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Students' Understanding Of The Ideal Concept In Ring Algebra Structure Course

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ABSTRACT
Conceptual understanding is a fundamental aspect of mathematics learning, particularly in algebraic structures such as subrings and ideals. Many students struggle to grasp these concepts, which negatively impacts their critical thinking and problem-solving abilities. This study aims to analyze the level of conceptual understanding among students in algebra structure learning and identify influencing factors, particularly from the perspectives of mathematical ability and creative thinking skills. This research uses a library research method with a descriptive qualitative approach, reviewing various research findings from nationally and internationally accredited journals published over the last five years. The results show that students with high mathematical abilities have better conceptual understanding, can construct mathematical arguments, and demonstrate highly creative thinking. Conversely, students with lower abilities struggle with interpreting concepts, generalizing, and composing logical solutions. The findings underscore the importance of concept-based learning approaches and problem-solving strategies to enhance students' understanding in the ring algebra structure course.

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INTRODUCTION

Mathematics is a cornerstone of the development of science and technology. Present across all educational levels, from elementary to higher education, mathematics plays an irreplaceable role in shaping logical, critical, and systematic thinking. It goes beyond numbers and operations, functioning as a language of symbols, a system of deductive logic, and a method for understanding patterns, structures, and abstract relationships. Therefore, mathematics is aptly referred to as the "queen and servant of the sciences." The growth of information and communication technology, for example, is deeply rooted in mathematical theories such as number theory, abstract algebra, mathematical analysis, and discrete mathematics. According to Arifin and Rahayu (2023), mathematical thinking is a crucial prerequisite for mastering science and technology, making early conceptual reinforcement essential for nurturing innovative generations.

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A key aspect of advanced mathematics education is a strong conceptual understanding, which includes the ability to connect mathematical concepts, explain ideas, and apply them in new contexts. Modern mathematics curricula, particularly at the tertiary level, emphasize a deep understanding of concepts like algebraic structures—not only teaching theories but also enhancing students' proof and reasoning skills.

Algebraic structure is a branch of abstract mathematics comprising sets and binary operations, such as groups, rings, and fields. Students are expected to comprehend definitions, axioms, and theorem proofs deductively and logically. Research by Rahmawati and Safitri (2021) reveals that students proficient in algebraic structures can better relate fundamental mathematical concepts to real-world applications.

As Purwanti et al. (2020) explain, algebraic reasoning involves generalizing patterns, evaluating arguments, and proving mathematical statements. This process is essential for solving complex mathematical problems. In the context of ring theory, the concept of ideals is one of the core topics that illustrate how elements in a ring form closed structures under certain operations.

Recent studies also highlight the importance of innovative learning media and contextual approaches to enhance students' conceptual understanding and mathematical reasoning. For instance, problem-based learning worksheets significantly improve critical and in-depth thinking skills (Handayani & Mustofa, 2024). Furthermore, character- and personality-based personalized learning positively influences mathematics achievement (Sari & Fitriani, 2025). Against this backdrop, this study focuses on evaluating students' competence in understanding the concept of ideals in ring structures and how this understanding supports mathematical thinking and reasoning at the tertiary level.

RESEARCH METHOD

This study employs a literature review method, also known as library research, which focuses on collecting data from various documentary sources, both printed and electronic. This method was chosen because the nature of the study does not require direct data

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collection in the field but rather involves a critical review of relevant and credible previous scholarly works. According to Fitriana and Wardhani (2020), literature review is an effective approach for exploring in-depth conceptual and theoretical information through various scientific references, such as accredited journals, textbooks, and prior research findings.

The data collected in this study were analyzed using content analysis, a systematic technique for examining, identifying, and interpreting the meaning of written texts. This method enables researchers to conduct an in-depth review of the content of documents or literature to draw valid, evidence-based conclusions. As explained by Mustofa and Fadhilah (2022), content analysis is a suitable approach for uncovering hidden meanings, logical structures, and patterns of thought within the scientific documents under investigation.

The steps involved in the data analysis include:

1. **Identification and selection** of sources relevant to the research topic, particularly those from nationally accredited journals (SINTA) and reputable international journals.
2. **Data categorization** based on relevant themes, concepts, or theories.
3. **Content classification** to examine the consistency of findings, perspectives used, and scientific contributions of each source.
4. **Interpretation and conclusion drawing**, involving synthesizing the analyzed data to formulate research findings in an objective and systematic manner.

This research is **descriptive-qualitative** in nature, resulting in a scientific narrative constructed through a logical and critical synthesis of the reviewed literature. This approach is particularly appropriate for conceptual studies in mathematics, especially in exploring students' understanding and reasoning regarding the concept of ideals within ring structures.

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RESULTS AND DISCUSSION

Conceptual Understanding in Mathematics Learning

Conceptual understanding is one of the key indicators in assessing the success of the mathematics learning process. It not only reflects students' ability to recall information but also their capacity to explain, connect, and apply learned concepts in various contexts. According to Pratiwi and Putri (2020), conceptual understanding involves deep skills in logically and comprehensively linking mathematical ideas.

In mathematics education, three types of understanding are particularly emphasized, as adapted from Skemp's theory (in Zaini et al., 2023):

- **Procedural Understanding**, which refers to the ability to carry out specific algorithms or steps systematically without necessarily understanding why those steps are performed. This type reflects mastery of routines or formulas.
- **Instrumental Understanding**, which is outcome-oriented. Students can quickly solve problems through memorization of formulas but lack a deeper understanding of the reasoning behind the procedures (Afriadi, 2020).
- **Relational Understanding**, which represents a deeper comprehension. Students not only know the procedures but also understand the reasons behind them and the relationships between concepts. They are able to explain, provide examples, and make meaningful connections between various mathematical ideas (Sagala & Hayuhantika, 2021).

In higher education, especially in abstract mathematics courses such as Algebraic Structures, relational understanding becomes particularly crucial. Students are expected to grasp concepts such as groups, rings, and ideals not only from formal definitions but also through their implications and applications. Research by Mataheru and Huwaa (2021) shows that students with relational understanding can solve mathematical proof problems with logical and consistent arguments.

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Furthermore, conceptual understanding is closely related to the representation of mathematical information. Students who truly understand concepts can accurately interpret data from graphs, tables, and diagrams and draw valid conclusions (Rachmawati, 2023). This aligns with the findings of Nahdawiyah and Nusantara (2023), which indicate that students' relational thinking ability is evident in their capacity to construct logical arguments from various forms of representation.

Therefore, conceptual understanding goes beyond simply memorizing definitions or formulas. It encompasses reasoning skills, the ability to form connections, and the capability to explain the rationale behind mathematical processes. In mathematics education, emphasizing relational understanding is highly recommended to foster higher-order thinking skills.

1. Teori Ideal

Definisi 2.4. [4] Let $(R, +, \cdot)$ be a ring and $U \subseteq R$ with $U \neq \emptyset$. U dikatakan ideal kanan dan ideal is said to be a right and left ideal of R if:

1) U is subgroup of R under addition +.
2) For every $a \in U$ and $r \in R$ both $ar \in U$ *and* $ra \in U$.

Definisi 2.5. [5] Let R be a commutative ring with unity 1 and let $I \neq R$ be an ideal in R, The ideal *I is called a prime ideal if for any* $a, b \in I$ implies $a \in I$ or $b \in I$.

Definisi 2.6. [5] Let R be a commutative ring with unity 1 and let *I* be an ideal of R, then the radical of *I*, denoted $\sqrt{I}$ is defined as:

$$\{x \in R \mid x^n \in I \text{ for some } n \in \mathbb{N}\}$$

Definisi 2.7. [1] Let R be a commutative ring with unity 1 and let $I \neq R$ be an ideal in R, The ideal *I* is called a primary ideal if for any $ab \in I$ implies $a \in I$ atau $b^n \in I$, for some $n \in \mathbb{N}$

Conceptual Understanding in Learning Algebraic Structures

Conceptual understanding is a fundamental aspect of mathematics learning, as it underpins problem-solving abilities in both formal and real-life contexts. This aligns with

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Marzuki and Hasanah (2020), who assert that conceptual understanding supports students in developing logical, systematic, and reflective thinking that is essential for solving various types of mathematical problems.

In learning algebraic structures, particularly the topic of subrings, conceptual understanding is crucial, as this concept serves as the foundation for more advanced topics such as ideals, factor rings, and ring homomorphisms. As explained by Riyanto and Lestari (2022), understanding substructures like subrings is inseparable from students' abstract and relational thinking abilities.

Difficulties in understanding algebraic structures are well-documented. Several studies have identified key contributing factors, including:

- Students' unfamiliarity with problem-solving question formats that demand higher-order thinking skills.
- Weak mastery of foundational concepts such as addition, subtraction, multiplication, and division in abstract contexts.
- Ineffective teaching methods that are overly procedural with minimal emphasis on conceptual approaches.

Research by Nuraini and Fitria (2021) shows that students tend to be passive in abstract algebra learning due to teaching approaches that do not sufficiently address their cognitive needs, such as concept visualization and interconceptual connections. Moreover, students' mathematical ability significantly influences their understanding of substructure concepts. A study by Lestari and Hidayat (2021) categorized students' mathematical abilities into three levels: high, medium, and low. Students with high and medium abilities demonstrated a good understanding in identifying examples and non-examples of subrings and provided logical justifications for their answers. In contrast, students with lower abilities struggled to explain concepts, construct arguments, and understand symbolic notations and manipulations.

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In relation to creative thinking abilities, Khaesarani and Maysarah (2021) found that students with high mathematical ability exhibited highly creative thinking traits. This was evidenced by their fluency, flexibility, and originality in solving problems related to prime and maximal ideals. These students not only solved problems accurately but also represented their ideas clearly and comprehensively using lattice diagrams. Conversely, students with lower abilities faced difficulties in grasping abstract content, especially in defining set elements and constructing initial steps for mathematical proofs. These findings are supported by Rosyid (2020), who revealed that common errors occur in the early stages of understanding formal definitions, as well as in formulating hypotheses and drawing logical conclusions.

Therefore, it is essential for instructors to design learning experiences that emphasize relational understanding and problem-based learning approaches, so that students not only master procedures but also comprehend the underlying meanings of the concepts being studied. The use of visual supports, reflective activities, and mathematical dialogue is also recommended to enhance learning quality.

CONCLUSION

Conceptual understanding in mathematics learning, particularly in topics such as algebraic structures including subrings and idealsis crucial, as it forms the foundation for the development of higher-order thinking skills and abstract problem-solving. Students with strong mathematical abilities demonstrate solid conceptual mastery and high levels of creative thinking when solving problems related to algebraic structures. Conversely, students with lower abilities tend to struggle with interpreting notations, constructing arguments, and formulating logical solutions. These difficulties are often exacerbated by a lack of problem-solving strategies, limited exposure to contextual practice problems, and monotonous teaching methods. Therefore, success in understanding subalgebra concepts is significantly influenced by cognitive ability, creative thinking skills, and the instructional approaches employed.

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SUGGESTIONS

1) Implementation of Concept- and Problem-Based Approaches: Instructors are encouraged to integrate conceptual understanding and problem-based learning approaches in teaching algebraic structures, in order to foster students' logical and creative thinking skills.
2) Use of Visual Media and Diagrammatic Representations: Visual aids such as lattice diagrams, concept maps, and interactive models can help students visualize algebraic abstractions and gain a deeper understanding of the interrelationships among concepts.
3) Training in Problem-Solving Strategies: Students should be systematically trained to develop mathematical thinking strategies through contextualized exercises and discussions that emphasize reasoning and mathematical argumentation.
4) Ability-Based Grouping and Collaborative Learning: Grouping students based on their mathematical abilities can encourage collaboration, allowing those with stronger conceptual understanding to assist their peers in comprehending abstract concepts.
5) Creativity-Based Learning Evaluation: Assessment of student learning should not be limited to final answers, but should also evaluate the creative thinking process—such as originality of solutions, flexibility in approaches, and fluency in constructing mathematical arguments.

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