JPPIPA 10(11) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Analysis of Problems in Learners' Collaboration Ability towards Chemistry Learning: Systematic Literature Review

Desma Linda[1]*, Ayu Windy Malisa Menno[1], Yanni Irma Waty Simanjuntak[1]

[1]Departement of Chemistry Education Program, Faculty of Mathematics and Natural Science, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia

Received: February 28, 2024
Revised: July 28, 2024
Accepted: November 25, 2024
Published: November 30, 2024

Corresponding Author:
Desma Linda
desma2911@gmail.com

DOI: 10.29303/jppipa.v10i11.7326

Abstract: Collaboration skills involving active participation, flexibility, responsibility, and appreciation are very important in chemistry learning, especially since chemistry contains abstract and complex concepts that are often difficult for students to understand. This research aims to describe the literature review on student collaboration skills in the context of chemistry learning. The method used in this research is Systematic Literature Review (SLR), with articles taken from the Scopus database and supported by Publish or Perish (PoP) in the range of 2013-2023. This research focuses on problems and solutions related to student collaboration skills, especially in the context of chemistry learning. The results showed that the difficulties faced by students in understanding chemistry materials can lead to low student collaboration skills. The problems of students' collaboration skills include the lack of teachers' ability to choose the right learning model/approach/method as well as physical limitations (practicum experience, limited access to materials and equipment), and lack of interactivity in chemistry lessons causing low student collaboration. Therefore, appropriate strategies, approaches, and learning models as well as supporting infrastructure are needed in learning chemistry. One of the appropriate learning models/approaches to improve student collaboration is Discovery Learning, and cooperative learning models of TGT, PBL, and PjBL types. In addition, this also needs to be supported by interesting teaching materials in order to help improve students' collaboration skills in learning.

Keywords: Chemistry Learning; collaboration skills; Systematic Literature Review

Introduction

Changes in various fields, including education, are influenced by the development of information and communication technology used in all aspects of life. This technology not only makes it easier, but also has an impact on individual competencies and qualifications (Daryanto, & Karim, 2017; Ayu et al., 2023). Education is expected to be able to produce high-quality human resources so that the country can compete globally. However, the quality of education in Indonesia is still low even though the main goal of 21st century education is to improve creativity, critical thinking, collaboration abilities, and other skills that are important in the future (Retiyanto et al., 2023; Virmayanti et al 2023).

Collaboration skills are one of the important elements in 21st century learning. Collaboration includes the ability to work together effectively, take responsibility, respect opinions, and work productively in teams (Sari et al., 2017; Greenstein, 2012). Unfortunately, many teachers still use traditional teaching approaches that emphasize individual tasks over group work. This leads to low social interaction and collaboration between students from the results of

How to Cite:
Linda, D., Menno, A. W. M., & Simanjuntak, Y. I. W. (2024). Analysis of Problems in Learners' Collaboration Ability towards Chemistry Learning: Systematic Literature Review. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 784–792. https://doi.org/10.29303/jppipa.v10i11.7326

research conducted by (Hinyard et al., 2019; Johnson & Johnson, 1999). The lack of teacher competence in implementing collaborative learning also affects students' opportunities to develop social and academic skills more broadly (Mashudi, 2021).

In the context of chemistry learning, which is known to be complex and abstract, many students have difficulty in understanding the concepts taught. Often students only memorize theories without really understanding the meaning and application of chemical concepts (Chang, 2000; Sariati et al., 2020). This difficulty is exacerbated by the lack of interaction between students and teachers and the low interest of students in chemistry lessons, which are considered difficult and boring (Zakiyah et al., 2018; Muderawan et al., 2019). Collaboration in chemistry learning has the potential to help students find solutions through cooperation, but many students are still passive in group discussions and contribute less (Firman et al., 2023).

Collaboration skills are divided into interpersonal and intrapersonal skills. Interpersonal skills involve the ability to cooperate with others, listen actively, and communicate well (Indraswati et al., 2020). Meanwhile, intrapersonal skills include motivation, time management, and engagement in collaborative learning (Hidayanti et al., 2020). In chemistry learning, it is very important for students to develop collaborative abilities in order to understand abstract concepts and apply them in real life (Ningsih & Hidayah, 2019; Rachman et al., 2017). This research aims to evaluate the problems related to the low collaboration capacity of students in chemistry learning. This problem is influenced by various factors such as the lack of selecting the right learning model and the limited teaching resources that support it (Nurlaela, 2019; Chu et al., 2012).The results of this study are expected to provide useful information and become a reference in the development of collaborative learning in the future.

Method

The approach used in this research is the Literature Review (SLR) approach. The SLR approach is a process for finding, evaluating, collecting, and critically analyzing data from research that is relevant to the topic being discussed the SLR approach is a scientific approach that strictly follows a set of processes to reduce the likelihood of systematic errors by finding, analyzing, and combining all relevant studies to answer a specific problem or set of questions Petticrew & Roberts (2006) and Aguinis & Glavas (2012). Activities include creating strategies for searching for data and/or information sources, selecting studies based on their quality utilizing eligibility criteria and quality evaluation instruments, and synthesizing and extracting data.

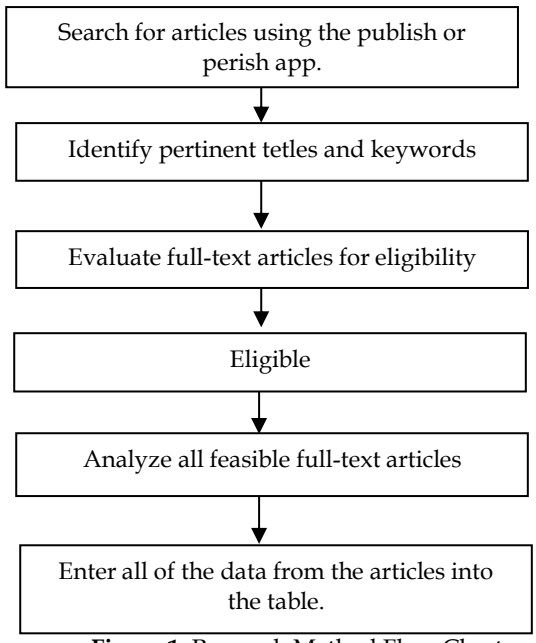

Figure 1. Research Method Flow Chart

A thorough search with the PRISMA approach resulted in 150 Scopus indexed publications from the title "student collaboration skills issues" and 30 Scopus indexed papers from the keyword "chemistry". After limiting the number of papers from 2013 to 2023, 25 scopus indexed articles were found. Then move on to the data synthesis stage.

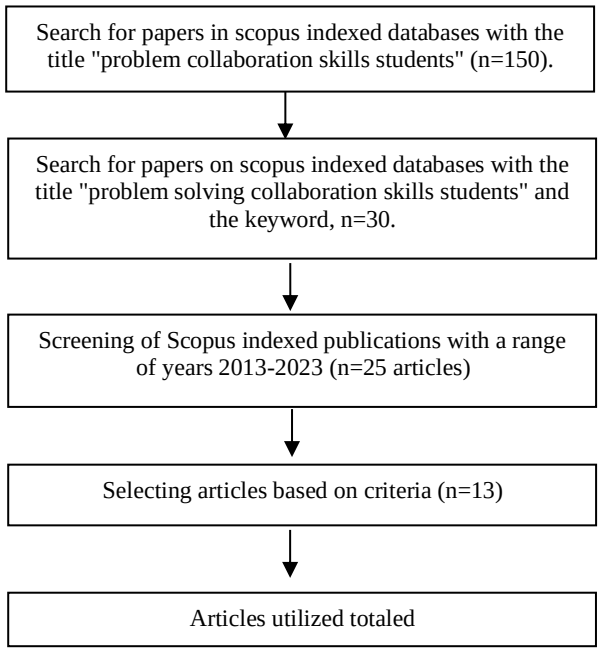

Figure 2. Article Screening Chart

The data synthesis approach for this investigation entailed comparing literature that fulfilled the quality evaluation, inclusion, and exclusion criteria. Data

synthesis is relevant to the research goal of mapping research topics on students' collaborative abilities in chemistry learning. The final step was data extraction. Data extraction produces a table containing the author's name, year of publication, review technique, research objectives, and research findings (Primadianningsih et al., 2023)

Result and Discussion

The results of research data included in this literature review in the form of articles related to student collaboration problem skills in chemistry learning are presented in Table 1. Skills are essential in the workplace and include written and oral communication, teamwork, problem solving, time management, and collaboration skills (Stephenson & Sadler-McKnight, 2015). According to Marisda & Handayani (2020), collaborative learning is a learning technique where students of all levels work together in small groups to achieve a common goal. Collaboration is a joint effort between students and each other or groups interact with each other to achieve common goals. Deep cooperation Group learning involves students, when students work together to completing group assignments, they provide encouragement or information to friends group of people who need help. Collaboration with students who understand better have the awareness to explain to friends who don't understand (Triana, 2018).

Table 1. Article Data

Author's Name, Year	Method	Purpose	Problem	Findings
(Koranto et al., 2021)	quasi-experiment	This study aims to describe the effect of Project Based Laboratory learning (PjBLL) on collaboration skills and basic science process skills of students.	Low student collaboration is caused by a lack of opportunities to collaborate, poor social skills, low motivation to work together, and a lack of understanding of the importance of collaboration.	The effect of PJBL combined with Whatssap and Google Form on students' collaboration skills.
(Atun & Latupeirissa, 2021)	quasi-experiment	Determine the effectiveness of KIT props in improving students' collaboration and creative thinking skills.	Weak student collaboration can be caused by several factors, including a lack of collaboration skills development at school, limited opportunities for complex tasks, a lack of teaching aids that stimulate collaboration, and a less active role of teachers in engaging students' collaboration skills.	The use of KIT as learning media can improve students' collaboration skills.
(McLaren et al., 2018)	Quantitative	Promotes conceptual learning in chemistry by having pairs collaborate on problems in a virtual laboratory (VLab), aided by collaboration scripts.	Student collaboration in chemistry learning requires guidance for productive interactions. Students often feel pressured by the demands of collaborating, instruction, and understanding chemistry materials simultaneously. Appropriate support and guidance are needed for effective student collaboration.	The research developed a system to promote conceptual learning of chemistry through student collaboration in a virtual laboratory. Adaptive collaboration support helps increase the potential for students to achieve conceptual understanding in chemistry.
(Indrawati et al., 2021)	Quasi Eksperimental	This study aims to determine the effect of the GI-GI learning model on collaboration and students' science process skills.	Teachers tend to use a teacher-centered model, so learning does not involve students actively through learning activities so that collaboration between students is not formed.	The use of GI-GI learning model was used to improve student collaboration by encouraging active interaction, critical thinking, and knowledge exchange within the group.
(Schwarz et al., 2020)	Qualitative Research	Discuss potential improvements and limitations of collaborative learning approaches	It was found that group work was generally positively received, and no formal roles were assigned within the groups. Nonetheless, some challenges were identified, including problems in operating the instruments, lack of clarity	collaborative learning-based approach. To improve students' collaboration skills.

Author's Name, Year	Method	Purpose	Problem	Findings
			regarding the challenges of analysis, communicating between groups, and differences in task load between groups.	
(Leopold & Smith, 2020)	qualitative research that uses qualitative data as the main source of analysis, with a grounded theory approach to analyzing data.	The main objective is to improve interactions between students and positively impact the group work experience, as well as enhance learning and the development of group work skills.	lack of support for collaborative learning in higher education, especially in STEM subjects.	The journal recommends providing skillful and clear support in collaborative learning in higher education, especially in STEM subjects. The focus is on explicit teaching, practice and demonstration of collaboration skills.
(Merdekawati et al., 2021)	quasi-experiment	This study was conducted to determine the effect of TGT related to the material "Acids and Bases" on student learning achievement and collaboration skills in chemistry learning.	lack of attention to collaborative skills in chemistry learning can hinder students' knowledge construction	The implementation of the Teams Games Tournaments (TGT) learning model is proven to have a positive impact on student achievement and collaborative skills in chemistry learning, according to the research findings.
(Lawrie et al., 2016)	The study utilized a mixed-methods approach	Investigates the implementation of group work activities in a general chemistry course to enhance student interactions and dynamics. In addition, the journal also aims to highlight the importance of skillful and deliberate facilitation of student interaction skills to achieve the potential benefits of collaborative learning.	A problem that may arise is the lack of student engagement in collaborative tasks, which may affect the quality of collaboration outcomes.	wiki as a collaborative laboratory notebook, where students can share data, co-author, and process information together.
(Rahayu et al., 2023)	This type of research is a collaborative Classroom Action Research (PTK).	This research aims to improve students' collaboration skills.	The teacher also did not routinely familiarize group learning because she anticipated that students would be crowded when learning in groups. So that students tend to be calmer when learning individually, but indirectly it will foster an individualist attitude, selfish, and less sensitive to others.	The application of Problem-Based Learning (PBL) model with project-based learning (PBL) method can effectively improve students' collaboration skills.
(Sinex & Chambers, 2013)	quasi-experimental	This article describes the incorporation of online collaboration skills in a general chemistry laboratory	lack of teaching materials or media to develop collaboration skills	use of online collaboration technologies such as Google Drive to develop students' collaboration skills.

Author's Name, Year	Method	Purpose	Problem	Findings
		using spreadsheets and Google Drive forms.		
(Du et al., 2023)	This research uses mixed methods analysis.	Reduce students' cognitive load and develop their collaborative problem-solving skills in a virtual laboratory environment.	Problems with student collaboration in learning include the unbalanced allocation of tasks in asynchronous collaboration via email or forums, the lack of instant feedback which can result in student isolation, and the increased cognitive load experienced by students in collaborative tasks.	Collaboration in virtual laboratories improves students' understanding and problem-solving skills. The use of supporting technologies, such as virtual laboratory (VL), facilitates effective collaboration through online shared virtual experiments.
(von & Halpin, 2013)	quantitative research	Develop a new assessment framework and statistical approach for Collaborative Problem Solving (CPS)-based assessment	Low student collaboration skills in learning can be caused by a lack of effective interaction and discussion between students, as well as students' lack of ability to build knowledge together.	Solutions to improve student collaboration: cooperative learning, collaborative technologies (virtual environments and MOOCs), and collaboration-based assessment. This combination is expected to create an effective and empowering learning environment.
(Le et al., 2018)	qualitative research	To determine the barriers to an effective collaboration perceived by teachers and students during the collaborative learning (CL) process and to identify antecedent factors that may explain these bajrriers.	The problem of student collaboration in learning stems from students' lack of collaborative skills, promiscuous behavior, competency status, and peer relationships. Another element that affects student collaboration is teachers' lack of attention to collaborative features in collaborative learning. In addition, teachers' lack of understanding and expertise in collaborative skills training can worsen the situation.	To address the problem of student collaboration in learning, solutions involve a balanced emphasis on cognitive and collaborative aspects, explicit instruction in collaborative skills, integration of collaborative goals in course objectives, teacher training in collaborative learning design, and adequate assessment of student collaboration. By implementing these measures, it is expected that the quality of student collaboration can improve in the context of collaborative learning.

Based on the thirteen journals, a coding process was carried out to categorize the main difficulties that cause low student collaboration in learning, as follows:

Table 2. Coding list of root causes of student collaboration

Article Code	Root of the Problem	Frequency
1,4,5,7,8,9	Lack of teacher's ability to choose suitable models/approaches/methods in learning	6
2,3,6,10,11,12,13	physical limitations (practical experience, limited access to materials and equipment), and interactivity	7

This research discusses the problem of students' collaboration skills in learning chemistry. From the results of the journal analysis above, it can be concluded that there are several factors that cause low student collaboration in learning, namely from the lack of supporting teaching materials in the learning process According to Belawati (2003), teaching materials in the learning process play a crucial role. Additionally, the teaching method of a teacher who only focuses on explanation without involving students in the learning process activities, and not choosing the right model/approach/method that is suitable in learning. So

that it makes students less active to collaborate in the learning process and learning becomes boring for students, and can cause students to be less interested in learning again.

The first problem is related to the lack of teachers' ability to choose a suitable model/approach/method in learning. The problem faced in chemistry learning is low student collaboration, which is caused by lack of opportunities to collaborate, lack of social skills, low motivation to work together, and lack of understanding of the importance of collaboration. The teacher-centered learning model causes learning to not involve students actively, so collaboration between students is not formed. Although working in groups was generally received positively, challenges such as instrument operation, ambiguity regarding analytical challenges, communication between groups, and differences in workload emerged. The lack of attention to collaborative skills in chemistry learning can hinder students' knowledge construction. Teachers also rarely introduce group learning due to the anticipation that students will be busy, causing students to prefer individual learning and fostering individualism, self-centeredness, and lack of sensitivity to others. Another potential problem is the lack of student engagement in collaborative tasks, which can affect the quality of collaborative outcomes.

From these problems, solutions to improve students' collaboration skills can be found through various innovative approaches in learning. The development of student collaboration skills in chemistry learning can be improved through various approaches. Research shows that the implementation of Project-Based Learning Approach (PJBL) combined with platforms such as WhatsApp and Google Form can be effective in improving students' collaboration skills. Systems that support adaptive collaboration in virtual laboratories have also proven beneficial for improving conceptual understanding in chemistry. In addition, the GI-GI learning model can motivate active interaction, critical thinking, and knowledge exchange in groups. The implementation of Teams Games Tournaments (TGT) model and Problem-Based Learning (PBL) approach also proved to have a positive impact on students' achievement and their collaborative skills in the context of chemistry learning. Thus, the combination of various learning models can be a holistic solution to overcome students' low collaboration skills in chemistry learning.

There was a study conducted in a private high school in Sleman on how students learn about acids and bases. They used something called "TGT learning model" which prioritizes students' collaborative skills. The results showed that there was a clear difference between students who learned by using the TGT model and those who learned by conventional methods. In the experimental class (which used the TGT model), students were actively involved in learning. They collaborated, asked questions, and discussed. Students were directly involved in the learning process. However, in the control class (which used the conventional method), students were more passive. They tend to receive explanations from the teacher and do the exercises on their own. They were less active in asking questions or discussing with the teacher or friends if they did not understand something. As a result, students who used the TGT model showed better improvement in learning achievement and collaborative skills compared to students who learned conventionally. So, the use of TGT learning model seems to be more effective in improving students' learning outcomes and collaborative skills compared to the more common conventional method. When viewed from the aspect of indicators on collaboration skills, the indicators in the experimental class are higher than the indicators in the control class (Merdekawatia et al, 2021).

According to research findings Indrawati et al (2021) using the GI-GI learning approach can help improve students' collaborative skills. The GI-GI learning model combines the Group Investigation and Guided Inquiry approaches. The GI-GI learning model is also related to Constructivist learning theory. The GI-GI learning model has four stages, namely building a concept (Constructing of Concept), proposing/requesting guidance from the instructor or teacher (Guiding), formulating and testing a hypothesis (Hypothesizing and Testing), and communicating and assessing the results. According to the study's findings, collaboration skills enable students to engage in activities that need them to work together to achieve goals by respecting differences, participating in conversations, exchanging ideas, listening, and supporting others. The GI-GI learning technique engages students in the learning process and helps them better understand chemical concepts and principles. In contrast, control class pupils are primarily passive, and the teacher actively participates in the learning process. When actively contributing, students can draw conclusions and present experimental data gathered under the teacher's supervision and instruction. In this method, students might interpret or evaluate a problem supplied by the teacher in order to reach a conclusion. The advantage of the learning process is that students can take an active position in the learning process, address difficulties in conversations, and participate directly in the learning process, making it easier to absorb the information.

So, based on this research, it can be concluded that the GI-GI learning paradigm has a considerable impact on students' teamwork and science process skills. This research shows that the GI-GI learning model can train

students to conduct research in groups, interact actively with friends and educators to exchange opinions, knowledge, or experiences, find and solve problems, and generate hypotheses through investigation, exploration, and discussion both inside and outside the classroom.

Other research results from Rahayu et al (2023) stated that using the Problem Based Learning (PBL) model. Apart from that, teachers can also apply project-based learning methods or problem-based learning (PBL) which have been proven effective in improving students' collaboration skills. This is also in line with the opinion of Schwarz et al (2020), saying that a student-based approach through collaborative learning in analytical chemistry project seminars can improve students' collaboration skills.

The research results also suggest providing skilled and clear support in collaborative learning in schools, especially emphasizing the learning process using STEM. The STEM approach is suitable for developing students' creative thinking abilities, because the engineering process is a process of training creative thinking abilities (Utami et al., 2018); (Kristiani et al., 2017), not only that with its emphasis on practical teaching, and collaborative modeling of collaboration skills. Explicitly, STEM can also increase student collaboration in learning.

The second problem is related to physical limitations (practical experience, limited access to materials and equipment), and student or teacher interactivity in learning. Where from the results of the journal analysis in the table, one of the causes of student collaboration problems in learning is the lack of student collaborative skills, free-wheeling behavior, competency status, and friendship relationships. Another factor that influences student collaboration is the teacher's lack of emphasis on the collaborative aspects of collaborative learning. Additionally, teachers' lack of knowledge and experience in collaborative skills training may also contribute to this problem (Du et al., 2023).

These problems may be minimized in various ways that teachers can overcome, one of which is by using KIT (Collaboration, Instruction and Technology) as a learning medium which can improve students' collaboration skills. Adaptive systems in virtual laboratories, skilled support in STEM, and online collaboration technologies such as Google Drive are effective solutions to overcome student collaboration problems, requiring increased use of technology, instant feedback, integration of visual aids, and learning approaches that take into account students' cognitive load and the use of conversational agents and collaborative scripts also supports collaborative learning. Other solutions involve a balanced emphasis between cognitive and collaborative aspects, explicit instruction in collaborative skills, integration of collaborative goals, teacher training, and adequate assessment. By implementing this solution, it is hoped that the quality of student collaboration can increase students' collaboration abilities in learning

Conclusion

Collaboration skills are the skills to work together effectively and show respect for a diverse team, practicing fluency and willingness to make decisions necessary to achieve common goals. Collaboration skills in chemistry learning are very important for students. There are problems with students' collaboration abilities, namely the teacher's lack of ability to choose a suitable model/approach/method in learning and physical limitations (practical experience, limited access to materials and equipment), and interactivity in chemistry lessons causing low student collaboration. Therefore, strategies, approaches and learning models are needed as well as appropriate infrastructure in learning chemistry. By implementing the right learning approach and model you can improve students' collaboration abilities. One suitable learning model/approach that can increase student collaboration in learning is Discovery Learning, and Cooperative learning models of the TGT, PBL, and PjBL types. In addition, it also needs to be supported with interesting teaching materials in order to help improve students' collaboration skills in learning.

Acknowledgments
The authors would like to thank the co-authors who have assisted the authors in completing this systematic literature review article.

Author Contributions
Author contributions include Desma Linda, Ayu Windy Malisa Menno, Yanni Irma Waty Simanjuntak collected data, analyzed data, wrote the original draft; as well as focused on writing the review.

Funding
This study received no external funding.

Conflicts of Interest
The authors declare no conflict of interest

References

Abd.Rachman, F., Ahsanunnisa, R., & Nawawi, E. (2017). Pengembangan LKPD Berbasis Berpikir Kritis Materi Kelarutan dan Hasil Kali Kelarutan pada Mata Pelajaran Kimia di SMA. *ALKIMIA : Jurnal Ilmu Kimia dan Terapan*, *1*(1), 16–25. https://doi.org/10.19109/alkimia.v1i1.1326

Aguinis, H., & Glavas, A. (2012). What We Know and Don't Know About Corporate Social Responsibility:

A Review and Research Agenda. *Journal of Management*, *38*(4), 932–968. https://doi.org/10.1177/0149206311436079

Atun*, S., & Latupeirisa, V. P. S. (2021). Science KIT Teaching Aid for the Earthquake in Improving Students' Collaboration Skills and Creative Thinking in Junior High School. *Science KIT Teaching Aid for the Earthquake in Improving Students' Collaboration Skills and Creative Thinking in Junior High School*, *10*(1), 187–197.

Ayu, H. D., Alfianda, F. V., Sabrina, F., Prameswari, I., Putri, A. N., & Hudha, M. N. (2023). Systematic literature review: Project-based learning terintegrasi dengan STEM. *Wiyata Dharma: Jurnal Penelitian Dan Evaluasi Pendidikan*, *11*(2), Article 2. https://doi.org/10.30738/wd.v11i2.16492

Belawati, T. (2003). *Pengembangan Bahan Ajar*. Pusat penerbitan UT.

Chang, R. (2000). *Kimia dasar Jilid I*. Erlangga.

Chu, K. W. S. (2012). *Developing upper primary students' 21st century skills: Inquiry learning through collaborative teaching and web 2.0 technology*. https://www.semanticscholar.org/paper/Developing-upper-primary-students%27-21st

Daryanto, & Karim. (2017). *Pembelajaran Abad 21*. Gava Media.

Du, X., Dai, M., Tang, H., Hung, J.-L., Li, H., & Zheng, J. (2023). A multimodal analysis of college students' collaborative problem solving in virtual experimentation activities: A perspective of cognitive load. *Journal of Computing in Higher Education*, *35*(2), 272–295. https://doi.org/10.1007/s12528-022-09311-8

Firman, Nur, S., & SL.Taim, M. A. (2023). Analisis Keterampilan Kolaborasi Siswa SMA pada Pembelajaran Biologi. *Diklabio: Jurnal Pendidikan dan Pembelajaran Biologi*, 82–89. https://doi.org/10.33369/diklabio.7.1.82-89

Greenstein, L. (2012). Assessing 21st Century Skills: A Guide to Evaluating Mastery and Authentic Learning. In *Corwin*. Corwin, A SAGE Publications Company.

Hidayanti, E., Savalas, L. R. T., & Jannatin 'Ardhuha. (2020). Keterampilan Kolaborasi: Solusi Kesulitan Belajar Siswa SMA dalam Mempelajari Kimia. *Prosiding Seminar Nasional Pendidikan Inklusif*, *1*(1), Article 1.

Hinyard, L., Toomey, E., Eliot, K., & Breitbach, A. (2019). Student Perceptions of Collaboration Skills in an Interprofessional Context: Development and Initial Validation of the Self-Assessed Collaboration Skills Instrument. *Evaluation & the Health Professions*, *42*(4), 450–472. https://doi.org/10.1177/0163278717752438

Indraswati, D., Marhayani, D., Sutisna, D., Widodo, A., & Maulyda, M. (2020). Critical Thinking Dan Problem Solving Dalam Pembelajaran Ips Untuk Menjawab Tantangan Abad 21. *Sosial Horizon: Jurnal Pendidikan Sosial*, *7*, 12. https://doi.org/10.31571/sosial.v7i1.1540

Indrawati, Mahardika, I., Prihatin, J., Supeno, S., Astutik, S., Sudarti, S., & Wicaksono, I. (2021). The effect of the group investigation-guided inquiry (GI-GI) learning model to improve students' collaboration and science process skills. *Journal of Physics: Conference Series*, *2104*, 012027. https://doi.org/10.1088/1742-6596/2104/1/012027

Johnson, D. W., & Johnson, R. T. (1999). Making cooperative learning work. *Theory Into Practice*, *38*(2), 67–73. https://doi.org/10.1080/00405849909543834.

Koranto, D., Setiani, R., & Widiasih, W. (2021). The Effect of PjBLL Online Platform on Student Collaboration Skills and Basic Science Process Skills During the Covid-19 Pandemic. *Journal of Physics: Conference Series*, *2110*, 012021. https://doi.org/10.1088/1742-6596/2110/1/012021

Kristiani, K. D., Mayasari, T., & Kurniadi, E. (2017). Pengaruh pembelajaran STEM-PjBL terhadap keterampilan berpikir kreatif. *Prosiding SNPF (Seminar Nasional Pendidikan Fisika)*, *0*, Article 0.

Lawrie, G. A., Grøndahl, L., Boman, S., & Andrews, T. (2016). Wiki Laboratory Notebooks: Supporting Student Learning in Collaborative Inquiry-Based Laboratory Experiments. *Journal of Science Education and Technology*, *25*(3), 394–409. https://doi.org/10.1007/s10956-016-9601-0

Le, H., Janssen, J., & Wubbels, T. (2018). Collaborative learning practices: Teacher and student perceived obstacles to effective student collaboration. *Cambridge Journal of Education*, *48*(1), 103–122. https://doi.org/10.1080/0305764X.2016.1259389

Leopold, H., & Smith, A. (2020). Implementing Reflective Group Work Activities in a Large Chemistry Lab to Support Collaborative Learning. *Education Sciences*, *10*(1), Article 1. https://doi.org/10.3390/educsci10010007

Marisda, D. H., & Handayani, Y. (2020). Model Pembelajaran Kolaboratif Berbasis Tugas Sebagai Alternatif Pembelajaran Fisika Matematika. *Prosiding Seminar Nasional Fisika PPs Universitas Negeri Makassar*, *2*(0), Article 0.

Mashudi, M. (2021). Pembelajaran Modern: Membekali Peserta Didik Keterampilan Abad Ke-21. *Al-Mudarris (Jurnal Ilmiah Pendidikan Islam)*, *4*(1), 93–114. https://doi.org/10.23971/mdr.v4i1.3187

McLaren, B. M., Rummel, N., Pinkwart, N., Tsovaltzi, D., Harrer, A., & Scheuer, O. (2008). *Learning Chemistry*

through Collaboration: A Wizard-of-Oz Studt of Adaptive Collaboration Support. https://doi.org/10.1184/R1/6470216.v1

Merdekawati, K., Kasjib, Z., A., & Febriana, B., W,. (2021). *TGT untuk pembelajaran kimia untuk meningkatkan prestasi dan keterampilan kolaboratif siswa | Prosiding Konferensi AIP | Penerbitan AIP*. https://pubs.aip.org/aip/acp/article

Muderawan, I. W., Wiratma, I. G. L., & Nabila, M. Z. (2019). Analisis Faktor-Faktor Penyebab Kesulitan Belajar Siswa Pada Pelajaran Kimia. *Jurnal Pendidikan Kimia Indonesia*, *3*(1), Article 1. https://doi.org/10.23887/jpk.v3i1.20944

Ningsih, R. K., & Hidayah, R. (2019). The Effectiviness Of Chemical Practicum Kit To Train Science Process Skill In 10th Grade. *JCER (Journal of Chemistry Education Research)*, *3*(1), Article 1. https://doi.org/10.26740/jcer.v3n1.p1-8

Nurlaela, E. U. (2019). Chemistry Stortell" Inovasi Literasi Pembelajaran Kimia. *Prosiding SNPS (Seminar Nasional Pendidikan Sains)*, *0*, Article 0.

Petticrew, M., & Roberts, H. (2006). Systematic Reviews in the Social Sciences: A Practical Guide. In *Systematic Reviews in the Social Sciences: A Practical Guide* (Vol. 11). https://doi.org/10.1002/9780470754887

Primadianningsih, C., Sumarni, W., & Sudarmin, S. (2023). Systematic Literature Review: Analysis of Ethno-STEM and Student's Chemistry Literacy Profile in 21st Century. *Jurnal Penelitian Pendidikan IPA*, *9*(2), Article 2. https://doi.org/10.29303/jppipa.v9i2.2559

Rahayu, E., S., Annis, D., & Khamid. (2023). *Efforts to Improve Student Collaboration Skills Using a Problem-Based Learning Model Based on a Culturally Responsive Teaching Approach in Class IV IPAS Materials. Proceedings of International Conference on Teacher Profession Education.*

Retiyanto, H. F., Putri, S. E., As-Shidiq, M. H., & Suyanta, S. (2023). Systematic Literature Review: Analysis of Student's Critical Thinking Skills towards Chemistry Learning. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), Article SpecialIssue. https://doi.org/10.29303/jppipa.v9iSpecialIssue.6436

Sari, K. A., Prasetyo, Z. K., & Wibowo, W. S. (2017). Pengembangan Lembar Kerja Peserta Didik Ipa Berbasis Model Project Based Learning Untuk Meningkatkan Keterampilan Kolaborasi Dan Komunikasi Peserta Didik Kelas Vii Development Of Science Student Worksheet Based On Project Based Learning Model To Improve Collaboration And Communication Skills Of Junior High School Student. *Jurnal TPACK IPA*, *6*(8), Article 8.

Sariati, N. K., Suardana, I. N., & Wiratini, N. M. (2020). Analisis Kesulitan Belajar Kimia Siswa Kelas XI pada Materi Larutan Penyangga. *Jurnal Ilmiah Pendidikan Dan Pembelajaran*, *4*(1), Article 1. https://doi.org/10.23887/jipp.v4i1.15469

Schwarz, G., Picotti, V., Bleiner, D., & Gundlach-Graham, A. (2020). Incorporating a Student-Centered Approach with Collaborative Learning into Methods in Quantitative Element Analysis. *Journal of Chemical Education*, *97*. https://doi.org/10.1021/acs.jchemed.0c00052

Sinex, S. A., & Chambers, T. L. (2013). Developing Online Collaboration Skills in the General Chemistry Laboratory. *Journal of Chemical Education*, *90*(9), 1244–1246.

Stephenson, N., & Sadler-McKnight, N. (2015). Developing critical thinking skills using the Science Writing Heuristic in the undergraduate chemistry laboratory. *Chem. Educ. Res. Pract.*, *17*. https://doi.org/10.1039/C5RP00102A

TRIANA, W. (2018). Meningkatkan Kerjasama Siswa Melalui Model Pembelajaran Kooperatif Tipe Numbered Heads Together (Nht) Tema Sehat Itu Penting Kelas V Sd Negeri 55/I Sridadi. *Jurnal Meningkatkan Kerjasama Siswa Melalui Model Pembelajaran Kooperatif Tipe Numbered Heads Together (Nht) Tema Sehat Itu Penting Kelas V Sd Negeri 55/I Sridadi*.

Utami, T. N., Jatmiko, A., & Suherman, S. (2018). Pengembangan Modul Matematika dengan Pendekatan Science, Technology, Engineering, And Mathematics (STEM) pada Materi Segiempat. *Desimal: Jurnal Matematika*, *1*(2), Article 2. https://doi.org/10.24042/djm.v1i2.2388

Virmayanti, N. K., Suastra, I. W., & Suma, I. K. (2023). Inovasi Dan Kreatifitas Guru Dalam Mengembangkan Keterampilan Pembelajaran Abad 21. *Jurnal Review Pendidikan Dan Pengajaran (JRPP)*, *6*(4), 515–527. https://doi.org/10.31004/jrpp.v6i4.20138

von Davier, A. A., & Halpin, P. F. (2013). Collaborative Problem Solving and the Assessment of Cognitive Skills: Psychometric Considerations. *ETS Research Report Series*, *2013*(2), i–36. https://doi.org/10.1002/j.2333-8504.2013.tb02348.x

Zakiyah, Z., Ibnu, S., & Subandi, S. (2018). Analisis Dampak Kesulitan Siswa pada Materi Stoikiometri terhadap Hasil Belajar Termokimia dan Upaya Menguranginya dengan Metode Pemecahan Masalah. *EduChemia (Jurnal Kimia Dan Pendidikan)*, *3*, 119.https://doi.org/10.30870/educhemia.v3i1.1784