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Research Trends in Group Investigation Learning Model for Critical Thinking Skills in Science Learning

Anisa Ayu Solikah, Sulistyo Saputro*, Sri Yamtinah, Mohammad Masykuri
Department of Science Education, Sebelas Maret University, Surakarta
*Corresponding Author. E-mail: sulistyo_s@staff.uns.ac.id

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Abstract: The 21st-century learning needs to be applied in science learning amidst the rapid development of this era to equip students with important skills, such as critical thinking skills. One of the factors that affect the success of learning is a learning model that has unique characteristics. The Group Investigation Learning Model is a learning model that allows students to play an active role in determining their learning goals and processes, including critical thinking skills. To see the application of the Group Investigation Learning Model in improving critical thinking skills, it is necessary to carry out a literature review study using the VOSviewer. This research used the publish or publish method with the Google Scholar database and obtained 985 articles selected using certain criteria to obtain 76 relevant articles. The results of the analysis with the VOSviewer based on network, overlay, and density visualization, show that the Group Investigation Learning Model is used to improve 21st-century skills, including critical thinking skills. Further analysis shows that research on high school biology subjects that apply the Group Investigation Learning Model dominates compared to other science fields. The implications of the results of this review can be a reference for further research to implement and develop learning models to improve critical thinking skills at the elementary and junior high school levels.

Keywords: critical thinking, group investigation, science learning.

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INTRODUCTION

Global competition in the 21st century is very fast and dynamic development requires that everyone must have good skills, expertise, and knowledge (Haviz et al., 2018). Problems in society that are increasingly complex encourage learning not only limited to theory but also skills so that human existence is not replaced by the role of technology. Now, technology plays an important role, where technology can be used in the industrial sector so that technology can replace manual work carried out by humans (Fuchs, 2010). Therefore, increasing skills as well as knowledge needs to be emphasized in every lesson at school, including science learning. One of the 21st-century skills that needs to be emphasized in learning is critical thinking skills.

Critical thinking skills are skills that include thinking logically, reflectively, and productively to assess something so that you can make the right decision (Facione, 2011). This skill is related to the ability to think reflectively and make judgments so that you can decide on information related to the given context (Gut, 2011). The focus on critical thinking skills is also related to providing important and valuable arguments preceded by filtering the information obtained (van Laar et al., 2020). Learning that focuses on efforts to improve critical thinking skills can increase mastery of subject matter because there is a positive relationship between critical thinking skills and mastery of the material, where the higher the critical thinking skills, the higher the students' mastery of the material (Prasetyowati & Suyatno,

2016). Critical thinking skills are important to hone because they can influence students' cognitive learning outcomes (Cano & Martinez, 1991) (Tuaputty et al., 2021).

However, students critical thinking skills are still low, which is proven by research Wayudi et al., (2019) which shows that high school students' critical thinking skills are still low with a score on the critical thinking skills test of only 46.60. Critical thinking skills are fundamental skills and can also describe other skills such as communication skills (Zubaidah, 2016). In Indonesia, natural science education is focused chiefly on remembering scientific concepts. Natural science teaching success is often judged by the number of scientific products (concepts, ideas, and laws) students correctly recognize and memorize. Students are not given sufficient opportunities to grow their critical thinking skills (Chusni, 2022).

The reason why 21st-century skills, such as critical thinking, are still low in schools is the lack of optimal approaches and teaching models used by teachers and the lack of teaching innovation in terms of teaching models and media that can train students to think systematically (Rivers & Kinchin, 2019) (Pauzi & Windiaryani, 2021). Therefore, teachers need to choose a teaching model.

A teaching model is a plan that can be used to create a curriculum (long-term teaching plan), teaching design materials, teaching guidelines in the classroom, and so on. (Joyce & Weil, 1980). A teaching model is a pattern that is used as a guide in planning lessons and tutorials in class (Suprijono, 2010). A teaching model can be defined as a conceptual framework that describes systematic procedures for organizing teaching experiences to achieve teaching goals (Ahyar & Edyansyah, 2021). In general, there are characteristics of teaching models, including the theoretical rationale prepared by the developer that can be applied in classes where students have diverse abilities and origins, there are teaching behaviors and learning environments that are needed so that the learning objectives can be successful and achieved, there is a basis for thinking about what and how students learn (Apriani, 2017)(Wulandari, 2021). Another characteristic is helping students learn how to learn because through each style of learning model, each model can help students improve their strategies increase responsibility in learning, and expand their abilities, helping students achieve new knowledge, skills, and self-understanding; scaffolding (built) into the learning process, where student independence is more emphasized in the learning process and the instructional goal is only to lead to a stronger understanding so that as young as possible the teaching model is expected to provide a place for teachers to stimulate students in overcoming the difficulties they experience and to the next level of learning. All teaching models provide opportunities for teachers and students to study progress, continue things that are going well, and make adjustments by adding or replacing processes that are not working well. (Bruce et al., 2015).

Each teaching model has specific characteristics so to achieve the goals of teaching, teachers must choose the type of learning model that is appropriate to achieve those specific goals. (Thanavathi, 2022). There are several kinds of teaching models which are grouped into four teaching models, namely: a) the group of information processing teaching models which emphasize ways of strengthening human internal drives through exploring and analyzing data, sensing problems, and producing appropriate solutions, and developing language to explain the data and solutions so that several models in this group can give students a concept, test hypotheses, and develop creative abilities; b) a group of behavioral systems teaching models that emphasize changes in behavior when responding to information about how successful the student's task is and how female students work on; c) group personal teaching model which starts from an individual perspective and emphasizes individual awareness so that a person can understand himself better, be responsible for his education, and learn to become a stronger, more sensitive, and creative person in seeking a prosperous life; d) group social teaching model that utilizes the phenomenon of cooperation between individuals through a learning community (Bruce et al., 2015). One type of learning model that comes from a group social teaching model that can encourage students to be active regarding what and how students will learn is the Group Investigation Learning Model. (Sharan & Sharan, 1990).

The Group Investigation Learning Model is a learning model that provides a class with the opportunity to work more actively and collaborate in small groups and allows students to take an active role in determining their learning goals and processes (Huhtala, 1994). The Group Investigation Learning Model is based on the opinion of John Dewey who explains that classes are like society and a small form of democracy, where students can participate in making decisions about what and how to learn something so that the class should be able to present situations in real life, allowing students to participate in learning activities that are interchangeable and flexible in the diversity of society (John

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Dewey, 1983) (Williams, 2017). This is in line with the opinion of Herbert Thelen (1960) which explains that education in a democratic society should teach the democratic process directly. The most urgent part of student education is cooperative research to solve social and academic problems. This teaching model is an organization of various social teaching models in which various other teaching models are still related applied and combined (Bruce et al., 2015). The Group Investigation Learning Model has been applied in all subject areas, and at all age levels, and is used as the main social teaching model by most schools. (Joyce, Bruce; Calhoun, Emily; Hopkins, 1999). Therefore, this learning model can also be used for science learning which until now still looks abstract and not relevant to real life, such as students from chemistry and biology who are burdened with memorizing information, while students from physics and mathematics find the learning content they are abstract and unrelated to the realities of the world (Kwok, 2018). Previous studies have examined research on the Group Investigation Learning Model on critical thinking skills, but no research has ever been conducted that reviews this learning model and its use for 21st-century skills and the extent of its application at every level of education (Asyari et al., 2016; F. Fauzi et al., 2021). Based on this background, it is necessary to examine the extent of Group Investigations in science learning to provide information to teachers in particular, researchers, and students as prospective teachers in general. This research provides findings that the Group Investigation Learning Model to improve critical thinking skills is still mostly carried out at the high school level. Therefore, future research examining the use and development of the Group Investigation Learning Model to improve critical thinking skills at the elementary and junior high school levels is urgently needed so that critical thinking skills can be trained from an early age.

RESEARCH METHOD

The method used in this research is the systematic literature review (SLR) method, which is a qualitative approach using a systematic review to compile the results of a descriptive study through literacy studies related to the topic being studied (Ahn & Kang, 2018). SLR is used to answer specific questions by collecting relevant evidence (Shamseer et al., 2015). The sources for this data collection are journal articles and proceedings selected based on certain criteria. The research questions are as follows.

1. What are the research trends for Group Investigation Learning Models for science learning in January 2013-December 2023 based on analysis with VOSviewer?
2. What is the implementation of the critical thinking skills model in science learning for the period January 2013- December 2023 like?

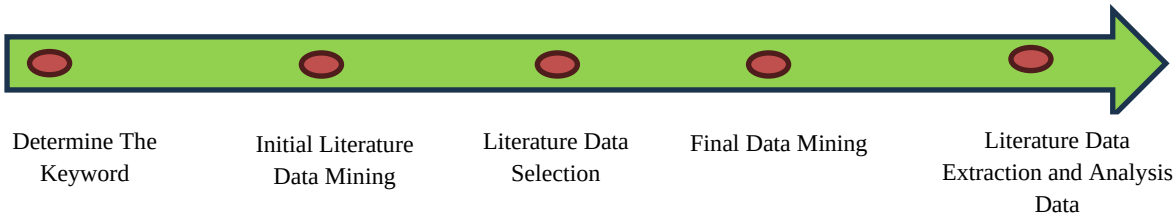

Figure 1. The procedure of systematic literature review analysis

The procedures for analyzing literature reviews can be explained as follows.

1. Determining Keywords

In this study, the keywords used are "Group Investigation" and "Science learning". These keywords are then used to obtain literature data from the Google Scholar database via PoP (Publish or Perish) software.

2. Initial Literature Data Mining

PoP search results show that there are 985 articles for 2013-2023. The PoP search was obtained from the Google Scholar database using the words "Group Investigation" and "Science learning".

3. Literature Data Selection

The selection of literature data was carried out manually by reading the titles and abstracts related to the Group Investigation Learning Model in science learning because in the initial data mining results

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many references did not match the topic being studied so they needed to be removed from publication. Apart from that, articles were also selected based on certain criteria presented in Table 1.

Table 1. Criteria for article selection

Criteria	Inclusion	Exclusion
Research	In science learning -Focuses on the Group Investigation Learning Model	- outside of science learning -does not focus on the Group Investigation Learning Model
Period	January 2013-December 2023	Before January 2013
Document Type	- Articles with empirical data from experiments in the field - Articles taken in the field of education -Conference proceedings	-Book Chapter -Book -Literature review
Language	English	Non-English
Publication Stage	Final	In Press

After selecting the language used, 292 articles were obtained in English including journals and proceedings. Furthermore, the 292 articles were analyzed to obtain articles that were relevant to the aim of the literature review. After going through the selection process, were obtained 76 articles that were relevant for analyzing the literature review. The results of data comparison when searching for initial data (initial literature data mining) with the results of article selection are presented in Table 2.

Table 2. Ratio Metrics

Citation metrics	Initial research	Final Data Mining
Publication years	2013-2023	2014-2023
Citation years	10 (2013-2023)	9(2014-2023)
Papers	985	76
Citations	4808	884
Cites/year	480.80	98.22
Cites/paper	4.88	11.63
Cites/author	2635.69	331.17
Papers/author	629.37	34.62
Authors/paper	2.02	2.66
h-index	32	16
g-index	46	28
hI, norm	21	10
hI, annual	2.10	1.11
hA-index	10	7

4. Final Data Mining

Articles from Google Scholar are downloaded via PoP software for further analysis in more depth regarding the content of the articles. Each article is reviewed to obtain data related to research on Group Investigation Learning Models for science learning.

5. Literature Data Extraction and Analysis Data

The data that has been obtained is then analyzed using VOSviewer software, which is software for constructing and visualizing bibliometric networks. This research qualitatively analyzes and describes the results of network visualization, overlay visualization, and density visualization.

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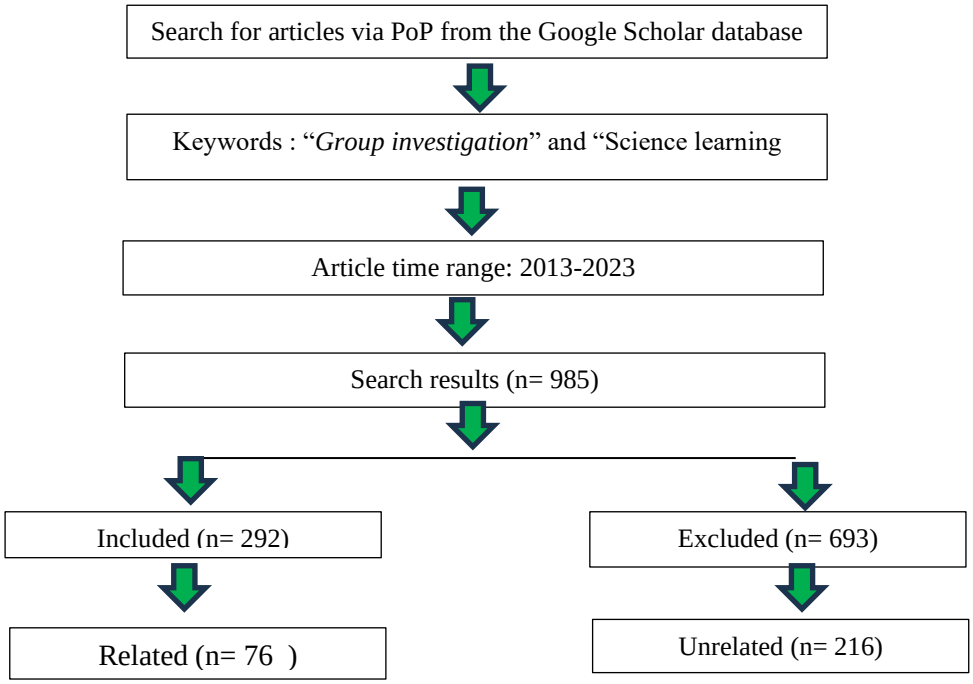

Figure 2. Literature Review Process

FINDING AND DISCUSSION

Research Trends in Group Investigation Learning Model for Critical Thinking Skills in 21st-Century Science Learning from January 2013 to December 2023 Based on Analysis with VOSviewer

Based on analysis carried out with VOSviewer with the Google Scholar database via Publish or Perish with the keywords "Group Investigation" and "Science learning", 985 articles written between 2013 and 2023 were obtained. After analysis and selection, were obtained 76 articles that were relevant to the aim of the literature study. Of the 76 articles, 10 journal articles are the articles with the most citations.

Table 3. Journal articles with the most citations

No	Authors/ Years	Cites	Title	Journal Title	Country
1.	(Asyari et al., 2016)	234	Improving critical thinking skills through the integration of problem-based learning and *Group Investigation*	International Journal for Lesson and Learning Studies	Indonesia
2.	(Made et al., 2015)	70	Improvement of Learning Process and Learning Outcomes in Physics Learning by Using Collaborative Learning Model of *Group Investigation* at High School (grade X, SMAN 14 Jakarta) I	Journal of Education and Practice	Indonesia
3.	(Listiana et al., 2016)	55	Empowering Students' Metacognitive Skills Through New Teaching Strategy (*Group Investigation* Integrated with Think Talk Write) In Biology Classroom	Journal of Baltic Science Education	Indonesia
4.	(Okur Akçay & Doymuş, 2014)	41	The Effect of Different Methods of Cooperative Learning Model on Academic Achievement in Physics	Journal of Turkish Science Education	Turki

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No	Authors/ Years	Cites	Title	Journal Title	Country
5.	(Arinda et al., 2019)	35	The Application *Group Investigation* (GI) Learning Model assisted Phet to Facilitate Student Scientific Work Skills	International Journal of Educational Research Review	Indonesia
6.	(F. Fauzi et al., 2021)	30	The Effectiveness of Collaborative Learning Through techniques on *Group Investigation* and Think Pair Share Students' Critical Thinking Ability on Chemical Equilibrium Material	Journal of Educational Science	Indonesia
7.	(Suhartono et al., 2019)	25	A Comparison Study: Effects of The *Group Investigation* Model and The Direct Instruction Model Toward Science Concept Understanding	Jurnal Pendidikan IPA Indonesia	Indonesia
8.	(Kazeni et al., 2018)	24	Effectiveness of individual and *Group Investigation*s in developing integrated science inquiry skills	South African Journal of Education	South Africa
9.	(Komala et al., 2020)	23	*Group Investigation* Model in Environmental Learning: An Effect on Students' Higher-Order Thinking Skills	Universal Journal of Educational Research	Indonesia
10.	(Parinduri et al., 2017)	23	The Effect of Cooperative Learning Model Type *Group Investigation* on Students' Conceptual Knowledge and Science Process Skills	IOSR Journal of Research & Method in Education (IOSRJRME)	Indonesia

The results of the analysis using VOSviewer obtained network visualization, overlay visualization, and density visualization, where this analysis relates to 76 articles. Based on the results of the VOSviewer analysis, the student, science, learning model, and Group Investigation model have larger sizes compared to other items. This shows that these words are related to the Group Investigation Learning Model which was studied from 2013 to 2023. The size of the circles and letters in the network visualization shows the frequency of appearance, where the larger the size of the circles and letters visible, the more the keywords appears in the literature (Kartimi Kartimi et al., 2021). Based on data from 76 articles, six clusters with 28 items were obtained which formed 125 links with a strength of 251.

Table 4. Elements represented each Cluster

No.	Cluster (Colour)	Elements
1.	First cluster (red)	Cooperative learning, effectiveness, Improvement, Interval, Science, Science process, Science process skill, Students academic achievement
2.	Second cluster (green)	Ability, activity, contextual teaching, critical thinking skills, Higher order
3.	Third cluster (blue)	*Group Investigation* model, learning model, outcome, social science, student
4.	Fourth cluster (yellow)	Achievement, implementation, learning achievement, self-efficacy, teacher
5.	Fifth cluster(purple)	Biology, Indonesian, physics
6.	Sixth cluster (light blue)	Thinking, talking, writing skills

Network visualization contains items represented by labels and networks, where the size of the labels and item circles is determined by the number of items. The more the items are there, the larger the label and circle size will be. Meanwhile, the color of an item is represented by clusters on that item.

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The overlay visualization represents what year the research related to the item was carried out, which is aimed at color changes, where the newer the research, the brighter (yellow) the color of an item group. Meanwhile, density visualization represents the density of items shown in blue, green, and red. The greater the number of items, the closer the color is to red. Conversely, the smaller the number of an item, the closer the color is to blue.

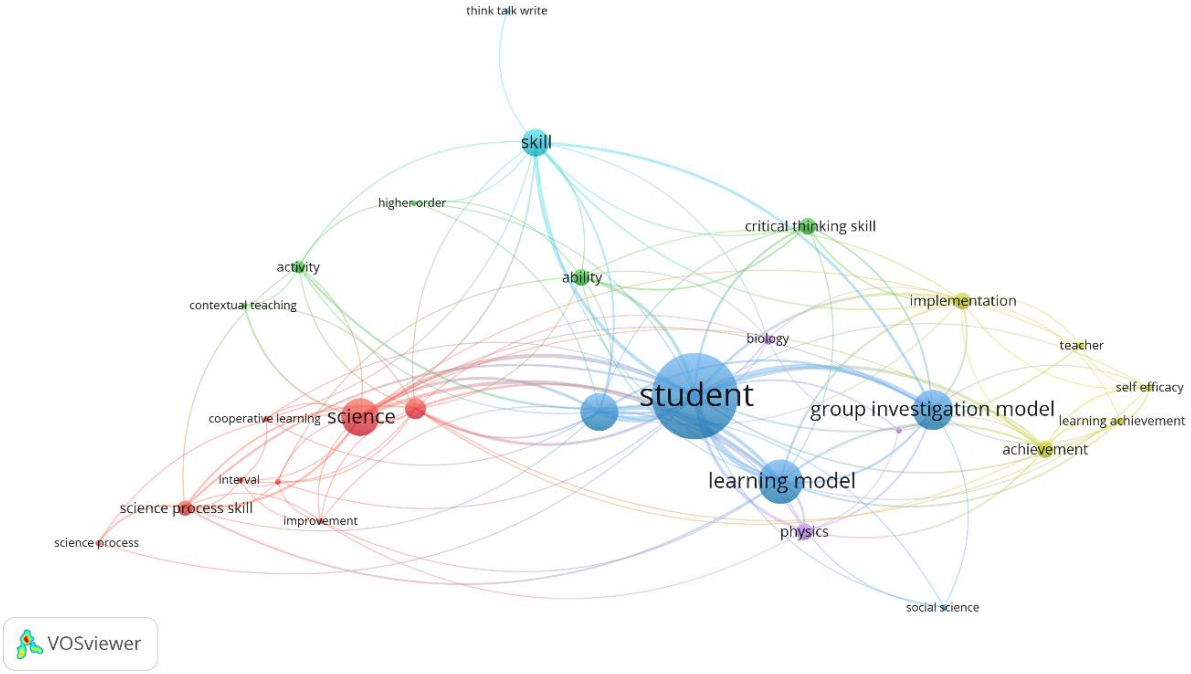

Figure 3. Network visualization Result

Figure 3 shows that research related to the Group Investigation Learning Model is closely related to students and the learning model used to improve the outcomes of learning, especially science learning. Research related to the Group Investigation Learning Model so far has been related to its application to improve skills and abilities, including critical thinking skills, self-efficacy, science process skills, activities, and achievement in students. Critical thinking skills are a variable that is widely researched in learning using the Group Investigation Learning Model. This is because the Group Investigation Learning Model is a learning model that combines communication and interaction with academic inquiry which encourages students to work to achieve a goal in learning and provides greater opportunities for students to be involved in learning in carrying out investigations so that critical thinking skills become more optimal (Oleo et al., 2020) (Asrul et al., 2021). Based on the network visualization results, research related to Group Investigation for other skills in the 21st century such as communication, collaboration, creative thinking, leadership, analytical thinking, problem-solving, and adaptability has not yet been carried out. Apart from that, based on the network visualization results, the fields of science that are most researched in the Group Investigation Learning Model are biology, physics, and science in general. Therefore, research on Group Investigation Learning Models in the fields of chemistry, astronomy, and earth sciences (geology), which are included in the field of science, needs to be carried out to increase knowledge and treasures related to the role of Group Investigation Learning Models.

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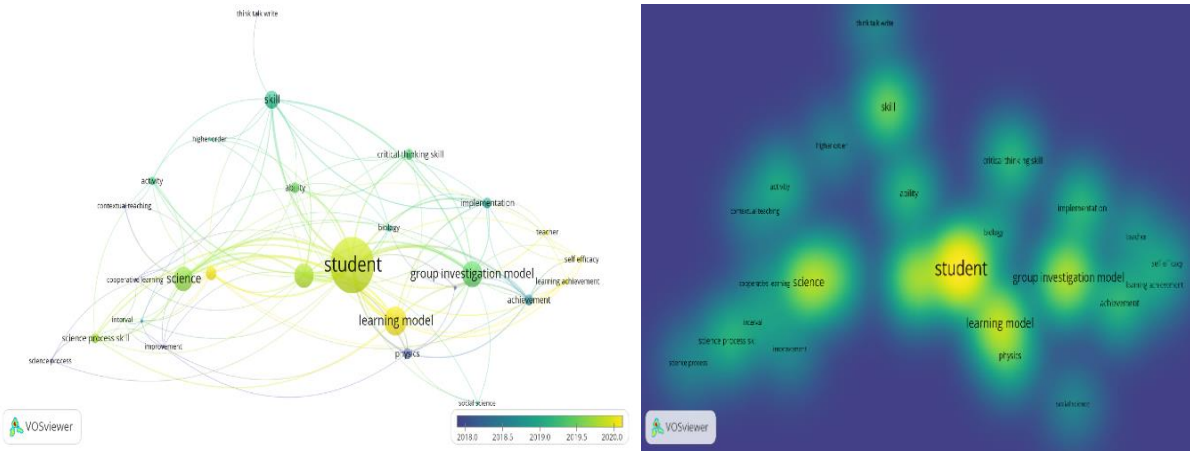

(a) (b)

Figure 4. (a) Overlay visualization results (b) Density Visualization results

Based on Figure 4, the overlay visualization results show that research related to learning models is research that has been a trend until now, namely in the 2020s, while the Group Investigation Learning Model is the trend of research that was carried out at the beginning of 2019. Critical thinking skills were the most common research objective targeted at learning with the Group Investigation Learning Model in 2019. Self-efficacy is one of the learning objectives that is expected to be achieved, especially in recent research (in the 2020s). Figure 4 related to the density visualization results shows that the Group Investigation Learning Model is yellowish green, which shows that research on this learning model has not been carried out too much globally so the resulting color is not greenish yellow like the student. The student has a greenish-yellow color which shows that this item has been studied the most because the current learning model is very student-oriented rather than teacher-oriented. (Tang, 2023).

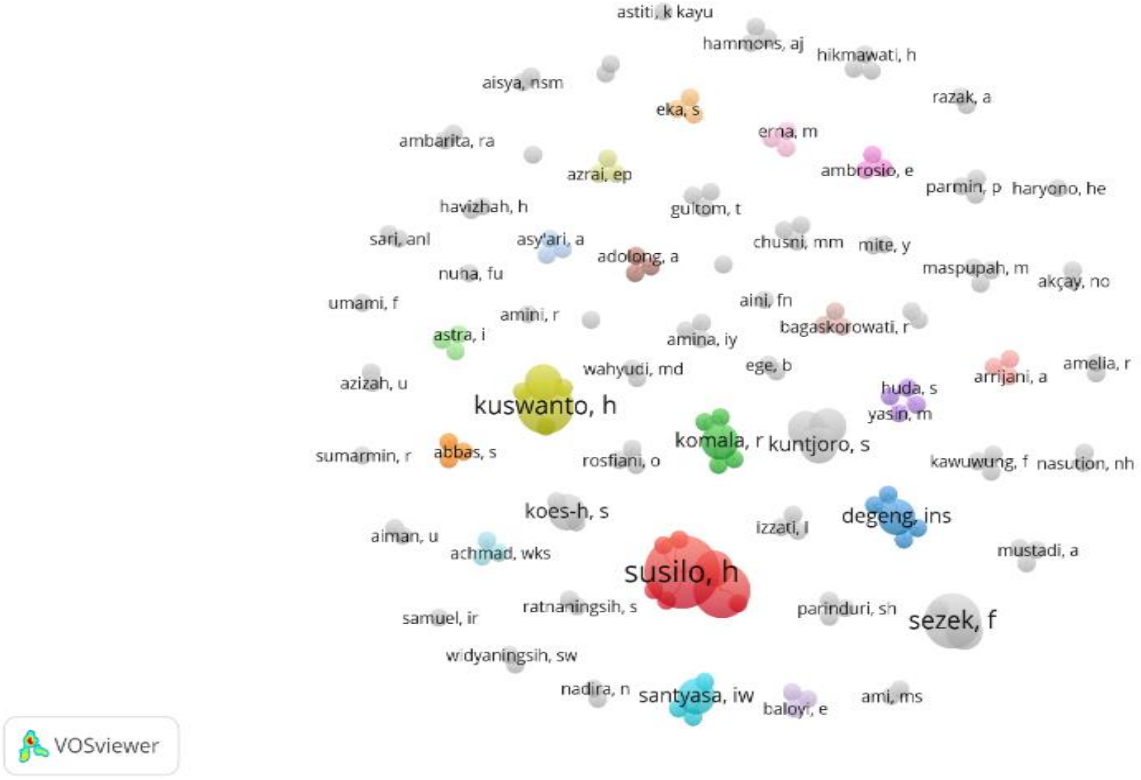

Figure 5. Co-authorship network based on data using VOSviewer

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A combined analysis of authors and networks related to collaboration patterns between individuals can be seen in Figure 5. In this network, each node represents an author in their writing connections. Figure 5 shows that the biggest points are the authors Susilo, H and Kuswanto, H. Furthermore, Table 5 shows that Susilo, H is the most productive author with four documents related to research related to the Group Investigation Learning Model, followed by authors Kuswanto, H and Listiana, L with three publications. Next, Degeng, ins; Komala, R; Kuntjoto, S; Prabowo, P; Suwono, H; Tirta, gar; and Wilujeng, Iwith two articles. Judged from the total link strength, Susilo, h has the highest total link strength, namely eight. Total link strength in VOSviewer is the link strength calculated according to full or fractional counting which shows the total strength of co-authorship links from one researcher to another. (Van Eck & Waltman, 2021). The higher the total strength value, the stronger the relationship is.

Table 5. Ten Productive Authors in Group Investigation Learning Model Research

No.	Author	Documents	Total link Strength
1.	Susilo, H	4	8
2.	Kuswanto, H	3	5
3.	Listiana, L	3	5
4.	Degeng, Ins	2	4
5.	Komala, R	2	4
6.	Kuntjoro, S	2	4
7.	Prabowo, P	2	4
8.	Suwono, H	2	4
9.	Tirta, Gar	2	4
10.	Wilujeng, I	2	4

Implementation of the Group Investigation Learning Model to Improve Critical Thinking Skills in Science Learning

Critical thinking skills are at the heart of the future for society in the world and are considered important in the learning process because, through these skills, students are allowed to learn through discovery. (Wayudi et al., 2019). Critical thinking skills are identified as important as people seek to create new resources with different goals and competencies (Starkey, 2011). Critical thinking skills are important to train in learning, especially science learning which examines natural phenomena that occur in the lives of living creatures. Based on the literature review study that has been carried out, 76 articles have been selected from Publish or Perish with the Google Scholar database showing that 15 articles discuss the application of the Group Investigation Learning Model to improve critical thinking skills in science learning, which includes biology, chemistry, physics, and integrated science. The results of the literature study are presented in Table 6.

Table 6. Implementation of the Group Investigation Learning Model to Improve Critical Thinking Skills in Science Learning

No.	Author/year	Research subject	Science Concepts	Result
1.	(Asyari et al., 2016)	Biology Education Students	Ecosystems and their components, biochemical cycles, natural resources, global warming.	Learning through a problem-based learning model that is integrated with group investigation can improve critical thinking skills as proven through arguments, solving problems, and carrying out evaluations.
2.	(Mite & Corebima, 2017)	High School Students	Biology	Critical thinking skills significantly contribute to learning outcomes and the Group Investigation Learning Model can create a good and conducive

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No.	Author/year	Research subject	Science Concepts	Result
				learning environment and provide greater opportunities for students to participate in learning actively and directly through investigations.
3.	(Santyasa et al., 2018)	Class X High School Students	Physics on the topic of energy and momentum	The Group Investigation Learning Model is better than the direct instruction learning model for improving critical thinking skills, social and spiritual attitudes, and character in studying physics.
4.	(Khasanah & Azizah, 2018)	Class XI High School Students	Chemistry (reaction rate concept)	The implementation of the Group Investigation Learning Model can improve students' critical thinking skills.
5.	(Setiani & Razak, 2019)	Class X High School Students	Plant	Implementation of the Reading Concept Map Group Investigation (Remap-GI) learning model can improve critical thinking skills by 37.04%
6.	(A. Fauzi et al., 2019)	Class X High School Students	Ecosystem	Applying the Group Investigation Learning Model can improve critical thinking skills
7.	(Koes et al., 2020)	Physics Education Students	Basic Physics Course	The implementation of conceptual scaffolding in the Group Investigation Learning Model is not significantly different from conventional learning in improving critical thinking skills.
8.	(Oleo et al., 2020)	Class XI High School Students	Biology subjects on the concept of the Immune System	The implementation of the Group Investigation Learning Model can improve critical thinking skills in immune system material as demonstrated by an increase in critical thinking skills pretest from 62.18 to 85.38 in the post-test. The Group Investigation Learning Model can improve critical thinking skills because this learning model provides more opportunities for students to explore their knowledge and students can be actively involved in learning.
9.	(Rosiani et al., 2020)	Class VIII students at Junior High School	Science subjects	Critical thinking skills can be influenced by the learning model, where the research results show that the Group Investigation Learning Model influences critical thinking skills with a coefficient of determination of 33%.
10.	(F. Fauzi et al., 2021)	Class XI students at Madrasah Aliyah	The concept of chemical equilibrium	Compared to the think-pair-share collaborative learning model, the Group Investigation Learning Model is no better than Group Investigation Learning Model for critical thinking skills
12.	(Ade Kartika, 2022)	Biology education students	Animal Ecology Concept	The Group Investigation Learning Model influences the critical thinking skills of biology education students.
13.	(Herlo et al., 2023)	Class XI High School Students	Chemical compound	The implementation of the Group Investigation Learning Model to elemental chemistry material can influence skills with a significance value of 0.028.
14.	(Pujiastuti et al., 2023)	Class X High School students	Environmental Change concept	The implementation of the Group Investigation and Reading, Questioning, answering (GIRQA) integrated learning model contributed 41.4% to increasing critical thinking skills
15	(Abbas et al., 2023)	Elementary school students	science lesson	Learning that implements the Group Investigation Learning Model shows higher critical thinking skills at the end of learning than learning that implements the conventional learning model (direct instruction).

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Table 6 shows that research related to the application of the Group Investigation Learning Model to improve critical thinking skills was mostly carried out in biology subjects in high school, namely 33%, while science learning was integrated with the Group Investigation Learning Model to improve critical thinking skills in elementary schools and junior high schools are still limited. Currently, Group Investigation Learning Model is widely used in high schools because this learning model can make students enjoy working in a group, find group investigative techniques useful, perform several roles, and move from an individual attitude to a cooperative attitude in groups (Sari et al., 2020) (Baki et al., 2010; Maleng & Hartati, 2021). Therefore, research related to learning using the Group Investigation model in elementary and junior high schools needs to be carried out because this model can encourage student activity in carrying out investigations during the learning process. (Mite & Corebima, 2017). Research shows that the Group Investigation Learning Model can improve critical thinking skills, but this literature study shows that the application of the Group Investigation Learning Model is still widely carried out in high school so further research for elementary and junior high schools needs to be carried out.

CONCLUSION

The research trend of the Group Investigation Learning Model in 21st-century science learning in the period of January 2013-December 2023 shows that the Group Investigation Learning Model is used to improve 21st-century skills and other abilities such as critical thinking skills, self-efficacy, science process skills, activities, and student achievement. Critical thinking skills dominated research in 2019. The implementation of the Group Investigation Learning Model to improve critical thinking skills in science learning is mostly carried out in biology learning in high school. The Group Investigation Learning Model can improve critical thinking skills because it creates a good and conducive learning environment and provides greater opportunities for students to participate in learning actively and directly through investigations.

Limitations and Future Research Directions

Primarily, this study is restricted to the Google Scholar databases as the principal document sources. Additional databases such as ERIC, Scopus, Wos, and Dimensions may be utilized in subsequent investigations. This becomes more interesting when the scoping review technique is combined with it. Therefore, future research using other databases such as WoS, Science Direct, and Dimension is needed to explore more research related to Group Investigation Learning Models to improve critical thinking skills in science learning.

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