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Effectiveness of NTGD-Based E-Books on Students' Analytical Thinking in Algebraic Derivatives Learning

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ABSTRACT
This study aims to analyze the effectiveness of an e-book based on the Numbered Team in Guided Discovery (NTGD) model in improving students' analytical thinking skills on the topic of derivatives of algebraic functions. The research employed a quantitative approach using a pre-experimental one-group pretest–posttest design involving a single class of 25 students selected through purposive sampling. The research instrument consisted of an essay-type analytical thinking skills test measuring three indicators: the ability to identify problems, analyze relationships among concepts, and draw logical conclusions. Data were analyzed using the Shapiro–Wilk normality test and a paired-samples t-test at a significance level of 0.05. The results indicated that both pretest and posttest data were normally distributed and that there was a statistically significant difference between pretest and posttest scores, with a t-value of –13.171 and a Sig. (2-tailed) value of 0.000 < 0.05. These findings indicate that the use of the NTGD-based e-book had a significant effect on improving students' analytical thinking skills on the topic of derivatives of algebraic functions. Therefore, the NTGD-based e-book is worthy of consideration as an alternative learning medium for developing higher-order thinking skills in mathematics learning.

Keywords: *Analytical Thinking Skills; NTGD-Based E-Book; Algebraic Derivatives; Mathematics*

INTRODUCTION
The development of digital technology has brought fundamental changes to instructional practices in schools, including mathematics education. This transformation requires educators not only to master subject matter content but also to effectively utilize technology as a meaningful and effective learning medium. One form of digital learning innovation that has been increasingly adopted is the e-book, which offers flexible access, multimedia integration, and the potential to promote active student engagement in the learning process (Putri et al., 2025).

In the context of mathematics learning, the use of e-books should not merely serve as a substitute for printed textbooks. Digital learning media need to be pedagogically designed to foster higher-order thinking skills, particularly analytical thinking. This ability is considered an essential 21st-century competency, as it plays a crucial role in enabling students to break down problems, connect concepts, and draw logical conclusions systematically (Mahyastuti et al., 2020). However, various research findings indicate that Indonesian students' analytical thinking skills remain relatively low, especially in mathematical topics that are abstract and require high-level reasoning (Sri Wulandari et al., 2022).

One mathematical topic that frequently poses difficulties for students is the derivative of algebraic functions. This topic demands not only procedural proficiency but also deep conceptual understanding and the ability to analyze relationships among concepts. Learning practices that remain focused on memorizing formulas tend to make students passive and less capable of explaining the reasoning underlying the procedures they use (Haqq et al., 2022)(Nurhasanah, 2022). Therefore, an instructional model that encourages active student participation while systematically developing analytical thinking skills is urgently needed.

The Numbered Team in Guided Discovery (NTGD) model is a learning approach that combines the principles of Guided Discovery Learning and Numbered Heads Together. This model emphasizes concept discovery through teacher guidance and structured group discussions, enabling students not only to independently construct mathematical concepts but also to communicate their reasoning to other group members (Sari et al., 2022). Several studies have demonstrated that instructional approaches based on guided discovery and cooperative group work are effective in enhancing students' analytical thinking skills and learning outcomes (Febriani et al., 2025).

Integrating the NTGD model into e-book media is considered an innovative solution to address the challenges of mathematics learning in the digital era. NTGD-based e-books allow for systematic, interactive, and problem-oriented presentation of learning materials, enabling students to learn both independently and collaboratively. Moreover, e-books provide opportunities for students to explore the concept of derivatives of algebraic functions through guided discovery activities, rather than merely following mechanical procedures (Maulida, 2021). Based on the above considerations, this study aims to examine the effectiveness of an e-book based on the Numbered Team in Guided Discovery (NTGD) model in improving students' analytical thinking skills on the topic of algebraic derivatives. This research is expected to provide empirical contributions to the development of digital learning media that are not only technologically innovative but also pedagogically robust in enhancing the quality of mathematics education.

METHOD

This study employs a quantitative approach with a pre-experimental research design. The specific model used is the one-group pretest–posttest design**,** which involves a single group without a control group to observe changes in students' analytical thinking skills before and after the intervention. The research design is systemically illustrated as follows : (Febriansyah, 2021)

O_1 x o_2

Note:
O_1: Pretest of analytical thinking skills.
X: Learning intervention using the NTGD E-Book.
O_2: Posttest of analytical thinking skills.

The research subjects consist of 25 students in a single class currently studying algebraic derivatives. Subjects were selected using purposive sampling**,** based on the criteria that the class had completed prerequisite materials and demonstrated readiness for digital-based learning. Utilizing a single class as the research subject aligns with the characteristics of pre-experimental research, which focuses on observing changes within a specific group (Fraenkel et al., 2012).

The research instrument is an analytical thinking skills test. The test consists of essay questions designed to measure three indicators: (1) the ability to identify problems, (2) the ability to analyze relationships between concepts, and (3) the ability to draw logical conclusions. The instrument's development refers to the characteristics of analytical thinking in mathematics education (Facione, 2011). The research procedure follows these stages:

- Administering a pretest to measure students' initial analytical thinking abilities.
- Implementing mathematics learning using the NTGD E-Book on algebraic derivative materials.
- Administering a posttest after the completion of the learning series to measure final capabilities.

Data analysis begins with a normality test **to** determine the distribution of pretest and posttest data. The Shapiro–Wilk test **is** employed because the sample size is less than 50, as this test is considered more sensitive and appropriate for small samples (Ghasemi & Zahediasl, 2012)

To test the effectiveness of the NTGD E-Book, a paired sample t-test **is** conducted to compare the mean scores of the pretest and posttest within the same group. This study uses a significance level of **0.05**. If the significance value is less than 0.05, it indicates a significant difference in students' analytical thinking skills before and after using the NTGD E-Book (Field, 2013).

RESULT AND DISCUSSION

Result

This study employed a one-group pretest–posttest design to examine the effectiveness of an E-Book based on Numbered Team in Guided Discovery (NTGD) on students' analytical thinking ability in the topic of algebraic derivatives. Data on students' analytical thinking ability were obtained through a pretest and a posttest administered to 25 students. Prior to hypothesis testing, the pretest and posttest data were examined for normality as a prerequisite for parametric statistical analysis. The normality test was conducted using the Shapiro–Wilk test. The results of the normality test are presented in the following table 1.

Table 1. Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Pretest	.147	25	.172	.929	25	.082
Postest	.135	25	.200*	.920	25	.052
*. This is a lower bound of the true significance.						
a. Lilliefors Significance Correction						

Based on the table 1, the results indicate that the significance value of the pretest in the Shapiro–Wilk test was 0.082, while the significance value of the posttest was 0.052. Since all significance values were greater than 0.05, it can be concluded that the pretest and posttest data were normally distributed.

Therefore, the analysis was continued using the Paired Samples t-Test. The results of the paired samples t-test are presented in the following table 2.

Table 2. Paired Samples Test

		Paired Differences					T	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	pretest – posttest	-58.480	22.200	4.440	-67.644	-49.316	-13.171	24	.000

Based on the results of the paired samples t-test table 2, there was a significant difference between the pretest and posttest scores. The mean difference between the pretest and posttest was –58.480, with a standard deviation of 22.200 and a standard error mean of 4.440. The 95% confidence interval ranged from –67.644 to –49.316. The obtained test statistic was t = –13.171 with 24 degrees of freedom (df) and a significance value of Sig. (2-tailed) = 0.000. Since the significance value was less than $\alpha = 0.05$, it can be concluded that there was a significant difference in students' analytical thinking ability before and after learning using the NTGD E-Book. These results indicate that the use of an E-Book based on Numbered Team in Guided Discovery (NTGD) had a significant effect on improving students' analytical thinking ability in the topic of algebraic derivatives.

Discussion

The results of the study demonstrate that learning using an E-Book based on Numbered Team in Guided Discovery (NTGD) had a significant positive impact on students' analytical thinking ability. The significant difference between pretest and posttest scores indicates that students experienced an improvement in their ability to analyze problems related to algebraic derivatives after participating in learning activities supported by the NTGD E-Book. This improvement in analytical thinking ability is closely related to the characteristics of the NTGD model, which emphasizes guided concept discovery and structured group discussion. Through the discovery stages, students are encouraged to identify problems, analyze relationships among concepts, and organize solution steps systematically. This process aligns with the indicators of analytical thinking, which require the ability to decompose problems, connect concepts, and draw logical conclusions.

In addition, the use of the E-Book as a learning medium serves as a visual and cognitive support that helps students understand the abstract concepts of algebraic derivatives. The systematic presentation of material, accompanied by examples, exercises, and NTGD-based discussion activities, enables students to develop a deeper conceptual understanding compared to conventional learning approaches that tend to focus on rote memorization of formulas.

The paired samples t-test result, which yielded t = –13.171 with a significance value of 0.000, further strengthens the empirical evidence that the improvement in students' analytical thinking ability did not occur by chance, but was a direct effect of the instructional treatment. Thus, the NTGD E-Book is proven to be effective in facilitating mathematics learning oriented toward the development of higher-order thinking skills, particularly analytical thinking.

These findings support previous studies suggesting that discovery-based learning and structured cooperative learning can enhance students' cognitive engagement and promote the development of analytical thinking skills. Therefore, the Numbered Team in Guided Discovery (NTGD) E-Book can be considered an effective alternative instructional medium for mathematics learning, especially in teaching the topic of algebraic derivatives.

CONCLUSIONS

This study demonstrates that an E-Book based on Numbered Team in Guided Discovery (NTGD) is effective in improving students' analytical thinking ability in learning algebraic derivatives. Using a one-group pretest–posttest design, the results show a significant difference between pretest and posttest scores **(**t = –13.171; p < 0.05). These findings indicate that the integration of guided discovery learning, structured cooperative activities, and digital media within the NTGD E-Book supports students in analyzing problems, connecting concepts, and developing logical reasoning. Therefore, the NTGD E-Book can be considered an effective alternative instructional medium for fostering students' analytical thinking skills in mathematics learning.

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