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What Methods are used for Statistical Reasoning Learning?: A Systematic Literature Review

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Abstract: A student's statistical reasoning ability is needed as a good and precise foundation, so that a teacher is demanded to use the proper methods to improve students' statistical reasoning. This research aims to know the appropriate methods used to improve students' statistical reasoning ability and the methods' steps. Systematic Literature Review (SLR) is employed in three steps. The SLR stages are carried out in three stages, namely Planning the Review, Conducting the Review, Reporting and Disseminating. Article searching by using Harzing's Publish or Perish Application and data analysis using atlas.ti with coding Histoorical Background, Context Solution, Research Questions or Objectives, Methodology, Conclusions, and Findings. The findings of statistical reasoning learning are Statistical Reasoning Learning Environment (SRLE), Experiential Learning, Blended Learning, 4MAT learning style system, and Brain-based Learning. From those methods, Statistical Reasoning Learning Environment is used primarily in the learning process.

Keywords: statistical reasoning, systematic literature review, publish or perish.

Abstrak: *Kemampuan penalaran statistik siswa dibutuhkan sebagai bekal bernalar statistik siswa dengan baik dan tepat, sehingga Guru dituntut untuk dapat menggunakan metode pembelajaran yang tepat dalam penerapan penalaran statistik siswa. Penelitian ini bertujuan untuk mengetahui metode seperti apa untuk pembelajaran penalaran statistik dan bagaimana tahapan metode tersebut. Penelitian ini menggunakan metode Sitematics Literature Riview (SLR). Adapun tahapan SLR yang dilaksanakan melalui tiga tahap yaitu Planing the Review, Conducting the Riview, Reporting and disseminating. Pencarian artikel dengan aplikasi Harzing's Publish or Perish dan analis data menggunakan atlas.ti dengan coding Histoorical Background, Context Solution, Research Question or Objectives, Metodologi, Conclusion, dan Finding. Adapun temuan metode pembelajaran penalaran stastistik diantaranya Statistical Reasoning Learning Environment (SRLE), Experiental Learning, Blended Learning, 4MAT learning style system, dan Brain Based Learning. Selanjutnya dari sekian metode pembelajaran statistic reasoning yang banyak digunakan adalah metode Statistical Reasoning Learning Environment (SRLE).*

Kata kunci: *penalaran matematis, tinjauan literatur sistematis, publish or perish.*

▪ INTRODUCTION

Information is widespread easily in the current digital era. The ease of information should get assessment policy on the level of information competency by the students (Martyniuk, Martyniuk, & Muzyka 2020). The information level assessment makes the students wisely sort out the correct and incorrect information. The related problems are sharing and storing the information. Those problems are usually connected to the lack of interoperability and usability of the digital services offered (Carlsson 2021). So, the incorrect information is easy to access by the students. It is necessary for the student to carefully in reasoning the information. One competence to sort out the information wisely

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is using statistical reasoning. Statistical reasoning is students' ability to understand the information in their daily life based on statistical data (Jauhari et al. 2021).

According to (Zhang et al. 2022), the reasoning is becoming popular in the academic and industrial fields. In education, reasoning is used to prove a theory, such as in mathematics. Mathematics is related to general deductive ability, related to specific reasoning ability (Morsanyi, McCormack, & O'Mahony 2018). Reflective reasoning is needed in proving mathematics. (Bao et al. 2022) added that reasoning is students' thinking power used to label a set of skills that support critical, problem solving, and creativity in learning. While according to (Masnick & Morris 2022), data reasoning is students' ability built on intuition and knowledge of mathematics and statistics. Comprehensive knowledge about scientific reasoning needs an understanding of data reasoning as a core competency. The next generation needs statistical reasoning to be careful in analyzing something based on the data. It is based on tremendous irresponsible information, so the students are expected to evaluate something wisely by statistical reasoning.

Statistical reasoning is the ability to understand daily life information based on statistics (Ariwinanda, Zubainur, & Sofyan 2022). While (Rapan and Valerjev 2021) stated that statistical reasoning is the best and most efficient operationalization based on the principles underlying the reasoning to do basic tasks on the statistical principles knowledge. So, the students' statistical reasoning uses statistical reasoning principles to understand the information in daily life. It is reported in the research from (Luque et al. 2022) that based on the students' positive attitude and performance, and there was reinforcement between statistical reasoning and life knowledge. The reasoning is necessary for daily life, especially statistical reasoning. When the students are accustomed to their statistical reasoning, they will be able to analyze, evaluate and conclude their answers to their daily life problems wisely.

Appropriate and efficient methods are used to improve students' statistical reasoning. They are Statistical Learning Reasoning Environment (SLRE), Reasoning Method Based on Intervals with Symmetric Truncated Normal Density, Blended Learning, 4MAT learning Style System, Demonstration, etc. SLRE is an effective and positive statistic class that develops more profound and more meaningful statistic understanding for the students that help them to develop their ability to think and reasoning statistically (Garfield & Ben-Zvi 2009). This approach is called a learning environment for its interactive text material, class and culture activity, discussion, technology, learning, and assessment approach (Garfield & Ben-Zvi, 2009; Rohana and Ningsih 2020) stated that Blended learning in statistical reasoning learning is used in two techniques; direct class and online learning. Moreover, (Yanti et al. 2021) added that the 4MAT learning style system combines four methods of statistical reasoning learning; innovated learning style, analytical learning style, dynamical learning style, and other learning styles that will be analysed in this research.

This study reviews some learning methods used in statistical reasoning learning by using Literature Review Method. According to (Nababan et al., 2021), the literature review method is used to identify learning methods used in statistical reasoning. It also will discover an appropriate method for implementing statistical reasoning. This discovery will also cover the implementation technique to fulfill the purpose of novelty in this research.

▪ METHOD

This research employed the Systematic Literature Review (SLR) method. (Siswanto 2010) stated that SLR is a research method that reviews primary research results to present more comprehensive and balanced facts by the research objectives. One of the SLR goals is to reduce the review bias that can lead to incomplete information or study. The bias also results in incorrect conclusions about particular topics (Van Klaveren and De Wolf 2019). SLR method has three stages; *Planning the Review, Conducting the Review*, reporting, *and disseminating*. The following is the detail of those three stages.

Planning the Review stage

This stage is divided into two, namely: Setting the Research Objective and Conducting the Review Stage. Setting the Research Objective, In this Stage, the researcher defines the literature purpose by referring to the research purpose, statistical reasoning method, and its stages implementation. Forward, Defining the Conceptual Boundaries, the researcher defines the research purpose based on the focus. It is conducted by searching the literature with Harzing's Publish or Perish Application. It includes the requirements, such as the articles defining the statistical reasoning methods with journal-oriented limitations. The articles specifically focus on learning methods and statistical reasoning.

Conducting the Review Stage

In this stage, the researcher limits the articles based on the inclusion criteria. According to (Juandi 2021), the inclusion criteria includes: a) Defining Search Boundaries, the search is conducted on Google Scholar by using Harzing's Publish or Perish Application. It is to search all the articles indexed in any kind of indexing site such as Sinta, Scopus, etc. The search uses the "Statistical Reasoning" keyword. b) Defining Search Terms, Defining the terms is conducted by using the following limitations: (1) The articles should be oriented on journals, not books, (2) The articles discuss the learning implementation focus, (3) The articles focus on statistical reasoning, (4) The articles focus on implementing the statistical reasoning learning method. c) Defining Cover Period, Defining cover period is the articles published in 2019-2022 and written in English.

Reporting and disseminating Stage

This stage is divided into two, namely Independent Data Coding and Validating Data Coding. Independent Data Coding, After the articles are sorted out in conducting the review stage, the qualified articles will be analyzed using atlas.ti with the following review codes, 1) Historical Background, describing the problems or related variables, 2) Context Solution, the topics or independent variable as solutions of dependent variable solution, 3) Research Question or Objectives, finding out the research question or purposes. 4) Method, the method used in the research, 5) Conclusion, the result of the research, or the conclusion in the articles, 6) Finding, the finding of the research, in this research, the coding will be related to learning method used and the steps of the learning. Validating Data Coding, Validation of data coding analysis is the adaptability of research finding with the purpose of the research that will descriptively generalize the article's finding.

▪ RESULT AND DISSCUSSION

Planning Review Stage

Determine the purpose of the research; to know the statistical reasoning methods, and know the implementation of the methods. The next is to focus the purpose of the research by using Harzing's Publish or Perish with the following details:

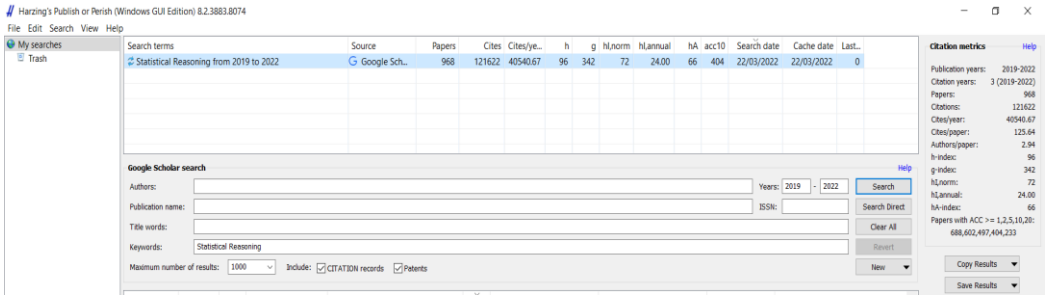

Figure 1. Searching format using Harzing's Publish or Perish

Figure 1. shows the search using Harzing's Publish or Perish. The search uses the keyword "Statistical Reasoning," with a limitation year from 2019 to 2022. It was conducted at22 March 2022 to the sources that were indexed in Google Scholar. The total article was 968 papers, with a citation total was 121622 times, and H-index was 96.

Conducting the Review Stage

This stage sort out the articles based on the given inclusion criteria. The following is the collection of 968 papers found.

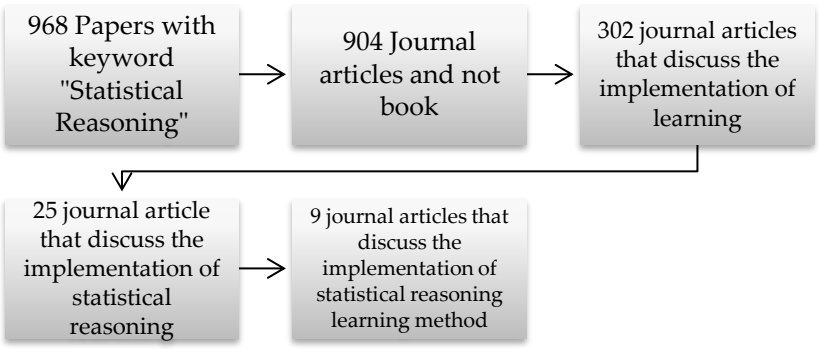

Figure 2. Plot selection of the given inclusion criteria

Figure 2. shows the selected reduction system from 968 papers into nine articles. Those articles then were analyzed using Atlas.ti. 8. 968 Papers with initial criteria that used Harzing's Publish or Perish Application, and then those article were sorted out based on the journal not book or book chapter. In this Stage, 904 papers fulfilled the criteria. In the next Stage, the articles were sorted out with the inclusion criteria. This criterion is applied the explanation of learning. This Stage resulted 302 papers which means from the initial sort-out percentage 67% papers into 33%. In the next Stage, those 302 papers were sorted from 25 articles into nine based on the point of discussion of statistical reasoning implementation criteria. The following table presents those nine articles. The order in table 1 is used in coding description.

Table 1. The selection result using Inclusion Criteria

No	Title	Author	Publisher	Year	Link
1	Review on Electrical Impedance Tomography: Artificial Intelligence Methods and its Applications	Talha Ali Khan and Sai Ho Ling	Algorithm	2019	https://scholar.google.com/scholar?cites=15434039501521574292&as_sdt=2005&sciodt=2007&hl=en
2	Attitudinal changes in face-to-face and online statistical reasoning learning environments	Daniel A. Showalter	JPR (Journal of Pedagogical Research)	2021	https://scholar.google.com/scholar?cites=18307172327351596569&as_sdt=2005&sciodt=2007&hl=en
3	Statistical reasoning through metacognitive brain-based learning	W Susilawati, R Abdullah dan M N Abdullah	Jurnal Analisa	2020	https://scholar.google.com/scholar?cites=9640565646227457344&as_sdt=2005&sciodt=2007&hl=en
4	Developing Statistical Reasoning Ability of Industrial Engineering Students Through Experiential Learning	Frena Fardillah, Ossa Sutaagra , Yani Supriani , Ehda Farlina , Nanang Priatna	Journal of Physics: Conference Series	2019	https://scholar.google.com/scholar?cites=13162257918317760176&as_sdt=2005&sciodt=2007&hl=en
5	Statistical Reasoning Ability Analysis Observed From 4MAT Learning Style System	Aning Wida Yanti, I Ketut Budayasa, Raden Sulaiman, Sutini, Atiyatun Hasanah	AIP Conference Proceedings	2021	https://aip.scitation.org/doi/abs/10.1063/5.0043454
6	Reasoning Method Based on Intervals with Symmetric Truncated Normal Density	Peng Wu, Zhenjie Hou, Jiqiang Liu, and Jinzhao Wu	Symetry	2021	https://www.mdpi.com/2073-8994/14/1/25
7	Statistical reasoning of prospective teachers through blended learning	Rohana and Y L Ningsih	Journal of Physics: Conference Series	2020	https://iopscience.iop.org/article/10.1088/1742-6596/1480/1/012006

No	Title	Author	Publisher	Year	Link
8	The Statistical Reasoning Learning Environment: A Comparison of Students' Statistical Reasoning Ability	Basil Conway, W. Gary Martin, Marilyn Strutchens, Marie Kraska & Huajun Huang	Journal of Statistics Education	2019	https://www.tandfonline.com/doi/full/10.1080/10691898.2019.1647008
9	The sport student's statistical literacy through statistical reasoning learning environment (SRLE)	N Hidayah , W Wahyudin and T Turmudi	International Conference on Mathematics and Science Education	2019	http://science.conference.upi.edu/proceeding/index.php/ICMScE/article/view/67

Reporting and disseminating Stage

Before deciding the analysis using atlas.ti coding, the researchers read first to confirm the appropriation of the article based on the coding. The researcher synthesized to cancel one article 1 for it's incompatibility with the code. So, the total articles to be analyzed using atlas.ti version 8 is 8. Here is the result of data analysis.

a. Historical Background

Historical Background is coding part of the article that discusses the issues or dependent variable as the core problem. Here is the result from historical backgroung coding.

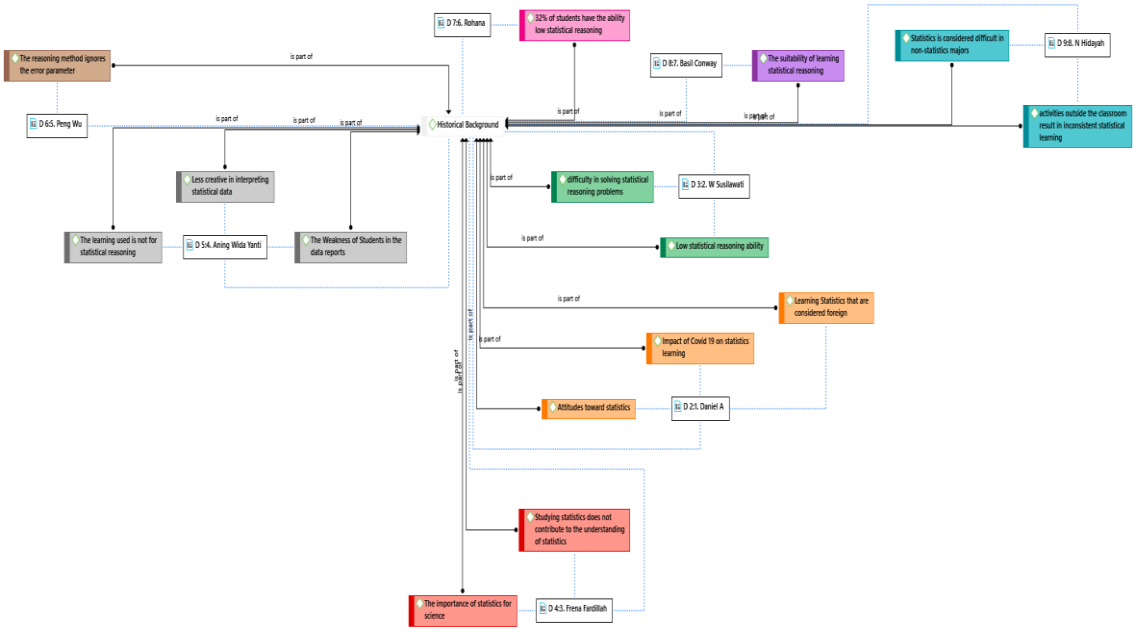

Figure 3. The analysis result of historical background

Figure 3. shows that many articles discuss historical background from a low level of statistical reasoning ability. An article also reported inappropriate learning that is used in statistical reasoning and the importance of statistical reasoning in science. There is also another article that discusses the difficulty and unfamiliarity of statistics for some students. The historical background they discuss lead to some impacts to the solution of their problems. However, in those articles, many researchers are interested in pointing out the low-level students' ability in statistical reasoning. That is why it is necessary to solve the problem in terms of improving students' statistical reasoning ability.

b. Context Solution

Context solution is coding the part of an article that discusses the alternative solution to solve the problems found in the historical background. Here is the coding analysis result.

Figure 4. Context solution analysis

Figure 4 describes some learning methods taken from the eight articles. Brain-based Learning proposed by Daniel A proposed in statistical reasoning learning. Aning Wida Yanti explained 4MAT method as new learning that can be applied in reasoning learning. While, Rohana dan

Frena Fardillah consecutively proposed Blended and Experiential Learning to improve students' statistical reasoning ability. Contrastively, Peng Wu proposed a new theory called Simple Interval to improve students' statistical reasoning understanding in math. However, from the analyzed articles, many articles discuss Statistical Reasoning Learning Envorimnet (SRLE) as an alternative solution to learning statistical reasoning.

c. Research Question or Objectives

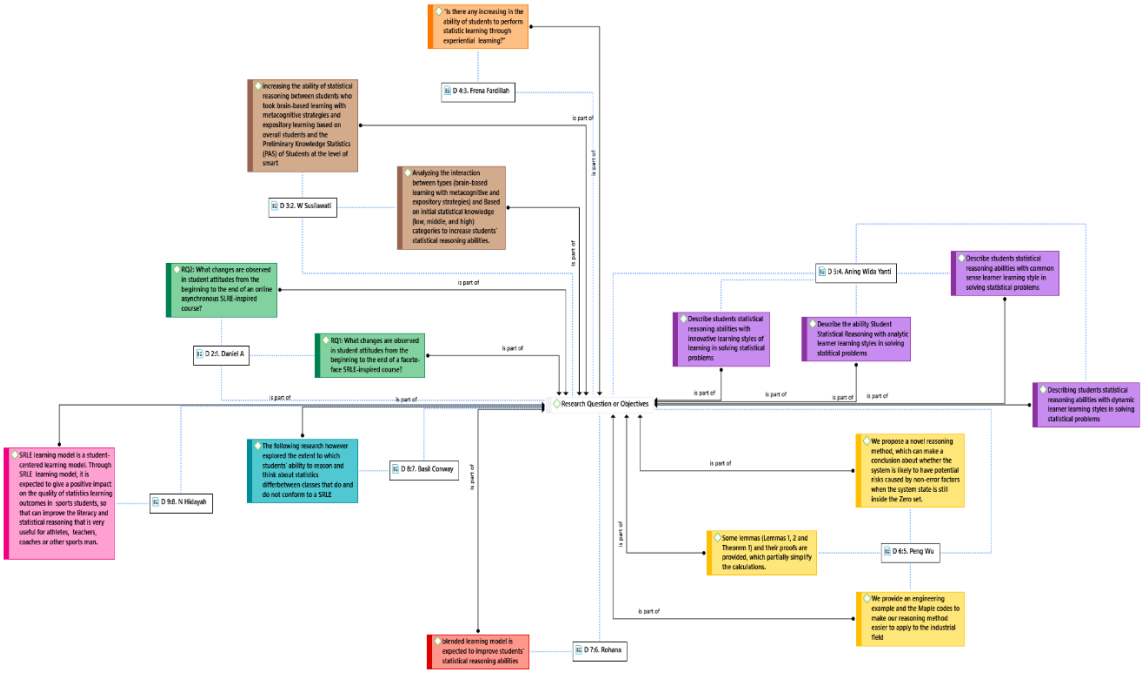

Figure 5. Question or objectives analysis

Figure 5 describes the Research Question or Objectives proposed in those articles. Frena Fardillah reviewed the students' statistical ability improvement while Susilawati not only on students' reasoning improvement but also on the students' interaction in Brain-Based Learning. In other words, Aning proposed four purposes in her article: to describe learning style and to describe students' statistical reasoning. Peng Wu in his new theorem, proposes that his research purpose is to make new effective steps in solving the students' statistics. Rohana stated that her research purpose is to explain Blended Learning as a method to improve students' statistical ability. However, Basil, N Hidayah, and Danil presented some questions and purposes about SLRE in statistical reasoning learning.

d. Methodology

Figure 6. describes the research method used in Descriptive, Experiment, and Theory Development research methods. From the eight articles presented in figure 6, it can be concluded that the Experimental research method is dominant in those articles.

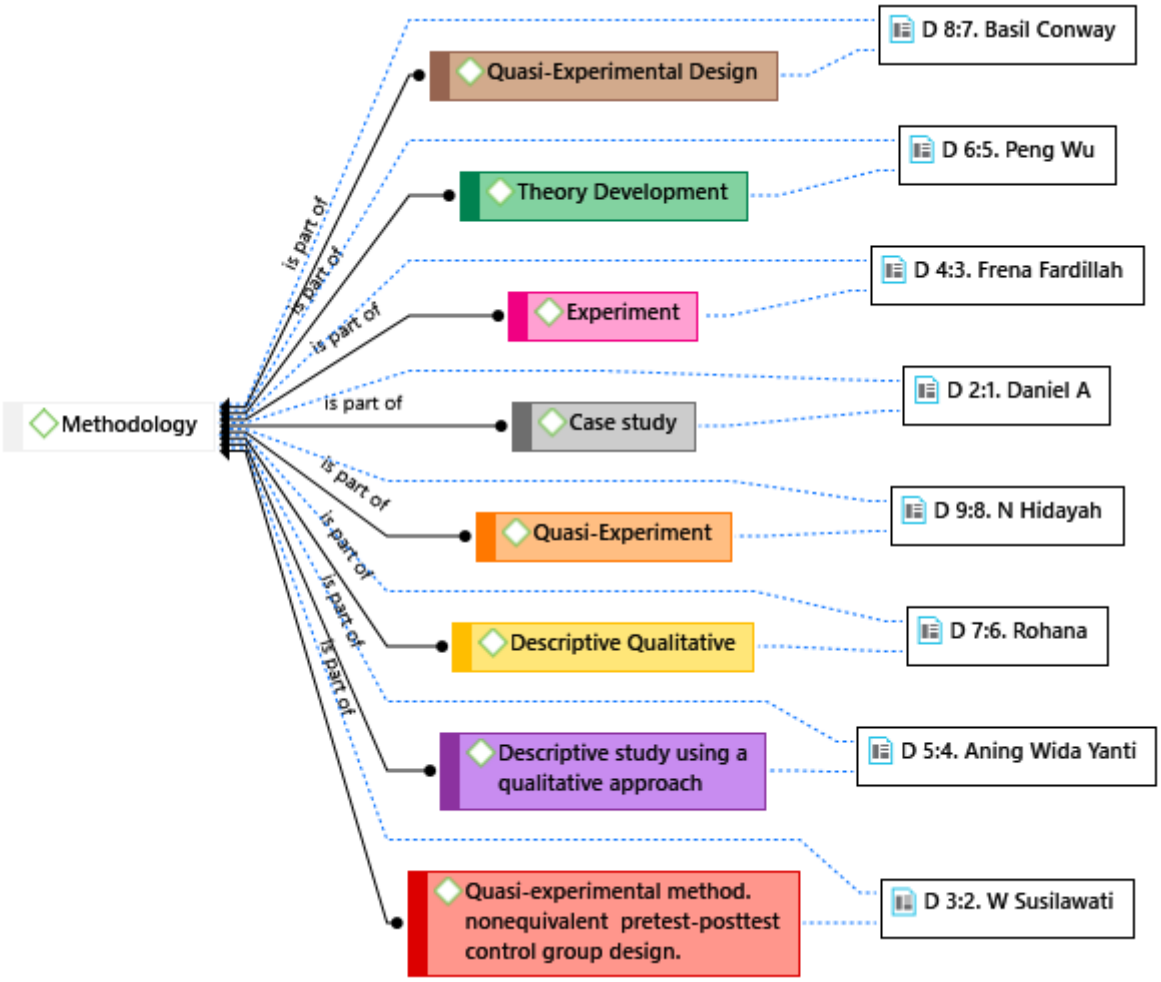

Figure 6. Methodology analysis

e. Conclusion

Figure 7. describes the conclusion of the articles. All articles reported positive conclusions. This result means that the methods used in those articles are successfully implemented. Susilawati implemented Brain-Based Learning and concluded that this method can improve the statistical reasoning ability of the students. It also created a productive and active classroom, so the students with high ability in statistics show a better results than the others. Aning Wida Yanti explained that 4MAT Learning Style System is an innovative method in statistical learning in implementing problem-solving. While, Frena Fardillah reported that experiential learning can improve students' statistical reasoning in line with Rohana, who reported that Blended Learning also improves reasoning ability. In another result, SLRE is reported better in the same way by Daniel A, Basil Conwar, and Hidayah. They elaborated that SLRE has a significant influence in statistical reasoning learning, so it can improve statistical reasoning. Daniel A added that SLRE made the students interested in statistics and made them easy to describe the data. He concluded that SLRE is an appropriate method in statistical learning

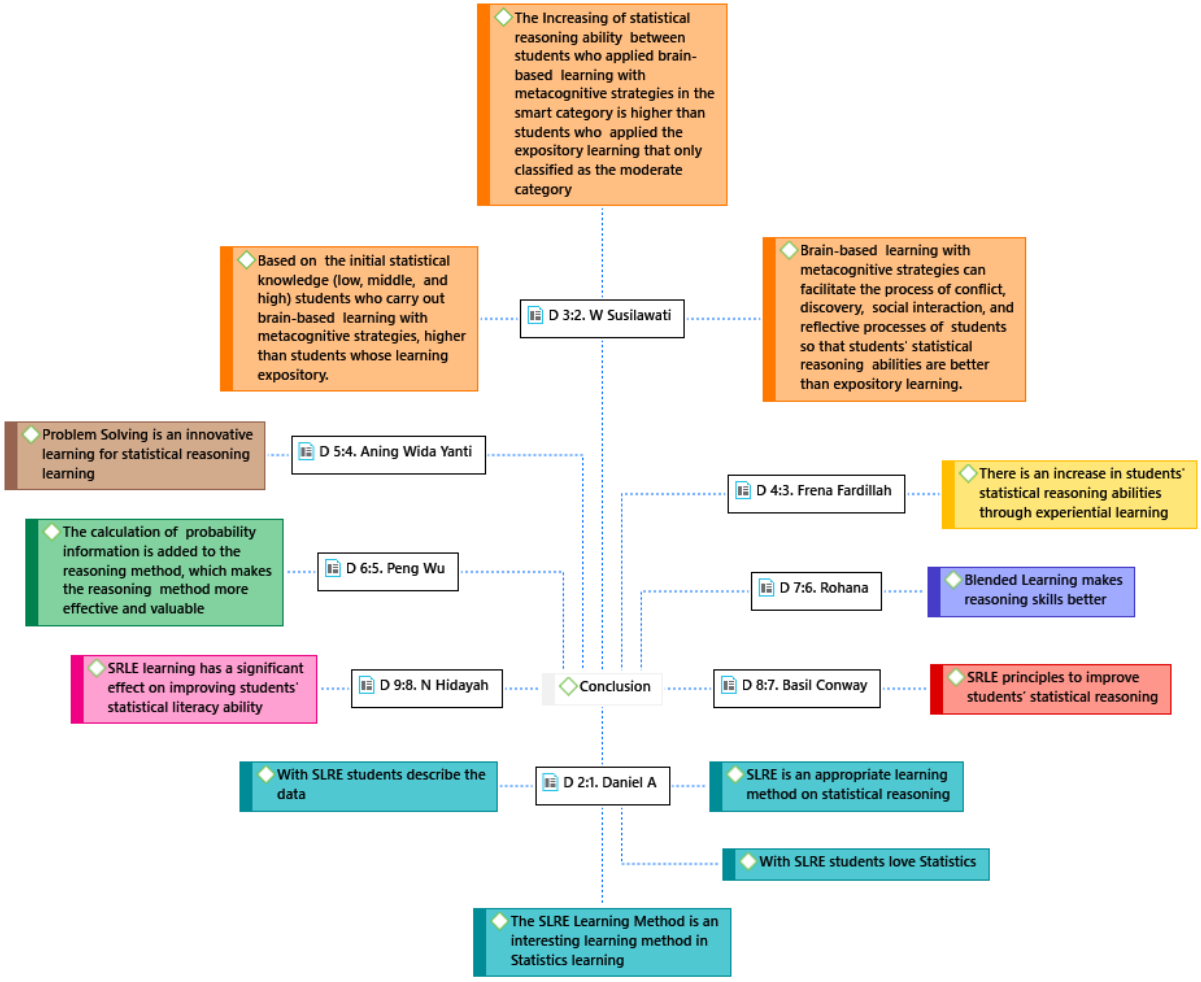

Figure 7. Conclusion analysis

f. Finding

Finding coding lead to the purpose of the research. It is to find out the appropriate method in statistical reasoning learning and the implementation in learning process. Here is the finding coding data analysis presented in the figure below. It is divided into two; Learning Methods and Teaching Steps. Figure 8 presents the learning methods used in those 8 articles. From 8 articles, it is found that 6 methods were discussed. The methods are Brain-Based Learning, 4MAT Learning Style System, Blended Learning, Symmetric Truncated Normal Density, Experiential Learning, and three other articles used Statistical Reasoning Learning Environment (SRLE). SLRE is the dominant one of 6 methods. This result is based on the appropriacy of statistical learning using SLRE.

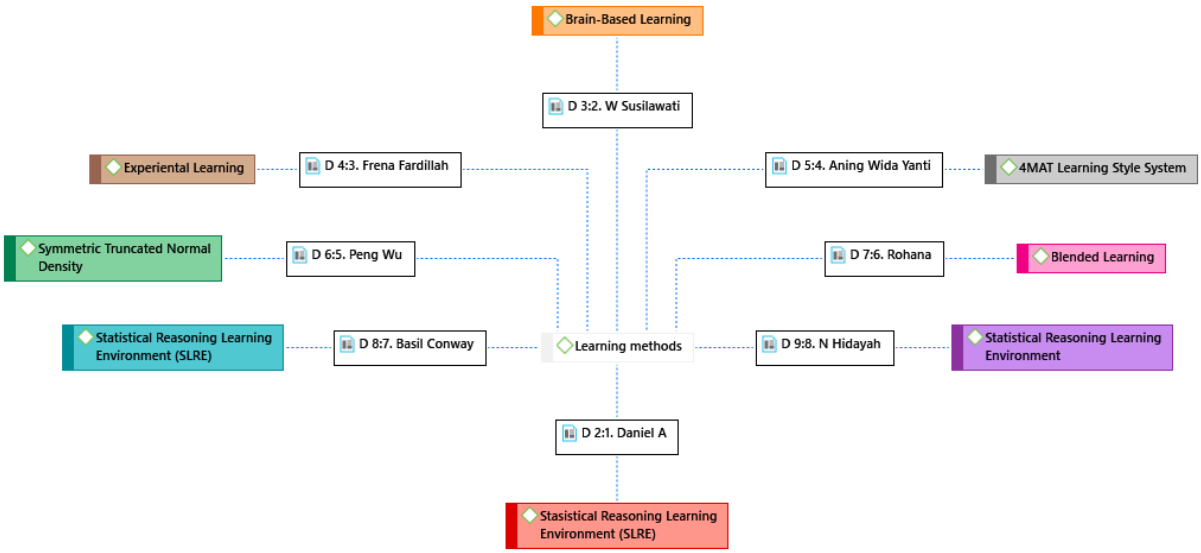

Figure 8. Finding analysis for learning methods

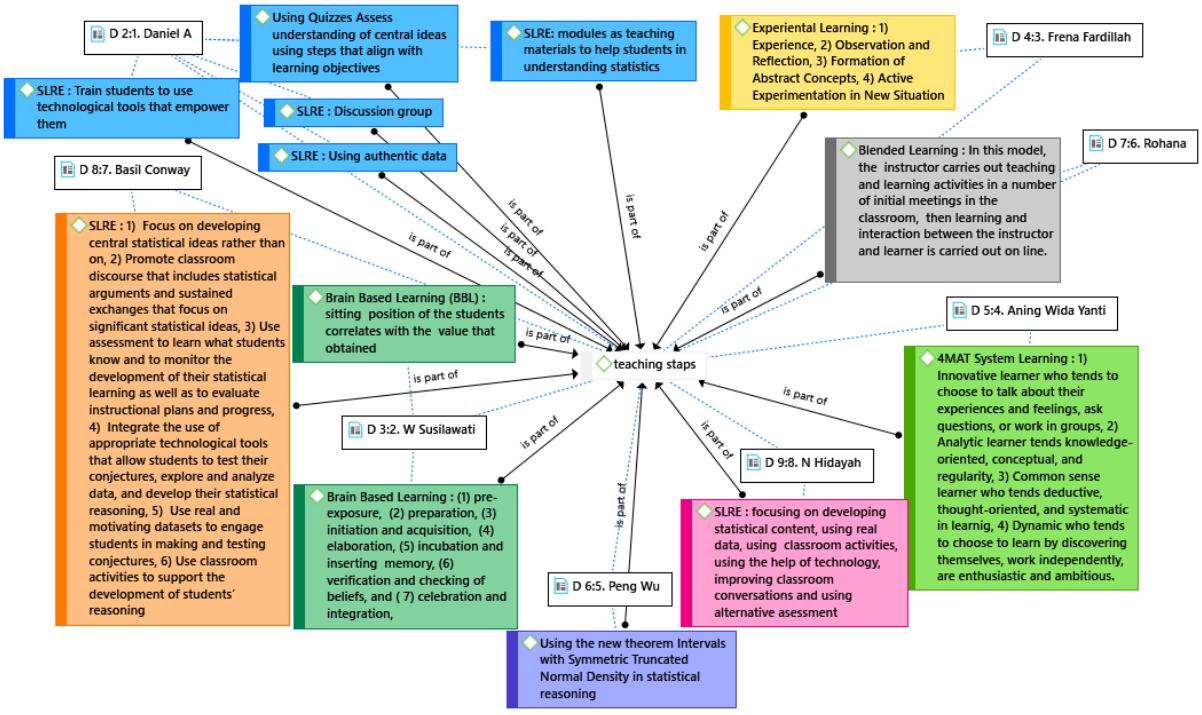

Figure 9. Finding analysis for teaching steps

Figure 9 presents the finding to find out the steps or information about learning based on the methods found in the articles. Here is the explanation.

Table 2. The Learning Method Stage for Statistical Reasoning

No	Method	Stage/Explanation
1.	Experiential Learning	1) Experience 2) Observation and Reflection 3) Formation and Abstract Concepts

No	Method	Stage/Explanation
		4) Active Experimentation in New Situation
2	Blended Learning	In this model, the instructor carries out teaching and learning activities in a number of initial meetings in the classroom, then learning and interaction between the instructor and learner is carried out on line
3	4MAT System Learning	1) Innovative learner who tends to choose to talk about their experiences and feelings, ask questions, or work in groups 2) Analytic learner tends knowledge oriented, conceptual, and regularity 3) Common sense learner who tends deductive, thought-oriented, end systematic in learning 4) Dynamic who tends to choose to learn by discovering themselves, work independently, are enthusiastic and ambitious.
4.	Truncated Normal Density	Using the new theorem Intervals with Symmetric Truncated Normal Density in statistical reasoning
5.	Brain Based Learning	1) pre-exposure 2) preparation 3) initiation and acquisition 4) elaboration 5) incubation and inserting memory 6) verification and checking of beliefs 7) celebration and integration
6.	Statistical Reasoning Learning Environment	1) Focus on developing central statistical ideas rather than on 2) Promote classroom discourse that includes statistical arguments and sustained exchanges that focus on significant statistical ideas 3) Use assessment to learn what students know and to monitor the development of their statistical learning as well as to evaluate instructional plans and progress 4) Integrate the use of appropriate technological tools that allow students to test their conjectures, explore and analyze data, and develop their statistical reasoning 5) Use real and motivating datasets to engage students in making and testing conjectures 6) Use classroom activities to support the development of students' reasoning

It is necessary to find the most appropriate method in statistical reasoning learning to create effective and efficient statistical reasoning to achieve the objectives of the learning. During 2019-2022, many researchers investigated reasoning or students statistical ability. However, this research aims to find the appropriate method in statistical reasoning learning and how the

methods are implemented. From the finding, 6 methods are reported used in statistical reasoning learning, they are Brain-Based Learning, 4MAT Learning Style System, Blended Learning, Symmetric Truncated Normal Density, Experiential Learning, dan Statistical Reasoning Learning Environment (SRLE). Those six learning methods have a positive impact in its implementation.

Brain-Based Learning can improve students' statistical learning and create effective learning for the students (Susilawati, Abdullah, and Abdullah 2020). On the other hand (Yanti et al. 2021) reported that the 4MAT Learning Style System is an innovative method of statistical reasoning learning implementation. Blended Learning is one of the solutions in implementing statistical reasoning learning during the pandemic, where the process was conducted face-to-face and online (Rohana and Ningsih 2020), and (Fardillah et al. 2019) reported that experiential learning can improve students' statistical reasoning ability.

From six methods, three articles reported the Reasoning Learning Environment (SRLE) method as the best solution for implementing statistical reasoning learning. According to (Showalter 2021), SLRE is an appropriate and interesting method in learning statistics. The students can describe the data very well and they began to be interested in the statistic. (Hidayah, Wahyudin, and Turmudi 2019) added that SLRE influences significantly to the statistical ability. (Conway et al. 2019) reported similar result that SLRE can significantly improve the students' statistical reasoning ability. SLRE is implemented in six stages; "(1) Focus on developing central statistical ideas rather than on, (2) Promote classroom discourse that includes statistical arguments and sustained exchanges that focus on significant statistical ideas, (3) Use assessment to learn what students know and to monitor the development of their statistical learning as well as to evaluate instructional plans and progress, (4) Integrate the use of appropriate technological tools that allow students to test their conjectures, explore and analyze data, and develop their statistical reasoning, (5) Use real and motivating datasets to engage students in making and testing conjectures, (6) Use classroom activities to support the development of students' reasoning (Conway et al. 2019).

▪ CONCLUSION

Based on the purpose of the research; to find out the appropriate method and its implementation, it can be concluded that Statistical Reasoning Learning Environment (SRLE) is the best solution for statistical reasoning learning. It is implemented in six steps; (1) focus on developing central statistical ideas, (2) promote classroom discourse that includes statistical argument and sustained exchanges that focus on significant statistical ideas, (3) Use assessment to learn what the students know and to monitor the development of their statistical learning as well as to evaluate instructional plans and progress, (4) Integrate the use of appropriate technological tools that allow students to test their conjectures, explore and analyze data, and develop their statistical reasoning, (5) Use real and motivating datasets to engage students in making and testing conjectures, (6) Use classroom activities to support the development of students' reasoning. From those six, the acts obtained from SLRE can form some learning steps: (1) the apperception begins by introducing the statistics ideas taken from the students' real-life examples. (2) form the group and give the statistic problems, (3) assign the rules such as reward and punishment to evaluate and motivate the learning process. (4) integrate the media as a tool to help the students understand statistics or as counting tools, (5) use the actual data

that is related to students' real life as an example or practice, (6) give feedback or open discussion in solving the given case.

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