International Journal of STEM Education for Sustainability, Vol 4, No.1, 2024, pp. 97-109
e-ISSN 2798-5091. DOI. 10.53889/ijses.v4i1.332

Challenges for Middle School Science Teachers in Assessing Scientific Inquiry Skills: A Thematic Analysis

Submitted 10 November 2023 Revised 30 January 2024 Received 31 January 2024

Mobinta Kusuma[1,3*], Insih Wilujeng[2], Purwo Susongko[3]

[1]Department of Educational Research and Evaluation, Graduate School,
Universitas Negeri Yogyakarta, Sleman, Indonesia

[2]Department of Science Education, Faculty of Mathematics and Natural Sciences,
Universitas Negeri Yogyakarta, Sleman, Indonesia

[3]Department of Science Education, Faculty of Teacher Training and Education,
Universitas Pancasakti Tegal, Tegal, Indonesia

Corresponding Email: *mobintakusuma@upstegal.ac.id

Abstract

Science learning assessment has always been challenging for science middle school teachers, especially when assessing students' scientific inquiry skills, which are essential to the science learning process. The study aims to highlight the challenges teachers confront when assessing high school pupils' capacity for scientific inquiry. It is a qualitative phenomenological study using thematic analysis techniques. Five middle school science teachers from junior high schools in Central Java participated in this study. Utilizing interviewing approaches, data was gathered. Using Clark & Braun's thematic analysis methodologies, data analysis is carried out in four steps: (1) identifying the data, (2) performing coding, (3) creating themes, and (4) reviewing and defining the themes. This study shows that both internal and external factors might affect teachers' ability to undertake scientific inquiry research. The issue of obstacles teachers confront from the perspectives of students and learning systems is summarized by external variables. The researchers advised science teachers to engage in active, ongoing competence development to help them overcome challenges in evaluating scientific inquiries.

Keywords: Challenges, Science teachers, Assessment, Scientific inquiry, Thematic analysis

INTRODUCTION

Scientific inquiry builds the ability of students to discover everything by studying in their nearest environment, developing strong arguments about the natural and physical worlds surrounding them based on facts and strong evidence, becoming aware of the importance of science, building information about what is done in life, and empowering the ability to think to the maximum (Pedaste et al., 2015). In many studies, it has been found that scientific inquisition approaches influence students' access to science skills (Abdi, 2014; Cairns, 2019; Chou et al., 2022; Toma, 2022; Wang, 2022) and student literacy skills (Aulia et al., 2018; Babaci-Wilhite, 2017; Kang, 2020; Takda et al., 2022).

The scientific inquiry into science education empowers the student to see himself as a researcher capable of rediscovering lessons and seeing subjects such as biology as activities in everyday life (Firman et al., 2019). Scientific inquiry approaches implemented in learning activities are said to improve critical thinking skills, science literacy, and science process skills. Research conducted by Wang (2022) explained that experimental learning results showed that inquiry-based learning models were more effective in developing students' scientific query skills compared to traditional methods, with significant improvements in process skills performance, comprehensive skills, learning attitudes, communication skills, and reflective skills. Inquiry learning packaged in an science module integrated with authentic assessment was also declared effective in improving critical thinking skills (Hairida, 2016) and students' access to queries. Ergul et al. (2011) conducted a study with elementary school students on how inquiry-based science learning affects science process skills and their attitudes toward science and concluded that inquiry-based science learning has a significant impact on the skills of science processes and student attitudes towards science. Based on information from previous research, a wide range of research has been done on scientific inquisition assessment that can influence the improvement of students' scientific inquiries (Gobert et al., 2012; Harrison, 2014; Lou et al., 2015; Sparks & Deane, 2015), which has an impact on improved learning outcomes, thinking skills, as well as affective abilities.

Assessment in learning has two closely related components. One way to measure learning success is by using certain assessments. According to Linn (1990), assessment in the learning process has three benefits: knowing the achievement of learning goals, improving the quality of learning, and making decisions. Assessments are a series of systematic procedures used to gather information that can be used to conclude the characteristics of persons or objects. (Lederman et al., 2014) stated that the lack of research focused on improving student understanding of scientific inquiry was also linked to a lack of readily accessible and meaningful assessment of the appropriate educational aspects of scientific inquiry. Teachers study scientific inquiry in several stages. Science inquiry skills can be built by implementing 7 steps (Sutaphan & Yuenyong, 2019), which are (1) identifying the problem or problem, (2) identifying the solution, (3) excavating knowledge, (4) making decisions, (5) having the ability to develop a product prototype, (6) trialling and evaluating the solution, and (7) socializing to complement findings. Scientific inquiry learning is used by teachers to study science to make it easier for students to learn more contextually. Schwartz (2004) explains that scientific inquiry refers to the characteristics of the process through which scientific knowledge is developed, including the determination of the measures involved in the development, acceptance, and usefulness of scientific knowledge.

The study of phenomenology is one type of approach that is widely used in qualitative research methods. In his explanation of (Creswell, 1998) studies with a phenomenological approach, he attempts to explain the meaning of the life experience of several people about a concept or symptom, including the concept of self or their own view of life. If researchers try to describe the phenomena of a community according to their own views, then the corresponding tradition for this research is phenomenology. In a phenomenological approach, researchers can criticize what is common to a number of individuals (participants) about their various life experiences of concepts or phenomena. The primary purpose of the phenomenological approach is to reduce the individual's experience of phenomena to a description of the universal essence (Gallagher & Sørensen, 2006). The use of thematic analysis in the study of phenomenology becomes a distinct art of stacking data codes that are then used to construct themes inductively and write them into research reports. The strength of thematic analysis in qualitative research lies in capturing, interpreting, and manipulating data (Setiawan, 2022).

The implications of scientific inquiry in learning and assessment have been much studied. However, the point of view of teachers as implementers of the learning process and scientific assessment has not been well studied and presented. Research by (Metin Peten, 2022) also explains that many teachers experience difficulties when performing practice assessments. The obstacles the teacher faces when drawing up a qualitative question are determined by determining the difficulty level of the constructed question (Van Rens et al., 2010). This study examines specific research questions with thematic analysis methods.

RQ1: What are the primary constraints restricting middle school science teachers in assessing students' scientific inquiry skills?

RQ2: What challenges do middle school science teachers encounter while evaluating scientific inquiry skills?

METHOD

Research Design

This research used a qualitative research design and incorporates some phenomenology approach. The phenomena are then examined to determine the challenges and constraints teachers face while performing assessments for scientific inquiry. Studies using phenomenological methods try to interpret the significance of a variety of people's life experiences about a concept or symptom, such as the notion of self or their worldview (Creswell, 1998).

Data Collection

Data collection was conducted via semi-structured online interviews via the Zoom Meeting application. Five participants were selected for the interviews; the details are outlined in Table 1. The proponents of this study are secondary school science teachers, specifically those from the Central Java Province region, who will serve as informants in the earliest stages of ST1 through ST5. The data collection process spanned six months, commencing in April and concluding in September.

Table 1. Interview Aspects

Aspect	Explorative Question
Challenges of Scientific Inquiry Assessment	1. What challenges and obstacles do teachers face in conducting learning and scientific evaluation inquiries? 2. What is the challenge of applying the scientific inquiry assessment that has been programmed in lesson plan?

Data Analysis

Thematic analysis techniques created by Clarke and Brauns (2015) are used to analyse the data. Usage of thematic analytics techniques through several stages Data recognition, coding, theme development, theme evaluation, and theme definition are the first four steps. In order to find material pertinent to the research's goal, the researchers reviewed the interview transcripts several times as part of the data reduction procedure. Data that has been reduced with codes following the goals of the research are used for coding. Based on the results of the pertinent code search, a topic development analysis is conducted, and the connected themes are then defined while considering the challenges and constraints teachers face when conducting scientific evaluations. As discovered by (Lincoln & Guba, 1989), data transparency is accomplished by randomly assigning information to participants to read back the findings of research studies that have been conducted to confirm the legitimacy of the data.

Ethical clearance

The various activities associated with data collection using interviews in this research are intended only for research purposes. The outcome of this activity has nothing to do with the future fate of the respondents. If some names or things feel necessary, the researchers will keep them secret. The ethical mechanism is also implemented by asking respondents to be available orally during an online interview (Barison et al., 2022).

RESULTS AND DISCUSSION

The main features of the phenomenological approach in this thematical analysis were used according to Creswell (1998), including (1) an emphasis on phenomena to be explored based on a single conceptual and ideological perspective; (2) an exploration of phenoms in groups of individuals who have all experienced the phenomenon; (3) a researcher "restricts himself" to discuss his personal experience with them; (4) a typical data-gathering procedure (interviews involving individuals who are experiencing them); (5) data analysis follows systematic procedures (from important statements to larger units); (6) ends with a descriptive section dealing with the "essence" of "what and how phenomes occur and so that they are easily understood". Based on data analysis, the research was found out theme analysis map (Figure 1).

The theme construction was built on a reduction of the data and then coded into 31 codes, and subsequently, the relevant code was merged into 12 codes to construct two themes. The variety of difficulties teachers face in assessing scientific queries is identified through data identification and coding, with 12 related data codes. Twelve codes influence the construction of themes: (1) control of student characteristics; (2) differences in student initial abilities; (3) control of learning facilities; (4) curriculum that supports inquiry; (5) hindrances in the timing of assessments; (6) teacher's pedagogy skills; (7) control of the selection of learning models; (8) obstacles to the implementation of scientific inquiries; (9) complaints about too much learning material; (10) lack of availability of evaluation tools; (11) difficulty in compiling test indicators; (12) difficulties in the compilation of test instruments.

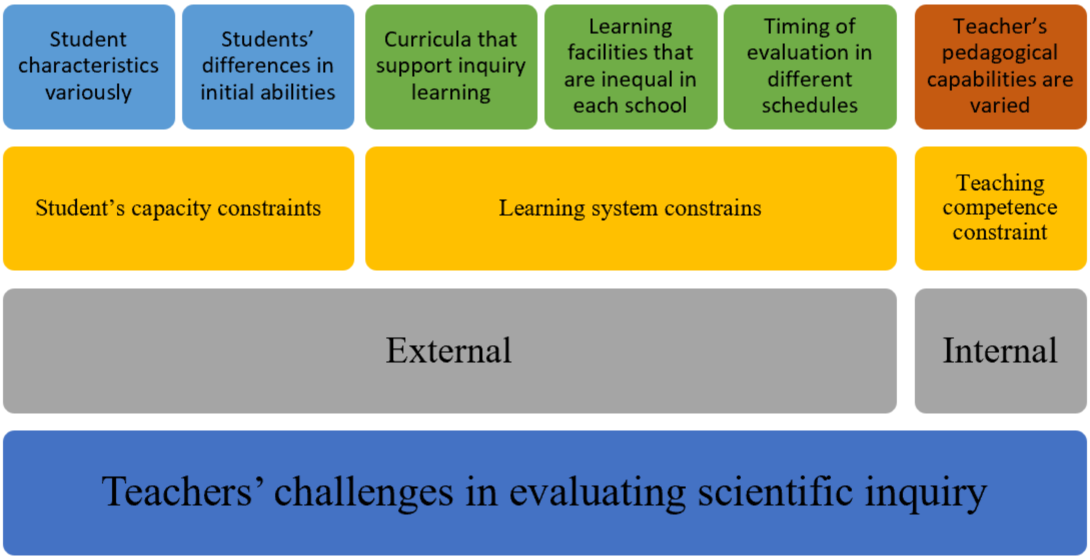

Figure 1. Resume Theme Analysis Map

Primary constraints in assessing students' scientific inquiry skills

Students' characteristics are one of the obstacles teachers face in evaluating students' scientific inquiry capabilities. The participant perceives the student's characteristic constraints. ST1 noted that *"student characteristics greatly influence the process of evaluation of scientific inquiry"* so that *"teachers can give the child the freedom to complete school duties according to the choice of freedom of work forms,"* continued ST1, as a form of assessment solution that accommodates the different characteristics of students. While the differences in students' initial abilities are also one of the difficulties teachers face in assessing scientific inquiry, ST2 stated that the pupils *"return to the characteristic condition of the pupils because of their different backgrounds. From the beginning, some abilities are not the same as those of the students in* *the school; the teacher must correctly guide them from the beginning to the learning phase process."* Student characteristics and learning difficulties experienced by students can be influenced by external and internal factors (Hedges, 2017; Cohn, 1972; Fleming & Malone, 1983). Internal factors such as emotional stability, self-awareness, and anxiety regulation. External factors such as the influence of the learning environment, learning support capacity, and academic atmosphere

Available learning facilities also affect the scientific evaluation process of queries carried out by teachers. The availability of learning facilities such as science laboratory equipment, computers, and other learning support facilities is one aspect that influences the learning process and assessment (Lavy & Nixon, 2017; Abidoye et al., 2022). This is reinforced by the ST3 statement, *"The facilities that are in this lab, when we minimize them, then we dig our children from the house, will have an impact".* ST4's statement also describes the availability of learning facilities as affecting the implementation of learning and evaluation, so ST4 performs modifications to learning by implementing alternative learning implementation that prioritizes the ease and accessibility of facilities. ST4 stated *"The first, the lack of means and prasarana, is also going like that but not perfect; the second, more in the direction, has to rotate the brain of the means and the prasarana is not there. So we're going to have to brainstorm. Yeah, yesterday it was pollution of the environment, what the kids want to do, yeah, finally yesterday I made it briefly, the kids were sent to the river to keep looking at the waters of the broken river, and there they were asked about whether the water could be used or not. The point is that you don't need any means or equipment. Because it's my habit, because it's an inquiry that I think is a personal learning that weighs a lot more than others, I think this is how it is. The difficulty is bigger, so maybe the kids are less familiar with the inquiry model."* Improving educational facilities such as school buildings, laboratory facilities, and learning facilities is important for achieving educational quality standards (Lackney, 1999; Muthanna & Sang, 2023).

Implementing learning and evaluating scientific queries should be supported by the availability of curricula that support the learning system. The curriculum becomes a crucial guide for implementing and assessing learning processes. The point of emphasis for achieving the scientific query capabilities is influenced by the learning standards listed in the curriculum, so the teacher's ability to translate curriculums into relevant learning forms and assessments is a solution to the difficulties teachers encounter. This is reinforced by ST1's opinion that *"Now in the newly applied curriculum, this differential learning is interesting to me. Maybe the skill inquiry is not measurable if it's connected to what the base learning inquiry was. Yeah, we're headed there. So, we adjust to the curriculum's demands. What the hell does the government* *expect for the expected competence? One of the differentials in learning may be that the picture is done. It's an evaluation section we've made; it's a general section; although the work is different, we're making the section as much as possible that accommodates all the works".* While the ST5 statement explains that the Merdeka curriculum implemented under the current government policy is stated to accommodate the teachers' ability to study and evaluate students' scientific inquiry capabilities, *"The learning material contains a lot of basic competencies; if the practice with this scientific learning takes a great deal of time and the basic competences are not fulfilled, then the curriculum is not completed. For instance, I have to complete five basic competencies in one semester, and it turns out that with rich practice, I won't waste my time. It's a classic. But then, as soon as we know that the independent learning curriculum demands more processes, the material curriculum is delivered only with the essential materials. I'm sure that the independent learning curriculum will be applied later on using much of the scientific inquiry, challenging the teacher to apply the scientific inquiry fully. It's probably a challenge that's always been a classic."* The disadvantage of not having sufficient assessment time is also felt by teachers when assessing scientific inquiries. ST5 stated, *"Practice with this scientific learning will take much time; if the basic competence is not fulfilled, then the curriculum is not completed."* While ST4 felt the difficulty of judging the inquiry from the side of the availability of time, *"If my limitation is that the value must be objective, Yes, at the time of judgment, the child can actually take the process of evaluation for one or two days, let alone if the inquiries have a process that they have to go through that gets the child to be able to inquire. So the barrier may be because his son is not used to it, and my abilities are still very poor, so it's sometimes difficult to set a standard for the child.."* The evaluation of scientific inquiry, according to participants, requires a specific effort of time provision; it is relevant to the implementation of the learning of scientific inquiry, which has a more specific syntax of the student's ability to access. Only when students apply their adequate content knowledge will their questions have the ability to gain (scientific) quality (O'Brien et al., 2022; Pols et al., 2022).

Teachers' capacity to engage in scientific inquiry study is influenced by both internal and external influences. Regarding the limitations of the instructor in interior elements, the theme is constructed based on facts about the teacher's abilities from the perspective of their competence. Teacher competence variances, particularly in pedagogical capacities, posed internal limits in evaluating scientific inquiry skills. The topic of teacher limitations in the external aspect focuses on facts about the constraints on students' abilities and the hindrances inside the learning system. Students' capacity restrictions were influenced by various student

e-ISSN 2798-5091. DOI. 10.53889/ijses.v4i1.332

variables and the varying talents of each student. The restrictions of the learning system were attributed to the curricula, learning facilities, and evaluation schedules. The obstacles encountered by teachers primarily were around practical aspects, such as identifying appropriate contexts, scheduling constraints, managing large class sizes, accommodating students with varying learning speeds, handling instructional materials, and addressing the teachers' desire for control (Walan et al., 2022) that's the reasons why science teachers need reforming their science teaching ways (Anderson, 2002; Henke & Höttecke, 2015).

Challenges encountered when evaluating scientific inquiry skills

Teachers' knowledge of how learning facilities obstruct instruction and the availability of inquiry-supporting curricula reinforces the learning system's impedimental elements. The theme construction for the topic of teachers' challenges when evaluating scientific inquiry skills was related to internal aspects of teacher capabilities from the teacher's competence aspects. As part of their pedagogical competency, teachers must have the capacity to evaluate student learning. Along with the ST1 statement, *"I'm doing as much as I can because every piece of material has a work bill, so whatever it is, please let's just give you a pattern of its content. I'm trying to get there even though it's not perfect."*

Pedagogical skills are one of the four competencies teachers need to have in the framework of teachers' capabilities in Indonesia's educational system. The Law of the Republic of Indonesia No. 14 of 2005 on Teachers and Lecturers contains this. Pedagogy is closely related to the teacher's ability to manage learning in the classroom, including teachers' ability to make judgments. Teachers' skill in determining learning models for optimal sanctified inquiry capabilities is also a challenge. ST1 stated, *"When you get stuck in a pack with a sign, it can also be an obstacle; yes, the essence of the entrance. If we want an open inquiry when we're expecting students to ask that question, it's pretty hard. That's why, for the first year of high school, although in theory, he said he could because he was already at the final level of thinking, the reality was that he shouldn't be fully open."* Teachers' flexibility in using learning models to develop scientific inquiry capabilities is one of the keys to the successful implementation of scientific inquiry assessment. Implementing the syntax of scientific inquiry learning is a personal challenge for teachers, not to mention implementing their assessments. ST3 reinforced this with his statement, "*I think it is very important because this stage is so difficult for children to start from observing, classifying, practicing, explaining, and communicating step by step that the formation of new knowledge and understanding is so systematic*". The obstacles to the implementation of learning with a very large amount of material are also the difficulties that teachers have to face, as presented by ST5, *"The challenge* *is actually a lot of classical teachers. Classical means very classical to give you enough time with very many basic competencies, and if the practice with this scientific learning will spend much time, the basic competencies will not be fulfilled, and the curriculum will not be completed."* Specifically, the evaluation obstacles teachers face are due to the availability of evaluation tools, the teacher's ability to determine indicators, and the teacher's ability to build instruments. ST4 stated, "*Oh, if I'm personal because I do not know what you're doing, it's probably less experience than I've ever found one like that. So we're usually limited only until we judge the kids in terms of what they get and do*".

The source barriers of the teacher's capacity to assess scientific inquiry were classified as follows, based on teachers' experience: (1) time constraints in assessment; (2) pedagogical limitations of teachers; (3) lack of control over the selection of learning models; (4) obstacles in implementing scientific inquiries; (5) concerns about excessive learning material; (6) inadequate availability of evaluation tools; (7) challenges in compiling test indicators; and (8) difficulties in creating test instruments. These were identified as the origins of internal factors. Moreover, many educators struggle to finish practice examinations successfully (Metin Peten, 2022). Identifying problems instructors face in producing qualitative questions can be achieved by evaluating the level of complexity associated with the developed question (Hasson & Yarden, 2012; Van Rens et al., 2010). Boakye & Ampiah (2017) also suggested that the inability to complete the integrated science syllabus is also an obstacle when teachers prepare for the assessment of science learning.

The results of this study are expected to cause worry among educational policymakers and practitioners, namely those involved in science education, over the ongoing difficulties teachers encounter in assessing students' advancement in scientific inquiry. Teachers face difficulties from both internal and external viewpoints. Since scientific inquiry is a crucial aspect of science education, teachers will probably be driven to deliver captivating courses due to their engagement in learning and assessing scientific inquiry.

This research has identified limitations in the data-gathering method of science instructors in upper secondary schools, which restricts the implementation of scientific inquiry. The lack of balanced political alignment in the Indonesian territory, coupled with the dominance of Western Indonesians, has resulted in inadequate scrutiny of the execution of policies in Indonesia's eastern and central regions. This is a significant limitation of the research.

CONCLUSION

Teachers have a multitude of challenges while carrying out scientific assessments. Teachers who possess a comprehensive comprehension of scientific inquiry will experience greater ease in facilitating the learning and assessment of scientific inquiries that impact their students' development of proficient scientific skills. The study revealed that teachers have specific challenges while applying their expertise and evaluating practical scientific matters. Both internal and external instructors can place restrictions on the level of difficulty. To tackle the challenges associated with assessing scientific investigation, the researchers propose that science educators proactively and consistently enhance their knowledge and skills.

ACKNOWLEDGEMENT

Authors thank the Ministry of Education, Culture, Research and Technology of the Republic of Indonesia, Directorate-General of Higher Education Research and Technology 2023, which has provided national competitive research funding support for the PhD Thesis Research scheme with an announcement of receipt of funding number 0557/E5.5/AL.04/2023 with research contract number 182/E5/PG.02.00.PL/2023, 011/LL.6/PB/AL.04.2023, 341a/K/A-4/LPPM/UPS/VI/2023.

REFERENCES

Abdi, A. (2014). The Effect of Inquiry-Based Learning Method on Students’ Academic Achievement in Science Course. *Universal Journal of Educational Research*, *2*(1), 37–41. https://doi.org/10.13189/ujer.2014.020104

Abidoye, F., Adebisi, A. M., Rihanat, A. A., & Aliyu, M. Z. (2022). Availability of Laboratory Facilities on Students’performance in Upper Basic Schools in Kwara State, Nigeria. *International Journal of Educational Research Review*, *7*(4), 262-267.

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education*, *13*(1), 1–12.

Aulia, E. V., Poedjiastoeti, S., & Agustini, R. (2018). The effectiveness of guided inquiry-based learning material on students’ science literacy skills. *Journal of Physics: Conference Series*, *947*(1), 012049. https://doi.org/10.1088/1742-6596/947/1/012049

Babaci-Wilhite, Z. (2017). A rights-based approach to science literacy using local languages: Contextualising inquiry-based learning in Africa. *International Review of Education*, *63*(3), 381–401. https://doi.org/10.1007/s11159-017-9644-3

Barisone, M., Ghirotto, L., Busca, E., Crescitelli, M. E. D., Casalino, M., Chilin, G., ... & Dal Molin, A. (2022). Nursing students’ clinical placement experiences during the Covid-19 pandemic: A phenomenological study. *Nurse Education in Practice*, *59*, 103297.

Boakye, C., & Ampiah, J. G. (2017). Challenges and solutions: The experiences of newly qualified science teachers. *Sage Open*, *7*(2), 2158244017706710.

Cairns, D. (2019). Investigating the relationship between instructional practices and science achievement in an inquiry-based learning environment. *International Journal of Science Education*, *41*(15), 2113–2135. https://doi.org/10.1080/09500693.2019.1660927

Chou, R. J., Liang, C. P., Huang, L. Y., & She, H. C. (2022). The Impacts of Online Skeuomorphic Physics Inquiry–Based Learning With and Without Simulation on 8th Graders' Scientific Inquiry Performance. *Journal of Science Education and Technology*, *31*(3), 357–371. https://doi.org/10.1007/s10956-022-09960-5

Clarke, V., Braun, V. and Hayfield, N. (2015) Thematic Analysis. In: Smith, J.A., Ed., *Qualitative Psychology: A Practical Guide to Research Methods*, SAGE Publications, London, 222-248.

Cohn, E. (1972). Students' characteristics and performance in economic statistics. *The Journal of Economic Education*, *3*(2), 106-111.

Creswell, J. W. (1998). *Qualitative Inquiry and Research Design: Choosing Among Five Traditions*. Sage Publications Inc.

Ergul, R., Simsekli, Y., Calis, S., Ozdilek, Z., Gocmencelebi, S., & Sanli, M. (2011). The Effects of Inquiry-Based Science Teaching On Elementary School Students' Science Process Skills And Science Attitudes. *Bulgarian Journal of Science and Education Policy (BJSEP*, *5*(1).

Firman, M. A., Ertikanto, C., & Abdurrahman, A. (2019). Description of meta-analysis of inquiry-based learning of science in improving students' inquiry skills. *Journal of Physics: Conference Series (Vol. 1157*, *2*, 022018. https://doi.org/10.1088/1742-6596/1157/2/022018

Fleming, M. L., & Malone, M. R. (1983). The relationship of student characteristics and student performance in science as viewed by meta‐analysis research. *Journal of Research in science teaching*, *20*(5), 481-495.

Gallagher, S., & Sørensen, J. B. (2006). Experimenting with phenomenology. *Consciousness and cognition*, *15*(1), 119-134.

Gobert, J. D., Sao Pedro, M. A., Baker, R. S., Toto, E., & Montalvo, O. (2012). Leveraging educational data mining for real-time performance assessment of scientific inquiry skills within microworlds. *Journal of Educational Data Mining*, *4*(1), 104–143.

Hairida, H. (2016). The effectiveness using inquiry based natural science module with authentic assessment to improve the critical thinking and inquiry skills of junior high school students. *Jurnal Pendidikan IPA Indonesia*, *5*(2), 209–215.

Harrison, C. (2014). Assessment of Inquiry Skills in the SAILS Project. *Science Education International*, *25*(1), 112–122.

Hasson, E., & Yarden, A. (2012). Separating the research question from the laboratory techniques: Advancing high-school biology teachers' ability to ask research questions. *Journal of Research in Science Teaching*, *49*(10), 1296–1320. Scopus. https://doi.org/10.1002/tea.21058

Hedges, S. (2017). Statistics student performance and anxiety: Comparisons in course delivery and student characteristics. *Statistics Education Research Journal*, *16*(1), 320-336.

Henke, A., & Höttecke, D. (2015). Physics teachers' challenges in using history and philosophy of science in teaching. *Science & Education*, *24*, 349–385.

Kang, J. (2020). Interrelationship between inquiry-based learning and instructional quality in predicting science literacy. *Research in Science Education*, 1–17. https://doi.org/10.1007/s11165-020-09946-6

Lackney, J. A. (1999). Assessing School Facilities for Learning/Assessing the Impact of the Physical Environment on the Educational Process: Integrating Theoretical Issues with Practical Concerns.

Lavy, S., & Nixon, J. L. (2017). Applications, enrollment, attendance, and student performance in rebuilt school facilities: A case study. *International journal of construction education and research*, *13*(2), 125-141.

Lederman, J. S., Lederman, N. G., Bartos, S. A., Bartels, S. L., Meyer, A. A., & Schwartz, R. S. (2014). Meaningful assessment of learners' understandings about scientific inquiry—The views about scientific inquiry (VASI) questionnaire. *Journal of Research in Science Teaching*, *51*(1), 65–83. Scopus. https://doi.org/10.1002/tea.21125

Lincoln, Y. S., & Guba, E. G. (1989). Ethics: The failure of positivist science. *The Review of Higher Education*, *12*(3), 221–240. https://doi.org/10.1353/rhe.1989.0017

Linn, R. L. (1990). Admissions testing: Recommended uses, validity, differential prediction, and coaching. *Applied Measurement in Education*, *3*(4), 297–318. https://doi.org/10.1207/s15324818ame0304_1

Lou, Y., Blanchard, P., & Kennedy, E. (2015). Development and validation of a science inquiry skills assessment. *Journal of Geoscience Education*, *63*(1), 73–85. https://doi.org/10.5408/14-028.1

Metin Peten, D. (2022). Influence of the Argument-Driven Inquiry with Explicit-Reflective Nature of Scientific Inquiry Intervention on Pre-service Science Teachers' Understandings About the Nature of Scientific Inquiry. *International Journal of Science and Mathematics Education*, *20*(5), 921–941. Scopus. https://doi.org/10.1007/s10763-021-10197-8

Muthanna, A., & Sang, G. (2023). A Conceptual Model of the Factors Affecting Education Policy Implementation. *Education Sciences*, *13*(3), 260.

O'Brien, S., McNamara, G., O'Hara, J., & Brown, M. (2022). Learning by doing: Evaluating the key features of a professional development intervention for teachers in data-use, as part of whole school self-evaluation process. *Professional Development in Education*, *48*(2), 273-297.

Pedaste, M., Mäeots, M., Siiman, L. A., Jong, T., Riesen, S. A., Kamp, E. T., & Tsourlidaki, E. (2015). 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

Pols, C. F. J., Dekkers, P. J. J. M., & de Vries, M. J. (2022). Defining and assessing understandings of evidence with the assessment rubric for physics inquiry: Towards integration of argumentation and inquiry. *Physical Review Physics Education Research*, *18*(1), 010111.

Setiawan, C. (2022). *Mengkonstruksi Tema: Konsep dan Panduan Praktis Analisis Data Kualitatif*. UNY Press.

Sparks, J. R., & Deane, P. (2015). Cognitively based assessment of research and inquiry skills: Defining a key practice in the English language arts. *ETS Research Report Series*, *2015*(2), 1–55.

Sutaphan, S., & Yuenyong, C. (2019). STEM education teaching approach: Inquiry from the context based. *Journal of Physics: Conference Series*, *1340*(1), 012003. https://doi.org/10.1088/1742-6596/1340/1/012003

Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Developing views of nature of science in an authentic context: An explicit approach to bridging the gap between nature of science and scientific inquiry. *Science education*, *88*(4), 610-645.

Takda, A., Jadmiko, B., & Erman, E. (2022). Development of INoSIT (Integration Nature of Science in Inquiry with Technology) Learning Models to Improve Science Literacy: A Preliminary studies. *Jurnal Penelitian Pendidikan IPA*, *8*(1), 18–31. https://doi.org/10.29303/jppipa.v8i1.957

Toma, R. B. (2022). Confirmation and Structured Inquiry Teaching: Does It Improve Students' Achievement Motivations in School Science? *Canadian Journal of Science, Mathematics and Technology Education*, *22*(1). https://doi.org/10.1007/s42330-022-00197-3

Van Rens, L., Pilot, A., & Van Der Schee, J. (2010). A framework for teaching scientific inquiry in upper secondary school chemistry. *Journal of Research in Science Teaching*, *47*(7), 788–806. Scopus. https://doi.org/10.1002/tea.20357

Walan, S., Mc Ewen, B., & Gericke, N. (2022). Enhancing primary science: An exploration of teachers' own ideas of solutions to challenges in inquiry-and context-based teaching. In *Contemporary Issues in Primary Education* (pp. 34–45). Routledge.

Wang, Y. (2022). Effects of augmented reality game-based learning on students' engagement. *International Journal of Science Education, Part B*, *12*(3), 254–270. https://doi.org/10.1080/21548455.2022.2072015