

A Review on Assessment of Scientific Attitudes of School Students: A case study of Indonesia

AJAY SHARMA^{1,2} & PUSPANJALI TRIPATHY^{1,2*}

¹CSIR-National Institute of Science Communication and Policy Research (CSIR-NIScPR), New Delhi, Delhi-110 012, India

²Academy of Scientific and Innovative Research, AcSIR Headquarters, CSIR-HRDC Campus, Ghaziabad, Uttar Pradesh-201 002, India

*E-mail: ptripathy@niscpr.res.in

ABSTRACT

Scientific attitude is essential for school students as it cultivates a mindset of inquiry, critical thinking, and evidence-based reasoning. Assessment of the scientific attitude of school students is crucial because it assesses essential skills and dispositions foundational to scientific thinking and inquiry. By assessing and fostering scientific attitudes, educators can empower students to be evolved as critical thinkers, lifelong learners, and active participants in a scientifically literate society. Using the Web of Science Database, this study systematically reviews the research papers published during 2001-2023 on assessing the scientific attitude of school students in Indonesia. It provides insight into the impact of science activities on students' scientific attitudes, a measurement of scientific attitudes, and an in-depth analysis of the factors impacting the scientific attitudes of school students. From this review, it can be concluded that after using different practical teaching methods as compared to conventional methods, there is a significant increase in the scientific attitude of school students. All the cases studied quantitative measurements of scientific attitudes of the students. The topic like relationship between scientific attitude and academic achievement remains unexplored in the reviewed literature. The dominance of quantitative approach and absence of both qualitative as well as mixed method researches are observed in these literature. This issue may be considered as an interesting topic of research in the field of science education.

KEYWORDS: Assessment of scientific attitude; Critical thinking;
Scientific attitude of school students; Science education

1. Introduction

Development of scientific attitude among school students is a major challenge in the current science education system as scientific attitude and the growth of science are interdependent. The general goal of twenty-first-century science education is to increase the number of scientifically literate individuals in society (Driver *et al.* 1996; Millar 2005). In a general sense, scientific literacy is defined as appreciating science and the contribution of science to society, having knowledge about the basic ideas and processes of science, and being able to consciously approach the information and discussions revealed by science (Kilic *et al.* 2008; McComas 2014).

The scientific attitude is the most important outcome in science teaching and is equally important as scientific knowledge (Gokul & Malliga, 2015). In summary, the essence of science encompasses a body of knowledge, a particular way of thinking, and a distinct approach of investigation (Collette & Chiapetta, 1994). It also refers to the required attitude in one's effort to explore or understand natural phenomena. A scientific attitude can support scientific learning and enhance the performance of scientific activity (Osman *et al.*, 2007). Learning outcomes have a broad domain, so that scientific attitudes are part of the learning outcomes carried out by students. In the class, students should desire to obtain information from trusted sources, avoid conclusions from limited evidence, and be open to changing their minds when other evidence is found (Amintarti *et al.*, 2018).

A scientific attitude is an ability or tendency to react consistently, rationally and objectively in a certain way to a new problem or situation. It can be conceptualized as (a) curiosity, (b) respect for data, (c) diligence, (d) creativity and discovery, (e) cooperation, (f) open-mindedness, (g) appreciation of others' opinions, and (h) sensitivity to the environment. The attributes of science, such as rationality, open-mindedness, and critical thinking are universal values that hold significance for personal and societal growth. They play a unique role in guiding societal rationality, often encompassing various dimensions of science, such as interest, attitude, values, and the processes involved in scientific inquiry, it is the inclination to value empirical evidence as the basis of belief in science (Vayssettes, 2016; Olasehinde & Olatoye, 2014; Harlen, 1996; Kumar & Singh, 2018).

In science classes, the goal is not limited to memorizing scientific knowledge; it also involves cultivating the necessary attitudes. Various indicators in science education research studies define the scientific attitude. Over the time, a need arises to assess the scientific attitude of school students, particularly in response to changing times and emerging technologies. These new technological tools can complement traditional teaching methods and play a vital role in instilling a scientific attitude in students, contributing to a scientifically literate society. The growth in one sector often translates to growth in another.

Here in this review, we have compiled the scholarly publications of around last twenty years i.e., 2001 to 2023 related to science education in Indonesia. The main objective is to study how different methods successfully implemented in Indonesia to enhance the scientific attitude of school students as compared to the traditional classroom teaching. In this review, the literatures concerned on Indonesia were selected as this country was ranked the lowest in the “Program for International Student Assessment (PISA)” report, although there was an individual performance enhancement recorded for this country (OECD 2023 PISA 2022 Results). PISA is a global assessment that measures the skills and knowledge of 15-year-old students in reading, mathematics, and science. In terms of science performance, Indonesia first took part in PISA in 2006. At first, students' performances were not good in 2006, but got enhanced and reached at its best in 2015. Even in 2018, performance level was higher than that in 2006, but in 2022, students' performance was at its lowest. However, in science, the percentage of students who scored below a baseline level of proficiency (Level 2) did not vary substantially from 2012. PISA Level 2 is regarded as the minimal degree of competency required to contribute successfully and constructively to society and future education. Students at levels 1a and 1b are thought to be capable of just completing the most fundamental PISA items because they have not effectively proved these abilities.

2. Method of Literature Selection

The present review revealed that to measure scientific attitude, the first instrument was constructed in 1924 by Curtis (Dani,

1989), which was based on four components i.e., the conviction of universal cause and effect relationship, habit of delayed response, habit of weighing evidence and open-mindedness. In India, the first instrument to measure the scientific attitude was constructed in 1960 in the Hindi language with six dimensions, i.e. rationality, curiosity, open-mindedness, aversion to superstitious belief, objectivity- intellectual honesty and suspended judgment (Srivastava, 1980). The “Web of Science” database was chosen to study the research literature. This review article includes the scholarly publications of the last twenty years, *i.e.*, 2001 to 2023, from “Web of Science” database, addressing the different methods that influence the scientific attitude of school students of Indonesia.

Using the keywords “scientific attitude and school students”, 73 references were found from the Web of Science portal. Out of these 73 articles, 21 were published in peer-reviewed journals, and 52 were peer-reviewed conference papers. Only those articles that demonstrated the implementation of different teaching methods for school students and measured students' scientific attitude after applying that method were considered for the present review. Depending on this criterion, only nine peer-reviewed journal articles that evaluated the scientific attitudes were considered out of the 21 journal papers collected during our initial search, and the twelve articles were excluded. Again, out of those nine journal articles, three articles validated the scientific attitude scale and three articles measured the scientific attitude of teachers. So, these six journal articles were excluded, and only the remaining three peer-reviewed journal articles were considered for further study.

Out of the conference papers, articles that did not assess the scientific attitude were excluded and only 24 peer-reviewed conference papers were selected. Again, out of these 24 papers, eight measured scientific attitudes based on research that was inappropriate for target groups (*i.e.*, for school children) and 1 validated the scientific attitude scale. So, those nine conference articles were not considered in our study. During next step, out of the remaining 15 conference articles, in 3 articles, the total number of students involved in the study was not mentioned. So, excluding these 3, rest 12 articles were qualified for the next

step. Out of these 12 conference articles, six were disqualified due to unclear mentions of the impact of the activities on school students' scientific attitudes. Thus, finally six conference papers were selected. Ultimately, total of nine references were referred, including three journal articles and six conference articles. The details about each reference are discussed in the following section.

3. Different teaching strategies and their effect on scientific attitude of school students

3.1. RANGKA contextual teaching and learning

In this study, the authors applied contextual teaching and learning (CTL) methods to observe the effect on the scientific attitude of junior school students in Indonesia. CTL is a holistic learning process that aimed to provide students with knowledge and skills they can utilize in the real world. The RANGKA approach was used in this investigation to create the CTL material. RANGKA contextual learning is the acronym of Rumuskan (conclude), Amati (observe), Nyatakan (state), Gabungkan (Combine), Komunikasi (communicate), and Amalkan (implement). Contextual modules are teaching resource materials that support teachers in guiding students through their learning (Suryawati *et al.*, 2010). CTL was conceptualized as a teaching approach. The biological subject of living diversity was selected for this study module to examine the efficacy of CTL.

Scientific attitude with seven sub-constructs, such as curiosity, open-mindedness, teamwork, diligence, discipline, tolerance and confidence, were covered in this assessment. In this study, 215 students of class VII from Pekanbaru, Riau, Indonesia, were selected to respond using a four-point Likert scale. Based on their ability to understand the subject, the students were categorized into high, middle, and low groups. Responses of students taught by conceptual and conventional learning were recorded and compared using the t-test method. Overall, the topics selected for the contextual and conventional groups were the same. However, in this research, the authors concluded that RANGKA contextual learning is essential in developing a scientific attitude, especially curiosity, responsibility, and teamwork. The students with low understanding ability taught by contextual method scored higher

than those with medium understanding ability taught through the conventional learning method. This study also showed that teachers can play a significant role in implementing instructional ideas if they want to foster a scientific mentality in the students.

3.2. Place-Based education in biology learning

The researchers discussed the effectiveness of “Place Based Education strategy” in student’s learning process based on a study with a group of students in Sumbawa, Indonesia (Ashari, 2018). Place-Based education is an approach where authentic, meaningful and engaging personalized learning for students can be created by taking advantage of the geography of the selected place of study. Various studies have demonstrated that place-based education can improve students' cognitive abilities, scientific attitudes, and scientific knowledge as a first step toward ensuring future generations' sustainability. In this article, Barrington River was selected to learn biology in Sumbawa. People use the Beringin Sila River for baths and washing clothes. Rawa Lake has many floras and 25 species of fauna and is also the largest lake in West Nusa Tenggara. Two groups of senior high students from two different places in Sumbawa were selected. They were exposed to the place-based education strategy for learning biology by visiting the above-mentioned river and lake. Scientific attitudes with indicators of curiosity, cooperation, open-mindedness, accuracy, responsibility, honesty, and caring of environment were analyzed before and after the activity. Total four activities were performed with students, and after each activity, students showed progress in their scientific attitude. Overall, inquiry into biology learning was improved along with the scientific attitude of students.

3.3. Take-Home-Experiment

Take-home experiment (T-H-E) can be seen as efficient and quick means to disseminate scientific knowledge, so those should be included under teaching science to school students (Zulirfan *et al.*, 2018). The study was conducted with 151 Indonesian students in lower secondary schools. The researchers provided a compact, adaptable T-H-E kit based on light and optics (physics). Three steps were followed: the first was pre-investigation at school, the

second was an investigation at home with the kit given, and the third was post-investigation at school. In this research, three student groups were formed: first, the T-H-E; second, the Laboratory-Experimental (LEM); and third, the Conventional Science Teaching method (CST) group. To measure the effectiveness of the T- H-E strategy, quantitative assessment was done with the help of a scientific attitude instrument (Zulirfan *et al.*, 2015) with eight sub-constructs such as curiosity, respect of evidence, willingness to change ideas, critical reflection suspended judgment, objectivity, rationality, and humility. The instrument has been validated by three experts who were doctors in the field of science education. Cronbach alpha is a coefficient that measures the internal consistency, or reliability, of a set of test items or scale. The value of Cronbach alpha was observed 0.68 for that instrument through the reliability test. Cronbach alpha 0.68 indicates a "moderate" level of internal consistency reliability. This means the items on a scale are somewhat correlated with each other, but not extremely strong; while it might be acceptable in certain situations. Generally, a higher value is preferred for robust research, with a typical benchmark being around 0.7 or higher for good reliability.

Responses for scientific attitude questionnaires were collected from the participants of each group before and after each intervention carried out. Effects of the intervention were identified and descriptive analysis and one- way-ANOVA were used to identify the effect of such intervention. The mean scores of scientific attitude of the three groups of students were approximately same before the interventions. Post-intervention results showed a better mean score for the T- H-E group than the LEM group followed by the CST group. As per the t-test results, there was no significant difference between the pre and post scientific attitude for the conventional learning group students. The researchers proved that applying T-H-E and LEM methods, an increase in the scientific attitude of the students can be observed. When compared between T-H-E and LME, T-H-E proved to be better as scientific experiments can be repeatedly carried out by the students within their comfort zone, which helped expand their curiosity.

3.4. Use of physics practicum

A study was conducted on a group of 30 vocational high school students in Indonesia to understand the use of physics practicum in developing science process skills and enhancement of scientific attitude of the students (Wiwin & Kustijono, 2018). Practicum is a component of instruction that tries to get the students to test and put into practice what they have learned in theory. There are three functions of Practicum: training, feedback, and motivation improvement. A practicum is required to educate information process skills (Intellectual and psychomotor skills that are conducted through a process that demands a scientific attitude (curiosity, honesty, collaboration, responsibility, and open-mindedness).

In the concerned article, the researchers used an attitude scale to measure the process of learning science skills and scientific attitudes after applying Physics learning using Practicum. The average score of students after the learning process was good, as measured using a five-point Likert scale, which indicated that physics learning using practicum has a good impact on both science process skills and scientific attitudes. They showed a good correlation between the science process skills and scientific attitudes of the students, with a correlation score of 0.828. According to their research results, a physics practicum can help students develop their scientific thinking skills and significantly impact their attitude towards science in vocational high school.

3.5. Implementation of PODE worksheet

A Class-room Action Research was conducted on 32 students of class VII of East Java, Indonesia to understand the implementation of PODE (Predict, Observe, Discuss and Explain) worksheet in natural science learning to improve students' scientific attitudes, students' analysis ability and students' self-regulation (Dewi & Utami, 2019). Students' scientific attitude before and after being given the worksheet were observed. Student worksheets are a teaching tool that can be used to meet the needs of the students. Worksheets for students are a teaching resource that can be utilized to accommodate students' requirements.

The PODE worksheet contains learning activities that can train thinking skills and improve students' scientific attitudes

through problem-solving activities with sequential steps. Starting from the first step, students make predictions on a problem step, and in the second, students observe, which is a continuation of the previous activity, in the third step, students conduct discussion activities from the observations through results, and in the last and fourth step, students explain the result of observations that have been carried out from all the previous stages through the presentation activities in front of the class. A one-shot case study research method was used in this research. Scientific attitude with six dimensions: honesty, openness with new ideas, responsibility, corporations, and critical thinking were considered for assessment. The scientific attitude of the students got increased after using the PODE worksheet, but the scientific attitude between males and females were not significantly different. The study also recommended the PODE worksheet method as additional teaching material in science learning in junior High school to foster a scientific attitude.

3.6. Project Based Learning

To compete in global competition, education at school should not only be oriented towards acquiring and understanding scientific concepts but also towards the student's ability and skill in critical thinking (Suastra & Ristiati, 2019). It means teachers must teach the students about how to learn science subjects and develop a scientific attitude. The project-based learning model is one of the teaching models that not only empower science as a product but also science as a process, especially for improving students' scientific performance and critical skills. Project-based learning has five steps: step first, establishing the project theme; step second, establishing learning content; step third, planning the activity; step fourth, processing the activity; step fifth, implementing the activity to implement the project.

In this study, 60 students from class IX were divided into two groups as experimental group and a control group for a quasi-experiment, where not all of the variables that had an effect on the results were controlled well and the process of sampling was not in a full randomization process. The experimental class was the group of students who learned through project-based learning and authentic assessment, and the control group was those who

learned using project-based learning and conventional assessment. Eight indicators: curiosity, respect for fact, critical reflection, diligence, open thinking, cooperation with others, willingness to accept the uncertainties and sensitivity towards the environment were used to prepare a questionnaire for evaluating scientific attitude of both the group of students.

There were two variables used in this study. The teaching model was the independent variable and scientific performance and critical thinking skill were the dependent variables. The use of teaching models in treatment groups was differentiated into two, i.e., the use of Project Based Learning model in the experiment group and the use of conventional teaching in the control group. There was a difference in the scores of measured scientific attitudes between the experimental and control groups. In teaching science using project-based learning, the given performance task can develop the student's critical thinking, scientific attitude, and self-efficacy higher than one in using conventional assessment. Authentic assessment, along with project-based learning, can improve scientific attitude. In a study, it was also recommended that principals provide full science laboratory facilities for teachers as soon as possible in order to promote the efficiency of scientific science education utilizing the project based learning model.

3.7. PhEt Assisted Group Investigation Model

The impact of a learning model i.e., Physics Education Technology Group Investigation on, students' scientific attitudes was evaluated by a group of researchers (Hilalliati *et al.*, 2019). A free interactive simulation of physical phenomena is called Physics Education Technology. Students can connect the real-world occurrences and the underlying science using a research-based approach that incorporates findings of prior studies, expanding their understanding and boosting their enthusiasm for physics. The learning physics in the class was benefitted from the results of simulations in Physics Education Technology, which was evidenced from the positive responses of 62% of the students in that class (Faour & Ayoubi, 2018).

In the studied paper, a study was conducted on group of class X students of a school. Providing them one modeling class and

one implementation class on a particular topic in Physics. The class was subdivided by four sub-groups. The method used in teaching physics in both classes was PhEt-aided Group Investigation learning models. The six stages of the Group Investigation learning model implemented were: focusing students' attention; identifying topics and grouping students into different groups; planning assignments; conducting investigations; presenting the findings of investigations that have been compiled into a report; and assessing the learning that has occurred. The learning model provides teachers with a foundation and direction for teaching. The responses received from students on questionnaires to measure the scientific attitude suggested that learning that employs the PhEt-assisted Group Investigation paradigm positively affects students' scientific views. The results showed that the scientific attitude of students' in the modeling and implementation classes were in the very high category. Curiosity, respect for data and facts, critical thinking, open-mindedness and cooperation, caring for the surrounding environment, and perseverance were the indicators of the scientific attitude of students, which were valued in this study. The characteristics of a learning model must include: (a) the existence of a theoretical foundation related to the learning model, (b) the existence of a learning model of syntax, (c) the existence of a classroom management system in the learning process, (d) the existence of a principle that the teacher must follow in the learning process, (e) the existence of a design of learning objectives as the results of ongoing learning, and whether the objectives that have been completed.

3.8. TPACK Based-Physics Learning Media

One of the problems for physics teachers is to teach the subject in a way that encourages students to develop a scientific mindset in addition to memorizing formulas (Ilmi *et al.*, 2020). The impact on student's attitudes towards science is seen in the study when media and "Technological, Pedagogical, and Content Knowledge (TPACK)" based learning are combined. Physics teachers get knowledge of spreadsheets but do not use them in teaching. It can overcome constraints in learning physics. The concept of TPACK is that is to combine the material content that is applicable in daily life based on pedagogy knowledge and using

technology to improve the exciting stimuli so students will be motivated to learn. This TPACK-based learning activity involved fifty-one students from ABBS High School of Surakarta, Indonesia.

According to the researchers, TPACK-based physics learning activity was helpful in understanding the concept and building their scientific attitude. Scientific attitudes can be improved with various learning media and learning models. In this learning, media with 4D (Define, Design, Develop, and Disseminate) method was developed to improve scientific attitude of the school students. Scientific attitudes with indicators like curiosity, environment awareness, open-mindedness, skepticism, perseverance, creativity, intellectual honesty and critical thinking were observed before and after the implementation of TPACK-based learning (Gauld & Hukins, 1980). There was an enhancement of scientific attitude observed after using the learning media, the highest was open-mindedness and the second highest was achievement in curiosity. All the indicators of scientific attitude showed a significant increment after using the TPACK based physics learning technique.

3.9. Research-Oriented Collaborative Inquiry Learning Model

Scientific attitude is one of the important attitudes that can support the learning of chemistry. Scientific attitude can make students more active in learning and the students will be more curious which is related to student achievement (Huda & Rohaeti, 2021). “Research-Oriented Collaborative Inquiry Learning” model was used to explain the profile of students' scientific attitudes during the learning process. Sixty-six senior high school students from the province of Bengkulu were considered as sample of study by the researchers. Through observation, testing, and experimentation, students took an increasingly active role in their education while using “Research-Oriented Research Inquiry Learning” models. By utilizing laboratories more frequently in the chemistry learning process, the implementation of learning in this lab not only seeks to improve learning results but also to make the subject matter easier to understand. Aspects of scientific attitude such as rationality, curiosity, open-mindedness, objectivity, honesty,

suspended judgment, and critical thinking (as suggested by Gauld & Hukins, 1980) were measured. A four-point Likert scale was employed to gather data. The questionnaire used in this study was developed based on indicators and validated using the Rasch model (Boone *et al.*, 2014) whose purpose was to find out the quality and appropriateness of the statement items with the model. Based on the results obtained it can be concluded that the scientific attitude of students who follow the learning process using the “Research-Oriented Research Inquiry Learning” model was in the average and high categories. This was influenced by the learning experience gained by students. Based on the eight aspects of scientific attitude, the highest percentage of aspects was rationality and the lowest was the aspect of suspend judgment and this scientific attitude might improve student learning achievement.

Sr. No	Strategy	Year	Type of study	Sample size	Respondents	Statistical method	Results
1	RANGKA contextual teaching and learning	2010	Quantitative	215	Class VII students	t-test	There is no increase in Scientific attitude, but there is a significant increase in curiosity, responsibility, and teamwork
2	Integrating Place- Based Education in Biology Learning through Inquiry	2017	Quantitative	120	Class X students	Average Score	Scientific attitude changes positively
3	Take-home-experiment: Enhancing scientific attitude	2018	Quantitative	151	Lower Secondary school students	t-test	Scientific attitude changes positively

4	The use of physics practicum to train science process skills and its effect on the scientific attitude of vocational high school Students	2018	Quantitative	30	Senior high school students	Average Score	Scientific attitude changes positively
5	Predict, Observe, Discuss Explain (PODE) worksheet	2019	Quantitative	32	Class VII students	Modus	Scientific attitude changes positively
6	Project-Based Learning and Authentic Assessment	2019	Quantitative	60	Class IX students	MANOVA	Scientific attitude changes positively
7	Physics Education Technology PhEt Assisted Group Investigation Models	2019	Quantitative	30	Class X students	percentage	Scientific attitude changes positively
8	Technological, pedagogical, and content knowledge (TPACK) based- physics learning media.	2020	Quantitative	51	Class X students	N-gain	Scientific attitude changes positively
9	Students' attitude profile towards chemistry based on Research-Oriented collaborative Inquiry learning Model (REORCILEA)	2020	Quantitative	66	Class X students	percentage	Scientific attitude changes positively

3. Discussion

This review provides information on different activities used by different researchers, especially on high school students to analyze

the effect of those activities on the scientific attitude of the students. Based on the studied literature, a summarization of different strategies used for influencing the scientific attitude of high school students is given in Table 1. Even though the reported articles do not specify the period of research work, it is reasonable to assume that in less than a year the class from which students participated in research is mentioned. The generalization of different sub-constructs of scientific attitude has been a salient goal of science education. Previous research has shown a positive relationship between scientific attitudes in student learning in schools, such as students' learning styles (Nugraha *et al.*, 2020), critical thinking (Damanik & Bukit, 2013), and attitudes toward science (Olasehinde & Olatoye, 2014). After employing the activities, an improvement in the scientific attitude of school students has been observed in all the articles.

This primary focus of the study was on students of classes VII to XI. It is mostly targeted at school students in this way. The range of the sample size was 51 to 215. First, in each of these methods, student responses were recorded using different scientific attitude scale to assess the scientific attitude of school students. Different scientific attitude scales used in these papers were 40-item Likert scale by [(Moore & Foy, 1997), (Gauld & Hukins, 1980)], 48-item scale (Kim *et al.*, 1998), and some other self-constructed scales. Most of the articles referred the scientific attitude scale with 40-item Likert scale by (Moore & Foy, 1997) for preparing the questionnaire for the students. After that, a variety of methods were applied, and students completed the objective given in each technique. It is important to remember that each activity employed a different set of actions. Furthermore, we see technology and practical science as the main pillars that support all of the approaches from a comprehensive viewpoint. In applied physics, the bulk of research is primarily focused on physics, with a scientific mindset being viewed as secondary. Researchers approach physics themes in a variety of ways, including investigating fundamental physics and applying physics to technology. To prepare the physics, geology, chemistry, and biology were also used. These activities don't include any mathematics related exercises.

In these articles, quantitative methods are mainly used to measure the scientific attitude of school students. In quantitative methods, several quantitative tools are used to assess the impact of the activities on students' attitudes towards science. A statistical hypothesis test called a *t*-test is used to determine whether there is a statistically significant difference between the responses of the two groups or not. The Multivariate Analysis of Variance (MANOVA) test is used when comparing more than two groups. Regression analysis and variance analysis for multiple dependent variables by one or more component variables, also known as covariates, are provided by the MANOVA process. The effects of methodologies on the scientific attitude of school students are observed using statistical tools like modus, average score, and percentage score for small populations.

Upon examining these scales, we observed that a few common sub-constructs —curiosity and open-mindedness were studied in all the articles. The above-discussed 9 activities can be viewed similarly, allowing us to identify activities such as the Take Home Experiment (T-H-E), which concentrates on physics experiments; students' attitude profile towards chemistry based on Research-Oriented Collaborative Inquiry learning (REORCILEA), which concentrates on hands-on chemistry experiment and place-based education in biology; and science camps, which are after-school programs. Without a scientific attitude, students can lose the spirit of studying science/physics (Ekawati, 2017). Scientific attitude also helps the student to apply the school science learning in out-of-school environments (Supardi *et al.*, 2019). Strategies like Physics Education Technology (PhET), employ technology, and Project-based learning and TPACK differentiate the experimental and theoretically based teaching techniques.

Research shows that intellectual and pedagogical changes require professional development activities to be of sufficient duration, including both the period over which the activity is executed (e.g., one day or one semester) and the number of hours spent in the activity (Cohen & Hill, 2001; Fullan, 1993; Guskey, 1994; Supovitz & Turner, 2000). The discussed articles in the present review have not mentioned the time domain of the

activities. It is also not mentioned whether these activities are part of their teachers' training program. Although the impact is positive in each activity, sub-constructs of scientific attitude are not observed separately. The policies regarding the enhancement of the scientific attitude of school students are not mentioned anywhere in these the discussed articles. Activities look like random activities designed and applied to students. When we talk about science education, it is seen as physics, chemistry, biology, and mathematics, but in the referred articles, the activities are designed only for one particular subject each time, and on behalf of that activity, a change in scientific attitude is observed.

3. Conclusion

This review can be concluded with the observation that effective science-based activities may positively change students' scientific attitudes. The scientific mindset in schools can be nurtured by allowing the development of a scientific attitude and process of inquiry among the students. This scientific mindset is reflected in the measurement of scientific attitude, for which the utilization of different scientific attitude scales and statistical programs is essential. The present review showed that there has been a significant enhancement in the students' scientific attitude by introducing a variety of science-based experiments, project-based modeling, scientific tours and camps, and technological interventions in teaching modules instead of conventional learning processes used by the students in schools. However, these activities do not reflect a complete picture. Time spent during these activities is not studied, and it is not mentioned whether these activities are part of their teaching policy as a whole. The relation between academic performance and scientific attitude needs to be included in these studies. It separates the rote learning and the scientific attitude of students, which is very important to study. This review emphasizes the need for inclusion of science-based activities in designing the courses for faculties of science education.

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