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Measuring the Difficulty Level of Mathematical Problems Based on Polya Criteria

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A R T I C L E I N F O

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A B S T R A K

Pembelajaran matematika perlu diarahkan pada pemahaman konsep dan prinsip matematika karena akan diperlukan untuk memecahkan masalah matematika, masalah dalam disiplin lain, dan masalah dalam kehidupan sehari-hari. Namun terkadang, kita melakukan kesalahan baik disengaja maupun tidak disengaja sehingga akan berdampak pada hasil soal matematika yang kita kerjakan. Saat ini banyak penelitian yang membahas tentang kesulitan siswa dalam menyelesaikan soal matematika namun belum ada penelitian yang membahas lebih jauh tingkat kesulitannya. Penelitian ini bertujuan untuk menganalisis tingkat kesalahan siswa dalam menyelesaikan soal matematika menurut kriteria Polya, kesalahan siswa berdasarkan tingkat pendidikan, berdasarkan bidang fokus, dan kesalahan siswa berdasarkan variabel moderator lainnya. Metode dalam penelitian ini menggunakan meta-analisis. Data harus memenuhi kriteria inklusi dan eksklusi database pengindeksan seperti Scopus, DOAJ, WorldCat, Google Scholar, dan Portal Garuda. Data dianalisis menggunakan perangkat lunak JASP. Hasil penelitian menunjukkan bahwa dari 53 data yang memenuhi kriteria kelayakan diperoleh informasi tingkat kesalahan pada kriteria (1) pemahaman masalah sebesar 37%, (2) menyusun rencana sebesar 36%, (3) melaksanakan rencana sebesar 36%, dan (4) melihat ke belakang sebesar 44%. Berdasarkan fokus bidang fokus diperoleh Model RE untuk kesalahan tertinggi pada kasus pola bilangan jika dibandingkan dengan kasus aljabar dan geometri.

A B S T R A C T

Mathematics learning needs to be directed in understanding mathematical concepts and principles because it will be necessary for solving mathematical problems, problems in other disciplines, and problems in everyday life. But sometimes, we make mistakes both intentional and unintentional so that they will have an impact on the results of the mathematical problems we work on. Today many studies discuss the difficulty of students in solving math problems but there has been no research that discusses further the level of difficulty. This study aims to analyze the level of error students solve math problems according to Polya criteria, student errors based on education level, based on focus areas, and student errors based on other moderator variables. The method in this study uses meta-analysis. Data must meet the inclusion and exclusion criteria of indexing databases such as Scopus, DOAJ, WorldCat, Google Scholar, and Garuda Portal. The data was analyzed using JASP software. The results showed that of the 53 data that met the eligibility criteria obtained error rate information on criteria (1) understanding of problems by 37%, (2) devising a plan by 36%, (3) carrying out the plan by 36%, and (4) looking back by 44%. Based on the focus field focus obtained the RE Model for the highest error is in the case of number patterns when compared to algebraic and geometric cases.

1. INTRODUCTION

Educational evaluation is the activity of controlling, ensuring, and determining the quality of education of the various educational components at all levels, levels, and types of education, forming educational implement accountability (Erwin et al., 2019; Logachev et al., 2021). Additionally, assessments of learners' learning outcomes are conducted by educators to continuously monitor the process, progress, and improvement of learners' learning outcomes (Antara et al., 2020; Zainal, 2020). The evaluation of learning aims to obtain accurate information about the achievement of the next learning objectives taken decisions about follow-up (Lukum, 2015; Pramesti, 2020). In mathematics subjects, a problem is encountered in the form of a question or math problem that must be solved by the student. One of the problems that require understanding first to then be able to be solved is the story of the description that the competence that students must have in solving the story problem is (1) verbal ability is the ability to understand the problem and interpret it so that it can change it into a mathematical model and (2) the ability of the algorithm is the ability of students to determine the right algorithm in solving the problem, The accuracy of the calculation and the ability of students to conclude from the results of calculations that

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students do and associate them with the initial problem to be completed (Katon & Arigiyati, 2018; Suciati & Wahyuni, 2018). Mathematics learning needs to be directed in understanding mathematical concepts and principles because it will be necessary for solving mathematical problems, problems in other disciplines, and problems in everyday life. But sometimes, we make mistakes both intentional and unintentional so that they will have an impact on the results of the mathematical problems we work on. Specific strategies as an alternative to analyzing student errors based on Polya steps. There are four steps to solving the problem: understanding the problem at this stage students must understand the given problem of determining what is known and what is asked to solve the given problem (Faseha et al., 2021; Utami et al., 2020). Devising a plan, at this stage students think a very bright and good idea to plan what will be done to solve the problem given, student able to determine strategy or method to be used and write down steps that will be used in solving the problem. Carrying out the plan, at this stage students undertake a plan that has been set at the planning stage of problem solving. The ability of students to understand the substance of the material and skills of students doing mathematical calculations will greatly help students to carry out the solution, and looking back at this stage students do the reflection of checking or testing solutions that have been obtained.

Research on the analysis of student errors in elementary school has been widely done by researchers such as obtained categories understanding the problem is as big as 80%, devising a plan as 69%, carrying out the plan as 67%, and looking back as 61% (Nurdiana Hidayanti et al., 2022; Utami et al., 2020), and understanding the problem by 50%, devising a plan 66%, carrying out the plan 83% and looking back by 83% (Rizaq & Sulikan, 2020). Another study retrieved understanding the problem 20%, devising a plan 35%, carrying out the plan 62% and looking back 65% (Rismadani et al., 2021). Research analysis of mistakes of junior high school students is conducted for the category understanding the problem by 51.7%, devising a plan by 20.7%, carrying out the plan 6.9% and looking back by 27.6% (Awantagusnik et al., 2021; Hasanah & Murtiyasa, 2020; Nurhalin & Ramlah, 2021; Sukmarini & Hasanah, 2022; Syahda et al., 2021; Wulandari & Dadi, 2021). Research analysis of high school students' errors such as (Wiyah & Nurjanah, 2021), according to (Baskorowati & Wijatanti, 2020) acquired category understanding the problem by 42.23%, devising a plan by 15.94%, carrying out the plan 16.73% and looking back by 25.1%. According to (Fauziyah et al., 2020) get understanding the problem of 11.35%, devising a plan by 21.28%, carrying out the plan by 29.79%, and Looking back by 37.59%, (Agustina et al., 2019; Komarudin, 2016; Nikmah et al., 2019; Sastri et al., 2019; Sulistyorini, 2017), and understanding the problem by 5.00%, devising a plan by 21.50%, carrying out the plan by 22.88% and looking back by 18.00% (Hidayah, 2016).

Some research on analyzing student errors in the field of focus has been done a lot, such as the field of focus geometry on Trigonometry material with an *understanding the problem* rate of 57.73% caused by students not understanding the concept of Trigonometry, *devising a plan* 9.27%, because students do not use all the information that has been collected or presented when planning problem-solving strategies, *carrying out the plan* by 15.83% caused by students not using the steps correctly, students are not skilled in applying algorithms, and inaccuracies answer questions and *looking back* by 17.16%, because students do not evaluate their work results to ensure the accuracy of answers (Gradini et al., 2022), broad material and circumference of triangles (Kurniawan et al., 2021), quadrilateral material (Fajri & Iwan, 2018). Number patterns focus fields such as row application materials and series (Sastri et al., 2019), social arithmetic material (Pitriani & Ocktaviaini, 2020), and permutation and combination materials students do understanding the problem by 51%, devising a plan 57%, carrying out the plan of 60% and looking back of 62% (Sukoriyanto et al., 2016), algebra fields such as the two-variable linear equation system students perform understanding the problem by 28%, because students are weak about understanding variable concepts, devising a plan of 10% of students are weak in understanding the concept of variables and do not understand about elimination methods and substitutions (Principles, Concepts), carrying out the plan of 30% and looking back of 18% of students are weak in understanding the concept of variables, and do not understand about elimination methods and substitution and are unable to understand problems in mathematical sentences such as concepts, principles, and operations (Lukas et al., 2021), algebraic materials (Fathonah et al., 2018; Khusniawati et al., 2019), and the matter of the quadratic equation (Sulistyaningsih & Rakhmawati, 2017). The purpose-based on the results of the above studies has not been further research that discusses the level of errors students solve math problems as a whole, the level of student error based on education level, student error rate based on focus area, and student error rate based on moderator variables, such as Publication Years and Sample Size (number of students). With this meta-analysis, research is expected the results achieved are the consultative value of how much influence or effect size of all studies that have been done before, and as a reference other research that will conduct research with meta-analysis.

2. METHODS

In this study, researchers used meta-analysis. A systematic review is one of the methods of literature review that formulates research questions using systematic methods in identifying, selecting, and critically assessing studies that are considered relevant to the research conducted, as well as collecting and analyzing the data entered into the literature review, so that the review process has a clear, comprehensive, transparent and, while meta-analysis is research conducted (Muharram, 2021). researchers by summarizing research data, reviewing and analyzing research data from some of the results of previously existing studies (Mandailina et al., 2021). As for research measures such as Figure 1.

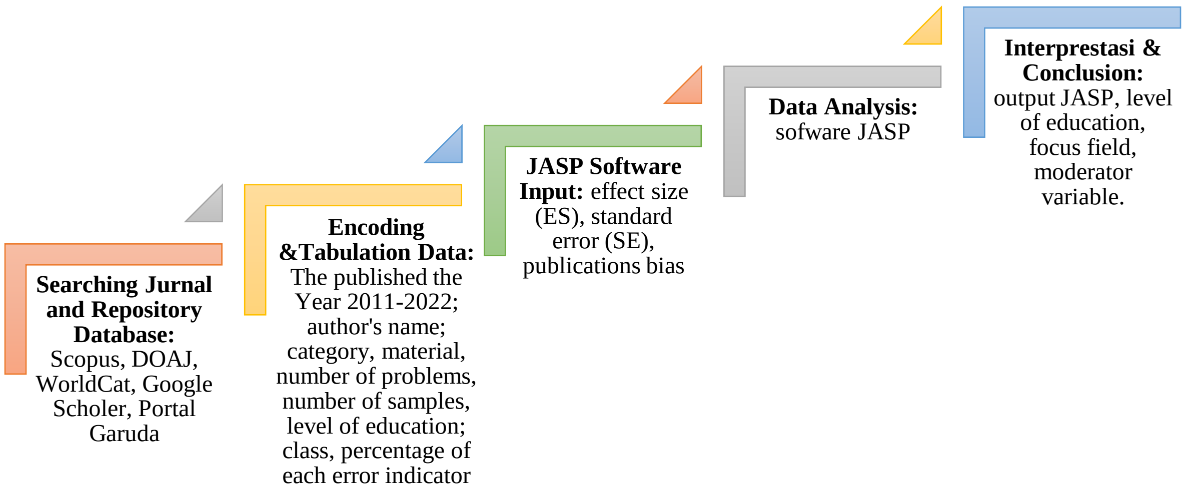


Figure 1. Research Flow Diagram

Articles sought from several databases must match the inclusion selection and exclusion criteria collected in a coding sheet in Microsoft Excel to facilitate statistical analysis of meta-analyses that continue to determine effect size (ES) and Standard Error (SE) values. There are two criteria used to determine which studies qualify for a systematic review with meta-analysis: inclusion criteria (eligibility criteria) refer to research characteristics relating to population issues (Education level, focus area, and moderator variables), related variables "Analisis Kesalahan Matematika" OR "Mathematical Error" OR "Kriteria Polya" OR "Polya Criteria" and the desired research design (systematic review and cashew-analysis). As for the eligibility criteria that refer to the characteristics of publications, concerned in the year (studies published since 2011-2022), language (using Indonesian and or English), and types of publications (Articles, Journals, Thesis) while these exclusion criteria are used to obtain articles that can be used for statistical analysis of meta-analysis of articles obtained based on inclusion criteria. The exclusion criteria are that there is data on the results of the study in the form of sample number (N), the percentage of each error indicator, effect size (ES), and standard error (SE) values (Syaharuddin et al., 2021). Meta-analysis is a systematic review that is used as a source of empirical evidence, where authors can summarize and analyze articles using several databases such as Scopus, DOAJ, WorldCat, Garuda Portal, and Google Scholar. Through this database, the main studies are tracked using keywords "Analisis Kesalahan Matematika" OR "Mathematical Error" OR "Kriteria Polya" OR " Polya Criteria". Thus, this database and keywords can help in determining and obtaining various articles contained in online journals that fit the criteria of inclusion and exclusion. Table 1 presents the search location data of each indexer database.

Table 1. Indexer Database and URL

No	Indexer Database	URL
1	Scopus	https://ww.scopus.com/home.url
2	DOAJ	https://doaj.org/
3	WorldChat	https://www.worldcat.org/
4	Google Scholer	https://scholar.google.com/
5	Portal Garuda	https://garuda.kemdikbud.go.id/

To achieve the goal of systematic high-quality review and meta-analysis, the main study selection process use the PRISMA method (Preferred Reporting Items for Systematic Reviews and Meta-analyses), through four stages, namely: (1) identification, (2) screening, (3) eligibility, and (4) included. Thus, this systematic review and meta-analysis study used these stages in selecting studies. Articles that have met the criteria are encoded into key information or data to be used in the meta-analysis process. Data or information includes the range of publication years 2011-2022, Study names, categories, languages, problem types, materials, number of questions, number of students, level, grades, S1 (understanding of the problem), S2 (devising a plan), S3 (carrying out the plan), S4 (looking back). In meta-analysis research requires statistical data that must be completed such as The number of research samples (N), the percentage size of each Polya criteria (S1, S2, S3, S4), ES values, and SE) using the formula looking for Effect Size (ES) and Standard Error (SE) values with meta-analysis criteria (Retnawati et al., 2018). Effect size (ES) = p with k is the number of events from as many as N events or with a proportion data formula with logit as the purpose of returning the formula from logit to proportion according to formula Number 1. Then calculate the value of Standard Error (SE) using the formula as in Number 2 which is calculated based on the ES of each study. In this meta-analysis, researchers use JASP 0.16.0.0 software which is free to use, flexible, and open source. To operate JASP prepare Effect Size (ES) and Standard Error (SE) data that are first calculated semi-manually using the Microsoft Excel program and stored with CSV (Macintosh) file type. Effect size is the main unit in a meta-analysis study that describes the strength of the effect, correlation, or association between two variables (Suparman et al., 2021). Intervals and Effect Size (ES) categories can be presented as in Table 2.

Table 2. Intervals and Effect Size Categories

No	Interval	Category
1	< 0.15	Ignored
2	0.15 – 0.40	Small Effect
3	0.40 – 0.75	Medium Effect
4	0.75 – 1.10	High Effect
5	1.10 – 1.45	Very High Effect
6	> 1.45	Excellent

Table 2 presents an interval that shows the value category of the effect size to determine the size of the practical significance of the study results as a measure of the magnitude of a correlation or difference between one variable and another variable. To find out the adequacy of the analysis data indicated publication bias if the p-value in the rank correlation test is greater than 0.01 then it is not indicated publication bias. That is, the data used is quite representative of the existing population.

3. RESULT AND DISCUSSION

Results

The process of selecting studies in a systematic review and meta-analysis study is presented in the PRISMA diagram flow (Preferred Reporting Items for Systematic Reviews and Meta-analyses) based on Figure 1.

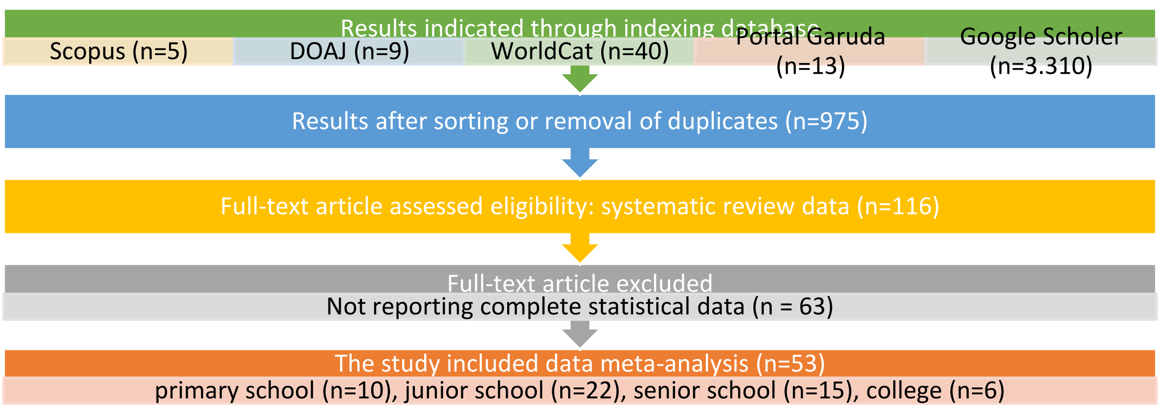


Figure 2. Diagram PRISMA

Figure 2 identified from the search results of articles from the database obtained 116 relevant studies. Of the remaining 116 articles then filtered back to find a journal that is relevant to the problem formulation obtained 63 articles that are not complete from statistical data such as 8 articles are not listed the number of students, but each percentage of error indicators is listed, 53 articles have not listed the magnitude of Polya step percentage value in full, but the number of students listed and 2 articles containing bias. Thus, only 53 articles are complete and meet the inclusion and exclusion criteria of 116 articles that have been collected. The results of the calculation of Effect Size (ES) and Standard Error (SE) values were calculated manually with Microsoft Excel according to Table 3.

Table 3. Effect Size (ES) and Standard Error (SE) Results

Studies	N	ES-S1	ES-S2	ES-S3	ES-S4	SE-S1	SE-S2	SE-S3	SE-S4
Study 1, 2014	28	0.432	0.589	0.397	0.75	0.094	0.093	0.092	0.082
Study 2, 2015	80	0.109	0.129	0.136	0.16	0.035	0.038	0.038	0.041
Study 3, 2016	40	0.05	0.215	0.229	0.18	0.345	0.065	0.066	0.061
Study 4, 2016	25	0.51	0.57	0.60	0.620	0.099	0.099	0.098	0.097
Study 5, 2017	26	0.492	0.269	0.342	0.415	0.098	0.086	0.093	0.097
Study 6, 2017	41	0.109	0.247	0.439	0.624	0.047	0.067	0.078	0.076
Study 7, 2017	16	0.669	0.853	0.734	0.617	0.118	0.089	0.110	0.122
Study 8, 2018	40	0.396	0.33	0.198	0.462	0.077	0.074	0.063	0.079
Study 9, 2018	6	0.792	0.458	0.333	0.667	0.166	0.203	0.192	0.192
Study 10, 2018	35	0.175	0.169	0.164	0.211	0.064	0.063	0.063	0.069
Study 11, 2018	25	0.160	0.259	0.363	0.217	0.073	0.088	0.096	0.082
Study 12, 2018	45	0.289	0.531	0.174	0.421	0.068	0.074	0.057	0.074
Study 13, 2018	32	0.2578	0.477	0.513	0.179	0.773	0.088	0.088	0.068
Study 14, 2018	31	0.347	0.625	0.76	0.79	0.085	0.086	0.1	0.073
Study 15, 2018	24	0.053	0.327	0.4	0.22	0.046	0.096	0.021	0.085
Study 16, 2019	422	0.207	0.262	0.264	0.267	0.019	0.021	0.173	0.022
Study 17, 2019	3	0.08	0.28	0.1	0.52	0.156	0.259	0.168	0.288
Study 18, 2019	6	0.259	0.201	0.216	0.324	0.179	0.164	0.168	0.191
Study 19, 2019	34	0.466	0.907	0.849	0.882	0.086	0.049	0.061	0.055
Study 20, 2019	37	0.351	0.432	0.405	0.731	0.078	0.081	0.081	0.073
Study 21, 2019	4	0.052	0.313	0.531	0.573	0.111	0.232	0.249	0.247
Study 22, 2019	20	0.075	0.125	0.55	0.731	0.059	0.074	0.112	0.099
Study 23, 2020	24	0.114	0.213	0.298	0.375	0.065	0.084	0.093	0.099
Study 24, 2020	36	0.38	0.14	0.24	0.24	0.081	0.058	0.071	0.071
Study 25, 2020	18	0.076	0.162	0.352	0.409	0.062	0.087	0.113	0.116
Study 26, 2020	32	0.68	0.3	0.22	0.02	0.082	0.081	0.073	0.025
Study 27, 2020	29	0.517	0.207	0.069	0.276	0.092	0.075	0.047	0.083
Study 28, 2020	36	0.422	0.159	0.167	0.251	0.082	0.061	0.062	0.072
Study 29, 2020	30	0.5	0.66	0.83	0.83	0.091	0.086	0.069	0.069
Study 30, 2020	27	0.17	0.03	0.35	0.45	0.072	0.033	0.092	0.096
Study 31, 2020	15	0.33	0.1	0.1	0.48	0121	0.077	0.077	0.129
Study 32, 2020	30	0.109	0.195	0.346	0.357	0.055	0.072	0.086	0.087
Study 33, 2020	41	0.317	0.366	0.356	0.595	0.073	0.075	0.075	0.077
Study 34, 2021	20	0.12	0.35	0.29	0.24	0.073	0.107	0.101	0.095
Study 35, 2021	20	0.559	0.5	0.324	0.441	0.111	0.118	0.104	0.111
Study 36, 2021	32	0.461	0.825	0.05	0.482	0.088	0.067	0.036	0.088
Study 37, 2021	22	0.67	0.71	0.63	0.7	0.100	0.098	0.103	0.098
Study 38, 2021	33	0.28	0.1	0.3	0.18	0.078	0.052	0.078	0.067
Study 39, 2021	28	0.917	0.345	0.245	0.381	0.052	0.089	0.081	0.092
Study 40, 2021	26	0.349	0.354	0.365	0.438	0.093	0.094	0.094	0.097
Study 41, 2021	22	0.325	0.129	0.252	0.299	0.099	0.071	0.093	0.097
Study 42, 2020	30	0.2	0.27	0.22	0.41	0.073	0.081	0.076	0.089
Study 43, 2020	16	0.94	0.6	0.64	0.64	0.059	0.122	0.12	0.12
Study 44, 2021	28	0.85	0.41	0.53	0.43	0.067	0.093	0.094	0.094
Study 45, 2021	30	0.988	0.866	0.63	0.883	0.019	0.062	0.088	0.057
Study 46, 2021	21	0.182	0.227	0.264	0.327	0.084	0.091	0.096	0.102
Study 47, 2021	46	0.187	0.133	0.119	0.176	0.057	0.050	0.047	0.056

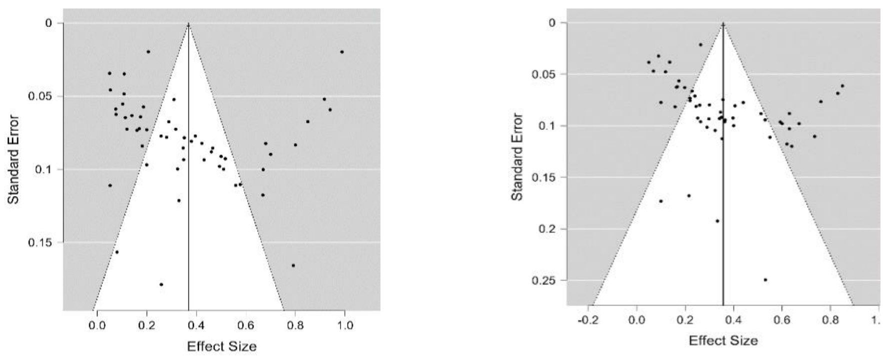
Studies	N	ES-S1	ES-S2	ES-S3	ES-S4	SE-S1	SE-S2	SE-S3	SE-S4
Study 48, 2021	17	0.2	0.35	0.62	0.65	0.097	0.116	0.117	0.116
Study 49, 2021	26	0.7	0.746	0.592	0.546	0.089	0.085	0.096	0.098
Study 50, 2021	30	0.14	0.467	0.26	0.613	0.063	0.091	0.080	0.089
Study 51, 2022	78	0.31	0.11	0.09	0.33	0.052	0.035	0.032	0.053
Study 52, 2022	23	0.8	0.69	0.67	0.61	0.083	0.096	0.098	0.101
Study 53, 2022	20	0.557	0.093	0.158	0.172	0.110	0.065	0.082	0.084

Table 3 shows the results of calculation of ES-S1 values: Effect Size of understanding the problem, ES-S2: Effect Size of devising a plan, ES-S3: Effect Size of carrying out the plan, ES-S4: Effect size of looking back. and SE-S1: Standard Error of effect size from understanding the problem, SE-S2: Standard Error of effect size from Devising a plan, SE-S3: Standard Error of effect size from carrying out the plan, and SE-S1: Standard Error of effect size from Looking back from 53 studies. To perform meta-analysis using JASP software version 0.16.0.0, it first needs to be activated by clicking (left) twice the program. After adjusting, the main view of JASP software will appear and to perform meta-analysis by selecting the main menu show menu in the top left corner, click open and select the location of the saved file and the type of file existence stored, here the researcher saves with CSV existence, then click open then the data will appear in JASP software and select the classical type meta-analysis menu. Move each data into the provided column such as Studies in the Study Label column, ES in the Effect Size column, and SE in the Effect Size Standard Error column. This study used a restricted ML (random effect model) model that can be selected in the method column to detect the occurrence of biased publications or not in click statistics data and diagnostics-check all existing menus, it will appear JASP output results as presented in Table 4.

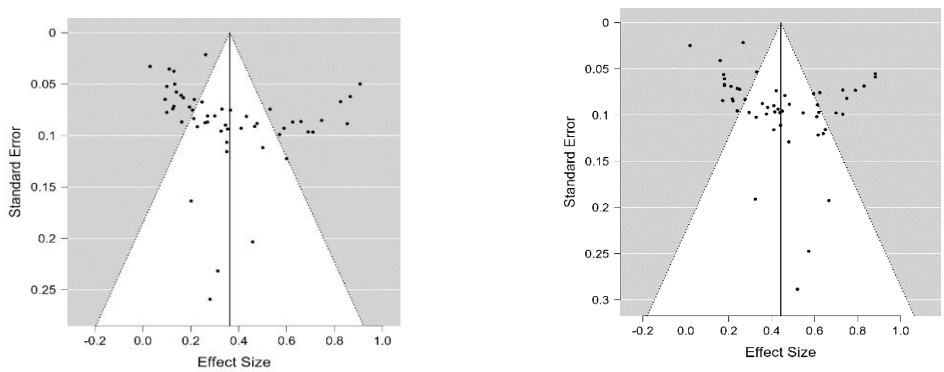
Table 4. JASP Output of Each Category

Error Category	N	Q_{RE}	Coefficient	Category	I^2 (%)	p-Rank Test	Forest Plot
Understanding the problem	53	1,768.797	0.369	Low	94.435	<0.001	0.37 [0.30 - 0.44]
Devising a plan	53	676.714	0.363	Low	91.847	<0.001	0.36 [0.30 - 0.43]
Carrying out the plan	53	462.978	0.357	Low	88.865	<0.001	0.36 [0.30 – 0.41]
Looking back	53	685.709	0.442	Enough	89.747	0.037	0.44 [0.38 – 0.50]

Table 4 shows the error category of understanding the problem with the number of samples 53 it is seen that the coefficient (summary effect size) shows a value of 0.369 including errors with a Low category based on the correlation coefficient interval table, and a forest plot value of 0.37 which compulsively students made mistakes understanding the problem with a percentage of 37% and the rest of 63% of students have answered correctly. Mistakes thinking about plans, coefficient values of 0.363 with low categories, and forest plot values of 0.36 compulsively students made mistakes thinking about plans by 36% and the rest by 64% have answered correctly. Error in carrying out the plan, a coefficient value of 0.357 is included in the low category, with a forest plot value of 0.36 compulsively students made mistakes in implementing the plan by 36% and the rest of the 64% of students have been able to answer correctly, errors re-examined answers with a coefficient value of 0.442 including the category of sufficient errors and forest plot values of 0.44 compulsively students made mistakes re-examining answers by 44% and the remaining 56% of students have been able to answer. The distribution of data patterns is seen in Figure 3.



(a) Understanding The Problem (c) Carrying Out the Plan



(b) Devising a Plan (d) Looking Back

Figure 3. Funnel Plot Each Mathematical Error

From the results of the JASP software output, it can be seen that the plot funnel of the four errors according to Polya shows that there is no research indicated by biased publications marked no open circle means that no research is lost. However, the entire circle is closed which means that the research sample meets minimal standards. In another way, it can be seen from the results of the P-Rank Test <α = 0.05 shows that the data is not indicated bias, this can be seen in Table 4 which shows the P-Rank Test results of each error are smaller than the significance value (α<0.05). Furthermore, the authors divided the data into four parts based on the level of education, namely elementary school, junior high, high school, and college. The following is JASP output based on the level of education presented as in Table 5.

Table 5. JASP Output Based on Education Level

Level	Error Category	N	Coefficient	Category	p-Rank Test	Forest Plot
Primary School	S1	10	0.380	Low	0.073	0.38 [0.24, 0.52]
	S2	10	0.520	Enough	0.601	0.52 [0.34, 0.70]
	S3	10	0.554	Enough	1.000	0.55 [0.38, 0.72]
	S4	10	0.613	Tall	0.484	0.61 [0.45, 0.77]
Junior High School	S1	22	0.379	Low	0.054	0.38 [0.25, 0.51]
	S2	22	0.376	Low	0.468	0.38 [0.29, 0.47]
	S3	22	0.324	low	0.239	0.32 [0.25, 0.40]
	S4	22	0.401	Enough	0.217	0.40 [0.30, 0.50]
Senior High School	S1	15	0.325	Low	0.093	0.33 [0.20, 0.45]
	S2	15	0.199	Very Low	0.004	0.20 [0.12, 0.28]
	S3	15	0.270	Low	0.003	0.27 [0.20, 0.34]
	S4	15	0.383	Low	0.027	0.38 [0.30, 0.47]
College	S1	6	0.415	Enough	0.056	0.41 [0.24, 0.59]
	S2	6	0.459	Enough	0.469	0.46 [0.28, 0.64]
	S3	6	0.324	Low	0.056	0.32 [0.16, 0.49]
	S4	6	0.428	Enough	0.469	0.43 [0.29, 0.57]

From the results of Table 5 based on the level of education for the Primary School level with N=10 the highest mistakes made by students on the error of looking back at the answers by 61% with a coefficient magnitude of 0.613 with a strong category, error understanding the problem by 38% with a coefficient level of 0.380 which belongs to the low error category, Thinking Plan Error of 52% with a coefficient level of 0.520 which belongs to the sufficient category, mistake of thinking of a plan of 55% with a coefficient level of 0.554 which belongs to the category of enough. Furthermore, the highest error rate at the Junior High School level with N=22 is in the error of re-examining the answer by 40% with a coefficient of 0.401 which is included in the sufficient category, Error in understanding the problem and implementing the plan by 38% with a low error category, error in implementing the plan by 32% with a coefficient of 0.324 including the low error category. In senior High School, the highest mistakes students make on the error of re-examining answers by 38% with a coefficient magnitude of 0.383 belong to the low category, error understanding the problem by 33% with a coefficient of 0.325 which belongs to the category of low errors, mistakes thinking of plans by 20% with a coefficient of 0.199 including the category of very low errors, mistakes of thinking plans by 27% with a coefficient of 0.270 belong to the low category. While errors at the public University level the largest error rate in thinking about plans was 46% with a coefficient of 0.459 included in the sufficient category, error in understanding the problem by 41% with a coefficient of 0.415 included in the sufficient category, error in implementing plans by 32% with a coefficient of 0.324 including the low category, error re-examining answers by 43% with a coefficient of 0.428 included in the sufficient category. At this stage, researchers perform a meta-analysis to see error rates based on mathematical focus areas such as number patterns, algebra, and geometry. Further analysis of errors based on the field of focus is presented in Table 6.

Table 6. JASP Output By Focus Field

Focus	Error Category	N	Coefficient	Category	p-Rank Test	Forest Plot
Patterns	S1	18	0.374	Low	0.081	0.37 [0.24, 0.51]
	S2	18	0.432	Enough	0.454	0.43 [0.32, 0.54]
	S3	18	0.403	Enough	0.021	0.40 [0.31, 0.50]
	S4	18	0.482	Enough	0.229	0.48 [0.38, 0.58]
Algebra	S1	14	0.312	Low	0.101	0.31 [0.18, 0.44]
	S2	14	0.225	Low	0.019	0.22 [0.15, 0.30]
	S3	14	0.297	Low	0.019	0.30 [0.23, 0.37]
	S4	14	0.372	Low	0.007	0.37 [0.27, 0.47]
Geometry	S1	15	0.413	Enough	0.011	0.41 [0.30, 0.53]
	S2	15	0.418	Enough	0.169	0.42 [0.29, 0.55]
	S3	15	0.355	Low	0.114	0.36 [0.21, 0.50]
	S4	15	0.488	Enough	0.697	0.45 [0.30, 0.59]

Table 6 shows the highest errors made by students in the focus area of the number pattern with an average of 0.42 or 42% at each level of education and Geometry which has an average error of 0.41 or 41%, these two fields have the largest average compared to the algebraic focal field of only 0.3 or 3%.This is the last stage to see the error rate based on the moderator variable. Here, the authors divide the data based on the year of publication and the number of participants in each study. This study conducted a follow-up analysis using moderator variables as in Table 7.

Table 7. Moderator Variable Analysis

Variable	Interval	Error Category	N	Coefficient	Category	p-Rank Test	Forest Plot
Publication years	2011-2019	S1	22	0.271	Low	<.001	0.27 [0.19, 0.35]
		S2	22	0.393	Low	0.102	0.39 [0.29, 0.49]
		S3	22	0.394	Low	0.178	0.39 [0.30, 0.49]
		S4	22	0.472	Enough	0.288	0.47 [0.37, 0.58]
	2020-2022	S1	31	0.431	Enough	0.096	0.43 [0.33, 0.53]
		S2	31	0.343	Low	<.001	0.34 [0.26, 0.43]
		S3	31	0.332	Low	<.001	0.33 [0.26, 0.40]
		S4	31	0.422	Enough	0.031	0.42 [0.35, 0.50]
Sample Size	≤ 20 participants	S1	13	0.371	Low	0.675	0.37 [0.21, 0.54]
		S2	13	0.334	Low	0.252	0.33 [0.20, 0.47]
		S3	13	0.377	Low	0.252	0.38 [0.25, 0.50]
		S4	13	0.087	Very Low	0.004	0.09 [0.05, 0,13]
	21 – 40 participants	S1	33	0.406	Enough	<.001	0.41 [0.32, 0.50]
		S2	33	0.398	Low	0.003	0.40 [0.31, 0.48]
		S3	33	0.382	Low	<.001	0.38 [0.31, 0.46]
		S4	33	0.446	Enough	0.200	0.45 [0.36, 0.53]
	≥ 40 participants	S1	7	0.208	Low	0.239	0.21 [0.14, 0.27]
		S2	7	0.245	Low	0.239	0.24 [0.14, 0.35]
		S3	7	0.214	Low	0.239	0.21 [0.12, 0.30]
		S4	7	0.359	Low	0.069	0.36 [0.22, 0.50]

Table 7 is an advanced table for analyzing errors based on moderator variables for article development based on publication years which shows that in 2020 - 2022 there was an increase in errors based on the application of Polya steps in analyzing student errors by 0.38 or 38%. Then from the sample size level used in the range of 21 - 40 participants had the largest error rate with an average of 0.41 or 41% compared to the number of ≤20 participants and ≥40 participants.

Discussion

Table 4 shows that the most mistakes students make on Looking Back with a percentage of 0.44 or 44%, with the lowest mistakes made by students in devising a plan and carrying out the plan which has the same percentage rate of 36%, and understanding the problem at 37%. This is in line with the research obtained error rate on understanding the problem was 10.93%, devising a plan 12.93%, carrying out the plan 13.6% and looking back 16.00% (Widodo & Sujadi, 2017). Based on the four funnel plot results for the density level is quite good, but there are still studies that exist outside of the layer based on forest plot results (Mustika et al., 2018). Figure (a) understanding the problem by 0.79% or 79%, (b) devising a plan by 0.46 or 46%, (c) carrying out the plan 0.33 or 33%, and (d) Looking back by 0.79 or 79%, another research on Figure (a) *Understanding The problem* by 0.08 or 8%, (b) *Devising a plan* by 0.28 or 28%, (c) *Carrying out the plan* 0.10 or 10%, and (d) *Looking back* by 0.52 or 52% (Jedaus et al., 2019); understanding The problem by 0.26% or 26%, (b) devising a plan by 0.20 or 20%, (c) carrying out the plan 0.22 or 22%, and (d) Looking back by 0.32 or 32% (Pratiwi, 2019); and Understanding The problem of 0.05 or 5%, (b) devising a plan by 0.31 or 31%, (c) carrying out the plan 0.53 or 53%, and (d) Looking back by 0.57 or 57% (Yulita & Ishartono, 2021). Based on Table 5 for primary school level with N = 10 highest mistakes made by students in looking back, namely 61%, understanding the problem by 38%, devising a plan by 52%, carrying out the plan by 55%. This is in line with the research who show that the biggest errors in the looking back type 62.43%, understanding the problem by 10.85%, devising a plan by 24.7%, and carrying out the plan by 43.97%, junior high school level with N=22 highest errors in looking back by 40%, understanding the problem and devising a plan by 38%, carrying out the plan by 32% (Jamilah, 2017). As for some other studies that have the highest percentage rate in the looking back category, looking back by 43.8%, understanding the problem by 34.9%, devising a plan by 35.4%, and carrying out the plan by 36.5% (Suharti et al., 2021), and looking back by 100%, understanding the problem by 35.14%, devising a plan by 43.24%, and carrying out the plan by 40.54%. Then the senior high school level had the highest errors made in the looking back category by 38%, understanding the problem by 33%, devising a plan by 20%, carrying out the plan by 27% (Yuliani et al., 2018). this percentage is lower than the study show that looking back by 45%, understanding the problem by 17%, devising a plan by 3%, carrying out the plan by 35% (Bani & Ate, 2020), looking back by 48%,%, understanding the problem by 33%, devising a plan by 10%, carrying out the plan by 10% (Ngura et al., 2020), and other research looking back by 100%, understanding the problem by 7.5%, devising a plan by 12.5%, carrying out the plan by 55%. The college error rate is highest in devising a plan at 46%, understanding the problem at 41%, carrying out the plan by 32, looking back by 43% (Apriliyanto, 2019). This is in line with the research with devising a plan category of 53.1%, understanding the problem 28.9%, carrying out the plan 17.4%, and looking back by 42.1% (Apriani, 2018).

Table 6 shows the highest errors students make in the number pattern focus area with each category understanding the problem at 37%, devising a plan 43%, carrying out the plan 40%, and looking back 48% with an average of 0.42 or 42%. This is in line with the research. The arithmetic sequence and series material state the category of Understanding the problem by 31%, Devising a plan 11%, Carrying out the plan 9%, and looking back 33%, and geometry focus areas with each category understanding the problem by 41%, devising a plan 42%, carrying out the plan 36%, and looking back 45% with an average error of 0.41 or 41% (Winarso et al., 2022). This is in line with the research with understanding the problem at 39.6%, Devising a plan 33%, carrying out the plan 19.8%, and looking back 46.2%, these two fields have the largest average compared to algebra focus areas of only 0.3 or 3% with each category of error understanding the problem by 31%, devising a plan 22%, carrying out the plan 30%, and looking back 37% (Jana, 2018). Table 7 is an advanced table for analyzing errors based on moderator variables obtained information that the student error rate in solving problems has been higher over the last three years with an average error of 38% with a sample size range rate of 21-40 participants with an average of 0.41 or 41% with the number of students, 28 has the highest error rate in the category understanding the problem 91.70%, devising a plan 34.50%, carrying out the plan 24.50%, and looking back 38.10% (Nova et al., 2021). Some research on analyzing student errors in the field of focus has been done a lot, such as the field of focus geometry on Trigonometry material with an *understanding the problem* rate of 57.73% caused by students not understanding the concept of Trigonometry, *devising a plan* 9.27%, because students do not use all the information that has been collected or presented when planning problem-solving strategies, *carrying out the plan* by 15.83% caused by students not using the steps correctly, students are not skilled in applying algorithms, and inaccuracies answer questions and *looking back* by 17.16%, because students do not evaluate their work results to ensure the accuracy of answers (Gradini et al., 2022), broad material and circumference of triangles (Kurniawan et al., 2021), quadrilateral material (Fajri & Iwan, 2018). Number patterns focus fields such as row application materials and series (Sastri et al., 2019), social arithmetic material (Pitriani & Ocktaviaini, 2020), and permutation and combination materials students do understanding the problem by 51%, devising a plan 57%, carrying out the plan of 60% and looking back of 62% (Sukoriyanto et al., 2016), algebra fields such as the two-variable linear equation system students perform understanding the problem by 28%, because students are weak about understanding variable concepts, devising a plan of 10% of students are weak in understanding the concept of variables and do not understand about elimination methods and substitutions (Principles, Concepts), carrying out the plan of 30% and looking back of 18% of students are weak in understanding the concept of variables, and do not understand about elimination methods and substitution and are unable to understand problems in mathematical sentences such as concepts, principles, and operations (Lukas et al., 2021), algebraic materials (Fathonah et al., 2018; Khusniawati et al., 2019), and the matter of the quadratic equation (Sulistyaningsih & Rakhmawati, 2017).

4. CONCLUSION

This research is used to summarize evidence from the many studies that analyzed mathematical problem errors based on Polya steps. From the analysis data, it can be concluded that the highest mistakes were made at looking back 44%, understanding the problem by 37%, devising a plan by 36%, carrying out the plan by 36% analysis of student errors based on education level, the highest type of error in error in re-examining answers at the elementary level (61%), junior high school (40%), high school (38%), while for the college level, the Division a plan type was 46%, for error analysis based on the focal plane that the focal plane of the Pilangan Pattern with an average error of 42% has the highest error rate followed by the focal plane geometry with an average of 41%, this error is greater than the focus plane of Algebra by only 3%. With a sample size in the range of 21-40 participants of 41%. As for suggestions for teachers in the field of study, in learning applications, it is needed to form the development of question models so that students have additional information so that students are not only focused on examples of the same questions; for students who make mistakes more thoroughly and practice more questions; and for prospective teachers, the results of this study can be used as additional information in preparing themselves to determine the right steps in overcoming student errors in solving math problems.

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