Enhancing Adaptive Reasoning Ability In Senior High School Students Using The Guided Inquiry Method: A Quasi-Experimental Study

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Abstract
This study aims to evaluate the effect of the guided inquiry method on students' adaptive reasoning ability at the secondary school level. With a quasi-experimental design using a Nonequivalent Control Group Design, class X IPS 1 applied guided discovery, while class X IPS 2 was the control with conventional learning. Adaptive reasoning ability data were obtained from pretests and posttests, then tested using paired-sample T-test. The results showed a significant increase in the experimental class (N-Gain: 0.64) compared to the control class (N-Gain: 0.55), with a significance value of 0.009. This finding indicates that the application of the guided discovery method has a more significant positive impact on improving students' adaptive reasoning ability when compared to conventional learning. The implication is that teachers and education practitioners can consider using this method to improve the quality of mathematics learning at the secondary school level. Further studies could explore specific aspects of this method and its long-term impact on student achievement.

INTRODUCTION
Mathematics is a rigorous field of study that examines numerical values, quantities, geometric forms, and other abstract notions that have tangible implications in practical contexts. The primary objective of mathematics education in educational institutions is to cultivate students' capacity for logical reasoning, particularly in mathematical problem-solving endeavours (Singer & Voica, 2013).
One of the primary aims of mathematics education is to cultivate in students a comprehensive mathematical proficiency encompassing various dimensions, including conceptual comprehension, procedural fluency, strategic competence, adaptive reasoning, productive disposition, and productive behaviour (Groves, 2012). The comprehensive proficiency in mathematics serves as a reflection of the individual student’s aptitude in the subject (Ala-Mutka, 2011).

The possession of adaptive reasoning skills is seen as crucial for students in establishing connections within mathematical concepts. Adaptive reasoning refers to the cognitive capacity to establish connections between various concepts and events (Nopitasari, 2016a). Adaptive reasoning is a cognitive process employed in non-routine problem-solving, reflection, explanation, and justification (Kilpatrick et al., 2001; Nahdi & Jatisunda, 2020). Adaptive thinking, characterized by a logical and complete problem-solving strategy, is vital in effectively addressing mathematical issues (Syukriani et al., 2016). Adaptive reasoning encompasses more than mere problem-solving; it entails fostering students’ logical thinking and promoting the accurate use of their reasoning abilities (Putra, 2016). The scope of adaptive reasoning is more comprehensive than reasoning in general, as the latter solely encompasses inductive and deductive reasoning. This distinction arises from including intuitive reasoning within the domain of adaptive Reasoning (Reid, 2018; Suhendra et al., 2016). Adaptive reasoning necessitates pupils to think logically, employ accurate reasoning, and attentively apply problem-solving techniques that adhere to relevant principles to answer problems grounded in preexisting knowledge (Harel & Weber, 2020). It is anticipated that students will possess the ability to enhance their adaptive reasoning skills. In addition, students are anticipated to possess the capacity to apply mathematical concepts, either through the collection of empirical data or by deriving inferences from preexisting information.

However, empirical evidence indicates that students’ proficiency in adaptive reasoning remains comparatively limited. The 2011 Trend International Mathematics and Science Study disclosed the information above, a comprehensive assessment evaluating eighth-grade students’ mathematical aptitude (Mullis et al., 2012). According to the test results, Indonesian students were rated 38th out of 42 countries. A separate survey by the Programme of International Assessment in 2018 revealed that Indonesia’s mathematics performance was The findings above shed light on the significant obstacles faced in mathematics education in Indonesia and suggest the necessity for more endeavours to enhance students’ adaptive reasoning abilities, hence enhancing their overall performance in mathematics.

The pedagogical approach to mathematics education in schools often follows an inductive method, wherein the teacher presents the subject matter, provides illustrative instances, and subsequently elucidates the problem-solving techniques (Nurcahyono et al., 2019). The above phenomenon exerts a notable influence on the learning process and emphasizes the faculties of reasoning, argumentation, and creativity. Consequently, this leads to a diminished development of adaptive reasoning skills among students (Permama et al., 2020). According to the research of Indriani et al. (2017), the adaptive reasoning ability of most students is low to very low, with 69.45% of students scoring 8-16. The research Nopitasari (2016b) Out of 38 students, 2 still have difficulties solving problems with adaptive reasoning skills. Only 3 students can solve problems well in inductive intuitive and deductive intuitive aspects.

Given the minimal demand for adaptable thinking abilities and competencies among students, it is imperative to prioritize student-centred learning by employing suitable instructional approaches. The selection of a learning methodology significantly impacts the process of acquiring knowledge and is anticipated to enhance the attainment of abilities. The guided discovery model is a viable solution
for attaining mathematics learning objectives. The guided discovery method is an instructional approach that prioritizes student-centred learning. It involves utilizing trial and error approaches, intuitive guesses, investigative processes, and conclusions. This method empowers teachers to offer advice and instructions to students throughout the learning process (Purnomo, 2011; Rasyid et al., 2022). One can motivate students to employ their thoughts, concepts, and talents to explore and uncover novel knowledge (Louth et al., 2023). Students might be motivated to utilize their ideas, thoughts, and skills to explore and acquire novel knowledge. (Purwitasari et al., 2018a). The clues are presented in the format of guided inquiries (Flores & Urrutia, 2022).

The Guided inquiry method is a pedagogical approach that multiple experts have recognized as a student-centred learning model. This method entails engaging in trial and error, employing intuitive reasoning, conducting investigations, and formulating conclusions based on the teacher’s guidance, typically delivered through questioning and step-by-step instructions provided in worksheets. This paradigm facilitates the active engagement of students in the process of concluding. Hence, the primary objective of this research is to assess the potential enhancement of students’ mathematical adaptive reasoning skills by implementing the guided inquiry method.

METHODS

This research is a quasi-experiment. The research design used in this study was Nonequivalent Control Group Design (Cohen et al., 2002). There are several stages in conducting research including the preparation stage, namely initial observation, determining the research sample, determining the material to be used, preparing a research proposal, preparing learning tools, making LKPD (Learner Worksheets), making instruments that will be used in research and conducting test instrument trials, then the research implementation stage, namely carrying out learning using the guided discovery method in the experimental class and convention learning in the control class, and conducting pretest-posttest adaptive reasoning skills in the experimental class and control class. Furthermore, the data collection technique in this study is a test technique. Adaptive reasoning ability tests before and after learning were conducted in experimental and control classes.

The population in this study were the students of class X in the 2023/2024 academic year at SMA Plus A-Tadzkir, consisting of 4 classes. Sampling was done using the purposive sampling technique, based on consideration and results of interviews with the teaching teacher with relatively the same student results before the treatment. Class X IPS 1 was selected as the experimental class, which receives learning with the guided discovery method, and Class X IPS 2 as the control class, which receives conventional learning. The data in this study required a set of test instruments. The test in this study is a description consisting of 5 questions. The material tested is an absolute value. The tests given to each class, both questions for pretest and posttest, are the same. Indicators of adaptive reasoning skills used in this study are: (1) guessing; (2) giving reasons or evidence for the truth of a statement; (3) drawing conclusions from a statement; (4) checking the validity of an argument; (5) finding patterns in a mathematical phenomenon. To obtain accurate data, the instruments used in this study must meet the criteria of a good test in terms of validity, reliability, discriminative power and difficulty index of the question.

The test instrument that will be used to collect data will first be tested on students who have received absolute value material and then analyzed for content validity using Anates software. Based on the assessment results, the test met the results of content validity with significant criteria, and then the test instrument was tested to determine the reliability, discriminating power and difficulty level. The test results showed that the test instrument had a reliability coefficient of 0.92. This result shows
that the test instrument has very high-reliability criteria. The discriminating power of the instrument has a value range of 0.21-0.41, which means that the tested test instrument has sufficient and suitable discriminating power. The difficulty of the test instrument ranges from 0.30 to 0.70, which means that the test instrument has a moderate difficulty level. The test instrument can collect data on students’ adaptive reasoning skills based on the test results.

A pretest was administered to the two samples before the treatment. It was used to determine the initial adaptive reasoning ability of the students in the experimental and control classes. In addition, each class was taught using the guided discovery method in the experimental class and a conventional learning model in the control class. After the treatment, each class was given a posttest. The posttest and pretest results were then analyzed to obtain the gain score in both classes. This analysis aims to determine the improvement in adaptive reasoning skills of students following the guided discovery method and conventional learning models. Table 1. Shows the results of the normality test of the data.

Table 1. Normality Test Results Of Students’ Adaptive Reasoning Data

<table>
<thead>
<tr>
<th>Class</th>
<th>$x^2_{\text{table}}$</th>
<th>$x^2_{\text{Count}}$</th>
<th>Test Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment</td>
<td>0,138</td>
<td>0,460</td>
<td>$H_0$ Retrieved</td>
</tr>
<tr>
<td>Control</td>
<td>0,126</td>
<td>0,460</td>
<td>$H_0$ Retrieved</td>
</tr>
</tbody>
</table>

The recapitulation of the calculation of the normality test results in Table 1 shows that the value of $x^2_{\text{table}} < x^2_{\text{Count}}$. Therefore, both the data on the adaptive reasoning ability of the students following the guided discovery method and the conventional learning method come from normally distributed populations. Next, the homogeneity of variance test was performed. The result of variance homogeneity shows that the variance of both populations is homogeneous. Therefore, the test of the similarity of the two means can be performed with the $t$-test, where the test result accepts $H_0$ if sig > 0.05. The purpose of this test is to determine whether the guided discovery method increases students’ adaptive reasoning skills.

RESULTS AND DISCUSSION

Based on the conducted research, the acquisition of data pertaining to students’ adaptive reasoning skills will be accomplished by administering pretests at the commencement of the session in experimental classes employing the guided discovery approach. In contrast, control classes will employ conventional learning methods. In the present study, information regarding the adaptive reasoning abilities of students was collected by administering posttests subsequent to their participation in experimental classes utilizing the guided discovery method, as well as control classes employing standard learning approaches.

Table 2: Adaptive Reasoning Pre-And Posttest Data From The Control Experiment

<table>
<thead>
<tr>
<th>Kelas</th>
<th>Minimal</th>
<th>Maximal</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiment</td>
<td>22</td>
<td>45</td>
<td>31,22</td>
</tr>
<tr>
<td>Control</td>
<td>20</td>
<td>45</td>
<td>30,67</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiment</td>
<td>60</td>
<td>95</td>
<td>75,57</td>
</tr>
<tr>
<td>Control</td>
<td>58</td>
<td>82</td>
<td>69,19</td>
</tr>
<tr>
<td>N-Gain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiment</td>
<td>0,36</td>
<td>0,93</td>
<td>0,64</td>
</tr>
<tr>
<td>Control</td>
<td>0,35</td>
<td>0,74</td>
<td>0,55</td>
</tr>
</tbody>
</table>
Table 2 presents the data pertaining to the pre-and posttest outcomes, along with the N-gain value, which reflects the improvement in adaptive reasoning capacity, for two distinct groups: the experimental class using the guided inquiry method and the control class employing conventional learning methods. The initial assessment results indicated that prior to instruction, the mean adaptive reasoning proficiency of students in the experimental group was 31.22, whereas in the control group, it was 30.67. Following their engagement in the educational intervention, the posttest outcomes exhibited a noteworthy augmentation, wherein the mean adaptive reasoning proficiency of the students in the experimental group reached 75.57, while in the control group, it reached 69.19. In addition, the N-Gain metric was utilized to assess the enhancement in adaptive reasoning abilities from the initial assessment to the final assessment. The experimental class exhibited a statistically significant increase in the N-Gain score, with a value of 0.64.

Conversely, the control class also saw an increase in the N-Gain score, but to a lesser extent, with a value of 0.55. The findings of this study indicate that the implementation of the guided inquiry method may yield more significant benefits in enhancing students' adaptive thinking abilities compared to traditional instructional methods. Both groups demonstrated improvement; however, the experimental class exhibited a greater degree of progress, as seen by the bigger N-gain value. The pretest and posttest data, which exhibited a normal distribution, were subjected to hypothesis testing using a parametric test (t-test) with a significance level greater than 0.05. The objective of this study is to evaluate the presence of a statistically significant disparity in students' adaptive reasoning capacity prior to and following the implementation of the adaptive reasoning method, with a significance threshold set at 5%. The findings of the t-test analysis conducted in this study utilizing the paired samples t-test are presented in Table 3. as follows.

<table>
<thead>
<tr>
<th>Table 3. T-test results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Df</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>N-Gain</td>
</tr>
</tbody>
</table>

The hypothesis was evaluated using a parametric test (t-test) with a significance level greater than 0.05, taking into consideration the pre-and posttest data as well as the normal distribution of the data. The objective of this study is to evaluate whether there exists a statistically significant disparity in the adaptive reasoning capacity of students prior to and following a learning intervention, utilizing a significance threshold of 5%. The findings of the t-test analysis conducted in this study, utilizing a paired sample t-test with a degree of freedom (df) of 52, revealed a significant value (Sig) of 0.009. The findings of this study indicate that there exists a notable disparity in the adaptive reasoning proficiency of students before to and following their exposure to the guided inquiry method in comparison to the standard style of instruction. The obtained p-value, which is less than the predetermined threshold of 0.05, suggests that the observed difference is statistically significant at the 5% level of significance, indicating that it is unlikely to have occurred by random chance. This finding suggests that the utilization of the guided discovery approach yields a beneficial impact on enhancing students' adaptive reasoning proficiency.

The Guided inquiry method is an educational strategy that facilitates the acquisition of knowledge by allowing students to actively engage in the collection, processing, and organization of information provided by the instructor (Dzamarah Syaiful Bahri, 2006). This pedagogical technique promotes student engagement in the educational process through the provision of explicit instruction and supervision from the teacher, hence facilitating comprehension and the exploration of concepts
Furthermore, the implementation of the Guided Discovery approach facilitates the development of student’s abilities to systematically, critically, rationally, and analytically explore and inquire, thus enhancing their confidence in formulating inquiries (Margunayasa et al., 2019). Consequently, pupils who possess a propensity for analytical and reflective thinking are able to articulate their discoveries with a sense of assurance. The utilization of the guided discovery method has the benefit of fostering the cognitive capacity of students (Sadeh & Zion, 2009). The guided discovery method of learning provides students with the opportunity to engage in observational activities that facilitate the process of making discoveries. The utilization of the guided discovery approach in education enhances students’ memorization process, resulting in higher levels of academic accomplishment as compared to students who are taught using conventional teaching methods (Kusniawati, 2021).

The guided discovery technique is an instructional approach that affords students the ability to actively acquire, analyze actively, and structure information presented by the instructor, leading to the deduction that this method is effective for learning purposes. The purpose of this approach is to foster students’ active engagement in the learning process through the provision of instructional direction and guidance from the teacher, hence facilitating comprehension and the exploration of various topics. One notable benefit of this approach is its capacity to augment the cognitive capabilities of pupils, particularly those inclined toward analytical and reflective thinking. The guided discovery method facilitates optimal student learning by harnessing their capacity for systematic, critical, logical, and analytical discovery and investigation. Consequently, this approach enhances their self-assurance in formulating inquiries and generating insights. The learning process is further expanded to encompass the incorporation of students’ observations and discoveries, affording them the chance to cultivate their skills in making original findings. Within a comparative framework, research has demonstrated that guided discovery learning yields superior learning outcomes when compared to standard teaching techniques.

Based on the findings derived from the conducted research and subsequent analysis of the data, it can be deduced that the implementation of the guided discovery approach yields favorable outcomes in enhancing students’ adaptive reasoning abilities (Purwitasari et al., 2018b). The outcomes and data previously analyzed indicate that this strategy has demonstrated a noteworthy influence on the enhancement of students' adaptive reasoning skills. The guided discovery method might be regarded as a more efficacious approach for enhancing students’ adaptive thinking skills within the domain of mathematics education. The discovery presented in this study has significant implications for the advancement of pedagogical approaches aimed at enhancing students’ adaptive reasoning abilities in the field of mathematics.

CONCLUSION

The implementation of the Guided inquiry method yielded a substantial enhancement in students’ aptitude for adaptive reasoning within the realm of mathematics education. The study of pretest and post-test data, along with the N-gain analysis, indicated that the experimental group, which employed the guided discovery approach, exhibited a greater improvement in adaptive reasoning ability compared to the control group that underwent traditional learning. The findings from the hypothesis testing utilizing the paired sample t-test indicated a statistically significant disparity in the adaptive reasoning capacity of the students prior to and following the implementation of the guided discovery approach. Hence, this methodology can be regarded as a viable strategy for enhancing adaptive reasoning abilities among secondary-level pupils. There are some positive
consequences associated with the development of more inventive and effective mathematics learning systems. The utilization of the guided discovery method presents a potentially superior approach to enhancing students’ adaptive reasoning capacity, facilitating the cultivation of logical, analytical, and creative cognitive abilities when confronted with mathematical difficulties. Hence, it is advisable to employ this approach as a means to enhance the caliber of mathematics education throughout various educational tiers.

REFERENCES


