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TREND OF INQUIRY ORIENTED COLLABORATIVE LEARNING IN CHEMISTRY: FROM RESEARCH DESIGN TO DATA ANALYSIS

Syahana S* and Widjajanti E

Yogyakarta State University, Indonesia

Abstract: Inquiry-oriented collaborative learning is the development of an inquiry learning model where the learning process is centered on students by involving students in the learning process in improve their understanding of the material taught, especially in chemistry learning. The purpose of this study is to analyze the trend of collaborative inquiry research in chemistry learning through bibliometric analysis using Vos Viewer and Excel applications program. The source of the data base used comes from Scopus, a mapping technique for enquiry-oriented collaborative chemistry learning. This research uses content analysis of articles published from 2015 to 2023, which consists of four stages: collecting data, filtering, selecting, and providing conclusions from the results of the analysis of trends in collaborative inquiry research. The results showed that 2020 was the period with the highest number of publications. Among these publications, the least type of research conducted was R&D research. In addition, the application of collaborative inquiry-oriented learning is mostly done in undergraduate programs that emphasize student involvement in carrying out learning. Questionnaires, tests, and t-tests are also the most dominant data collection and data analysis techniques used in this study, with different syntax from collaborative inquiry-oriented learning. The syntax of this learning model emphasizes the experimental stage, which supports student involvement in conducting investigations. In the context of this research, some recommendations on chemistry learning with inquiry oriented collaborative learning include the number of studies on this learning model, the selection of appropriate data analysis techniques, and its application to elementary and secondary school students.

Keywords: bibliometric analysis, chemistry, inquiry collaborative, research design

Introduction

The demands of the 21st century encourage students to be successful learners with strong motivation, communication, writing, collaboration and social skills. This encourages educators to provide meaningful and effective learning. Based on research (Lee & Yang,2023) Meaningful and effective learning can be done in the classroom, because the support of a constructivist learning environment achieves student involvement in carrying out the learning process. With direct learning, there will be a direct reciprocal relationship between teachers and students, as well as between students and their peers (Huda & Rohaeti, 2021). This can certainly encourage students to be able to exchange ideas, increase social interaction, get direct learning experiences and can train student participation in following the learning

*Corresponding Authors' Email: *syazasyahana.2022@student.uny.ac.id*

process. When students tend to be silent in following the learning process or lack the ability to participate such as asking questions, expressing opinions then students tend to memorize learning concepts and relate them to phenomena that occur in everyday life. Chemistry learning is a science that includes basic ideas, underlying principles and facts that describe the nature, structure and changes in matter and energy that occur in chemical reactions. (Özgelen S, 2012). Chemistry, which is abstract material, will make students have difficulty understanding it. Therefore, various kinds of learning models, learning methods, media, learning tools and other supporting materials are needed to achieve learning objectives. In addition, to understand chemical concepts, students must also have the ability to explore chemical concepts more deeply. Collaboration between students and teachers and peers can enrich the learning process, encourage creativity and deepen understanding of chemistry. For this reason, it is necessary to implement learning that encourages students to conduct investigations by conducting experiments in the laboratory. As chemistry learning activities cannot be separated by the laboratory so that performance and initial ability are the main factors in conducting chemical experiments.

Based on research (Veiga, et al., 2019), that the initial ability of students when entering the university has low laboratory skills. This is certainly influenced by the learning carried out at the previous level which is caused by several factors such as: limited facilities, lack of guidance from teachers so that students do not get clear directions, fear of mistakes in carrying out practicum and lack of basic knowledge. For this reason, constructivist-oriented teaching is needed that can improve students' conceptual understanding in understanding abstract chemical material with collaborative inquiry learning (Fahmidani & Rohaeti, 2023).

Collaborative inquiry is a model that is able to increase student inquiry into a phenomenon or chemical problems, because this model carries out investigations that are carried out systematically, methodologically and consistently in testing the truth of chemical concepts. This model is derived from a student-centered inquiry learning model with the teacher as a facilitator. (Eshetu et al., 2022). The learning that is carried out focuses on the active involvement of students in participating in learning which is stimulated to carry out learning independently, starting from identifying questions, formulating hypotheses, conducting experiments to the stage of presenting the results that have been obtained. The goal is that students not only receive knowledge provided by the teacher, but students must also be able to

increase strong curiosity towards collaborative problem solving. When using this learning model, it will help students in connecting theory with what actually happens.

Research on collaborative inquiry learning models must be able to be optimally improved in supporting students' conceptual understanding, scientific attitudes, literacy skills, higher order thinking skills and so on. The number of various studies related to this model is a foundation for other researchers in designing collaborative inquiry learning models. Many studies have discussed inquiry learning models such as guided inquiry, open inquiry, free inquiry and so on, but in implementing chemistry learning that conducts investigations in the laboratory, the collaborative inquiry learning model is appropriate to use.

By analyzing research data from several scientific journals related to collaborative inquiry in chemistry published from 2015 to 2023, this study aims to collect information in discussing collaborative inquiry learning models. The aspects discussed in this study consist of the number of publications of the collaborative inquiry learning model in chemistry each year, the syntax of the collaborative inquiry learning model, the type of research used, data collection techniques, data analysis techniques and research subjects used. This study is different from previous studies that discuss collaborative inquiry in the aspect of articles published from 2015 to 2023, this study investigates collaborative inquiry in chemistry as well as the parameters used in conducting data analysis.

Methode

The research uses the principle of content analysis, which focuses on the findings of various published studies by reading, recording, and processing raw data in the form of graphs, bar charts, tables, and pie charts. The stages in this research are: first, collecting data sourced from scientific journals and conference results from Scopus and Google Scholar. The search results used the keyword "inquiry-oriented collaborative" as the focus of the research. In the scopus search, there are 172 articles, and from Google Scholar, there are 131 articles that focus on educational research in the field of science. In the second stage, articles that were not sourced from books, book chapters, and proceedings were filtered, so there were 84 articles. Furthermore, in the third stage, selecting inclusion and exclusion data with the focus of data analysis in the field of chemistry, which can be seen in Figure 1 (Guan et al., 2024).

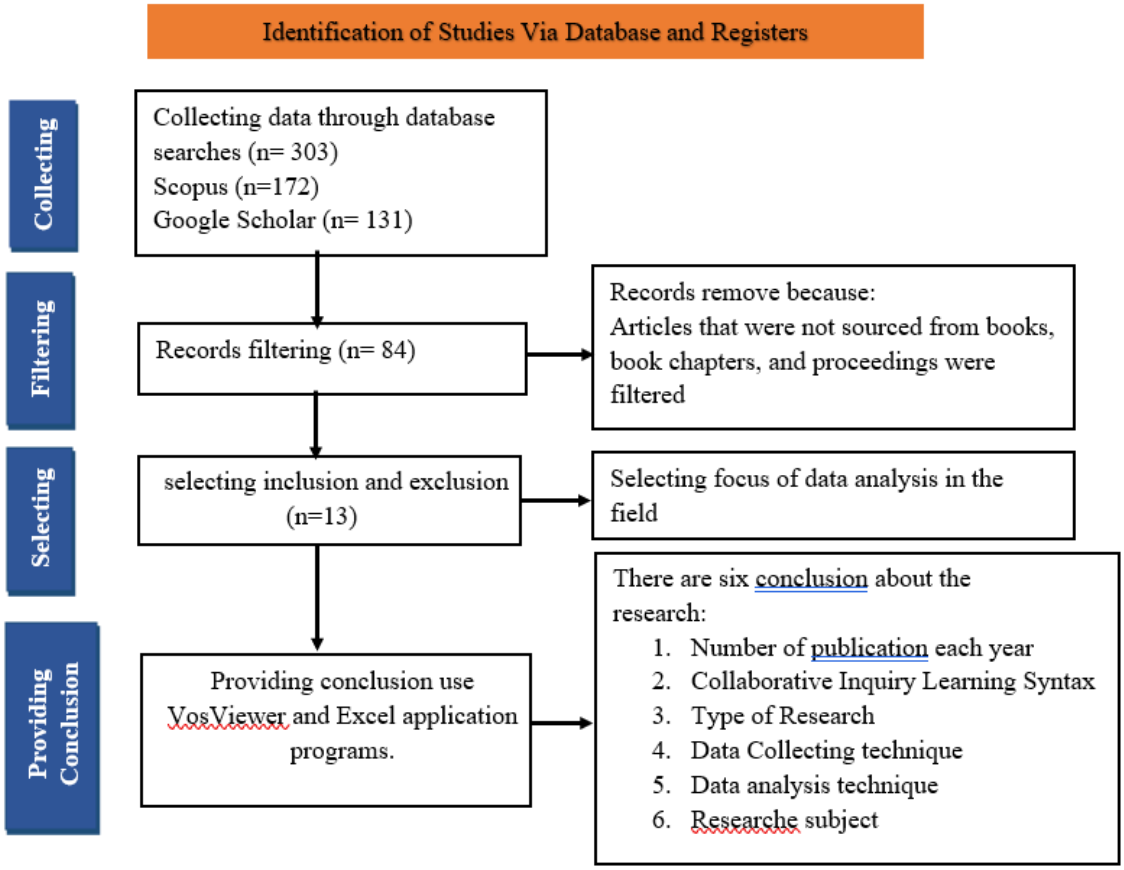

Figure 1. The Screening and Filtering Process of Research Methode

There are 13 articles focusing on collaborative inquiry in the field of chemistry from 2015 to 2023 can be seen in Table 1. In the last stage, namely the conclusion, based on the results of data analysis using the VosViewer and Excel application programs, The research method of collaborative inquiry research trends in this study.

Table 1. List of Journals used in Research

No	Journal	Title	Website
1	Journal of Technology and Science Education (Irwanto, 2023)	Improving Preservice Chemistry Teachers' Critical Thinking And Science Process Skills Using Research Oriented Collaborative Inquiry Learning	https://doi.org/10.3926/jotse.1796
2	Advances in Social Science, Education and	Research-Oriented Collaborative Inquiry Learning Model to Improve Students'	https://doi.org/10.2991/assehr.k.210305.

	Humanities Research (Fiolida et al., 2021)	Science Process Skills in Reaction Rate Topic	029
3	Journal of Baltic Science Education (Rohaeti et al., 2020)	Research Oriented Collaborative Inquiry Learning Model; Improving Students Scientific Attituded In General Chemistry	https://doi.org/10.33225/jbse/20.19.108
4	J. Pijar MIPA (Fahmidani & Rohaeti, 2023)	How Is Student Scientific Attitude Profile Toward Chemistry Learning With Research-Oriented Collaborative Inquiry Learning?	https://doi.org/10.29303/jpm.v18i2.4658
5	Internasional Journal of Computer Supported Collaborative Learning (Pietarinen et al., 2021)	Guidance in Computer-Supported Collaborative Inquiry Learning: Capturing Aspects of Affect and Teacher Support in Science Classrooms	https://doi.org/10.1007/s11412-021-09347-5
6	Chemistry Education Research and Practice (Özkanbaş & Taştan Kırık, 2020)	Implementing Collaborative Inquiry in a Middle School Science Course	https://doi.org/10.1039/C9RP00231F
7	Journal of Physics: Conference Series (Hardianti & Wusqo, 2020)	Fostering students' scientific literacy and communication through the development of collaborative-guided inquiry handbook of green chemistry experiments	https://10.1088/1742-6596/1567/2/022059
8	Pancasakti Science Education Journal (Nugraheni, 2022)	Collaborative Guided Inquiry for Chemistry Learning Outcomes Improvement on Solubility Product Concept	https://10.1088/10.24905/psej.v7i1.134

9	J Sci Educ Technol (Lawrie et al., 2016)	Wiki Laboratory Notebooks: Supporting Student Learning in Collaborative Inquiry-Based Laboratory Experiments	https://10.1007/s10956-016-9601-0
10	Chemistry Education Research and Practice (Yin & Buck, 2015)	There is another choice: an exploration of integrating formative assessment in a Chinese high school chemistry classroom through collaborative action research	https://10.1007/s11422-014-9572-5
11	International Journal of Science Education (Lamminpää & Vesterinen, 2018)	The use of humour during a collaborative inquiry	https://10.1080/09500693.2018.1508926
12	Cult Stud of Sci Educ (Yin & Buck, 2015)	There is another choice: an exploration of integrating formative assessment in a Chinese high school chemistry classroom through collaborative action research	https:///10.1007/s11422-014-9572-5
13	Journal of Technology and Science Education (Irwanto, 2022)	The Impact of Research-Oriented Collaborative Inquiry Learning On Pre-Service Teachers' Scientific Process Skills And Attitudes	https:///10.3926/jotse.1583

In the third stage, data presentation was conducted from 13 articles regarding the number of articles published each year, the syntax of collaborative inquiry learning, the type of research, data collection techniques, data analysis techniques, and research subjects presented in the form of bar charts and pie charts. Furthermore, in the last stage, conclusions were drawn from the results of the analysis regarding the presentation of research data.

Results and Discussion

Number of Publication Each Year

The first aspect of this research is to analyze the number of studies conducted each year related to inquiry collaborative learning. Based on 13 articles in this study, there are subjects

that are the focus of research, namely chemistry. The chemistry learning materials that use inquiry collaborative learning are: acid-base, chemical equilibrium, reaction rate, green chemistry, solubility and product of solubility, the nature of matter in high school students, and in undergraduate only in basic chemistry. The difference in material from each study is influenced by the learning objectives that will be achieved by each different material. The total articles that have been published from 2015 to 2023 have decreased in the last two years from 13 articles. The highest number of articles published was in 2020 with five articles which can be seen in Figure 2.

The decline in publications is due to the development of inquiry learning models that have been adapted from various studies so as to produce various types of inquiry research such as guided inquiry, open inquiry, modified free inquiry, free inquiry, discovery inquiry learning models and so on. This development is adjusted to the topic and the inquiry learning model used, the different skill levels of students and adjusts to the learning objectives to be achieved. The changes and modifications of the inquiry learning model show progress regarding the development of the model which can be used as a reference for further development. However, with the development of inquiry collaborative learning, it will have a big impact on education if it can be used as the main focus in learning, because this learning can maximize the student learning process with its learning syntax that can support students' abilities in scientific thinking, science process skills, critical thinking skills, humor and students' ability to collaborate in conducting various investigations. Furthermore, this research can be improved again with various other modifications.

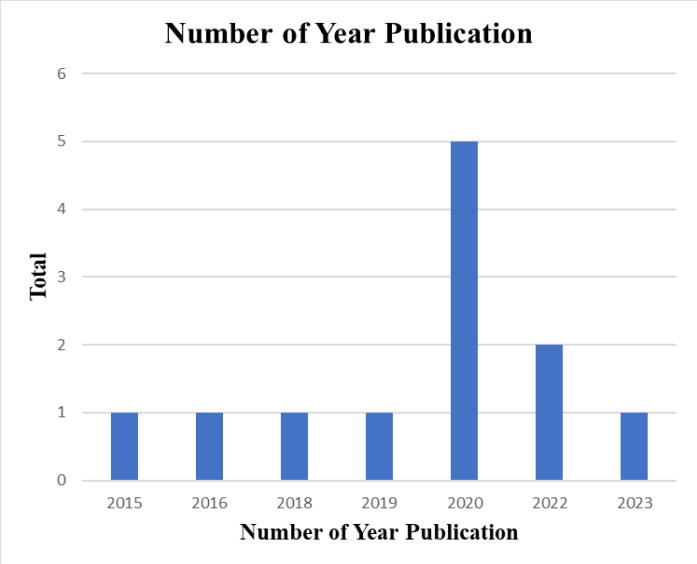

Figure 2. Number of articles published each year

In addition, in chemistry learning, the use of this learning model is often carried out through research on reaction rate material. This is in accordance with the results of the analysis using Vos viewer, which show that a lot of research related to the reaction rate was carried out in 2022, as shown in Figure 3.

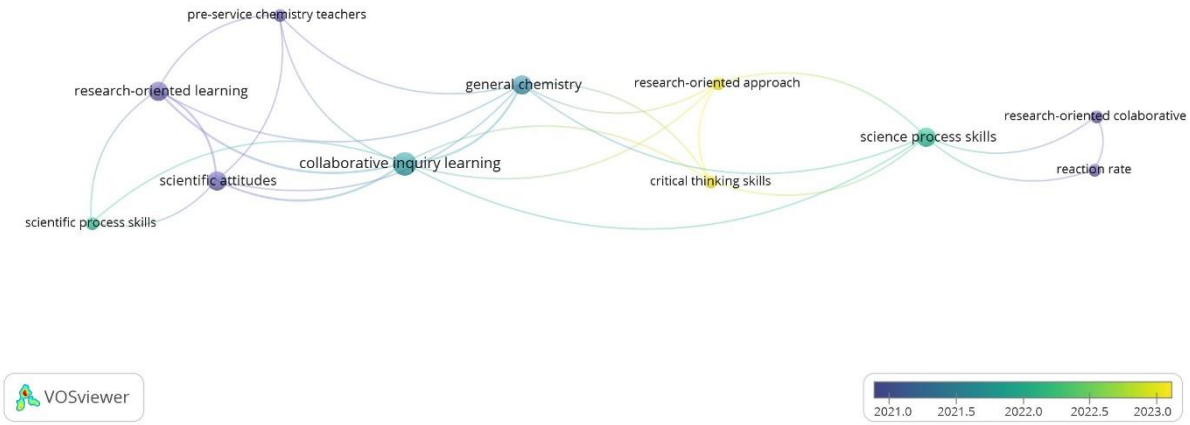

Figure 3. Overlay Visualization of Chemistry Materials

Collaborative Inquiry Learning Syntax

The syntax of the inquiry collaborative learning model is the focus of this research. Based on the 13 articles analyzed, there are various differences in implementing inquiry collaborative learning, but it still focuses on the six stages of the inquiry collaborative learning model consisting of: (1) intiating, teachers or lecturers give freedom to students in choosing learning materials that are considered relevant based on the learning objectives that have been set. The selection of this learning material is carried out in small group discussions in advance in analyzing each problem related to finding solutions to each problem given in the learning material. (2) formulate hypotheses, students formulate hypotheses from the problems they choose supported by preliminary data collection and determine the appropriate research methods / data collection techniques in investigating these problems. (3) experiment / investigation, students test the results of their hypotheses by conducting experiments to investigate the truth of the hypothesis proposed, (4) writing, students are able to collect, and write down the data obtained from the results of the research conducted. (5) reflecting,

drawing conclusions from the results of the research conducted by analyzing the experimental data obtained in testing the hypothesis that has been proposed. (6) evaluating, students are able to connect the problems / phenomena given with phenomena that occur in everyday life / real life.

Based on the data analysis in Figure 4, it is found that the syntax of the inquiry collaborative learning model which is the main stage is conducting experiments. This is because investigation is the main stage in this learning and is used as a benchmark for students to be able to improve their collaboration with peers and teachers, besides that the initiating, hypothesizing and evaluating stages are also a major part of this learning, in order to determine the continuation of the experimental stage.

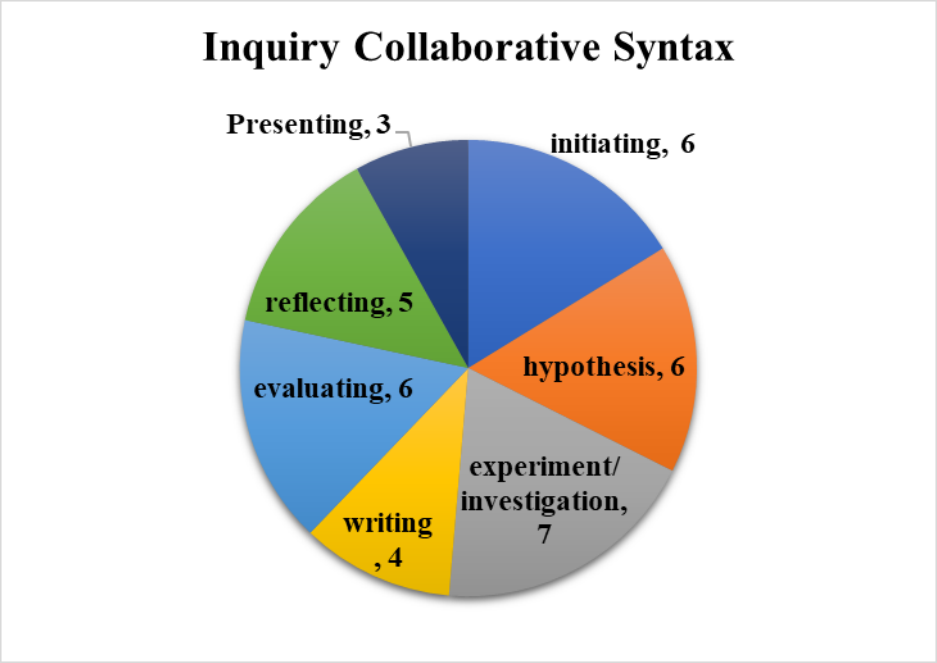

Figure 4. Collaborative inquiry learning syntax

While the writing and presenting stages have a smaller number than other syntaxes. Whereas writing really determines how the results of the hypothesis that has been tested in interpreting the experimental data, as well as the presenting stage which is the way students communicate the results of the research they get is also the most important part of this study. Furthermore, the syntax of inquiry collaborative learning can be used as a guideline in determining the stages of learning in inquiry collaborative.

Type of Research

Based on data analysis from 13 articles, there are four types of research conducted, namely quantitative, qualitative, R&D and quantitative & qualitative research. Quantitative research is the trend in this study which consists of quasi-experiment research and survey research. The results of this study are in line with research (Susetyarini & Fauzi, 2020) which states that research in the field of education has more quantitative research than qualitative research. However, qualitative research is still in a position after quantitative research, because it can define in detail and comprehensively the issues in education. In collaborative inquiry learning can provide a good opportunity for researchers because there are student abilities that cannot be interpreted quantitatively, so it requires a detailed and in-depth explanation to students by conducting data collection techniques in qualitative research. In addition, qualitative research also helps in understanding students' perspectives, mindsets, and experiences so as to enable the development of more effective and efficient learning strategies in collaborative inquiry learning.

In addition, combined qualitative and quantitative research will make the research results more complex with the research data obtained, but from the results obtained there are only two articles that use this type of research. This is due to the long time of the research, the complexity of the research that requires in-depth interpretation and the higher confidence of quantitative data. The following interpretation of the type of research is shown in Figure 5.

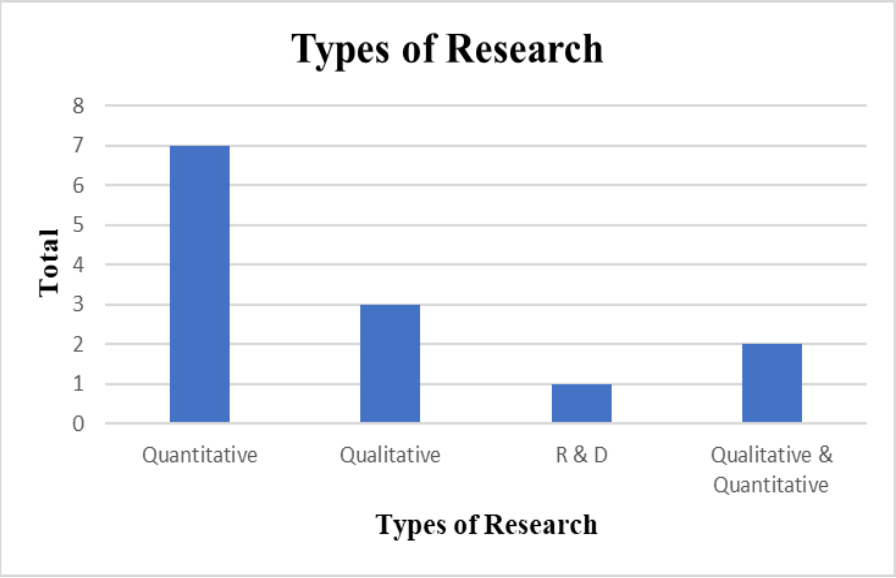

Figure 5. Types of Research

R&D research in inquiry collaborative learning is conducted in developing student handbooks/guidelines in participating in learning. This type of research has the smallest range compared to other studies. Furthermore, the development of various learning media, books, worksheets and so on using collaborative inquiry learning can be used as recommendations in future research, so that students and students can be more directed in following collaborative inquiry learning.

Data Collection Technique

When conducting research, researchers need data collection instruments to help them collect data. Collaborative inquiry learning with variables consisting of scientific attitude skills, science process skills, higher order thinking skills, humor and so on requires data collection instruments shown in Figure 6. Observation is the most chosen by researchers in conducting inquiry oriented collaborartive learning, because observation is often used in educational research because it has several very important advantages. First, observation allows researchers to obtain more accurate and objective data, especially in complex and dynamic situations. In addition, observation allows researchers to collect data in a systematic and calm way, resulting in research findings that are more reliable and easy to understand. Third, observation allows researchers to understand the phenomena that occur in the field more thoroughly and clearly, helping to identify complex and diverse problems. However, observation allows researchers to examine cases and events chronologically and strictly, thus helping to explain certain cases or studies with a high degree of accuracy.

Meanwhile, other data collection techniques have almost the same range chosen by researchers such as tests, interviews, questionnaires, and video recording. The use of survey techniques can be used, of course, based on the choice of the type of qualitative research conducted.

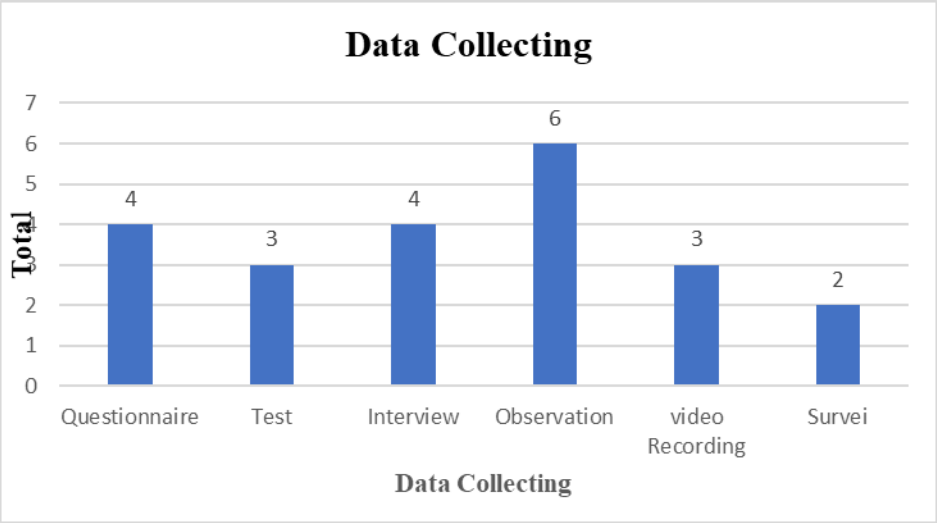

Figure 6. Data Collection Technique

Data Analysis Technique

Based on the type of research conducted, the analysis techniques used in the collaborative inquiry learning research article consist of Rasch model, t test, percentage, transcription analysis, anova, cohen's d and NVIVO, as shown in Figure 7.

The most widely used data analysis technique is the t test, this is in line with data analysis research with the t test which has the largest number of previous studies. The t test is widely used because it compares the means of two different groups or to determine whether the difference between two groups is significant or not, then the t test helps researchers to determine whether the intervention or change has a significant impact.

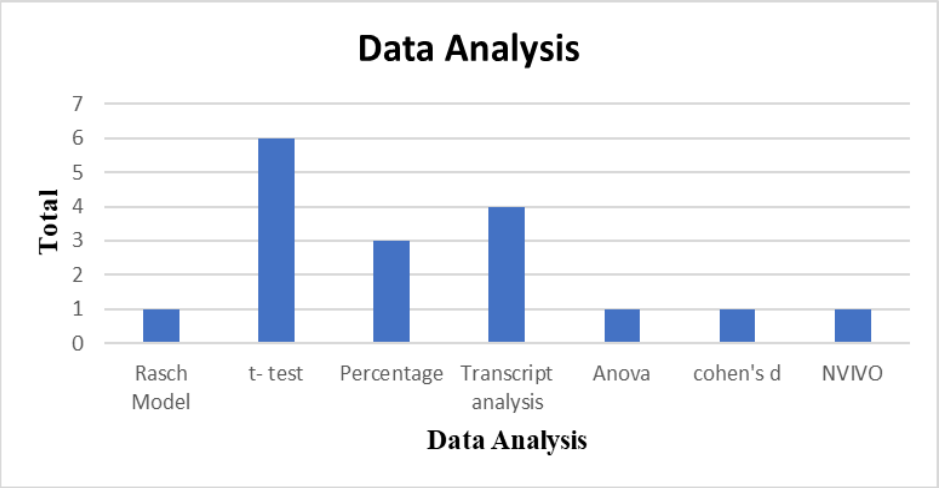

Figure 7. Teknik Analisis Data

Therefore, based on the data analysis used above, ancova is recommended because the researcher can control external variables that may affect the relationship between the independent and dependent variables. Furthermore, using ancova can identify differences that occur between groups based on the characteristics of the research subjects.

Research Subject

The research subjects of the 13 articles analyzed consisted of junior high school, senior high school and undergraduate students. Where the research subjects between senior high school and undergraduate have the same amount of inquiry collaborative learning in chemistry learning. This shows that there is a balance of research conducted on different subjects, because chemistry learning is widely practiced at the senior high school and undergraduate levels. In addition, the learning process in conducting collaborative inquiry can also be done at the senior high school and undergraduate levels. Unlike the junior high school level, where the material taught here is about the nature of matter which is part of chemistry learning, but not all stages of collaborative inquiry can be done. For more details can be seen in Figure 8.

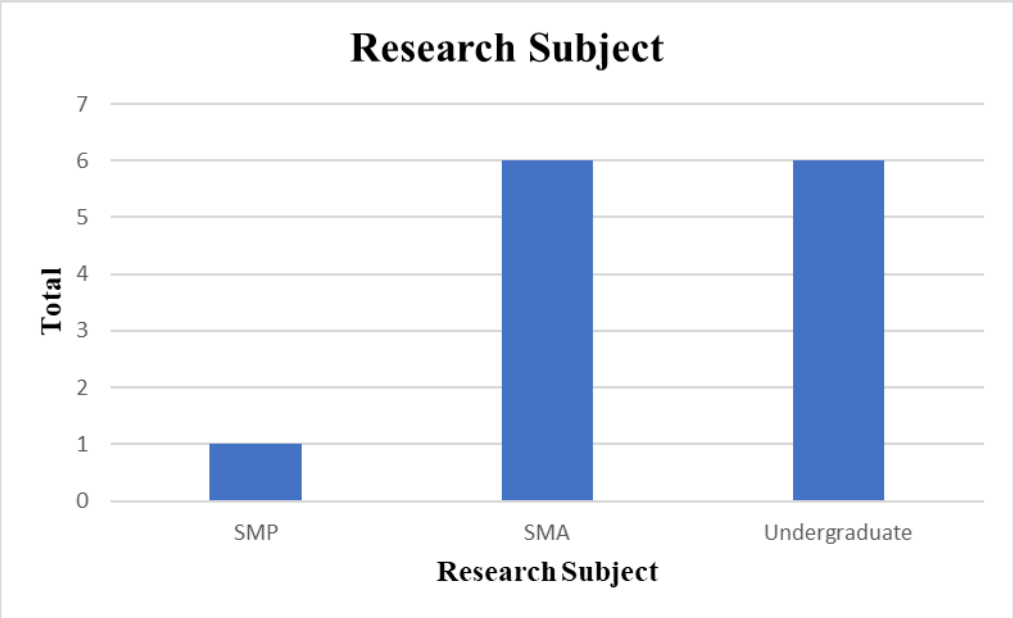

Figure 8. Research Subject

In addition, at the junior high school level, the application of this collaborative inquiry learning model is rarely done due to the limited time in learning, the demands of the curriculum, which are different from junior high school, senior high school and undergraduate, student readiness, and also the infrastructure and resources owned by the

school. This is in accordance with the results of the VOS viewer, which reveal that the use of collaborative inquiry learning models is mostly done at the undergraduate level, as shown in Figure 9.

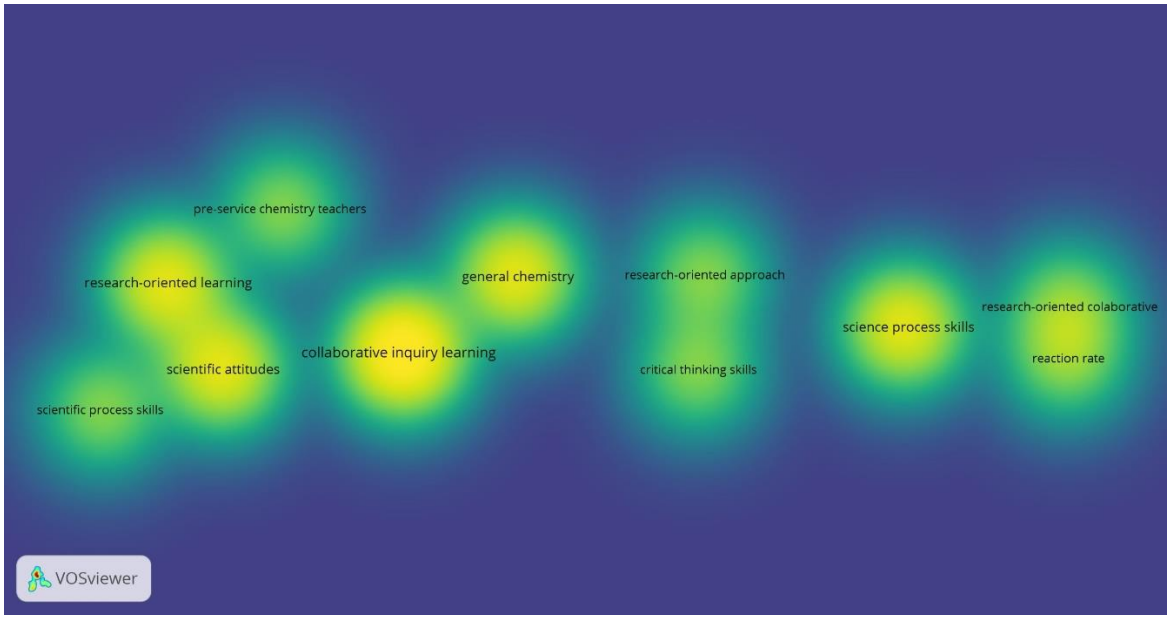

Figure 9. Density Visualization of Research Subjects

Furthermore, research using inquiry-based collaborative learning at the junior high school, senior high school and undergraduate levels can encourage students' ability to conduct investigations and improve collaboration with their peers, and at the junior high school level, it can also be done with the readiness of teachers and students to implement inquiry-based collaborative learning with sufficient time.

Conclusion

In research with data analysis focusing on inquiry collaborative learning and published from 2015 to 2023 in the field of chemistry, 13 articles have been analyzed. The trend in this study is reviewed from the number of publications each year, the syntax of inquiry collaborative learning, the type of research, data collection techniques, data analysis techniques and research subjects found the use of balanced research subjects between senior high school and undergraduate which is one of the learning that can help students in participating in learning because it is in accordance with the demands of the curriculum and learning objectives. In addition, the application of collaborative inquiry learning is appropriate for use in learning chemistry, because it requires some investigation of abstract chemical concepts in testing the

hypothesis given which is in accordance with the most dominant syntax of each article, namely the experimental stage.

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