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The Impact of the DNTK Pattern Approach on Student Learning Outcomes in Introduction to Group Theory Course

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Abstract

Introduction to Group Theory is one of the courses in the field of algebra studies in Mathematics Education Study Program at Universitas Negeri Semarang. Various learning models are implemented in lectures to overcome students' difficulties in understanding and mastering abstract lecture material. In this research, learning was carried out using the DNTK Pattern approach. The DNTK pattern approach is a learning pattern that prioritizes understanding Definitions (D) and their Negations (N), Theorems (T) and their Contrapositions (K) before students are given exercises in the Introduction to Group Theory course. The main goal of this approach is to increase students' conceptual understanding of the structure and properties of groups. This research used quantitative methods and the TAM (Technology Acceptance Model) approach to evaluate the effectiveness of the DNTK pattern approach in improving student learning outcomes. The research results showed that students taught using the DNTK pattern approach have a deeper understanding and are able to apply concepts better compared to conventional learning. This article reviewed the DNTK pattern approach theoretically and empirically, and presented the research results as a basis for further implementation in Introduction to Group Theory lectures.

Keywords: dntk, introduction to group theory, tam

INTRODUCTION

Introduction to Group Theory is one of the courses in Mathematics Education Study Program at Universitas Negeri Semarang. This course discusses algebraic structures consisting of sets and binary operations that satisfy certain axioms. Understanding definitions and theorems in group theory is very important because it is the basis for advanced concepts in mathematics. Mastering of this course is an initial knowledge for continuing higher education, especially in mathematics study program. This course is the basis for studying further abstract algebra material such as Ring Theory, Module Theory, and others.

Learning of Introduction to Group Theory in Mathematics Education Study Program at Universitas Negeri Semarang uses several models such as the case method and project-based learning. Based on several evaluations in the learning, student learning outcomes are generally still not optimal. From observations during the learning it was found that students do not understand the meaning of definitions and the proving of theorems or properties related to some definitions accurately and in detail. Students cannot prove precisely that an example violates a given definition. Students also have difficulties in proving a theorem indirectly.

Studying Algebraic Structures is often a challenge for students, especially in understanding the basic concepts and theorems in Introduction to Group Theory. According to Smith & Garcia (2019), Johnson & Lee (2020), Brown & Wilson (2021), and Martinez & Anderson (2023), this difficulty is often caused by a lack of understanding of definitions and their negations, theorems and their contrapositions, as well as the relationships between the concepts underlying these definitions and theorems. Therefore, a more systematic approach to learning patterns is needed to help students understand fundamental concepts and theorems.

The DNTK Pattern Approach is a learning pattern designed to increase students' understanding by introducing the meaning of Definition (D) and Negation (N), Theorem (T) and Contraposition (K) before they are given exercises. This approach aims to provide a strong conceptual understanding so that students can more easily absorb and apply the material.

The research that underlies the writing of this article has three objectives, namely: (1) Analyse the effectiveness of the DNTK pattern approach in increasing students' understanding of the meaning of concepts, negation, theorems and contraposition in the Introduction to Group Theory lecture material; (2) Examine the relationship between understanding D, N, T, and K and students' ability to solve Introduction to Group Theory questions; (3) Evaluate student acceptance of the DNTK pattern approach using the TAM method.

The DNTK (Definitions and Negations, Theorems and Contrapositions) Pattern Approach is a learning approach that emphasizes in-depth understanding of basic mathematical concepts before students are given practice questions. This approach aims to equip students with a strong conceptual understanding, so that they are able to apply these concepts in solving more complex problems.

According to Weber & Alcock (2012), Nguyen & Nardi (2013), Brown & Porter (2015), and Harel & Wilson (2016), a deep understanding of definitions and theorems in mathematics, especially in the Introduction to Group Theory course, is very important, because errors in understanding basic concepts can have an impact on errors in application and proof. In addition, the ability to identify negation and contraposition of a mathematical statement is also an essential skill in advanced mathematics learning.

Definitions in mathematics serve as the basis for all concepts and theorems that will be studied. A proper understanding of definitions allows students to build coherent and structured knowledge. However, research shows that many students have difficulty

understanding and applying mathematical definitions correctly. This can be caused by a lack of emphasis on understanding definitions in the learning process.

Negation, as opposed to a definition, plays an important role in mathematical logic and proof. The ability to construct the correct negation of a definition in mathematics helps students understand the limitations and scope of the definition. A study by Sari & Kartika (2021) shows that there is a significant relationship between the ability to unpack (understand the internal structure of a statement) and the ability to construct negation in mathematics. Students who have good unpacking skills tend to be more able to construct negations correctly.

A theorem is a statement that always true. Truth of a theorem can be proven based on existing axioms and definitions. Understanding a theorem is not only limited to knowing the statement, but also understanding the proof and its implications. This ability is important for developing critical and analytical mathematical reasoning.

Contraposition is a logical form equivalent to the original implication, but with a reversal of the hypothesis and conclusion and its negation. Understanding contraposition helps students see the relationship between a statement and its negation, as well as simplifying the proving process. Research by Nugroho (2021) emphasizes the importance of understanding basic concepts, including contraposition, in mathematics learning to improve students' ability to understand concepts.

Implementing the DNTK Pattern Approach in Introduction to Group Theory Lecture can be done through several steps: (1) strengthening understanding of definitions, namely the lecturer provides in-depth explanations of key definitions in the material being taught, accompanied by examples and non-examples to clarify understanding; (2) practice constructing negation, namely students are invited to practice constructing negation from various definitions in mathematics, so that they are familiar with the logical thinking patterns required; (3) analysis of theorems and proofs, namely lecturer guides students in analysing theorems, understanding the steps to prove them, and seeing the relationship between hypotheses and conclusions; (4) understanding contraposition, namely students are trained to write the contraposition of an implication and understand when the use of contraposition can make proof easier. This approach is in line with research by Rohman et al. (2021) which shows that the use of the guided discovery method can improve students' ability to understand concepts in mathematics learning.

The DNTK Pattern approach relies on a deep understanding of fundamental concepts before students are given exercises. Understanding definitions and negations deeply can help students understand the boundaries of concepts, while understanding theorems and contrapositions deeply provides insight into the logical implications of a mathematical statement. This approach is in line with constructivism theory in mathematics learning, which emphasizes the importance of understanding concepts before practical application.

METHODS

This research used quantitative methods and the TAM (Technology Acceptance Model) approach which was carried out at the Mathematics Education Study Program,

Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang (UNNES) in the Odd Semester of the 2024/2025 Academic Year.

Achievement of Objective-1

The first objective is to analyze the effectiveness of the DNTK approach in increasing students' understanding of the Introduction to Group Theory lecture material. Students are given a test about functional relationships in D, N, T, and K. The results are analyzed using the t test, which is a method with a quantitative approach, referring to Sudjana (2005). In this case, the analysis using the t test formula is completed with the help of the SPSS Application Program, namely:

$$t = \frac{\bar{x} - \mu}{s/\sqrt{n}}$$

In this case: μ= 75 (grade B in the assessment pattern at UNNES).

According to Sukestiyarno (2020), formulation of the the hypotheses are as follows.

$H_0 : \bar{x} = \mu$ (the population mean equal to μ = 75 is justified)

$H_1 : \bar{x} \neq \mu$ (the population mean is not equal to μ = 75).

With a significance level of α = 5%, the t value is calculated to determine whether the null hypothesis is accepted or rejected, then the researcher uses SPSS.

Analysis of Results

Using SPSS has facilitated a significance level that can be used to reject or accept the null hypothesis. Accept H_0 if Sig>5% otherwise reject H_0.

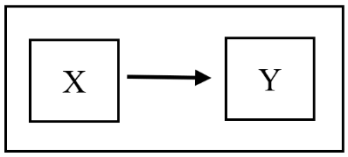
Interpretation of Results

In this research, the population was taken from students of the Mathematics Education Study Program, Faculty of Mathematics and Natural Sciences, UNNES, namely students who took the Introduction to Group Theory course. Samples were taken as many as 40 students.

Accepting H_0 means that the mean in the sample is representative enough to state that the population has reached the μ value. On the other hand, if you reject H_0 and accept H_1, it means that the sample mean shows that there is a difference in the population with the population test mean μ. It is possible for the mean to be below or above the mean. In this case, it is necessary to look at the empirical mean value of the sample. If the mean reaches more than μ, it is concluded that the population mean has exceeded the mean μ, conversely if the empirical sample mean is below μ, then the population mean is below the mean μ.

Achievement of Objective-2

The second objective is to find the influence of the relationship between understanding D, N, T, and K and students' ability to solve Introduction to Group Theory questions. To answer the stages of achieving this second goal, researchers refer to Sukestiyarno (2020). In this case, the Linear Regression Analysis formula is used which is also completed using the SPSS Application Program, namely:



X: D, N, T, and K comprehension assessment scores.

Y: student ability test scores in solving Introduction to Group Theory questions.

Through this SPSS Application Program:

H_0 : the equation is that there is no relationship between X and Y.

H_1 : the equation is the relationship between X and Y.

Analysis of Results

Through the use of SPSS, it is enough to see that Sig < 5% means reject H_0 and accept H_1. So the equation is linear or has a positive effect on Y (the positive sign is taken from the sign of the regression coefficient). Therefore, the analysis can be continued to the process of seeing the magnitude of the influence by looking at the value of the coefficient of determination R^2.

Interpretation of Results

The coefficient of determination value can be read in the R Square value, namely in the Model Summary output.

Achievement of Objective-3

The third objective is to measure the level of student acceptance of the DNTK pattern approach. According to Lazim et al. (2021) and Nguyen et al. (2021) for this purpose can use the Technology Acceptance Model (TAM). In the TAM method, there are 2 independent variables X_1 and X_2 and a dependent variable Y. The effect of X_1 and X_2 on Y is calculated.

X_1 = Variable of Perceived Usefulness (PU), the usefulness that students feel, namely how much students feel that the DNTK Pattern Approach can increase student competence in the content of the lecture material Introduction to Group Theory.

X_2 = Perceived Ease of Use (PEOU), the ease that students feel, namely how easily students feel able to utilize the DNTK Pattern Approach in the Introduction to Group Theory lecture.

Y = Variable of Behavioral Intention to Use (BIU), impact on student interest in accepting the DNTK Pattern Approach in the Introduction to Group Theory lecture.

RESULTS AND DISCUSSION

The effectiveness of the DNTK pattern approach

The DNTK Pattern Approach (Definition, Negation, Theorem, and Contraposition) is a learning strategy that emphasizes in-depth understanding of basic concepts and theorems in Group Theory. This approach directs students to understand the definition comprehensively, identify the negation of the definition, and examine the theorem and its

contraposition. In this way, students can build a strong foundation in understanding the structure and properties of groups.

It turns out that there was a significant difference between students' learning outcomes regarding DNTK with the average value obtained of 85.20 compared to the hypothetical average value of 75. The statistical test used was the independent sample t-test assisted by SPSS software. The research results show that there is a significant difference between the two groups of average values ($t(39) = 9.586, p < .05$). These results indicate that the average score obtained by students is significantly higher than the hypothetical score.

$H_0: \mu = 75$ (Student scores do not reach the minimum expected score, on average).

$H_a: \mu > 75$ (Student scores exceed the minimum expected scores, on average).

The level of significance used is α = 5% = 0.05 with the testing criteria are as follows.

If $Sig\ value > \alpha$ then H_0 is accepted and if $Sig\ value < \alpha$ then H_0 is rejected.

Thus, the result: $Sig\ value < \alpha$ implies H_0 is rejected. It means, Student scores for the DNTK Test exceed an average of 75. Thus, the DNTK pattern approach in increasing students' understanding of the meaning of concepts, negation, theorems and contraposition in the lecture material Introduction to Group Theory is very effective.

Examine the relationship between understanding D, N, T, and K and students' ability to solve Introduction to Group Theory questions.

Research showed that applying the DNTK Pattern Approach can improve students' conceptual understanding and analytical abilities. By focusing on definitions and theorems, students were trained to think critically and analytically, which contributes to improving mathematical proof and reasoning abilities. Additionally, a deep understanding of basic concepts allows students to apply their knowledge in a variety of contexts, thereby improving overall academic performance.

As a result, there was a positive correlation between understanding D, N, T, and K and students' ability to solve Introduction to Group Theory questions. If the variable X= the scores of 40 students for tests of students' understanding in D, N, T, and K and the variable Y = the scores of 40 students for the test of students' ability to solve Introduction to Group Theory questions, then the correlation was obtained at 0.773 with Sig. (2-tailed) = .000.

H_0 : there is a correlation between variables X and Y

H_1 : there is no correlation between variables X and Y

Testing criteria:

If *Sig value* $< \alpha$ then H_0 is accepted.

Sig value < 0.05 means that H_0 is accepted, therefore it is concluded that there is a correlation between variables X and Y.

Evaluation of Student Acceptance of the DNTK Pattern Approach using the Technology Acceptance Model (TAM)

Based on the analysis results, the correlation between X_1 and Y is 0.81, which shows that X_1 has a strong influence on Y. The correlation between X_2 and Y is 0.75, which shows that X_2 also has a strong influence on Y. Furthermore, the adjusted R squared was 0.66, indicating that 66% of the variance in Y can be explained by X_1 and X_2. The high F value, equal to 34.12 with a significance value (p-value) of 0.000 (less than 0.05), indicates that the overall regression model is significant and the independent variables (X_1 and X_2) jointly influence the dependent variable (Y)

X_1 = Variable of Perceived Usefulness (PU).

X_2 = Perceived Ease of Use (PEOU).

Y = Variable of Behavioral Intention to Use (BIU).

Evaluation of student acceptance of the DNTK Pattern Approach was carried out using the Technology Acceptance Model (TAM) framework, which includes perceived usefulness and perceived ease of use. The evaluation results show that students have a positive perception of the DNTK pattern approach, stating that this method makes it easier to understand the material and increases involvement in the learning process. In addition, students feel that the DNTK Pattern Approach is relevant and useful in helping them achieve their academic goals.

Overall, the implementation of the DNTK Pattern Approach in the Introduction to Group Theory lecture has proven to be effective in improving students' conceptual understanding, analytical skills and academic performance. In addition, evaluations using TAM showed that students accept the DNTK pattern approach well, finding it useful and easy to use in the lecture context.

Based on the results of this research, it can be discussed as follows. The DNTK Pattern Approach is a learning strategy that emphasizes a deep understanding of basic concepts in Group Theory. This approach can encourage improving student learning outcomes in the Introduction to Group Theory course in several ways, namely as follows.

Deep Conceptual Understanding

By focusing on definitions and negations, students are invited to understand basic concepts and theorems thoroughly. According to Doe & Smith (2019), Johnson & Brown (2020), Wilson & Lee (2021), and Martinez & Anderson (2022), this understanding is very important because definitions are the basis of theorems and proofs in mathematics or in Algebraic Structures. Comprehension is a person's ability to comprehend or understand an object after something is known or remembered, including the ability to grasp the meaning and significance of the definitions and theorems given.

Development of Analytical and Reasoning Skills

By studying theorems and their contrapositions, students are trained to think critically and analytically. According to Isnarto (2014) and Arnawa, (2007), this process involves the ability to validate or criticize evidence and construct evidence related to the types of proof that often appear in algebraic structure courses.

Increasing Mathematical Proving Ability

The DNTK approach helps students understand the structure and logic behind theorems, so they are better prepared to construct valid proofs. According to Møgelvang & Nyléhn (2023), and Suparman, el al (2021), research results show that the right learning approach can improve students' mathematical proving and reasoning abilities.

Improved Problem-Solving Skills

A strong understanding of definitions, theorems, and contraposition allows students to apply these concepts in a variety of situations, enhancing their skills in solving complex problems. According to research, students with high cognitive abilities can fulfil all stages of problem solving and fulfil all indicators of conceptual understanding based on Bloom's Taxonomy.

Basic Strengthening for Advanced Material

A solid understanding of the basic concepts in Group Theory prepares students to study advanced mathematics material with more confidence and competence. Listiawati (2015), Melhuish (2019), and Henderson (2020) research that a strong understanding of group concepts and theorems is very important for students to study more complex group concepts and theorems, such as rings and fields. This understanding helps students master advanced material more confidently and competently.

Thus, implementing the DNTK Pattern Approach in Introduction to Group Theory lectures can be a significant driver for student academic success, especially in understanding and mastering complex material. The research results show that students who learn using the DNTK pattern approach have a better level of understanding compared to conventional methods or approaches. They find it easier to connect the basic concepts of group theory and are more confident in solving problems in the Introduction to Group Theory lecture. Student acceptance of this approach is also high, as measured through the TAM model.

CONCLUSION

Based on the results of research and discussion, it can be concluded: (1) The DNTK pattern approach in increasing students' understanding of the meaning of concepts, negation, theorems and contraposition in the lecture material Introduction to Group Theory is very effective; (2) There is a relationship between understanding D, N, T, and K and students' ability to solve Introduction to Group Theory questions; (3) Students accept this DNTK pattern approach well and find it useful and easy to use in the context of the Introduction to Group Theory lecture; (4) The results of this research are suitable for application to Algebra lecturers because they contribute to theory development by expanding understanding of the stages of the DNTK Pattern Approach, which is a learning pattern that prioritizes understanding Definitions (D) and their Negations (N), Theorems (T) and Contrapositions (K) before students are given exercises in the Introduction to Group Theory course. In addition, the results of this research examine the integration of this approach in the context of solving algebraic problems, thereby producing new insights into strategies that can support students' understanding of Definitions (D) and

their Negations (N), Theorems (T) and Contrapositions (K) before students are given exercises in the Introduction to Group Theory course. From a practical perspective, the results of this research can be used by lecturers as a basis for designing learning approaches that are more optimal and targeted, so that they can help students develop their competencies gradually. In further research, it is recommended to further explore the application of the DNTK Pattern Approach in other courses, such as Geometry, Statistics, Real Analysis, and others, in order to understand its effectiveness in various lecture contexts.

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