JURNAL PENDIDIKAN KIMIA (JPKIM)
ISSN: 2085-3653| e-ISSN: 2549-3116

J. Pendidik. Kim 2023, 15(2), 140 - 147
DOI 10.24114/jpkim.v15i2.48881

Review Article

Scientific attitudes in chemistry learning: A systematic literature review

Intan Shanderi and Suwardi

Department of Chemistry Education, Faculty of Mathematics and Science, Universitas Negeri Yogyakarta, Yogyakarta 55283, Indonesia

Received 17 July 2023 ♦ **Revised** 30 August 2023 ♦ **Accepted** 31 August 2023

Citation: Shanderi, I., & Suwardi, S. (2023). Scientific attitudes in chemistry learning: A systematic literature review. Jurnal Pendidikan Kimia (JPKIM), 15(2), 140–147. https://doi.org/10.24114/jpkim.v15i2.48881

Keywords

Chemistry learning
Instructional method
Instrument
Scientific attitudes

Corresponding author:
E-mail:
intanshanderi.2021@student.uny.ac.id
(Intan Shanderi)

OpenAcces

Abstract

This systematic review analysis study aimed to examine the scientific attitudes in chemistry learning. The method used a Systematic Literature Review which consists of 5 stages adopted from Denyer and Tranfield. The main criteria for the selection of articles are scientific attitude in the field of chemistry learning with a period of 2012 until 2023 from the well-known national and international database. There were 29 articles were obtained that fit into the criteria. The article's aspect focused on the parameters such as aim, sample level, instructional method, instruments, and chemistry subject. The result showed that the attitude scale is the most instrument that can be used to measure scientific attitude in chemistry learning. Meanwhile, PBL has become the most instructional method that has been used to enhance scientific attitude. Moreover, the studies mostly aim to investigate the influence of teaching methods on scientific attitudes. Most researchers involve high school students in scientific attitude research on analytical chemistry concepts. There are different codes for each theme of scientific attitudes. Thus, the review helps to evaluate the instrument and instructional methods in chemistry learning and also provides recommendations for examining students' scientific attitudes in further explorations.

Introduction

Students who have a scientific attitude can acquire 21st-century competencies (Kusuma et al. 2021). Wildan et al. (2019) added that scientific attitude is defined as a term for scientific pressure in education. This attitude is important because learning does not only emphasize science concepts but should also focus on an interest in science (Villafañe and Lewis, 2016). Based on the findings of research done by Hacieminoglu (2016) students who had a more positive attitude toward science had higher achievement scores. Scientific attitude effect on students' performance (Rampean et al. 2021). Based on the described statement, intellectual achievement, and attitudes are intertwined, so enhancing scientific attitudes is needed

The teacher's role in the teaching and learning process influences scientific attitudes. An effective way to improve students' scientific attitude is to use methods or activities that involve students actively in scientific attitude (Zulirfan et al. 2018). The teacher who provides examples of scientific attitudes in learning, students will imitate them in everyday life (Astuti et al. 2020). Based on several studies, the scientific attitude of students still tends to be low because the teacher is not trained to promote scientific attitudes in the classroom (Dwi et al. 2020). The teachers experience difficulties in developing a scientific attitude. As well as Widowati et al. (2017) also claim that teachers have difficulties in designing learning strategies and processing the result of scientific attitudes to enhance scientific attitudes so these attitudes are often ignored. This relates to the learning method applied. This is in line with what Thahir et al. (2020) said that teacher-centered learning cannot improve students' scientific attitudes. So, learning should be student-oriented.

In several research, the use of instructional methods to improve scientific attitudes has been used widely. The current curriculum in Indonesia implies learning should be process-oriented. In chemistry education, many studies have focused on trying to investigate the impact of learning models on scientific attitudes. The chosen learning model should help students learn to study, and help students acquire knowledge by finding it themselves (Kustijono et al. 2018). Scientific attitudes can be developed through contextual and student-centered learning (Fitriani et al. 2020).

The result of the PISA found that the aspect of scientific attitude of Indonesian students is still low within the scope of scientific literacy (Wartawan, 2017). An instrument that has been generally used becomes one of the factors that contribute to the low scientific attitude. The inadequacy of assessment of scientific attitude is one of the factors that influence the low scientific attitude (Maulina and Senam, 2023). The instruments used to measure students' scientific attitudes sometimes do not pay attention to reliability and validity (Hillman et al. 2016). However, there are limited systematic literature reviews of instruments of scientific attitudes toward chemistry learning. Toward this end, there is a need for systematic research related to scientific attitudes in chemistry learning offered from several existing studies to see the variation and the possible development, so that they can be used as reference for others.

Method

This study used a systematic literature review method (SLR). As we know that systematic literature review aims to produce a comprehensive, and impartial synthesis of one study from various relevant studies in the paper (Aromataris and Pearson, 2014). The systematic review was focused on using the themes that emerge in the articles. This study was prioritized in the aim, sample, and instrument to measure students' scientific attitudes, instruction methods, and chemistry concepts that are generally used. The predetermined themes are presented and discussed one by one. The procedure adopts the step from Denyer and Tranfield (2009). The steps of systematic literature review as presented in Fig.-1.

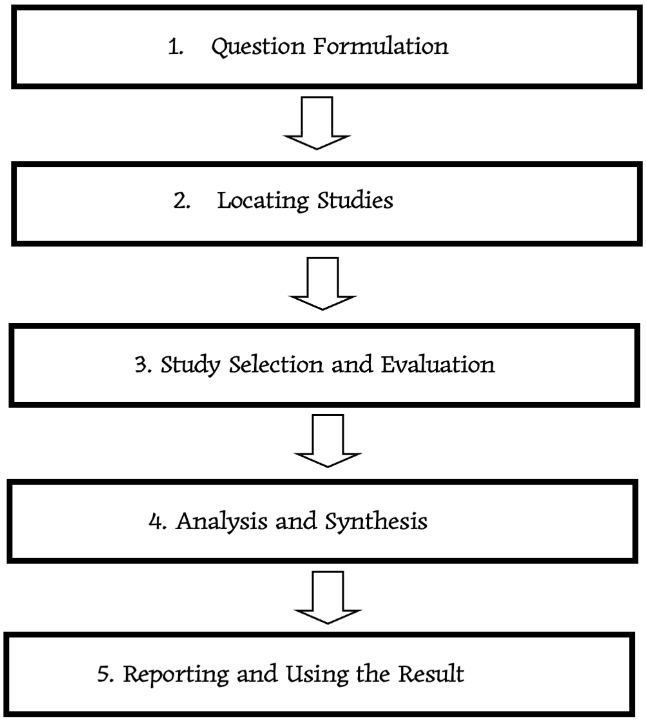

Fig.-1. The steps of a systematic literature review

Questioning Formulation

A good systematic review is based on formulation. The questions are based on the selection topic. The questions are as follows:

a. What were the aims of scientific attitude research in chemistry learning?
b. Who were the samples involved in these studies?
c. What instructional methods have been used to improve scientific attitude in chemistry learning?
d. What instruments have been used to measure scientific attitude in chemistry learning?
e. What were the chemistry concepts focused on?

Locating Studies
This second step aims to find search databases related to questions. The keywords used in the search are "Scientific attitudes in chemistry learning". These keywords are used to find articles published in national and international journals obtained from Google Scholar and Research Gate from 2012 to 2023. Then, the articles are saved and then arranged in a table format for easy filtering.

Study Selection and Evaluation
These articles used in this research are based on inclusion criteria as follows: 1) related to the use of instruments to measure scientific attitudes in chemistry learning, 2) related to the instructional method to enhance scientific attitudes in chemistry learning 3) focusing on chemistry 4) an article explaining in English. Based on the results, there are 29 selected articles were found and fit into the criteria.

Analysis and Synthesis
The next step is to synthesize the findings based on the relevant literature. Data synthesis is carried out by thematic codes in table form and explained narratively.

Reporting and Using the Result
The final step contains a summary of all the studies including the data that has been extracted from the studies. Results are written systematically.

Results and Discussion

A total of 29 scientific attitudes in chemistry learning papers published from 2012 to 2023 were analyzed.

Result of Aim Theme
The number of aimed themes is presented through a code that can be found in Table 1. Based on Table 1, the aimed theme is divided into three different code outlines. Most codes explore the effectiveness of instructional methods toward scientific attitudes. Researchers mostly want to examine how instructional methods such as learning models, media, approaches, and strategy effective can be used to increase students' scientific attitudes in chemistry learning. Many studies have explored how effective the learning method is in scientific attitudes. Therefore, there were various studies have been conducted to investigate the relationship between students' attitudes toward other outcomes there were three articles that explored the profile of students' scientific attitudes.

Table 1. Frequencies of Aim Theme in the Scientific Attitudes

No	Aim Code	F
1	Explore the effectiveness of instructional methods (learning models, media, strategy, approach) on students' scientific attitude	22
2	Investigate the relationship between scientific attitudes with other learning outcomes	4
3	Explore the profile of students' scientific attitudes in chemistry learning	3
	Total	29

Table 2. Frequencies of Sample Theme in the Scientific Attitudes

No	Sample Code	F
1	Senior High School Student	19
2	University	3
3	Pre-Service Teachers	4
4	Chemistry Teachers	2
5	Junior High School Student	1
	Total	29

Result of Sample Theme
The number of the sample themes through the codes can be found in Table 2. As seen in Table 2, the frequencies of the sample theme in scientific attitude in chemistry learning studies were 29 consisting of high school students 19, 3 university students, 4 pre-service chemistry teachers, 2 chemistry teachers, and 1 junior

high school student were also involved. The fact that most scientific attitudes studies involved high school students. This is the right target sample for exploring how to increase students' scientific attitudes in chemistry learning. Some studies also involved preservice teachers. It's important because the preservice teachers will be directly involved in chemistry learning in the school. This is in line with Nursiwan and Hanri (2023) that teachers have an essential part in developing students' scientific attitudes, so prospective teachers must have the ability to give the role so that scientific attitudes can increase. Furthermore, researchers argue that the scientific attitude of teachers does not only affect their performance but also affects the attitudes and success of students (Hadiati et al. 2019). The number of studies that involved them a little bit. It should be researched with such learning methods for pre-service teachers. As suggested by Rohaeti et al. (2020) the development of scientific attitudes of prospective chemistry teachers can be done through learning models that can integrate theory and practice so that can assist the lecture process.

Result of Instructional Method Theme

The number of instructional method themes through the codes can be found in Table 3. Based on Table 3, it can be informed that problem-based learning is the most conducted instructional method used. Problem-based learning is most widely used to improve scientific attitudes. This is in line with (Saklirессy et al. 2021) that problem-based learning has been widely used in learning to enhance various abilities and one of them is a scientific attitude. Problem-based learning has been used to enhance scientific attitude because the model gives the students the opportunity to actively learn and is required to understand new knowledge in new areas so that students learn scientifically, individually, and structured (Andriani and Supiah 2021). Research done by Dirmanto et al. (2021) explains that problem-based learning models can enhance students' scientific attitudes. Problem-based learning is effective in changing students' scientific attitudes (Yoon et al. 2018).

Table 3. Frequencies of Instructional Method Scientific Attitude

No	Instructional method Code	F
1	Problem-based learning	5
2	Guided inquiry learning	4
3	Research-oriented collaborative learning (REORCILEA) model	3
4	Inquiry learning	2
5	Science Technology Society (STS) model	1
6	Science Environment Technology and Society SETS Model	1
7	Cooperative learning	1
8	OD3R Method	1
9	CRTT Model	1
10	Media (3D virtualization)	2
	Total	21

The use of guided inquiry learning also can increase scientific attitude. This model can enhance students' scientific attitudes because in this model students are encouraged to solve problems by finding solutions to the problems given. The process of finding a solution includes the stage of scientific methods so that, this process can develop students' scientific attitudes (Rasyid et al. 2022). The learning process in guided inquiry encourages students to discover and investigate consistently, think critically, and think logically, and analytically, so that students can develop their attitudes (Putra et al. 2018).

The third instructional method code is REORCILEA. Some research has shown that REORCILEA is effective in increasing students' attitudes. In this model, students are required to develop ideas through several scientific steps such as promoting ideas, asking questions, explaining phenomena, and connecting learning (Irwanto, 2022). The effectiveness of the REORCILEA towards scientific attitudes is evidenced by previous studies such as the student who applies REORCILEA in learning had a high score for scientific attitude, so REORCILEA effectively improve students' scientific attitude (Huda and Rohaeti, 2021).

The fourth code is inquiry. Inquiry is related to constructivism theories. Inquiry activities can enhance their scientific attitudes (Ketpichainarong et al. 2010). This is also because the inquiry approach gradually allows students to design the investigation process. While the five code is the STS model. Learning using the STS model involves students being active in the experiences and problems they face directly related to their lives (Devi and Aznam, 2019). In her research, the implementation of the STS model affects scientific attitudes. It was found from the average score in the experimental class which used STS higher than direct instruction. Unlike from STS, there are additional elements of the environment in SETS. In this stage, the teacher connects concepts with problems that occur in society and everyday environments (Maimunah, 2017).

The next code is the TPS model. The Think Pairs Share (TPS) is one of the types of cooperative learning that emphasizes student participation in which students learn from their classmates and try to exchange opinions and express their findings in front of the class (Mardiana and Ningsih, 2023). Research done by Jatmiko et al. (2018) claims that using TPS can help the teacher improve students' scientific attitudes. The other method codes such as CRTT and OD3R are unfamiliar methods. CRTT or Culturally Responsive Transformative Teaching is a method used to connect culture with chemistry using learning tools (Najid et al. 2021). Orientation/Develop/Do/Discuss/Reflect (O3DR) is a method that integrates theory and practice and consists of 5 stages (Arian et al. 2018). There are two codes using media to enhance scientific attitudes such as 3D.

The use of instructional methods that involve active students through the stages of scientific methods in the learning process and the role of the teacher who encourages students during the learning process can improve scientific attitude. So, the selection of learning method is needed to improve students' scientific attitudes in chemistry learning.

Result of Instrument Theme

The number of instruments through the codes is presented in Table 4. As displayed in Table 4. The instrument of scientific attitudes theme consisted of 3 different codes. 20 attitude scales had the highest number. They use attitude scales such as scientific attitude scales, a scientific attitude inventory, and scientific attitude surveys. Attitude scales in these studies analyzed mostly used questionnaire technique. This is consistent with what is presented by Suryawati and Osman (2018) that the central instrument that is often used to measure scientific attitudes is a questionnaire. In these studies, generally, attitude scale development uses the 4-point Likert scale. This is to avert neutrality which could lead to tendency bias (Rohaeti et al. 2020). The attitude scales were first proved for its validity and reliability. Based on the result, the researcher created a new instrument and adapted the sub-scales from the various literature then tested their validity and reliability. This is in line with Blalock et al. (2008) that educational researchers rarely use the available instruments, they more often create new instruments.

Table 4. Frequencies of Instrument Theme in Scientific Attitude

No	Instrument Code	F
1	Attitude Scale	20
2	Observation Sheet	6
3	Observation sheet and Interview Guidelines	3
	Total	29

Based on the result, observation sheets and interview guidelines are rarely used in measuring scientific attitudes. This is in line with Tretter et al. (2019) which observation and interviews are used the least. This results in a lack of understanding of the factors, positive and negative, and the development of scientific attitude. Each instrument has advantages and disadvantages. Therefore, the existence of an attitude scale can help teachers know students' attitudes toward learning to optimize learning outcomes.

Result of Chemistry Concept Theme

The number of the chemistry concept theme through the codes are presented in Table 5. The code provides chemistry concepts in detail which are presented in Table 5. Most frequencies of scientific attitudes examined analytical chemistry. As displayed in Table 5, 8 studies discussed them. They were analytical chemistry including buffer, acid-base, redox, solubility, and chemical equilibrium. Chemistry topics that are commonly discussed are usually difficult subjects for many students. Buffer, acid-base, redox, solubility, and chemical equilibrium topics are difficult for students to discuss in various studies. The next chemistry concept studied general chemistry. The third chemistry concept studied was the chemistry laboratory and colloid system. The next concepts studied were organic chemistry which is hydrocarbon, inorganic chemistry which is chemical bonding and atomic structure, and physical chemistry which is chemical reaction and stoichiometry. Then biochemistry and basic chemistry. Studies are rarely done on the concept of organic chemistry.

Table 5. Frequencies of Chemistry Concept Theme in Scientific Attitudes

No	Chemistry Concept Code		F
1	Physical Chemistry	Stoichiometry	1
		Chemical Reaction	1
2	Inorganic Chemistry	Chemical Bonding	1
		Atomic structure	1
3	Analytical Chemistry	Buffer	2
		Acid-Base	2
		Redox	1
		Solubility	2
		Chemical equilibrium	1
4	General Chemistry		5
5	Organic Chemistry	Hydrocarbon	1
6	Chemistry Laboratory		3
7	Biochemistry		2
8	Colloid system		4
9	Basic Chemistry		2
	Total		28

From the codes that have been presented, many articles focused on scientific attitudes toward several chemistry concepts. All chemistry concepts can be investigated to improve scientific attitudes. Therefore, future studies need to develop other concepts in chemistry not mentioned in Table.

Conclusion

A scientific attitude is a crucial part of learning, especially in chemistry. Scientific attitude is often linked to achievement of learning outcomes because it is considered to influence learning outcomes. Many researches have been conducted to investigate scientific attitudes in chemistry learning. As the research is frequently conducted, various instruments for measuring scientific attitudes are developed. Not only instruments, but various instructional methods used to improve scientific attitudes, objectives in investigating scientific attitudes, samples involved in scientific attitude research, and chemistry concepts that are frequently used in research. From the analysis that has been obtained, the variety of methods and instruments used to measure scientific attitudes and the variety of samples used in research can add our insight into research. All the diversity that exists for the good purposes. This research can be used by other researchers, teachers, students, and others to estimate what instruments, instructional methods, and chemistry concepts can be used in measuring scientific attitudes in chemistry learning.

Conflict of Interests

The author (s) declares that there is no conflict of interest in this research and manuscript.

References

Andriani, R., & Supiah, Y. (2021). Effect of problem based learning models on students' analytical thinking abilities and scientific attitudes in chemistry. *Journal of Physics: Conference Series*, 1806(1), 1–6. https://doi.org/10.1088/1742-6596/1806/1/012190

Arian, Y., Anwar, S., & Sukib, S. (2018). The Influence of Orientation / Develop / Do / Discuss / Reflect (OD3R) Method on Students' Writing Skills and Scientific Attitudes in Biochemistry Laboratory Course. *Proceedings of the 2nd International Conference on Education ICE*, 46(2), 107–113. https://doi.org/10.4108/eai.28-9-2019.2291020

Aromataris, E., & Pearson, A. (2014). The systematic review: An overview. *American Journal of Nursing*, 114(3), 53–58. https://doi.org/10.1097/01.NAJ.0000444496.24228.2c

Astuti, T. N., Sugiyarto, K. H., & Ikhsan, J. (2020). Effect of 3D visualization on students' critical thinking skills and scientific attitude in chemistry. *International Journal of Instruction*, 13(1), 151–164. https://doi.org/10.29333/iji.2020.13110a

Blalock, C. L., Lichtenstein, M. J., Owen, S., Pruski, L., Marshall, C., & Toepperwein, M. A. (2008). In pursuit of validity: A comprehensive review of science attitude instruments 1935-2005. *International Journal of Science Education*, 30(7), 961–977. https://doi.org/10.1080/09500690701344578

Denyer, D., & Tranfield, D. (2009). Producing a Systematic Review. The SAGE Handbook Organizational Research Method.

Devi, M. G., & Aznam, N. (2019). The effect of science-technology-society (STS) model on scientific literacy and scientific attitude of students on the subject of buffer. *Journal of Physics: Conference Series*, 1156(1). https://doi.org/10.1088/1742-6596/1156/1/012027

Dirmanto, A., Cahyono, E., & Sulistyaningsih, T. (2021). Journal of Innovative Science Education The Effectiveness of Problem Based Learning on Acid-Base Materials to Improve Scientific Attitude and Creativity of SMA N 1 Comal Students. *Journal of Innovative Science Educaion*, 10(77), 193–198.

Dwi, I., Bibin, P., Clarissa, R., & Putri, D. (2020). The Effectiveness of the PBL-STEM Model in Online Learning to Improve Students' Scientific Attitudes. *Journal of Education and Practice*, 11(29), 39–45. https://doi.org/10.7176/jep/11-29-04

Fitriani, A., Zubaidah, S., Susilo, H., & Al Muhdhar, M. H. I. (2020). PBLPOE: A learning model to enhance students' critical thinking skills and scientific attitudes. *International Journal of Instruction*, 13(2), 89–106. https://doi.org/10.29333/iji.2020.1327a

Hacieminoglu, E. (2016). Elementary school students' attitude toward science and related variables. *International Journal of Environmental and Science Education*, 11(2), 35–52. https://doi.org/10.12973/ijese.2016.288a

Hadiati, S., Kuswanto, H., Rosana, D., & Pramuda, A. (2019). The effect of laboratory work style and reasoning with Arduino to improve scientific attitude. *International Journal of Instruction*, 12(2), 321–336. https://doi.org/10.29333/iji.2019.12221a

Hillman, S. J., Zeeman, S. I., Tilburg, C. E., & List, H. E. (2016). My Attitudes Toward Science (MATS): the development of a multidimensional instrument measuring students' science attitudes. *Learning Environments Research*, 19(2), 203–219. https://doi.org/10.1007/s10984-016-9205-x

Huda, R., & Rohaeti, E. (2021). Students' attitude profile towards chemistry based on Research-Oriented Collaborative Inquiry Learning Model (REORCILEA) Students' attitude profile towards chemistry based on Research-Oriented Collaborative Inquiry Learning Model. *Journal of Physics : Conference Series*, 1806(1), 1–5. https://doi.org/10.1088/1742-6596/1806/1/012193

Irwanto, I. (2022). The impact of research-oriented collaborative inquiry learning on pre-service teachers' scientific process skills and scientific attitudes. *Journal of Technology and Science Education*, 12(J2), 410–425. https://doi.org/10.3926/jotse.1583

Jatmiko, A., Kartina, Y., Irwandani, I., Fakhri, J., Pricilia, A., & Rahayu, T. (2018). Reading Concept Map-Think Pair Share (Remap-TPS) Learning Model on Cognitive Ability and Scientific Attitude. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, 3(2), 183. https://doi.org/10.24042/tadris.v3i2.3184

Ketpichainarong, W., Panijpan, B., & Ruenwongsa, P. (2010). Enhanced learning of biotechnology students by an inquiry-based cellulase laboratory. *International Journal of Environmental and Science Education*, 5(2), 169–187.

Kustijono, R., Jatmiko, B., & Ibrahim, M. (2018). The effect of scientific attitudes toward science process skills in basic physics practicum by using peer model. *International Journal of GEOMATE*, 15(50), 82–87. https://doi.org/10.21660/2018.50.IJCST50

Kusuma, A. K., Utami, B., & Mulyani, B. (2021). The relationship between students' problem solving skills and scientific attitude with students' learning outcomes on stoichiometry at tenth grade at high school in Boyolali, Central Java, Indonesia. *Journal of Physics: Conference Series*, 1842(1). https://doi.org/10.1088/1742-6596/1842/1/012027

Maimunah. (2017). The Use of Science Environment Technology and Society (SETS) Learning Model for Enhancing the Critical Thinking Skills and Scientific Attitudes. *Jurnal Penelitian dan Pembelajaran Ipa*, 3(1), 65–73.

Mardiana, F. M., & Ningsih, N. Y. (2023). Cooperative Learning Model on Atomic Structure Material and It's Influence on the Scientific Attitude of Class X Students at Senior High School. *Integrated Science Education Journal*, 4(1), 23–29. https://doi.org/10.37251/isej.v4i1.273

Maulina, A., & Senam. (2023). How are student's scientific attitude in buffer solution topic? *The 8^TH^ International Conference on Research Implementation and Education of Mathematics and Science* (ICRIEMS 2021), 2556(1), 040015-1-040015–040016. https://doi.org/10.1063/5.0110367

Najid, A. A., Rahmawati, Y., & Yusmaniar. (2021). Developing students' attitudes towards chemistry learning through culturally responsive transformative teaching (CRTT). *AIP Conference Proceedings*, 2331. https://doi.org/10.1063/5.0041989

Nursiwan, W. A., & Hanri, C. (2023). Relationship between level of scientific creativity and scientific attitudes among prospective chemistry teachers. *International Journal of Evaluation and Research in Education*, 12(1), 174–179. https://doi.org/10.11591/ijere.v12i1.22852

Putra, G. D., Milama, B., & Saridewi, N. (2018). Scientific Attitude Profile of Student Through Guided Inquiry by Experiment Method. *3Rd International Conference on Education in Muslim Society* (ICEMS), 115(Icems 2017), 191–195. https://doi.org/10.2991/icems-17.2018.37

Rampean, B., Roheti, E., Septriwanto, J., & Lengkong, M. (2021). How Can Open Inquiry Enhancing Students' Scientific Attitude Through Chemistry Learning? *Proceedings of the 7th International Conference on Research, Implementation, and Education of Mathematics and Sciences* (ICRIEMS 2020), 528(Icriems 2020), 238–245. https://doi.org/10.2991/assehr.k.210305.035

Rasyid, A., Mustari, M., Aziziy, Y. N., & Nahdi, D. S. (2022). Guided inquiry with sparkol videosribe in science learning: a study of students' scientific attitudes. *International Journal of Educational Innovation and Research*, 1(1), 34–41. https://doi.org/10.31949/ijeir.v1i1.1899

Rohaeti, E., Prodjosantoso, A. K., & Irwanto. (2020). Research-oriented collaborative inquiry learning model: improving students' scientific attitudes in general chemistry. *Journal of Baltic Science Education*, 19(1), 108–120. https://doi.org/10.33225/jbse/20.19.108

Saklirressy, M. T., Sunarno, W., & Nurosyid, F. (2021). Students Scientific Attitude in Learning Physics Using Problem Based Learning Model with Experimental and Project Methods. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 10(1), 59–70. https://doi.org/10.24042/jipfalbiruni.v10i1.8347

Suryawati, E., & Osman, K. (2018). Contextual learning: Innovative approach towards the development of students' scientific attitude and natural science performance. *Eurasia Journal of Mathematics, Science and Technology Education*, 14(1), 61–76. https://doi.org/10.12973/ejmste/79329

Thahir, A., Anwar, C., Saregar, A., Choiriah, L., Susanti, F., & Pricilia, A. (2020). The Effectiveness of STEM Learning: Scientific Attitudes and Students' Conceptual Understanding. *Journal of Physics: Conference Series*, 1467(1). https://doi.org/10.1088/1742-6596/1467/1/012008

Tretter, T. R., Ardasheva, Y., Morrison, J. A., & Karin Roo, A. (2019). Strengthening science attitudes for newcomer middle school english learners: visually enriched integrated science and language instruction. *International Journal of Science Education*, 41(8), 1015–1037. https://doi.org/10.1080/09500693.2019.1585993

Villafañe, S. M., & Lewis, J. E. (2016). Exploring a measure of science attitude for different groups of students enrolled in introductory college chemistry. *Chemistry Education Research and Practice*, 17(4), 731–742. https://doi.org/10.1039/c5rp00185d

Wartawan, P. G. (2017). The Effectiveness of the Use of Portfolio Assessment by Controlling Prior Knowledge to Enhance Scientific Attitude among Senior High School Students. *International Journal of Physical Sciences and Engineering*, 1(3), 9–18. https://doi.org/10.21744/ijpse.v1i3.54

Widowati, A., Nurohman, S., & Anjarsari, P. (2017). Developing science learning material with authentic inquiry learning approach to improve problem solving and scientific attitude. *Jurnal Pendidikan IPA Indonesia*, 6(1), 32–40. https://doi.org/10.15294/jpii.v6i1.4851

Wildan, W., Hakim, A., Siahaan, J., & Anwar, Y. A. S. (2019). A Stepwise Inquiry Approach to Improving Communication Skills and Scientific Attitudes on a Biochemistry Course. *International Journal of Instruction*, 12(4), 407–422.

Yoon, H., Woo, A. J., Treagust, D. F., & Chandrasegaran, A. L. (2015). Second-year college students' scientific attitudes and creative thinking ability: Influence of a problem-based learning (PBL) chemistry laboratory course. *Affective Dimensions in Chemistry Education*, 217-233. https://doi.org/10.1007/978-3-662-45085-7_11

Zulirfan, Iksan, Z. H., Osman, K., & Salehudin, S. N. M. (2018). Take-Home-Experiment : Enhancing Students ' Scientific attitude. Journal of Baltic Science Education, 17(5), 828–837. https://doi.org/10.33225/jbse/18.17.828