited to the research activities conducted during the study, meaning that the findings represent students' cognitive characteristics within the observed learning context rather than their development over an extended period. Finally, the interpretation of cognitive characteristics was based on classroom observations and clinical interviews and should therefore be understood as a contextual interpretation of students' reasoning rather than a comprehensive assessment of cognitive development.

Future studies may involve a larger number of classrooms, longer observation periods, and multiple schools to examine whether similar patterns emerge across different learning contexts. Quantitative or mixed-methods research could also be used if the objective is to examine changes in mathematical achievement or the effectiveness of particular instructional materials.

CONCLUSION

Based on the findings and discussion, the 15 second-grade students at SDN Tridadi demonstrated cognitive characteristics that were consistent with the early concrete operational

stage during mathematics learning. The students showed developing abilities in classification and number conservation when working with concrete mathematical objects. Reversibility and the transition from concrete representations to symbolic mathematical reasoning were also observed, although these abilities were not equally stable across learning situations. Students generally expressed mathematical reasoning more clearly when they could manipulate or visualize concrete quantities. The findings suggest that concrete manipulatives provided meaningful opportunities for students to represent, compare, combine, and separate mathematical quantities during addition and subtraction activities. The students' classroom behaviors and clinical interview responses also indicated that concrete representations helped connect mathematical ideas with familiar experiences. From a Piagetian perspective, these findings are consistent with the view that children's mathematical reasoning develops through active interaction with their environment and through the gradual organization and reorganization of existing cognitive structures. However, the present study does not establish that concrete manipulatives directly cause cognitive development or improved mathematical achievement.

For mathematics teachers, the findings suggest several practical considerations. Teachers may introduce mathematical concepts through concrete objects before gradually moving toward pictorial and symbolic representations. Teachers can also use observation and questioning to identify how students reason, rather than relying only on the correctness of their final answers. When students experience difficulties with abstract numerical representations, returning to concrete or pictorial representations may provide additional support for connecting mathematical symbols with quantities. Learning activities that encourage students to explain, compare, and reverse mathematical operations may also provide opportunities to develop logical reasoning. This study has several limitations. The participants were limited to 15 second-grade students in one school, SDN Tridadi, so the findings should not be generalized to all elementary school students. The study also employed a descriptive qualitative design, meaning that it cannot establish statistical effects or causal relationships between the use of concrete manipulatives and students' mathematical achievement. In addition, the observation period was limited to the learning activities conducted during the study, and therefore the findings do not describe students' cognitive development over a long-term period. The interpretation was based primarily on classroom observations and clinical interviews within one specific learning context. Future research may involve participants from several schools, longer observation periods, and multiple learning contexts to obtain a broader understanding of how concrete operational characteristics are manifested in mathematics learning. Studies using quantitative or mixed-methods designs may also be conducted when the objective is to examine changes in mathematical achievement or the effectiveness of specific concrete learning materials.

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