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RESEARCH ARTICLE

Impact of Problem-Based Learning and Genders on Scientific Attitudes of Eighth-Grade Students

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ABSTRACT

Curiosity, objectivity, perseverance, critical thinking, and open-mindedness are the five main dimensions of scientific attitudes that have not currently been studied together. Developing students' scientific attitudes can be done through implementing learning strategies, such as using problem-based learning (PBL), which has been proven to foster positive attitudes during learning and increase students' knowledge, learning achievement, and problem-solving skills. This research aims to analyze learning strategies to improve students' scientific attitudes and their relationship with gender. Learning strategies were carried out on 30 eighth-grade students to see five scientific attitudes: curiosity, objectiveness, perseverance, critical thinking, and open-mindedness. Attitude assessment was carried out using an observation with four rating scales. General scientific attitudes are grouped into dichotomies good and poor. Association analysis between learning strategies, scientific attitudes and genders was carried out using the Chi-square test; while the size effects were carried out using Phi and Cramer's V test. This research proves that PBL and gender appear to influence students' scientific attitudes. PBL was able to improve five dimensions of scientific attitudes. However, of the five attitudes, critical thinking did not show a significant association with the learning strategies used. In general, scientific attitude and the learning strategies studied also show a very strong association. Gender also shows a strong association with students' scientific attitudes, both in direct instruction learning and PBL.

INTRODUCTION

The focus of learning outcomes is on the knowledge, abilities, and competencies that students should possess. Baber dan Mejia-Rodriguez claims that students' learning results are favourably influenced by classroom interactions, student characteristics, learning structures and practices, teacher expertise, and learning facilitation (Baber, 2020; Mejía-Rodríguez & Kyriakides, 2022). On the other hand, learning outcomes correlate with student attitudes (Dias, 2018; Díez-Palomar et al., 2020). Attitude is the most essential part of educational psychology (Shuyang, 2021); through education, we can build positive attitudes that have an impact on life satisfaction (Šmitas & Gustainienė 2019). Attitudes can function as a source of information for teachers, schools, and researchers in assessing whether learning needs improvement (Kanyesigye et al. 2022). One of the essential attitudes to develop is a scientific attitude because it can shape students' character in solving problems (Fathayati et al., 2022).

Developing students' scientific attitudes can be done through implementing learning strategies (Bahri et al., 2021), such as using problem-based learning (PBL) (Fathayati et al., 2022), which has been proven to foster positive attitudes during learning (Demirel & Dağyar, 2016; Hanefar et al., 2021) as well as increasing knowledge (Jamshidi et al., 2021), learning achievement (Funa & Prudente, 2021), and problem-solving skills (Hidayati & Wagiran, 2020). Learning should focus on activating and improving students' learning methods, which in this case can be done by providing learning strategies, so as to reduce passive attitudes in students (Hattie & Donoghue, 2016; Rossi et al., 2021). PBL is student-centered teaching (Jaganathan et al., 2020), with a constructivist pedagogical approach that requires students to work together to solve problems and find solutions (Ferreira & Trudel, 2012). PBL is an all-encompassing method that involves students actively in their education (Ghani et al., 2021). Instead of concentrating on finding clear answers to problems, the PBL process fosters the growth of other desirable abilities and skills, such as knowledge acquisition, enhanced teamwork, and communication (Wang, 2021). An important aspect of the PBL process is students' capacity to assess what they already know, identify knowledge and experience gaps, and fill up the gaps with fresh information (Radcliffe & Kumar, 2016). Three components make up the implementation's single universal framework of PBL: the issue as a learning initiator, the instructor as a group facilitator, and group work as a catalyst for cooperative engagement (Dolmans et al., 2005).

Not all instructional and educational activities can assess the dimension of students' scientific attitudes on the process, and this is mainly because teacher-centered learning (Adejimi et al., 2022) does not touch students' daily problems and is less enjoyable (Rahmadani et al., 2024). As the case in Junior High School, Hulu Sungai Utara, which is in a small town far from the Indonesian capital, requires innovation and development of learning outcomes such as in the scientific attitude dimension. As a small town school, developing a scientific attitude can increase students' curiosity, objectivity, perseverance, open-mindedness and critical thinking attitude so that it can become a trigger for further education, especially in the fields of science and technology.

Although scientific attitudes have been studied for 40 – 50 years, mainly because of concerns about declining attitudes and in development of learning strategies to improve scientific attitudes (Simon, 2015). On the other hand, gender studies on students' scientific attitudes are still not widely carried out (Khan et al., 2022). Science motivation among grade 8 students in various countries shows that boys have stronger motivation than girls (Liou et al., 2023). Wrigley-Asante stated that STEM learning outcomes are not the same between genders. Learning outcomes between genders are also not the same between levels of education, where male students are better than female students at the high school level, while at tertiary education the opposite is true where female learning outcomes are actually better (Wrigley-Asante et al., 2023). Female pre-college STEM students also showed a stronger correlation to scientific attitudes than males (Khan et al., 2022).

Considering the background of this case, researchers interested in analyzing the relationship between learning strategies, scientific attitudes and genders. We utilize PBL to help students develop more scientific attitudes because it strategy may stimulate many areas of students' abilities. Modified from Davies (2020), we developed a research plan to improve and assess students' scientific attitudes. The research stages are arranged through 1) determining objectives, 2) determining the learning strategies that will be used, and 3) determining assessment methods. The novelty of this research is that scientific attitudes are observed based on five dimensions of attitude, namely curiosity, objectiveness, perseverance, critical thinking, and open-mindedness. This research aims to analysis of learning strategies to improve students' scientific attitudes and their relationship with gender. The study results will answer the following questions:

1) How does learning strategy associate and improve the dimensions of a scientific attitude?
2) How does learning strategy associated with general scientific attitudes?

3) How are students' genders related to scientific attitudes?

METHODOLOGY

Research design

This study will employ a quantitative component and will focus on a statistical analysis of the impact of Problem-Based Learning (PBL) on scientific attitudes across different genders of learning strategies in a group of participants. Before the intervention, participant observation was carried out at the beginning of the study using direct instruction learning. Furthermore, participants were given PBL, and their scientific attitudes were observed. PBL intervention and gender groups are the independent variables of the research, while students' scientific attitudes are the dependent variable that is observed.

Participants

This research involved 30 eighth-grade students at Hulu Sungai Utara. The sample was selected non-probably based on discussions and findings on students' scientific attitudes between researchers and teachers. The students consisted of 21 males and 9 females.

Instrument

Attitude assessment is carried out using student scientific attitude observation sheets. The scientific attitudes studied include curiosity, objectiveness, perseverance, critical thinking, and open-mindedness. The attitude observation sheet was developed based on a Likert scale because it is a psychological measurement tool that is very important, basic, and frequently used (Jebb et al., 2021; Xu & Leung, 2018) in the educational and social fields (Joshi et al., 2015), and is often used in measuring attitudes (Batterton & Hale, 2017). The Likert scale values used consist of four levels, sequentially from most minor to largest, representing the following categories: poor (score 1), sufficient (2), good (3), and excellent (4). The instrument's validity was tested using Pearson correlation. It can be categorized as valid with a p-value <0.001 to 0.001. The instrument was tested for reliability using Cronbach's alpha.

Data collection

Data collection was carried out through observations of students during learning activities. Teaching and learning activities are carried out using PBL with material on the human excretory system. PBL is implemented through the following stages (Arends & Soetjipto, 2008): 1) the teacher orients the problem to the students; 2) students define and organize tasks with the help of the teacher; 3) students carry out investigations to obtain appropriate information and obtain explanations or solutions; 4) students develop and present their work based on the information, solutions; and 5) analysis and evaluation by students of the results of investigations carried out with the assistance of the teacher.

Two observers carried out observations to assess the student's scientific attitudes. The attitude of curiosity assessed during the teaching and learning process includes observing, reading, hearing, and listening (Sthephani & Yolanda, 2021). Objectiveness is an attitude of viewing something as an object in a measurable manner without reducing feelings, behavior, or character (Sommers, 2007). In this study, the assessment was based on making and asking questions. Perseverance refers to dedication to carrying out tasks, working hard, tolerance, and efforts to continue doing (Mouli et al., 2018), overcoming obstacles and challenges in order to achieve (Merriman, 2017). Perseverance is assessed based on students' activities in collection and data exploration. Critical thinking attitudes are assessed based on students' activities in processing, analyzing, and presenting data (Uribe-Enciso et al., 2017). An open-minded attitude is a person's tolerant attitude toward the norms and values of his culture that are different from his own and an attitude of not being prejudiced towards members

of different groups (Van der Zee & Van Oudenhoven, 2001; C. Wang et al., 2022). An open-minded attitude can be seen from a person's ability to consider different points of view, assess objectively, and put aside one's own beliefs (van Brussel et al., 2023). The open-minded attitude in this research was assessed based on discussion activities and data presentations carried out by students.

Data analysis

It can be categorized as reliable with a p-value of 0.802. The categorical data obtained was then tabulated and analyzed descriptively in frequency and percentage. General scientific attitudes are grouped into dichotomies good and poor. The good category is a representation of students with modes of scientific attitude dimensions in good and excellent. Meanwhile, the bad category represents students with modes of scientific attitude dimensions in poor and sufficient. Statistics analysis was carried out using the Statistical Package for the Social Sciences (SPSS) 26, with a 95% confidence interval and p-value <0.05. Association analysis between learning strategies, scientific attitudes and genders was carried out using the Chi-square test, while the size effects were carried out using Phi and Cramer's V test.

RESULTS AND DISCUSSION

General characteristics of scientific attitudes

Table 1 presents an overview of the outcomes of applying PBL for student scientific attitudes. The table presents the distribution of frequencies and percentages of student procurement in the five dimensions of scientific attitudes observed. Moreover, Table 1 also shows the association between learning strategies and the five dimensions of scientific attitude. All scientific attitudes observed generally show an increase in the frequency of students obtaining the criteria for good and excellent scientific attitudes. The results of the Likelihood ratio test show that there is a significant association between the PBL strategy and the dimensions of scientific attitude, except for critical thinking.

Table 1. Overview of PBL implementation on the dimensions of scientific attitude

Dimension of scientific attitudes		Direct instruction		PBL		p-value	Cramer's V value
		n	%	n	%		
Curiosity						<0.001[a]	0.745
	Poor	5	16.67	0	0.00		
	Sufficient	14	46.67	0	0.00		
	Good	11	36.67	17	56.67		
	Excelent	0	0.00	13	43.33		
Objectiveness						0.002[a]	0.436
	Poor	1	3.33	0	0.00		
	Sufficient	26	86.67	17	56.67		
	Good	3	10.00	5	16.67		
	Excelent	0	0.00	8	26.67		
Perseverance						0.001[a]	0.444
	Poor	0	0.00	0	0.00		
	Sufficient	27	90.00	16	53.33		
	Good	3	10.00	6	20.00		
	Excelent	0	0.00	8	26.67		
Critical thinking						0.052[a]	nc
	Poor	0	0.00	0	0.00		
	Sufficient	22	73.33	13	43.33		

	Good	6	20.00	11	36.67		
	Excelent	2	6.67	6	20.00		
Open-mindedness						<0.001[a]	0.595
	Poor	8	26.67	0	0.00		
	Sufficient	17	56.67	9	30.00		
	Good	5	16.67	16	53.33		
	Excelent	0	0.00	5	16.67		
n is frequencies of participant; % is percentages; [a] Likelihood ratio test; nc is not checked							

The frequency distribution and percentage of two categories of scientific attitudes, poor and good, are presented in Table 2. It shows the differences between direct instruction and PBL learning. This is in line with Fisher's exact test, which shows a significant association between the two variables.

Table 2. PBL association to the student's scientific attitude

Scientific attitude	Direct instruction		PBL		p-value	Phi value
	n	%	n	%		
Poor	30	100.00	17	56.67	<0.001[a]	0.526
Good	0	0.00	13	43.33		
n is frequencies of participant; % is percentages; [a] Fisher's exact test						

Impact of gender on scientific attitudes

Gender association analysis with learning strategies and the total analysis are presented in Table 3. Women show a higher good category scientific attitude at all layers than men. This is in line with the Pearson Chi-square test which shows a significant association.

Table 3. Gender association with student scientific attitudes

Scientific attitudes category		Male		Female		p-value	Phi value
		n	%	n	%		
Direct instruction						0.001[a]	0.683
	Poor	21	100.00	4	44.44		
	Good	0	0.00	5	55.56		
PBL						0.003[a]	0.572
	Poor	13	61.90	0	0.00		
	Good	8	38.10	9	100.00		
Total						<0.001[b]	0.558
	Poor	34	80.95	4	22.22		
	Good	8	19.05	14	77.78		
n is frequencies; % is percentages; [a] Fisher's exact test; [b] Pearson Chi-square							

Based on Table 1, the frequency of students observed in direct instruction learning tends to be in the criteria of poor and sufficient, of the 30 respondents, curiosity as many as 19 students (63.33%), objectiveness as many as 27 students (90%), perseverance as many as 27 students (90%), critical thinking as many as 22 students (73.33%), and open-mindedness as many as 25 students (73.33%). Observations after the implementation of PBL showed changes in scientific attitudes, where the frequency of the poor and sufficient categories decreased and the good and excellent categories increased. Changes in the frequency of good and excellent categories occurred in the five dimensions observed, including curiosity from 11 (36.67%) to 30 students (100%), objectiveness from 3 (10%) to 13 students (43.33%), perseverance from 3 (10%) to 14 students (46.67%), critical thinking from 8 (26.67%) to 17 students (56.67%), and open-mindedness from 5 (16.67%) to 21 students (70%).

Likelihood ratio analysis shows that there is a relationship between learning strategies and student curiosity ($p < 0.001$), with a Cramer's V value of 0.745 which shows a strong association between these two variables. This is in line with the research conducted by Prastika et al., (2019) and Suhirman et al., (2021), who studied the implementation of PBL to improve the curiosity of high school students. We observe, that in the problem orientation stage in the implementation of PBL, the teacher as a facilitator succeeded in making students focus on the learning carried out. Students' knowledge and minds are triggered to discuss problems and recognize the lack of knowledge in learning topics. This is in accordance with Ghani et al. (2021) and Wijnia et al. (2024). Because curiosity is a basic instinct, learning strategies that are fresh and out of the ordinary provide enthusiasm for students. Binson, (2009) states that curiosity is a natural trait, especially in children, they will learn very persistently to get to know the world so that deep knowledge and relationships will be produced between children and the elements around them. Students with good curiosity will strongly desire to make discoveries and play with positive enthusiasm (Rajashekar, 2020). Inquiry-based learning, such as PBL, is perfect for cultivating student curiosity (Graham & Helen, 2011). Analyzing changes in frequency between the two learning strategies, the strong relationship in this case can be interpreted as implementing PBL can significantly increase students' curiosity attitudes.

Objectiveness observed shows that there is a significant relationship between learning strategies and attitude categories, analyzed using the Likelihood Ratio test (p 0.002), and the Cramer's V value is 0.436, which means the association between the two variables is strong. Researchers believe that the cultural customs of society which are reticent and respectful of other people affect students' objectiveness at the beginning of observations. This makes students tend not to participate in building or asking questions. Slowly, in accordance with PBL steps, this habit is eroded so that some students show good objectivity. This can be seen from the fact that some of them show that they are able to pay attention to the facts being discussed and argue well within a scientific framework. Having an objective attitude is an essential aspect of showing respect for facts (Anwar, 2009). If students strive for objectivity, they must scientifically analyze objects without regard for robust moral responsibility (RMR) for character or behavior (Sommers, 2007). The strong relationship in this case interpreted as implementing PBL can significantly increase students' objectiveness attitudes.

The observed perseverance shows a similar pattern to objectiveness, where the sufficient category dominates students' attitudes. Students seem less accustomed to cooperative learning, and minimal in participatory, initiative and communicative aspects. This is especially because students are infrequently trained in collecting and exploring data when learning takes place through direct instruction. In this case, they then experience difficulty in completing the task of discovering scientific truth. Students' perseverance will determine their success in pursuing education (Thorsen et al., 2021). Students' perseverance in learning can be influenced by three factors: themselves, school, and the environment, where the most dominant factor is from within oneself and is followed by the school. Meanwhile, external factors such as family, activities, or work only impact less than 10 percent (Li & Wong, 2019). The implementation of PBL can slowly change some categories of students into good perseverance. This cannot be separated from student activities demand in PBL which are involved in collecting and exploring data. The results of the Likelihood Ratio analysis show that there is a relationship between learning strategies and student perseverance (p 0.001), and the Cramer's V test shows a strong relationship between these two variables, with a value of 0.444. This means that implementing PBL can increase student perseverance significantly compared to direct instruction learning.

Students' critical thinking attitude shows changes in frequency between direct instruction learning and PBL. The change in student frequencies from sufficient to good and excellent categories was 30%. This is in line with research conducted by Issa & Khataibeh (2021), Alsarayreh (2021), Astra et al., Darhim et al. (2020), and Suhirman et al. (2021). PBL offers an efficient learning environment that supports the growth of critical thinking (El-Shaer & Gaber, 2014). However, in this case, even though

it showed a change in attitude frequencies, the learning strategy did not show a significant relationship with students' critical thinking when tested with the Likelihood Ratio (p 0.052). Educational habits, lack of preparation, dominant facilitators and dominant groups can make PBL implementation ineffective (Dolmans et al., 2005; Ghani et al., 2021; McKendree, 2010). Researchers believe that students are not trained in developing analytical, processing and data presentation skills. This may be related to the direct instruction learning strategy that has been implemented by teachers, which rarely stimulates students to think critically. Critical thinking attitude that requires direction and practice (Snyder & Snyder, 2008), the role of teachers is very necessary to develop this attitude because students spend most of their time at school (Uribe-Enciso et al., 2017). Several factors that influence students' critical thinking attitudes are learning (methods, media, and learning atmosphere), students (learning outcomes, reading abilities, motivation, intentions, learning attitudes, and emotional intelligence), personal (personality, character, and parenting style), classroom environment, social media and learning resources, culture, family and community traditions (Mahapoonyanont, 2012; Thongnuypram & Sopheerak, 2013).

Open-mindedness is an attitude that has changed a lot after the implementation of PBL, with a change percentage of 53.33% being good and very good. Students being able to accept the opinions of their peers, without forcing justification for their own opinions, is a characteristic of open-mindedness seen in this research. Improving attitudes through the implementation of PBL was also confirmed by other research, which noted the development of students' positive attitudes (Demirel & Dağyar, 2016; Hanefar et al., 2021). A societal culture that emphasizes reticence, respect, and respect for others can foster an open-minded attitude in the students being observed. As stated by Wang (2021) trait of open-mindedness correlates with cultural skills and is a component of intercultural communication competence. Implementing discussions in PBL also helps ("forces") students to be involved in presentations and receive colleague's opinions. Bosser and Lindahl's research states that group discussions allow for an open-minded attitude (Bossér & Lindahl, 2020). Open-minded attitude show more creative and artistic behavior, while people with a low open-minded attitude tend to be more habitual, pragmatic, and less innovative (Shao et al., 2021). The Likelihood ratio test shows that there is a relationship between learning strategies and open-mindedness ($p < 0.001$), and the Cramer's V test shows a strong relationship between these two variables (value 0.595). This can be interpreted, the application of PBL significantly increases open-minded attitudes compared to direct instruction learning.

Table 2 shows that there is a relationship between learning strategies and scientific attitudes in general, analyzed through Fisher's Exact ($p < 0.001$). The Phi test shows a strong relationship between the two variables with a value of 0.526. Improving attitudes through the implementation of PBL was also confirmed by Demirel in his research, which noted the development of students' positive attitudes (Demirel & Dağyar, 2016; Hanefar et al., 2021). Students experience an exciting and challenging learning process through PBL and gain a positive scientific attitude, which is also confirmed by Caramay & Ortega-Dela Cruz (2023). The positive impact of PBL on scientific attitudes is due to the learning atmosphere that arises as a result of the learning syntax, which is in line with the dimensions of scientific attitudes. When the teacher carries out problem orientation, this will create curiosity in students. Then this is continued with how they organize tasks in solving problems which creates an objective attitude through discussion, asking-answering questions and collaboration. When they carry out investigations to solve the problem, an attitude of perseverance is formed to be patient, thorough, and continue to carry out investigations until the correct answer is obtained. Open and critical thinking is then also built into the stages of presenting and evaluating investigation results. They can process, analyze and convey the results of their investigations critically, or also listen, appreciate and criticize the opinions of their colleagues. PBL increases self-confidence, problem-solving, communication, critical thinking, independent learning, and collaboration. To ensure successful peer teaching in PBL, students need to comprehensively

understand the content of the learning material and summarize the content in an organized manner (Ghani et al., 2021).

Gender analysis shows a relationship with students' scientific attitudes. Of the three layers analyzed (direct instruction, PBL, and total), all layers show a relationship between gender and scientific attitudes ($p < 0.05$). The Phi test shows a strong effect size in all layers of the two variables (Phi value >0.5). PBL is student-centered learning, with a constructivist pedagogical approach that requires students to work together to solve problems to find solutions. The PBL process does not focus on solving problems with definite solutions; instead, it allows for the development of other desirable skills and attributes, including knowledge acquisition, increased collaboration time, and communication. Some of the positive values obtained by implementing PBL include independence and direction in learning; learning is carried out in groups; the teacher acts as a facilitator; encourages equal group involvement; achieving attitude, motivation, teamwork, problem-solving, and involvement in tasks. Females show a higher percentage in the good scientific attitude category in the third layer. In fact, in implementing PBL, women reached a percentage of 100% in the good scientific attitude category. In line with other research, the scientific attitude of female students tends to be greater than that of male students (Yamtinah et al., 2017), and the differences are statistically significant in many of the observed dimensions (Fadli, 2021). Female students correlate more strongly with scientific attitudes than males, which is influenced by social culture (Khan et al., 2022), including father and mother support in science, socio-economic background, and having scientific friends (Breakwell & Beardsell, 1992). Female students seem to have a tendency to be more focused and disciplined in learning, this is in line with Duckworth & Seligman (2006) findings. On the other hand, men's involvement in extracurricular activities and economic endeavors or broader socio-economic influences such as economic hardship, financial constraints, and gender ideology tend to influence men's academic performance (Wrigley-Asante et al., 2023).

The limitation of this research is that it did not involve many samples between classes, schools and regions. A small sample is not enough to generalize the situation of a population, but as explained previously, scientific attitudes are not exactly the same across regions, education levels, gender, or other demographics. However, we categorize this research data as unique because it was explored from schools whose educational facilities and culture are not as strong as those of favourite schools in big cities in Indonesia. This also contains the potential for confounding from student characteristics that can provide different responses to learning strategies and can be studied extensively in the future.

This study can be used as a basis for implementing PBL in developing scientific attitudes in junior high school students and should be carried out continuously because it can build positive character during the transition period of students' adolescence. In learning, more attention should be given to male students so that they are more focused and disciplined so that they can achieve learning goals better. PBL has been proven to positively influence teacher self-efficacy, including efforts to build interesting, student-centered learning, improve problem-solving skills, and a scientific attitude. Therefore, PBL should be used by teachers, combined with other cooperative learning models, because the majority of the attitude factors were found to be significantly related to learning strategy use.

CONCLUSION

PBL was able to improve five dimensions of scientific attitudes - curiosity, objectivity, perseverance, critical thinking, and open-mindedness. However, of the five attitudes, critical thinking did not show a significant association with the learning strategies used. Meanwhile, the other four dimensions show a strong association with learning strategies. In general, scientific attitude and the learning strategies studied also show a very strong association. This can be defined as the use of PBL

significantly improving students' scientific attitudes. Gender also shows a strong association with students' scientific attitudes, both in direct instruction learning and PBL.

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