META ANALYSIS: APPLICATION OF THE KNISLEY MATHEMATICS LEARNING MODEL

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Abstract

This study aimed to conduct a meta-analysis of the application of Knisley's mathematical learning model and its impact on students' mathematics abilities. Research begins with formulating a research problem tracking the research results that are relevant for analysis. The data was collected by browsing the electronic journals through Google Scholar, a Garuda portal with the keywords "Knisley mathematical learning model" and "Mathematical ability". From the search, I obtained 86 articles, but relevant only 12 articles from journals that entered the inclusion criteria to be analyzed with the site meta-mar to obtain a large combination effect size. From the interpretation of the measurement of this combined effect, the overall application of the Knisley Model has a strong influence on the student's mathematical abilities. Characteristics of the study were researched in terms of education and years of research. From statistics, if the application of the Knisley Model to improve the ability of the student's mathematical reasoning is influenced by the level of education and years of research.

Keywords: Knisley mathematics learning model, mathematical skills, Meta analysis

INTRODUCTION

Learning mathematics is one part of the education provided at school. Mathematics is important to study at the school level because it is a basic science that makes a big contribution and plays an important role in the development of science and technology. Mathematics is a universal science that underlies the development of modern technology, has an important role in various disciplines and develops human thinking power. Therefore, mastering and creating technology in the future requires a strong mastery of mathematics from an early age. (National Education Standards Agency, 2006:145).

The objectives of mathematics learning in schools are listed in the Content Standards (National Education Standards Agency, 2006:146) that students have the following abilities:

1. Understand mathematical concepts, explain the relationship between concepts and apply concepts or algorithms flexibly, accurately, efficiently and precisely in solving problems;
2. Using reasoning on patterns and properties, performing mathematical manipulations in making generalizations, compiling evidence, or explaining mathematical ideas and statements;
3. Solving problems, which includes the ability to understand problems, design mathematical models, complete models and interpret the solutions obtained;
4. Communicate ideas with symbols, tables, diagrams, or other media to clarify situations or problems; And
5. Have an attitude of appreciating the usefulness of mathematics in life, namely having curiosity, attention and interest in studying mathematics, as well as a tenacious and confident attitude in solving problems.

The National Council of Teachers of Mathematics or NCTM (2000:29) The Principles and Standards for School Mathematics also states that the mathematics learning process should facilitate problem-solving, reasoning, communication, connection, and representation abilities.
According to Darwanto, (2019) the five mathematics competency criteria determined by NCTM can also be called mathematical hard skills or mathematical abilities.

Ability development: Mathematics can be done by implementing a mathematics learning model that makes students the centre of learning and involves students actively discovering concepts, applying problem-solving strategies, and fostering student cooperation, responsibility and self-confidence. Each model has its uniqueness, disadvantages and advantages. There are several such learning models. One of them is the Knisley learning model. Regarding mathematical abilities, Rodiawati considers that the syntax of Knisley learning provides students with the opportunity to discover new concepts that are constructed from previously held concepts (Rodiawati, 2017). The stages in the model can encourage students to develop individual strategies based on the new concepts they acquire to solve problems. Apart from bringing a sense of joy to students, Aditya said that implementing the Knisley learning model also makes students enthusiastic about learning (Aditya et al., 2012).

In 2003, Knisley (2003) developed a learning model. A learning model based on Kolb's experiential learning or Kolb model (Akhyar & Rokhmah, 2018) divides the learning stage into four learning style stages, namely:

1. Concrete experience stage (concrete, reflection)
2. Active reflection observation stage (concrete, active)
3. Conceptualization stage (abstract, reflection)
4. Active experimental stage (Abstract, active)

In theory, each stage of Kolb's learning style is a separate stage, but in practice transitions between stages occur frequently, making it difficult to determine when a change has occurred.

Knisley (2003) developed the four syntaxes of the Kolb learning style model into the syntax of the Knisley learning model, namely: (1) Allegorization: at this stage, students reformulate new concepts from known concepts. Teachers act as storytellers, visually explaining new concepts that are generally familiar to students' environments; (2) Integration: at this stage, students carry out exploration, experimentation, and measurement and make comparisons between new and known concepts. Teachers are motivators; (3) Analysis: At this stage, students analyze new concepts and connect them with known concepts, but they still need detailed information to solve problems using the new concept. The teacher acts as a source of information; (4) Synthesis: students understand new concepts and use them to form problem-solving strategies. The teacher acts as a coach.

Various studies have been conducted to test the effectiveness of implementing the Knisley learning model on students' mathematical abilities. Research conducted by Hanijah Br. Saragih et al (2018) shows that the application of the Knisley learning model using mathematics learning tools is effective in improving mathematical understanding and disposition. Jatiairiska et al. (2020) also showed similar results. Jatiairiska combines Geogebra with the application of the Knisley learning model in mathematics learning. The results show that this application was successful in improving students' mathematical connections and dispositions. Other research by Khairani et al. (2020) shows that students who apply the Knisley learning model have better mathematical critical thinking skills than those who apply ordinary learning. Meanwhile Nurfauziah, P., Sari, (2018) They conducted research on critical thinking skills through the application of the Knisley learning model with attention to gender, where the study group was divided based on male and female gender. His research showed different results from previous studies where students in the male group who used the Knisley learning model showed mean critical thinking ability scores that were no better than the male group who applied the conventional learning model. These findings question the validity of the Knisley learning model, which is claimed to be able to improve students' mathematical abilities. Teachers need clarification on whether to use the Knisley learning model in their learning activities.

Based on this, the author needs to conduct meta-analysis research regarding the application of the Knisley mathematics learning model to students' mathematical abilities. So, the following
research aims to investigate the effect of applying the Knisley Mathematics learning model on mathematical abilities, namely understanding concepts, reasoning, problem-solving, mathematical communication, mathematical connections, logical thinking, critical thinking, and creative thinking with a comparison with conventional learning models based on level characteristics. Education and year of research, so it is hoped that the research results will provide accurate information for teachers regarding the application of Knisley in mathematics learning.

**METHOD**

Research using analytical methods by reviewing articles in national journals. Meta-analysis is a statistical method for combining, analyzing and synthesizing several studies systematically in order to obtain the latest findings and conclusions with a study effect. (Shah et al., 2020). According to Borenstein (in Rohmatulloh et al., 2022) said the meta analysis stage was: determining inclusion criteria for study analysis, empirical data collection procedures, as well as explaining the coding of study variables, and explaining statistical techniques. The following primary research study is related to the Knisley model of students’ mathematical abilities. Articles in primary studies were researched following the specified inclusion criteria, namely:

1. The range of article publication years is from 2012 to 2021.
2. Articles conducting research studies in Indonesia that have been published in journals indexed by SINTA.
3. Articles with quasi-experimental research methods and randomized control group pretest-posttest design, randomized control group posttest only design, nonequivalent group pretest-posttest design, and nonequivalent group design posttest only.
4. Article with primary study population, namely junior high school, high school and college students in Indonesia.
5. Study articles with statistical data on primary studies, namely sample size, mean and standard deviation.

Article searches were carried out on databases such as Google Scholar, Garuda Portal, and Sinta Ristekbrin with the keywords "application of the Knisley mathematics learning model", "Mathematical Ability", and "Kinsley". Based on the search carried out in the 2016-2022 publication year, there were 73 articles. These articles will be selected based on the inclusion criteria. Finally, ten studies meet the criteria at the junior high school/MTs, high school/equivalent and tertiary levels. So, there are articles in the following research.

The next process is implementing the study code. The instruments in the following process are a coding protocol in the form of a coding form on paper or computer and a manual code with an instruction guide regarding how to code each item based on data in the primary study. (Wilson, 2012). The coder for this study is in the form of information in the meta-analysis process, namely the study code, writer, year of publication; mean, standard deviation, number of samples of the experimental group; mean, standard deviation, number of control group samples; level of education and year of research. The process after coding is calculating the effect size; the calculation uses the standardized mean difference, namely Hedges's $g$ (Fritz, CO, Morris, PE, & Richler, 2012). Interpretation according to Cohen (Cohen, L., Manion, L., & Morrison, 2007) Hedges's $g$ formula is as follows:

$$Hedges'\ g = \frac{M_1 - M_2}{SD_{pooled}} \ (1)$$

Information:
$M_1 - M_2$ = difference in means.
$SD_{pooled}$ = pooled and weighted standard deviation.

**Table 1. Interpretation of Effect Sizes**

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The next process homogeneity test will be carried out to determine the analysis model using the p-value. (Retnawati, H., Apino, E., Kartianom, Djidu, H., & D, 2018). If the p-value < 0.05, then it has a heterogeneous nature, with the analysis model using a random effects model. If the p-value > 0.05, then it has a homogeneous nature, with the analysis model using a fixed effects model (Retnawati, H., Apino, E., Kartianom, Djidu, H., & D, 2018). In order to prevent incorrect representation in the findings, it is necessary to check for publication bias.

Studies that have been published are more likely to be included in a meta-analysis than their unpublished counterparts, which raises concerns that meta-analyses may overestimate the original effect size. (Borenstein et al., 2009). Methods for detecting and resolving publication bias include funnel plots and Rosenthal's Fail-Safe N (FSN). (Retnawati, H. et al., 2018). The initial way to detect publication bias is to use a funnel plot. If the study effect size distribution is asymmetrical or not completely symmetrical, Rosenthal's FSN will be used to make it easier to determine the presence of publication bias (Tamura et al., 2020). When the value of FSN / (5k + 10) > 1 where k is the number of studies in the meta-analysis, the study is held against publication bias (Mullen et al., 2001). If there is no publication bias, the analysis process will continue. Through the analysis model, the author can test H0 (Retnawati, H., Apino, E., Kartianom, Djidu, H., & D, 2018). If the p-value < 0.05, then H0 will be accepted. If the analysis model uses random effects where there are different research characters, then the author can analyze the research character and interpret the results of the analysis (Borenstein et al., 2009).

**RESULT AND DISCUSSION**

The following research aims to determine the size of the combined effect of applying the Knisley model on students' mathematical reasoning abilities to obtain results regarding the effect of applying the Knisley model on students' mathematical abilities. The following is a list of studies in the following research. Table 2. Studies Used in the Meta-Analysis

<table>
<thead>
<tr>
<th>Kode Studi</th>
<th>Judul Studi</th>
<th>Nama Jurnal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Studi 1</td>
<td>Efektifitas Model Pembelajaran Knisley Terhadap Penalaran Matematis Siswa</td>
<td>Jurnal Akademik Pendidikan Matematika</td>
</tr>
<tr>
<td>Studi 2</td>
<td>Pengaruh model pembelajaran matematika Knisley terhadap kemampuan berpikir kritis peserta didik kelas X MIPA SMA Negeri Semarapura</td>
<td>Jurnal Pendidikan Matematika Undiksha</td>
</tr>
<tr>
<td>Studi 3</td>
<td>Pengaruh model pembelajaran Knisley terhadap aktivitas dan hasil belajar matematika siswa kelas VIII SMP Negeri 43 Padang</td>
<td>Jurnal Edukasi dan Pendidikan Matematika</td>
</tr>
<tr>
<td>Studi 4</td>
<td>Meningkatkan kemampuan advanced mathematical thinking dengan menggunakan model pembelajaran matematika Knisley pada mata kuliah Trigonometri</td>
<td>Jurnal Pembelajaran Matematika Inovatif</td>
</tr>
<tr>
<td>Studi 5</td>
<td>Model pembelajaran Knisley untuk meningkatkan kemampuan pemahaman konseptual matematis siswa SMP</td>
<td>KALAMATIKA Jurnal Pendidikan Matematika</td>
</tr>
<tr>
<td>Study Code</td>
<td>Writer</td>
<td>ASI Public Year</td>
</tr>
<tr>
<td>------------</td>
<td>--------</td>
<td>----------------</td>
</tr>
<tr>
<td>Study 1</td>
<td>Dian Sustainable, Sardin</td>
<td>2020</td>
</tr>
<tr>
<td>Study 2</td>
<td>INAW Putra, et al</td>
<td>2020</td>
</tr>
<tr>
<td>Study 3</td>
<td>Melisa, Sri Elniati</td>
<td>2019</td>
</tr>
<tr>
<td>Study 4</td>
<td>Nelly Fitriani, Praise Nurfauziah</td>
<td>2020</td>
</tr>
<tr>
<td>Study 5</td>
<td>Wieka Septiyana and Heni Pujiastuti</td>
<td>2018</td>
</tr>
<tr>
<td>Study 6</td>
<td>Nurhidayah, Ade Susanti</td>
<td>2019</td>
</tr>
<tr>
<td>Study 7</td>
<td>Elvira Rosa</td>
<td>2017</td>
</tr>
<tr>
<td>Study 8</td>
<td>Ardamevia Rizky Icha Romadhon, et al</td>
<td>2022</td>
</tr>
</tbody>
</table>
Based on Table 3, each study had varying effect sizes with 10 studies having effect sizes ranging from 0.6004 to 1.3117. By interpreting the effect size according to Cohen's classification, information was obtained that 3 studies had a strong effect size or the application of the Knisley model in these 3 studies had a strong influence on students' mathematical reasoning abilities, 6 studies were of medium size or the application of the Knisley model had a moderate effect on students' mathematical reasoning abilities and there was 1 simple sized study or the application of the Knisley model in 1 study had a weak influence on students' mathematical reasoning abilities.

In order to determine the combined effect size for all primary studies, the author must create an estimation model by testing the homogeneity of all studies. Table 4 provides information regarding the homogeneity test for all primary studies.

Table 4. Heterogeneity of Effect Size Distribution

<table>
<thead>
<tr>
<th>Heterogeneity</th>
<th>Chi-Squared</th>
<th>Df</th>
<th>P-Value</th>
<th>I-Squared</th>
<th>$\sigma^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>41.85</td>
<td>9</td>
<td>&lt; 0.01</td>
<td>78%</td>
<td>0.3374</td>
</tr>
</tbody>
</table>

Based on Table 4, there is a p-value <0.05, meaning the distribution of study effect sizes Primary meta-analyses are heterogeneous in nature. Therefore, the estimation model to determine the combined effect size is a random effects model. Then, identification of publication bias was carried out

![Funnel Plot](image)

Figure 1. Funnel Plot

Based on Figure 1, the study effect size distribution is asymmetrical. So, the author detected publication bias with Fail-Safe N (FSN) 331 of the 10 observed studies (k). By using the formula the conclusion was that the studies in this meta-analysis had sufficient tolerance for publication bias $FSN = \frac{331}{5k+1} = \frac{331}{5(10)+1} = 6.49 > 1$(Tamur et al., 2020).

Furthermore, Table 5 shows the results of meta-analysis from primary studies with fixed effects and random effects models

Table 5. Meta Analysis Results Based on Estimation Model
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<table>
<thead>
<tr>
<th>Model</th>
<th>n</th>
<th>Size Effect</th>
<th>S. E</th>
<th>Limit Lower</th>
<th>Limit On</th>
<th>Z-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Effects Model</td>
<td>10</td>
<td>0.8016</td>
<td>0.1707</td>
<td>0.6309</td>
<td>0.9723</td>
<td>9.20</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Random Effects Model</td>
<td>10</td>
<td>0.8656</td>
<td>0.4757</td>
<td>0.3899</td>
<td>1.3413</td>
<td>4.12</td>
<td>0.0026</td>
</tr>
</tbody>
</table>

With the previous primary study homogeneity test, there was a heterogeneous distribution of study effect sizes, so the analysis was using a random effects model. From Table 5 in the random effects model row, there is a p-value in the Z test, namely 0.0026. Because the p-value is <0.05, overall, the use of the Knisley mathematics learning model has a more significant influence on students' mathematical abilities than the conventional model. In the following study, the combined effect size was obtained, namely 0.8656, so from Cohen's classification, it was classified as a Medium effect size. In conclusion, overall, the application of the Knisley model has a moderate effect on students. Also, the combined effect is 0.8656, meaning the mean mathematical reasoning ability of 78% of students in the control group. Because we already know that the distribution of primary study effects is heterogeneous, we are required to carry out an analysis of study characteristics to create heterogeneity in students' mathematical reasoning abilities. The results of the meta-analysis on several characteristics are presented in Table 6.

Based on Figure 2, in the study characteristics of educational level, information is obtained that in the junior high school category, the effect size is strong. So, the conclusion is that students' mathematical abilities through the application of the Knisley mathematics learning model are influenced by educational level, and the educational model is suitable for use at junior high school level with its strong influence.

In other research, conducted by Lestari & Sardin (2020). Based on the research results obtained: (1) The average value of the mathematical reasoning ability of class VII students at SMP Negeri 4 Baubau in solving integer arithmetic operation problems taught using the Knisley learning model was 73.22 higher than those taught without using the learning model Knisley whose average score is 67.94. (2) The Knisley learning model is more effective on mathematics learning outcomes at SMP Negeri 4 Baubau than without using the Knisley learning model. Therefore, one strategy that is considered capable of improving students' mathematical abilities is to use the Knisley mathematics learning model (Nurhidayah & Susanti, 2019).

Figure 2. Meta-Analysis Results for Each Study Characteristic

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CONCLUSION

Based on the results of a meta-analysis with ten studies that have been carried out, information was obtained that the combined effect size of primary studies, namely 0.8656, is in the medium effect group according to Cohen's classification. The overall conclusion is that the use of the Knisley mathematics learning model has a stronger impact on students' mathematical abilities than the traditional model, meaning traditional learning is learning where, in general, the centre of learning is the teacher and places students as objects of learning. In addition, the application of the Knisley mathematics learning model to increase student's mathematical reasoning abilities in several research characteristics is influenced by the level of education and year of study. These findings will help educators use the Knisley mathematics learning model as an alternative learning method that helps educators improve students' mathematical abilities.

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