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Investigation-Based Scientific Collaborative (IBSC) Learning Model to Foster Students' Communication and Collaboration Skills

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ABSTRACT

The development of communication and collaboration skills constitutes a critical demand in 21st-century learning. However, classroom practices remain predominantly teacher-centered, limiting students' opportunities to actively engage in scientific investigation and collaborative work. This study aims to examine the effectiveness of the Investigation-Based Scientific Collaborative (IBSC) learning model in enhancing students' communication and collaboration skills.
This research employed a quasi-experimental design involving students as research participants. The experimental group received instruction using the IBSC model, while the control group was taught using conventional methods. Data were collected through assessment instruments measuring communication and collaboration skills, observation sheets, and supporting documentation. Data analysis was conducted using descriptive and inferential statistics to determine differences between the two groups.
The findings indicate that students taught using the IBSC model demonstrate significantly higher communication and collaboration skills compared to those taught through conventional learning. The IBSC model promotes active student engagement in investigative activities, scientific discussions, and collaborative problem-solving, thereby positively influencing their ability to communicate and work effectively in teams.
This study concludes that the Investigation-Based Scientific Collaborative (IBSC) learning model is effective as an alternative instructional approach for developing students' communication and collaboration skills.
Keywords: model IBSC, keterampilan komunikasi, keterampilan kolaborasi, pembelajaran kolaboratif, keterampilan abad ke-21

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1. INTRODUCTION

Science learning in the 21st century no longer focuses solely on the mastery of concepts but also requires students to possess communication and collaboration skills as integral components of 21st-century competencies. Various international reports emphasize that scientific communication and teamwork are crucial aspects in solving science-based problems (OECD, 2019; UNESCO, 2023). In science learning, dialogic interaction and well-structured group work provide opportunities for students to construct conceptual understanding through processes of argumentation, discussion, and negotiation of meaning. Recent studies indicate that collaborative learning has a significant effect on improving students' scientific communication skills (Kurniawati & Farida, 2022; Wikanengsih & Rostikawati, 2024; Hidayat et al., 2023).

However, classroom practices are still predominantly teacher-centered, resulting in suboptimal development of scientific interactions among students. Empirical studies reveal that the implementation of collaborative learning without clear structure tends to fail in establishing effective positive interdependence (Gillies, 2020; Rahmawati et al., 2022). In addition, students' scientific communication skills, particularly in presenting evidence-based arguments, remain relatively low when not supported by systematic and well-directed instructional design (Llorente & Revuelta, 2023; Sánchez & Martínez, 2021).

The inquiry-based learning (IBL) approach has been proven effective in enhancing students' scientific literacy and scientific thinking skills (Amaditha et al., 2024; Diser Research, 2025; National Research Council, 2020). Furthermore, studies show that integrating investigative processes with collaboration in inquiry learning has a positive impact on students' scientific problem-solving abilities (International Journal of Educational Research, 2022; Lee et al., 2021). Nevertheless, the implementation of inquiry without clearly structured collaboration may lead to unequal participation among group members.

From a social constructivist perspective, social interaction plays a fundamental role in knowledge construction (Suparno, 1997; Moreno, 2010; Vygotsky revisited studies, 2022). Therefore, a learning model is needed that explicitly integrates scientific investigation with structured collaboration. The Investigation-Based Scientific Collaborative (IBSC) model was developed to address this need through a learning syntax that combines investigation phases with sharing tasks and jumping tasks, thereby fostering academic empathy, collective responsibility, and productive scientific communication.

The development of the IBSC model adopts the Educational Design Research (EDR) approach, which is oriented toward producing learning models that are valid, practical, and effective (Plomp, 2013; Nieveen et al., 2007; McKenney & Reeves, 2021). This approach enables an iterative process involving design, implementation, evaluation, and revision, resulting in a model that is not only theoretically grounded but also empirically validated. Accordingly, this study aims to develop an IBSC model that systematically and measurably enhances students' communication and collaboration skills in science learning. The novelty of this research lies in the integration of scientific investigation and structured collaboration within a single learning syntax specifically designed to develop both skills simultaneously, thereby offering an innovative alternative for strengthening competency-based science learning in the 21st century.

2. RESEARCH METHOD

A. Research Design

This study employs a Research and Development (R&D) design aimed at developing the Investigation-Based Scientific Collaborative (IBSC) learning model to foster students' communication and collaboration skills. The R&D approach was selected as the study not only examines the effectiveness of an intervention but also produces an educational product that meets the criteria of validity, practicality, and effectiveness (Borg & Gall, 2003; Sugiyono, 2012).

The development of the IBSC model follows the procedures of Borg and Gall (2003), modified to suit field conditions, comprising three main stages: (1) preliminary study, (2) product development, and (3) product testing. During the testing phase, a one-group pretest–posttest design was employed (Fraenkel & Wallen, 2012). This design was applied in both Trial I (limited trial) and Trial II (replication across three classes) to examine the improvement in students' communication and collaboration skills before and after the implementation of the IBSC model.

B. Research Procedure

The research procedure was carried out systematically following the development framework adapted from Borg and Gall (2003). The first stage was the preliminary study, which aimed to identify the need for model development through literature review, expert consultation, and field study (Suharsimi, 2006). The literature review was conducted to analyze theories and previous research related to communication and collaboration, while the field study aimed to obtain an empirical overview of Biology learning practices as well as students' communication and collaboration skills.

The second stage involved product development. Based on the identified problems, the researcher developed an initial draft (Prototype I) of the IBSC model along with its instructional tools, including syllabus, lesson plans, student worksheets, student textbooks, communication skills test instruments, collaboration skills observation sheets, student activity observation sheets, student response questionnaires, and model implementation observation sheets. The draft was validated by experts to assess both content and construct validity (Nieveen et al., 2007). Revisions were made based on expert feedback, resulting in Prototype II and Prototype III.

The third stage was product testing through Trial I and Trial II. Trial I was conducted on a limited basis using the O_1 X O_2 design. Following revisions, Trial II was carried out in three replication classes using the same design. The subjects in Trial II were ninth-grade students of MTs Negeri Rantauprapat and MTs Abu Hurairah Rantauprapat, selected purposively based on the heterogeneity of their academic abilities.

C. Data Collection Techniques

Data were collected using multiple techniques in accordance with the research variables. The validity of the model and instructional tools was obtained through expert validation using validation sheets. The practicality of the model was assessed through observations of learning implementation, student activity observations, and interviews regarding instructional constraints. The effectiveness of the model was measured through communication skills tests, collaboration skills observations, and student response questionnaires. The tests were administered before (pretest) and after (posttest) the implementation of the IBSC model. Student response data were analyzed using descriptive quantitative methods by calculating the percentage of positive and negative responses.

A complete matrix of the research procedures, variables, data collection techniques, instruments, data types, and analysis techniques is presented in Table 1.

Table 1. Research Matrix

No.	Research Variables	Data Collection Techniques	Instruments	Type of Data	Data Analysis Techniques
1	IBSC model for fostering communication and collaboration skills	Expert validation	IBSC model validation sheet	Qualitative	Descriptive qualitative analysis
2	Quality of IBSC syllabus	Expert validation	Syllabus validation sheet	Qualitative	Descriptive qualitative analysis
3	Quality of IBSC lesson plans	Expert validation	IBSC lesson plan validation sheet	Qualitative	Descriptive qualitative analysis
4	Quality of IBSC student worksheets	Expert validation	IBSC worksheet validation sheet	Qualitative	Descriptive qualitative analysis
5	Quality of IBSC student textbook	Expert validation	IBSC textbook validation sheet	Qualitative	Descriptive qualitative analysis
6	Implementation of the IBSC model	Observation	IBSC implementation observation sheet	Qualitative (quantified)	Descriptive quantitative analysis
7	Student activities in IBSC model	Observation	IBSC student activity observation sheet	Qualitative (quantified)	Descriptive quantitative analysis
8	Constraints in implementing the IBSC model	Observation and interview	Observation notes and interview guidelines on implementation constraints	Qualitative	Descriptive qualitative analysis
9	Students' responses to IBSC model	Questionnaire	IBSC student response questionnaire	Qualitative (quantified)	Descriptive quantitative analysis
10	Communication skills	Test, product assessment, observation	Communication skills test, product assessment sheet, communication skills observation sheet	Quantitative and qualitative (quantified)	t-test, ANOVA, and descriptive quantitative analysis

11	Students' collaboration skills	Observation	Collaboration skills observation sheet (IBSC model)	Qualitative (quantified)	t-test, ANOVA, and descriptive quantitative analysis

D. Data Analysis Techniques

Data analysis was conducted to evaluate the validity, practicality, and effectiveness of the IBSC model. Content and construct validity were analyzed using the mode of expert judgment scores and the reliability coefficient measured by the percentage of agreement. An instrument was considered reliable if the reliability coefficient reached ≥ 75% (Borich, 1994).

The practicality of the model was analyzed using descriptive quantitative methods based on the percentage of learning implementation and student activities. The effectiveness of the model was examined through parametric statistical tests, including the t-test to determine differences in mean scores before and after the treatment, and ANOVA to assess the consistency of the model's effect across replication classes.

Overall, the research design and procedures adhere to systematic educational development research principles, involving expert validation, staged trials, and both quantitative and descriptive analyses to ensure the scientific validity of the findings.

3. RESULTS AND DISCUSSION

A. Results of IBSC Model Development

This study produced an instructional product in the form of the Investigation-Based Scientific Collaborative (IBSC) learning model, systematically designed to foster students' communication and collaboration skills in science learning. The model was developed in response to the demands of 21st-century education, which emphasize the integration of conceptual understanding with socio-cognitive skills. Conceptually, the development of the IBSC model is grounded in the principles of social constructivism, which position interaction as the primary means of knowledge construction (Suparno, 1997; Moreno, 2010; Rahmawati et al., 2022).

The IBSC model structure consists of five main phases: (1) motivation and problem orientation, (2) collaborative investigation through sharing tasks, (3) presentation of results, (4) collaborative investigation through jumping tasks, and (5) evaluation. Each phase is designed to promote active student engagement in the learning process, both individually and collaboratively. The sharing task phase serves as an initial stage of collaboration to build foundational understanding, while the jumping task phase provides more complex challenges to stimulate higher-order thinking and advanced collaboration. This design aligns with the principle of scaffolding in learning, where students are provided with gradual support to achieve higher levels of understanding (Sato, 2014; Vygotsky revisited studies, 2022).

The development of the IBSC model also integrates the inquiry-based learning (IBL) approach, which emphasizes scientific investigation as the core of science instruction. Through activities such as observation, data collection, analysis, and conclusion drawing, students are trained to think scientifically and systematically. The integration of inquiry and collaboration has been shown to be effective in enhancing students' scientific literacy and problem-solving skills (Amaditha et al., 2024; National Research Council, 2020; Lee et al., 2021).

B. Validity of the Model and Instructional Materials

The validation results indicate that the IBSC model demonstrates both content validity and construct validity at a very high level. The reliability coefficient for all aspects reached 100%, thereby meeting the inter-observer agreement criterion of ≥ 75% (Borich, 1994). A summary of the construct validity of the IBSC model is presented in Table 2.

Table 2. Construct Validity Results of the IBSC Model

No.	IBSC Model Category	Mean Validation Score	Validity Level	R (%)	Reliability
1	IBSC Model Structure	4.00	Very Valid	100%	Reliable
2	Theoretical and Empirical Support of the IBSC Model	4.00	Very Valid	100%	Reliable
3	Planning and Implementation of the IBSC Model	4.00	Very Valid	100%	Reliable
4	Learning Environment Management	4.00	Very Valid	100%	Reliable
5	Use of Evaluation Techniques	4.00	Very Valid	100%	Reliable
6	IBSC Model: A Final Reflection	4.00	Very Valid	100%	Reliable
	Mode of validity and reliability across all categories	—	Very Valid	100%	Reliable

The validity of the instructional materials (syllabus, lesson plans, and student worksheets) was also categorized as very valid, with a reliability coefficient of 100%. This indicates that the developed materials meet the criteria of theoretical soundness, syntactic consistency, linguistic appropriateness, and alignment with learning objectives. Conceptually, these findings support the view of Nieveen et al. (2007), which states that a development product is considered valid when it possesses a strong theoretical foundation and logical internal consistency. The high level of validity suggests that the IBSC model is appropriate for implementation testing in instructional settings.

C. Practicality of the IBSC Model

The practicality of the model was evaluated through the implementation of learning activities, student engagement, and constraints encountered during the instructional process. The observation results indicate that the implementation of the IBSC model syntax was categorized as very good in both Trial I and Trial II. Teachers were able to carry out each phase in accordance with the planned design, particularly in the collaborative investigation phase, which constitutes the core of the model.

Student activities showed increased participation in discussions, presentations, and group work. Interactions among group members became more balanced compared to conventional cooperative learning models. This suggests that the design of sharing tasks and jumping tasks effectively fosters positive interdependence.

These findings are consistent with collaborative learning theory, which posits that the success of group work depends on individual accountability and promotive interaction (Slavin, 2011; Suyatno, 2009). Therefore, the IBSC model is not only theoretically sound but also practical for classroom implementation.

D. Effectiveness of the IBSC Model

The effectiveness of the model was analyzed based on improvements in students' communication and collaboration skills using pretest–posttest results, t-tests, ANOVA, and N-gain analysis. The statistical results indicate a significant difference between pretest and posttest scores following the implementation of the IBSC model in both Trial I and Trial II. The increase in students' mean scores is presented in Figure 1.

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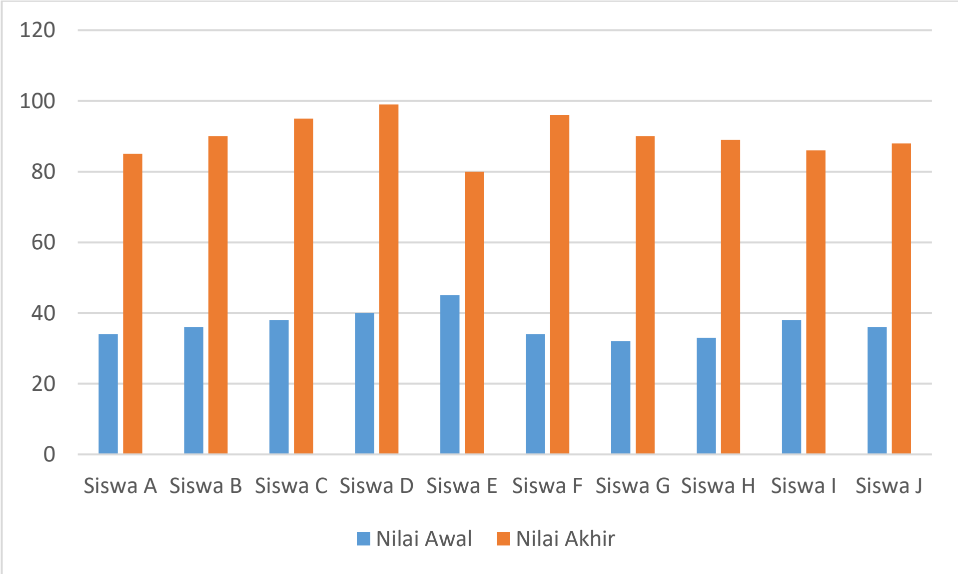

Fig. 1. Communication Skills Mastery Graph

The figure indicates moderate to high improvement categories, suggesting that the IBSC model is effective in enhancing students' communication skills. Furthermore, the ANOVA results across the three replication classes demonstrate that the IBSC model exerts a consistent effect on students' collaboration skills.

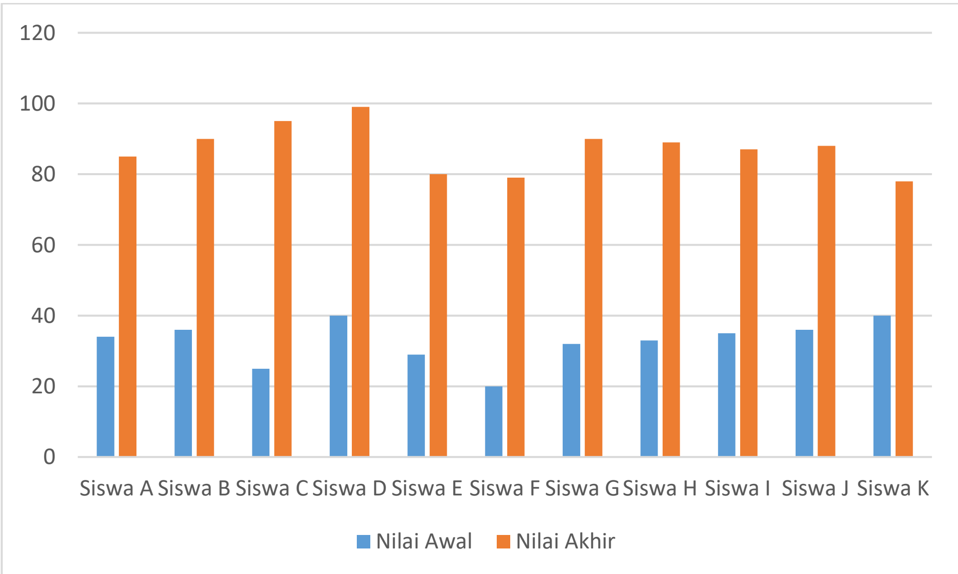

Fig. 2. Proportion of Students' Communication Skills Mastery at Pretest and Posttest in Replication Class I (Trial II)

Pedagogically, this improvement can be explained by the integration of scientific investigation and collaborative learning, which enables students to construct knowledge through dialogue and reflection. Scientific communication practices, facilitated through presentations and discussions, reinforce conceptual understanding (Wrench et al., 2009). Meanwhile, deliberately structured heterogeneous groupings support the development of academic empathy and shared responsibility.

E. Theoretical Discussion and Implications

The findings of this study indicate that the IBSC model not only meets the criteria of validity, practicality, and effectiveness, but also reinforces the social constructivist paradigm, which emphasizes the importance of interaction in the process of knowledge construction. Through investigative activities and collaborative discussions, students are actively engaged in constructing conceptual understanding both individually and collectively. This is consistent with the view that knowledge is constructed through social interaction and negotiation of meaning within learning contexts (Suparno, 1997; Moreno, 2010; Rahmawati et al., 2022).

More specifically, the integration of sharing tasks and jumping tasks within the IBSC model has been shown to effectively establish positive interdependence, which is central to collaborative learning. This structure enables students with diverse abilities to support one another and contribute to task completion. These findings are aligned with cooperative learning theory, which posits that successful group work depends on individual accountability, promotive interaction, and shared goals (Gillies, 2020; Slavin, 2011; Hidayat et al., 2023).

From the perspective of science education, the IBSC model also strengthens the effectiveness of the inquiry-based learning approach in enhancing scientific thinking skills and evidence-based communication. The integration of investigative processes with group discussions provides opportunities for students to develop scientific argumentation skills, interpret data, and present findings systematically. This is consistent with studies indicating that inquiry combined with collaboration enhances scientific literacy and problem-solving abilities (Amaditha et al., 2024; Llorente & Revuelta, 2023; National Research Council, 2020).

The practical implications of this study suggest that the IBSC model can serve as a strategic alternative for teachers in addressing the dominance of teacher-centered instruction. With its clear and structured syntax, the model facilitates more interactive, participatory, and skill-oriented learning aligned with 21st-century competencies. It also supports the creation of an inclusive learning environment in which each student has the opportunity to actively contribute within the group (Hidayat et al., 2023; Wikanengsih & Rostikawati, 2024).

Furthermore, from a curriculum development perspective, the IBSC model has the potential to be integrated into competency-based learning implementation, particularly in supporting the achievement of communication and collaboration skills as key targets of 21st-century education. This integration aligns with global recommendations emphasizing the importance of strengthening 21st-century skills within modern education systems (OECD, 2019; UNESCO, 2023).

In summary, the IBSC model not only provides empirical contributions to improving students' communication and collaboration skills, but also enriches the theoretical discourse in science education through the integration of scientific investigation and structured collaboration within a systematic and innovative instructional design.

4. CONCLUSION

This study aimed to develop an Investigation-Based Scientific Collaborative (IBSC) learning model that is valid, practical, and effective in fostering students' communication and collaboration skills. Based on the findings, the IBSC model was determined to be highly valid in terms of both content and construct, with a high level of reliability. The implementation of the learning syntax was categorized as very good during the trial stages, indicating that the model is practical for classroom application. In terms of effectiveness, the results of statistical tests revealed a significant improvement in students' communication and collaboration skills following the implementation of the IBSC model. Thus, the problems identified in the Introduction have been addressed, demonstrating that the IBSC model can serve as an innovative solution for enhancing communication and collaboration skills in science learning. In the future, the IBSC model has the potential to be further developed across different educational levels and subject areas, as well as integrated with educational technology to broaden its contribution to the development of 21st-century skills.

Furthermore, the findings of this study confirm that the integration of scientific inquiry and structured collaboration within the IBSC model not only improves communication and collaboration skills quantitatively but also enhances the quality of meaningful scientific interaction among students. The IBSC model creates a learning environment that promotes active participation, evidence-based idea exchange, and collective responsibility in problem-solving processes. This indicates that the instructional design combining sharing tasks and jumping tasks plays a strategic role in fostering positive interdependence and productive scientific communication.

From a theoretical perspective, this study reinforces the relevance of the social constructivist approach in modern science education while contributing a more structured inquiry-based collaborative learning syntax. From a practical standpoint, the IBSC model provides implications for teachers in designing instruction that emphasizes not only learning outcomes but also the process of students' scientific interaction. Therefore, this model has the potential to serve as a pedagogical innovation that supports the effective and sustainable implementation of competency-based learning in the context of 21st-century education.

REFERENCES

Amaditha, F. F., Fitri, S. G. S., & Ekanara, B. (2024). Students' communication skills and scientific literacy ability in biology through guided inquiry learning. *International Journal of Biology Education Towards Sustainable Development, 4*(1). https://doi.org/10.53889/ijbetsd.v4i1.43

Borg, W. R., & Gall, M. D. (2003). *Educational research: An introduction* (7th ed.). Allyn & Bacon.

Borich, G. D. (1994). *Observation skills for effective teaching*. Macmillan Publishing Company.

Diser Research. (2025). Inquiry-based learning in Bangladesh: Insights into 21st century skill development. *Disciplinary and Interdisciplinary Science Education Research*. https://doi.org/10.1186/s43031-025-00122-2

Fraenkel, J. R., & Wallen, N. E. (2012). *How to design and evaluate research in education* (8th ed.). McGraw-Hill.

Gillies, R. M. (2020). Cooperative learning: Review of research and practice. *Australian Journal of Teacher Education, 45*(3), 39–54. https://doi.org/10.14221/ajte.2020v45n3.3

idayat, T., Sari, M., & Pratama, R. (2023). Collaborative learning and scientific communication skills in science classrooms. Jurnal Pendidikan IPA Indonesia, 12(2), 145–156.

International Journal of Educational Research. (2022). Mapping primary students' mobile collaborative inquiry-based learning behaviours in science collaborative problem solving. *International Journal of Educational Research, 114*, 101992. https://doi.org/10.1016/j.ijer.2022.101992

Kurniawati, E., & Farida. (2022). The influence of collaborative learning model on students' communication ability in natural science lessons. *Indonesian Journal of Education and Social Humanities, 1*(4). https://doi.org/10.62945/ijesh.v1i4.707

Lee, H., Kim, Y., & Park, J. (2021). Integrating inquiry and collaboration in science education: A framework for enhancing students' problem-solving skills. Science Education International, 32(3), 210–220.

Llorente, C., & Revuelta, G. (2023). Models of teaching science communication. *Sustainability, 15*(6), 5172. https://doi.org/10.3390/su15065172

McKenney, S., & Reeves, T. C. (2021). Educational design research (2nd ed.). Routledge.

Moreno, R. (2010). *Educational psychology*. John Wiley & Sons.

National Research Council. (2020). Inquiry and the National Science Education Standards: A guide for teaching and learning. National Academies Press.

Nieveen, N., McKenney, S., & van den Akker, J. (2007). Educational design research. In T. Plomp & N. Nieveen (Eds.), *An introduction to educational design research* (pp. 35–53). SLO Netherlands Institute for Curriculum Development.

OECD. (2019). *PISA 2018 results (Volume I): What students know and can do*. OECD Publishing. https://doi.org/10.1787/5f07c754-en

Partnership for 21st Century Learning. (2019). *Framework for 21st century learning definitions*. P21.

Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., & Tsourlidaki, E. (2021). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review, 14*, 47–61. https://doi.org/10.1016/j.edurev.2015.02.003

Plomp, T. (2013). Educational design research: An introduction. In T. Plomp & N. Nieveen (Eds.), *Educational design research* (pp. 11–50). SLO Netherlands Institute for Curriculum Development.

Rahmawati, Y., Nurhayati, S., & Widodo, A. (2022). Structured collaborative learning in science education: Enhancing student engagement and achievement. Jurnal Pendidikan IPA, 11(1), 67–78.

Sánchez, G., & Martínez, L. (2021). Evidence-based argumentation in science classrooms: Challenges and opportunities. International Journal of Science Education, 43(5), 789–804.

Sato, M. (2014). *Dialog dan kolaborasi di sekolah menengah pertama: Praktik learning community*. Pelita.

Suparno, P. (1997). *Filsafat konstruktivisme dalam pendidikan*. Kanisius.

Telaumbanua, D. M. N., & Syafriani, D. (2022). The influence of learning models and student learning activities on collaboration skills and student learning outcomes. *Jurnal Teknologi Pendidikan, 9*(2). https://doi.org/10.33394/jtp.v9i2.11184

UNESCO. (2023). Education for Sustainable Development: Progress report. UNESCO Publishing.

Wikanengsih, & Rostikawati, Y. (2024). Team based learning model to improve student collaboration and communication through lesson study. *Journal for Lesson and Learning Studies, 7*(1), 193–200. https://doi.org/10.23887/jlls.v7i1.73769

Wrench, J. S., Richmond, V. P., & Gorham, J. (2009). *Communication, affect, & learning in the classroom* (3rd ed.). Kendall Hunt Publishing Company.