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KR-Heuristic Learning: Strategies to Develop Mathematical Lateral Thinking Skills for Gifted Students

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Abstrak

Berpikir lateral merupakan proses kreatif yang dilakukan seseorang dalam memecahkan masalah. Penelitian ini bertujuan untuk menganalisis kemampuan berpikir lateral matematis siswa berbakat, selama dan setelah diberikan strategi Heuristik-KR. Penelitian ini menggunakan metode single subject research (SSR) dengan desain A-B-A yang dilaksanakan di salah satu madrasah aliyah di wilayah Tangerang Selatan tahun ajaran 2019/2020. Subjek penelitian ini adalah 3 siswa yang termasuk dalam kategori siswa berbakat. Instrumen penelitian yang digunakan adalah tes esay yang telah diuji validitas isi dan reliabilitasnya. Data dianalisis menggunakan statistik deskriptif dengan penyajian data melalui grafik dan tabel. Hasil penelitian menunjukkan bahwa kemampuan berpikir lateral matematis tertinggi untuk ketiga subjek diperoleh pada kondisi baseline 2 (A2). Kemampuan berpikir lateral matematis G1 dan G3 pada kondisi intervensi lebih rendah dari baseline 1 dan 2. Untuk G2, kemampuan berpikir lateral matematis pada kondisi baseline 2 lebih tinggi dari intervensi dan baseline 1. Dalam penelitian ini dapat disimpulkan bahwa strategi Heuristik-KR yang terdiri dari tahapan membaca dan berpikir, mengeksplorasi dan merencanakan, memilih strategi, menemukan jawaban, serta merefleksikan dan memperluas cukup efektif. Strategi Heuristik-KP berpengaruh terhadap kemampuan berpikir lateral matematis pada indikator identifikasi ide, keterbukaan, pengembangan, fleksibilitas, orisinalitas, dan analisis fakta.
Kata Kunci: Kemampuan berpikir lateral matematis; pembelajaran heuristik-KR; siswa berbakat.

Abstract

Lateral thinking occurs when students used a creative method to solve problems. This study aimed to analyze the mathematical lateral thinking skills of gifted students during, and after being given the Heuristic-KR strategy. This study used a single subject research (SSR) method with an A-B-A design which was carried out at one of the aliyah madrasas in the south Tangerang for the 2019/2020 academic year. The study involved 3 gifted students and use a descriptive test that had been tested using content validity and reliability. The data were analyzed using descriptive statistics by presenting data through graphs and tables. The results showed that the highest mathematical lateral thinking ability for the three subjects was obtained during baseline condition 2 (A2). The mathematical lateral thinking ability of G1 and G3 reached the lowest score in the intervention condition. For G2, the mathematical lateral thinking ability reached the highest score in the baseline 2. The study concluded that the Heuristic-KR strategy was quite effective, consisting of reading and thinking stages, exploring and planning, selecting a strategy, finding an answer, and reflecting and extending. The Heuristic- KP strategy affected the mathematical lateral thinking ability on the indicators of idea identification, openness, development, flexibility, originality, and facts analysis.
Keywords: Gifted students; mathematical lateral thinking skills; heuristic-KR learning.

I. INTRODUCTION

The distinctive characteristics of mathematics lessons are to encourage, train and habituate students to critical-analytical and systematic thinking skills (Goldsmith et al., 2014; Mason, 2020; Somatanaya, 2017). For this reason, learning mathematics requires the students to be prepared to be critical, responsible, responsive, and durable in solving problems (Fatra & Anggraini, 2020). Therefore, mathematics is widely known as a subject that significantly encourages and assists students in developing various thinking skills, one of which is lateral thinking (Pei et al., 2018; Sihombing & Fatra, 2021; Tate, 2020). Lateral thinking is a process of actualizing the ability to think creatively, encouraging and training students to have the courage to pursue alternatives or other solutions in solving mathematical problems (Nggaba et al., 2018).

Lateral thinking is also recognized as zig-zag thinking. In lateral thinking, individuals might acquire multiple possible solutions, even jump from one idea to another (Ariani & Batubara, 2017; Sloane, 2018; Wantika, 2019). Therefore, mathematical lateral thinking is a process of solving problems by using imagination which emphasizes the demand for various different problem solving from new ideas. In other words, the essence of lateral thinking is a strategy to solve problems in new or different (varied) ways from what is usually done (Nggaba et al., 2018; Nur et al., 2022; Susilawati et al., 2018). Generally, lateral thinking is triggered by challenging tasks. Unfortunately, students tend to show more vertical thinking skills because students are used to being given questions with only one correct answer and are not allowed to make mistakes. In other words, lateral thinking allows the creation of different learning, which is unusual. Therefore, learning mathematics could be developed with the ability to think laterally so that students did not quit easily (Pratiwi, 2017; Purnomo et al., 2021; Putri et al., 2019). Up to this point, the existing literature on the study of mathematics in lateral thinking and KR-Heuristic learning has been quite varied, such as a study by Siswono (2016) dealing with the role of mathematics lessons in the formation of critical-analytical thinking skills (Rosnawati, 2011). Another study showed the formation and development of lateral thinking skills in students in learning mathematics. A study by Muliawati (2017) examined the issue of lateral thinking in a gender perspective on mathematical ability (Sundari et al., 2022). This study was different from the previous study as it focused on the implementation of lateral thinking skills strategy in learning mathematics specifically for students with special talents, called gifted students.

One of the privileges of gifted students is that they excel in creativity (Bulut et al., 2020; Erdogan & Yemenli, 2019). As Idrus (2013) emphasized, a child was so called a gifted child if he demonstrated intelligence

above average with high creativity, and high commitment to the task. They are usually called gifted students. Gifted students are used to taking part in Olympiads, especially mathematics Olympiads held in Indonesia and abroad.

One strategy to develop the potential of gifted students is through appropriate educational programs. In the law on the national education system no. 20 of 2003 article 5 paragraph 4 stated that citizens with potential intelligence and special talents are entitled to special education (Law of the Republic of Indonesia Number 20 of 2003 Law of the Republic of Indonesia Number 20 of 2003 Concerning the National Education System, Pub. L. No. Chapter Ii, Article 3, 1 (2003)., 2003). Through laws and regulations, it appears that the Indonesian government has shown support for developing the potential of gifted students. In this case, the teacher's assistance is needed so that the potential of gifted students can develop by providing questions that require creativity to find solutions in solving problems. One learning strategy to develop the potential and mathematical abilities of gifted students was to apply the KR-Heuristic learning(Darma & Sujadi, 2014; Sundari et al., 2022).

Krulik and Rudnik defined a heuristic strategy as a way for students to find solutions in solving problems which consists of five stages of learning, namely: 1) reading and thinking (read and think), 2) exploring and planning (explore and plan), 3) choosing strategy (select a strategy), 4) find the answers (find an answer), and 5) reflecting and developing (reflect and extend) (Kusdinar et al., 2017).

The KR Heuristic Strategy could facilitate gifted students in developing mathematical lateral thinking skills. Students were provided the opportunity to develop their ability to think freely and choose the appropriate steps for existing problem, in order to construct the patterns of the problems, thus students could develop mathematical lateral thinking abilities (Ariani & Batubara, 2017). To obtain a comprehensive description of gifted students by prioritizing objectivity and focusing on individual data as a research sample, the Single Subject Research research method was used (Ledford, 2018).

This study was designed by the hypothesis that there was a relationship between mathematical lateral thinking skills and KR-Heuristic strategies. The reading and thinking stages of the KR-Heuristics might support students' mathematical lateral thinking skills on the indicators of idea identification and openness (Pratwi, 2017). The exploration and planning stages of the KR-Heuristics could support students' mathematical lateral thinking skills on the indicators of openness and development. The stage of choosing a strategy in the KR-Heuristics could support students' mathematical lateral thinking skills on the indicators of idea identification, openness, and

flexibility. The stage of seeking answers to the KR-Heuristics could support students' mathematical lateral thinking abilities on the indicators of flexibility and fact analysis. Finally, the reflection and development stage of the KR-Heuristics could support students' mathematical lateral thinking skills on the indicators of development, originality and fact analysis.

II. METHOD

The study used Single Subject Research (SSR). Single Subject Research was experimental research using a single subject (Ledford & Gast, 2018). The basic principle was to examine individuals in two conditions, namely without treatment and with treatment known as baseline conditions (without treatment) and intervention conditions (with treatment). The design used in this study was the ABA design which was a development of the AB design (Indra, 2021). The researcher retested the participants after treatment/intervention (B) followed by a state without treatment. The symbols used in this study were A1–B–A2, which A1 was the baseline condition when intervention had not been given, B was the intervention given after the baseline, and A2 was the first repetition of the baseline after being given the intervention. The participants consisted of three students from Madrasah Aliyah Pembangunan who were considered as gifted students with an average IQ between 115 – 130. The research instruments used were tests of mathematical lateral thinking abilities and interviews with the three gifted students. The test instrument referred to the indicators of the ability to think laterally mathematically, including the ability to identify ideas, openness, development, flexibility, originality, and analyzing facts with algebra, geometry and statistics materials. Interviews were conducted after administering the test instrument to strengthen the final results of this study. Mathematical lateral thinking ability tests were given before, during, and after the participants were treated by the Heuristic-KR strategy. The mathematical lateral thinking ability test administered before implementing the strategy was the baseline (A1), the mathematical lateral thinking ability test administered while being given Student Worksheets in the Heuristic-KR model was the intervention (B), whereas the mathematical lateral thinking ability test administered after the strategy implementation was the baseline 2 /repetition (A2). The visual analysis used was visual analysis between conditions. The analysis between conditions included the number of variables, changes in direction trends and their effects, changes in stability trends, changes in data levels and data overlap.

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III. Result and Discussion

A. Mathematical literal thinking ability (MLT) subject g1, g2, and g3

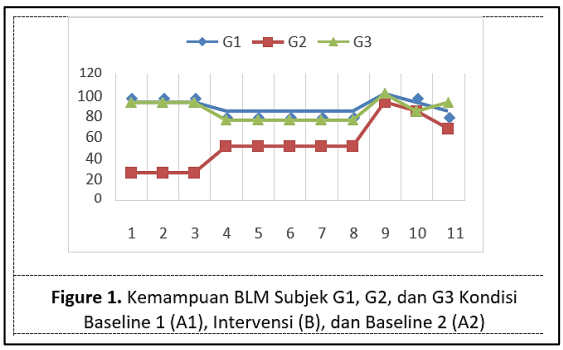

Figure 1. Kemampuan BLM Subjek G1, G2, dan G3 Kondisi Baseline 1 (A1), Intervensi (B), dan Baseline 2 (A2)

Figure 1 presented the MLT abilities of participant G1, G2, and G3 in baseline 1 (A1), intervention (B), and baseline 2 (A2). MLT abilities of participant G1 and G3 achieved the highest average score in baseline 1 (A1) and baseline 2 (A2). Meanwhile, participant G2 obtained the highest average score in baseline condition 2 (A2). Of the three subjects, the highest scores were owned by participant G1 and G3 with a perfect score of 100. Subject G3 had lower MLT abilities than the other two subjects, but after the eighth session there was a significant increase.

In the learning processes, G1 in baseline condition 1 (A1) got an average score of 91.7 with a very good score category, then in the intervention condition (B) got an average score of 83.83 with a very good score category, while in baseline condition 2 (A2) received the same average score as baseline condition 1 (A1), namely 91.7 with a very good score category. This implied that the IQ score of 130 demonstrated a very good quality of work on the questions as it showed consistency of the scores obtained. Based on Gast and Ledford, the Heuristic-KR strategy was said to be ineffective for the participant 1 because there was no difference between the baseline conditions and the intervention.

Participant G2 in baseline condition 1 (A1) got an average score of 25 with a very poor value category, then in the intervention condition (B) got an average score of 50 with an adequate score category, while in baseline condition 2 (A2) got an average score of 80.6 with a very good value category. Gifted 2 always experienced an increase in the average value in each condition. This implied that with 115 IQ the participant demonstrated a good learning performance which increased in each condition. Based on the opinion of Gast and Ledford, implementing the Heuristic-KR strategy to participant G2 was considered to be effective to develop the mathematical lateral thinking ability because there were positive changes between the baseline conditions and the intervention.

Participant G3 in baseline condition 1 (A1) got an average score of 91.7 with a very good score category, then in the intervention condition (B) got an average score of 75 with a good score category, while in baseline condition 2 (A2) got the average value of 91.7 with a very good value category. G2 participant's score was decreasing while receiving the

intervention condition (B) but at baseline 2 (A2) it increased again. This implied that that 115 IQ score the participant demonstrated a good performance on the questions so that the average score had increased or decreased in each condition. Based on Gast and Ledford, the implementation of Heuristic-KR strategies to G3 participant was considered to be effective for the lateral thinking abilities because there were differences between baseline conditions and interventions.

B. The Effect of Heuristic-KR Strategy on MLT Capability

The variable that had changed was the ability of Mathematical Lateral Thinking (MLT) among gifted students. Changes in the trend of stability were intended to determine the stability of the participants' ability in each condition without and with intervention. Changes in data level from baseline 1 and intervention conditions were determined by calculating the difference in last session data in baseline 1 conditions and the first session in intervention conditions, while changes in data level from intervention conditions to baseline 2 conditions were determined by calculating the difference in last session data in the intervention conditions and first session baseline condition 2. Overlap meant the similarity of baseline conditions (A) with the interventions (B). the smaller the percentage of the overlap, the better the effect of the intervention on the target behavior, conversely if more than 90% of the data in the baseline conditions overlapped with the intervention conditions, the effect of the intervention were not reliable. To determine the overlap of data in baseline conditions (A) with interventions (B), the study followed these strategy: a) re-evaluating the lower and upper limits of the baseline conditions, b) calculating the data point in the intervention conditions (B) and in the range of conditions (A), c) measuring the gain in condition (B) and divided by the number of data points in the condition then multiplied by 100. The following data was the overall condition of participant G1, G2 and G3.

Tabel 1. Rangkuman Analisis Visual antar Kondisi Subjek G1

Perbandingan Kondisi	B/A_1 (2 : 1)	A_2/B (3 : 2)
Jumlah Variabel	1	1
Perubahan Kecenderungan Arah dan Efeknya	(=) (=)	(=) (-)
Perubahan Kecenderungan Stabilitas	Stabil ke Stabil	Stabil ke Variabel
Perubahan Level Data	91,7% – 83,3% = 8,4% (-)	100% – 83,3% = 16,7% (+)
Overlap Data	0%	0%

Tabel 2. Rangkuman Analisis Visual antar Kondisi Subjek G2

Perbandingan Kondisi	B/A_1 (2 : 1)	A_2/B (3 : 2)
Jumlah Variabel	1	1
Perubahan Kecenderungan Arah dan Efeknya	(=) (=)	(=) (-)
Perubahan Kecenderungan Stabilitas	Stabil ke Stabil	Stabil ke Variabel
Perubahan Level Data	50% – 25% = 25% (+)	91,7% – 50% = 41,7% (+)
Overlap Data	0%	0%

Tabel 3. Rangkuman Analisis Visual antar Kondisi Subjek G3

Perbandingan Kondisi	B/A_1 (2 : 1)	A_2/B (3 : 2)
Jumlah Variabel	1	1
Perubahan Kecenderungan Arah dan Efeknya	(=) (=)	(=) (-)
Perubahan Kecenderungan Stabilitas	Stabil ke Stabil	Stabil ke Variabel
Perubahan Level Data	91,7% – 75% = 16,7% (-)	100% – 75% = 25% (+)
Overlap Data	0%	0%

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As supporting data for the analysis within and between conditions in this study, the effect size calculation was performed using a two-way Analysis of Variance (ANOVA) with SPSS. The following was the result of the statistical calculation.

Table 4.
Effect Size Calculation Results using 2 Way ANOVA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	52.976[a]	4	13.244	13.683	.000	.368
Intercept	855.057	1	855.057	883.409	.000	.904
Subjek	42.202	2	21.101	21.801	.000	.317
Kondisi	10.774	2	5.387	5.566	.005	.106
Error	90.983	94	.968			
Total	1023.000	99				
Corrected Total	143.960	98				

Based on Table 4 , the influence of research conditions or treatments had an influence on the MLT ability score of η^2 = 0.106. This implied that learning using the Heuristic-KR strategy had a moderate effect toward the participants' MLT abilities.

In other words, learning with the Heuristic-KR strategy was quite effective for the gifted students' MLT abilities. In addition, internal factors also effected the participants' MLT abilities.

The findings of this study revealed that the highest mathematical lateral thinking skills of participant G1 and G3 were obtained during baseline 1 and baseline 2 conditions, while participant G2 was obtained during baseline 2 conditions. It meant that the treatment was quiet effective to encourage mathematical lateral thinking as the Heuristik-KR included the stages of read and think, explore and plan, select a strategy, find an answer, and reflect and extend (Ariani & Batubara, 2017).

To support the data, the study administered virtual interviews with each participant. The three participants stated that online learning was one of the factors in the difficulty of working on the questions given. Direct guidance from the teacher and interaction between friends made it easier for them to solve difficult problems. As shown in the following interview excerpts: "...in online learning, it is difficult for me to understand the math problems given because of the teacher's brief explanations" (G1, G2, G3, 5 September 2020). When working on the problem, one participant (G1) needed help and two more participants worked on the problem without the help of others. Besides, while working on the worksheet one of the participants (G2) also needed the teacher's assistance to explain the stages of the Heuristic-KR strategy. The increase in the ability of MLT during and after the KR-Heuristic strategy were influenced by the KR-Heuristic strategy stage itself. At the reading and thinking stages, the students were allowed to choose several activities including identifying facts, identifying questions, visualizing situations, explaining settings and determining actions. This stage familiarized students with identifying problems and considering or determining actions before making decisions. This

corresponded to the indicators of MLT capability, namely the aspects of identifying ideas and openness. Furthermore, at the explore and plan stage students were allowed to choose several activities including organizing information, seeking suitable/required information, drawing a model of the problem, and creating diagrams, tables, or pictures. This stage trained and motivated students to express ideas to solve the problems, both information related to the concept of the material directly. The students would get used to looking for and finding relevant and irrelevant information in solving problems. The activities at this stage are related to the openness and development aspects of MLT's capabilities.

At the strategy selection stage, the students were allowed to choose several activities including determining or making patterns, working backwards, trying and doing, simulating or experimenting, simplifying or expanding, making lists in series, logical deduction, and dividing or categorizing problems. This stage familiarized students with recognizing problems and understanding possible concepts or strategies to consider or categorize problems and linking a concept or idea into several strategies. Furthermore, in the finding and answering stage the students were allowed to choose several activities including predicting or estimating, using arithmetic skills, using algebraic abilities, using geometric abilities, and using a calculator if needed. This stage familiarized the students with perceiving problems from various perspectives to predict or estimate various alternative solutions. Then at the reflecting and extending stage, the students re-examined answers, determined alternative solutions, developed answers in other situations, developed answers (generalization or conceptual), discussed answers, and created variations of problems from the original problem. This stage familiarized students with adjusting answers that were appropriate or not and familiar with unique and unusual answers and being able to re-examine answers to be developed and logical. This stage trained MLT abilities in the aspects of development, originality, and fact analysis.

Specifically, this study showed that for each indicator, subject G1 obtained the highest score from the openness and originality indicator items, participant G2 from the openness indicator items, while participant G3 from the openness, development, and originality indicator items. The findings were in line with the previous studies regarding the characteristics of gifted students, namely being able to use high-order thinking skills and being used to efficient strategies, a tendency for something new, a tendency for something new, and being able to explore knowledge for new situations (Bulut et al., 2020; Özdemir & Işiksal Bostan, 2021).

Other findings revealed that participant G1 performed quite well in all conditions as the lateral thinking pattern and the understanding were developed demonstrating when the participant understood the mathematical problem given. The characteristics of gifted students were creative/resourceful and feeling satisfied to use their own way (Idrus, 2013; Carrol, 2020). In terms of the time aspect used for the MLT ability test in baseline 1 conditions participant G1 was the fastest, but in baseline 2 conditions he took relatively longer time. This occurred as the participant was too relaxed and lacked focus during the learning process. It took an average of 54 minutes to work on the MLT ability questions which consisted of 3 questions. He worked on the problems relatively slower than the other two participants. G1 had persistence and perseverance in doing the tasks given as the Ohio Association for Gifted Children stated that one of the characteristics of gifted students was having long enough attention and high curiosity (Basister & Kawai, 2018; Dada & Akpan, 2019; Idrus, 2013). Participant G2 in baseline condition 1 and intervention was still unfamiliar with the questions and his lateral thinking pattern was not very visible. Even though participant G2 seemed to have difficulty in these conditions, he always answered the question problems completely. In baseline condition 2, participant G2 was much better than in the previous condition. This implied that one of the characteristics of gifted students was high energy and enthusiasm. The participant spent 45 minutes to do the MLT ability test in the intervention conditions, the fastest time compared to others. As for the baseline condition 2, G2 worked the longest among the other conditions. This implied that G2 did not yet have the stability in working on MLT questions. G3's performances were good in all conditions even though in the intervention conditions there were several indicators that still used lateral thinking patterns. G2 reached the fastest time in MLT ability test in baseline 2 conditions and the longest was in baseline 1 conditions. G3 spent an average of 49 minutes to work on the MLT ability instrument which consisted of 3 questions. This implied that G2 completed the task quickly and diligently.

IV. CONCLUSION

The implementation of the KR-Heuristic strategy encompassing the stages of read and think, explore and plan, select a strategy, find an answer, reflect and extend was quite effective in increasing the gifted students' mathematical lateral thinking skills. These lateral thinking aspects included the ability of ideas identification, openness, flexibility development, originality, and fact analysis.

This study reflected that giften children needed special treatment and training so to grow and manifest their ability in their creativity which encouraged them to

generate the desired results beyond ordinary students. In addition, as a theoretical-conceptual and empirical contribution, this study enriched the existing literature on gifted-student topic in learning Mathematics. Despite its findings, this study also had shortcomings as it only involved a small number of gifted students as the participants. Accordingly, the findings of this study could not be generalized to all gifted students. For this reason, future research was suggested that it involved a larger number of participants.

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