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Practicality and Effectiveness of Learning Tools with Predict-Observe-Explain Assisted Conceptual Change Text to Minimize Students' Misconceptions

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ABSTRACT---- ***In achieving learning objectives, a lecturer must be able to design the learning tools he uses by considering the analysis of the needs of his students. This study is part of the research and development process to create learning tools with Predict-Observe-Explain (POE) assisted by Conceptual Change Text (CCT) in minimizing misconceptions of prospective elementary school teacher students. The main focus of this research is to test the level of practicality and effectiveness of these learning tools by involving users, namely lecturers and students. Data was collected using instruments in learning implementation observation sheets, student activity observation sheets, and learning outcomes tests. The data collected was analyzed quantitatively by calculating the average score to determine whether the product is practical and effective to use. The results of this study indicate that the learning tools are proven to be practical and effective so that they are feasible to be used more widely. With these findings, it is hoped that lecturers can design similar learning products to improve mastery of fundamental natural science concepts for prospective elementary school teachers.***

Keywords: POE, CCT, Practicality, Efectiveness

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1. INTRODUCTION

Primary education is a level of education that needs extra attention from the government, society, and educators. This is based on the fact that primary education is the initial foundation for every student to acquire knowledge and skills as capital for the next level of education. However, there are still many obstacles that affect the optimal achievement of the educational goals that have been set. One of the obstacles faced came from the teachers in elementary schools. Many teachers have misconceptions about a subject matter, one of which is the basic concept of natural science

Many factors can be a source of misconceptions for prospective teacher students, including (1) prior knowledge, (2) daily life experiences, (3) language, culture, teacher, textbooks, and (4) learning (Cetin et al., 2015). That is, a teacher and the learning process carried out can also cause misconceptions among students. Likewise, lecture practices carried out by supporting lecturers that are not by the characteristics of the material (concepts) discussed can impact the inability of students to understand the teaching material as a whole.

Misconceptions are resistant to the entry of new, more scientific ideas or ideas. Even students who experience misconceptions can reject the new ideas or ideas they receive (Gurel et al., 2015), making it difficult to accept the conception which ultimately hinders the achievement of a complete understanding of the teaching material. Efforts to reconstruct (change the conception) that is wrong that has already been firmly entrenched in mind are more complicated than constructing a new conception. A person who experiences misconceptions will not realize that his conception is wrong. They have a higher level of belief about the truth of the conception they have.

Given this condition, a learning strategy is needed that facilitates the development of thought by accommodating the principles of constructivism in science learning. One of the learning strategies that can be used is the Predict Observe Explain (POE) strategy. This strategy has been proven to improve students' mastery of concepts for different topics and is considered good for increasing students' understanding of certain learning concepts (Adebayo & Olufunke, 2015; Sreerekha et al., 2016; Teo et al., 2016). In addition, another study suggests that the POE strategy can also correct the misconceptions of prospective teachers and teachers (Afacan & Gürel, 2019). Laboratory activities based on Predict Observe Explain (POE) are also considered to improve and improve the understanding and attitudes of prospective teachers compared to traditional learning (Acarsesen & Mutlu, 2016; Gernale et al., 2015; Hilario, 2015).

A conceptual change approach is needed to support the success of the POE strategy in learning related to concept change. One of them is Conceptual Change Text (CCT) which introduces theories that can convince students that they have misconceptions about scientific facts (Ozkan & Selcuk, 2013). CCT is a text that identifies and analyzes misconceptions and then rejects the misconceptions in the students' minds based on the concept change process (Setyaningrum & Sopandi, 2015). In this CCT, students are explicitly asked to provide predictions on a situation and scientific explanations related to the position (Aydin, 2012; Ozmen & Naseriazar, 2018).

There are several previous studies related to the use of POE strategies that researchers have carried out. (Rini et al., 2018) developed subject matter with POE strategies in thematic learning. In addition, the POE strategy has also been proven to increase the understanding of prospective teacher students in the natural science concept courses (Banawi et al., 2019). In addition to the concept understanding aspect, the POE strategy has also been shown to positively impact improving creative thinking skills in high school students (Neolaka & Corebima, 2018).

From the several examples of research above, it is still rare to find research that focuses on developing CCT-assisted POE-based learning tools in minimizing student misconceptions. For this reason, researchers are interested in developing learning tools through a research and development process for prospective elementary school teacher students. The learning products that have been designed are then tested for quality, one of which is by testing the level of practicality and effectiveness. Thus, the formulation of the problem in this study are: (1) how is the level of practicality of CCT-assisted POE learning tools in minimizing student misconceptions? and (2) how effective is the CCT-assisted POE learning tool in minimizing student misconceptions?

2. LITERATURE REVIEW

2.1. Cconcepts and misconceptions

(Soeharto et al., 2019) state that a concept is a verbal sign that represents a specific fact or reality. This concept is also defined as a medium that connects the subject (mind) and known object (reality) (Sudarminata, 2002). On the other hand, (Eggen et al., 2004) claim that concepts are ideas that form objects or abstractions that help individuals understand phenomena in the scientific field.

Furthermore, (Suparno, 2005) defines conception as the ability to understand concepts obtained through interaction with the environment and concepts obtained from formal education. In participating in classroom learning, students' circumstances are certainly not like blank paper, but they already have an initial understanding of a concept obtained through interaction with the environment, which of course, is not all true (Balci, 2006). This initial understanding of students about a concept is called a conception.

On the other hand, misconceptions are described as an idea or insight of students who give the wrong meaning to something they build based on an event or experience of people (Balci, 2006). This initial understanding of students about a concept is called a conception.

On the other hand, misconceptions are described as an idea or insight of students who give the wrong meaning to something they build based on an event or experience of people(Martin et al., 2001). However, (Queloz et al., 2017) stated that misconceptions had been defined inappropriately and naively so far. According to them, this situation impacts the inability of teachers to deal with students' misconceptions.

(Ojose, 2015) states that misconceptions are defined as misunderstanding or misinterpretation based on the meaning of the wrong thing. This happens because of the "naive theory" that can hinder students' rational reasoning (Aufschnaiter & Rogge, 2010). In line with this statement, (Kuczmann, 2017) states that misconceptions occur supported by clear arguments and even come from several practical experiences. If not addressed, these misconceptions can mislead students in understanding scientific phenomena. If students are not aware of their misconceptions, there will be confusion and incoherence in themselves (Duda & Adpriyadi, 2020).

2.2. Predict-Observe-Explain (POE)

POE stands for Predict, Observe, and Explain. POE was first developed by White dan Gunstone (Cinici & Demir, 2013). This strategy is considered effective for promoting discussion about the conception of science among students. POE is a strategy that actively involves students in demonstrations by predicting what will happen. After predicting activity, students continue their learning activities by conducting experiments, observing, and finally explaining orally and in writing (Mancuso, 2010).

The POE strategy requires students to carry out three tasks in stages (Marks, 2014). First, students must predict the outcome of some event or situation and must justify those predictions. They describe what they saw and observed. Third, they must harmonize and explain the difference between prediction and observation. The POE strategy has been widely used as a vehicle to investigate students' understanding of science concepts (Costu et al., 2012).

The POE strategy is based on constructivism theory to promote concept learning for students (Karamustafaoglu & Mamlok-Naaman, 2015). Based on this theory, student understanding must be considered in the development of teaching and learning programs. The existence of an exciting event can create conditions where students are ready to start re-examining their understanding of a scientific concept and further change that understanding (Joyce, 2006).

2.3. Conceptual Change Text (CCT)

According to a literature review on applying an effective method of changing conceptions, Conceptual Change Text (CCT) is one of the most effective tools to minimize student misconceptions regarding concepts in science studies. This technique was first introduced by Wang and Andre, who proposed to detect student misconceptions and eliminate them by activating the components in the method (Caycı, 2018). CCT is a text specifically created to minimize misconceptions experienced by students through confronting students' misconceptions and scientific explanations about a concept (Durmus & Bayraktar, 2010).

Conceptual changing texts are different from traditional/conventional textbooks because CCT emphasizes the remediation side of misconceptions experienced by students and encourages students to change their misconceptions (Cetingul & Geban, 2011). The writing style of the concept changing text varies from one author to another, but the format remains the same. In the first step, students are asked to submit views or make predictions about a natural phenomenon and provide responses related to the level of confidence in their answers. After that, the student's belief in the solution can be confronted until he realizes a misconception in his mind. When students see the dissimilarity between the observed reality and the views in their minds, so the cognitive incompleteness needs to be corrected (Durmus & Bayraktar, 2010).

In the next step, students are given a scientific explanation of the correct concept so that conception accommodation occurs. Concept accommodation is a process in which students who experience misconceptions can absorb all or part of the concepts that they feel need improvement as the desired improvement efforts in achieving scientific conceptions. In the end, students are asked to answer questions that can strengthen their conceptions and show accurate improvements to their misconceptions (Ozkan & Selcuk, 2015).

2.4. CCT-assisted POE Learning Tools

In testing the quality of learning products, a researcher must conduct a series of trials to determine their validity, practicality, and effectiveness (Nieveen, 1999). In this study, two tests were conducted, namely the validity and effectiveness test. In this study, two tests were conducted, namely the validity and effectiveness test. The validity test is a test carried out by involving experts (Pandiangan et al., 2017). The experts were asked to assess the products produced by researchers, which included aspects of material, presentation, language, and others.

This learning tool developed is designed based on the POE strategy, which is integrated with CCT techniques. The learning tools developed are Semester Learning Plans (SLP), textbooks, and student worksheets. The tool was developed based on three main stages, namely predicting, observing, and explaining. These three stages are the main stages in the POE strategy used as the basis for developing this research product.

3. METHODS

3.1. Research Design, Site, and Participants

This research is part of research and development that adopts the 4D theory (Design, Define, Develop, and Disseminate) proposed by (Thiagarajan et al., 1974). This research focuses on the development stage by testing the practicality and effectiveness of learning products in the form of CCT-assisted POE learning tools to minimize misconceptions of prospective elementary school teaching students in the Basic Science Concept Course on electricity and magnetism.

This research was conducted on prospective elementary school teacher students at the Indonesian Christian University (UKI) Toraja, South Sulawesi, Indonesia. There were 30 students involved in this study. In addition, other participants involved in this study were three lecturers (observers) who provided data in the form of observations of the implementation of the model and observations of student activities. The selection of participants was carried out using a purposive sampling technique to select participants according to specific considerations.

3.2. Data Collection

Learning Implementation Observation Sheet

The researcher used an instrument in the form of an observation sheet on the implementation of learning. The goal is to measure the level of practicality. Researchers designed this observation sheet with three main parts: preliminary activities, core activities, and closing activities. This observation sheet consists of 13 statements with four answer choices, namely a score of 1 as the lowest score to 4 as the highest score.

Student activity observation sheet

In addition to learning implementation observation sheets, practicality tests were also carried out using student activity observation sheets. This observation sheet is designed to consist of three main parts, namely the predict, observe, and explain sections. Each section consists of 4 statements, so that the total statements in this observation sheet are 12 items. Similar to the learning implementation observation sheet, this student activity observation sheet consists of 4 alternative answers, namely 1 for the lowest score and 4 for the highest score.

Learning outcome test

Learning outcomes tests were used in the pretest and posttest sessions to determine whether there was a positive impact of CCT-assisted POE learning tools in minimizing misconceptions of prospective elementary school teacher students. This test is a multiple-choice test with ten items based on electricity and magnetism. Before being used, this test was tested for reliability as evidence that this test was feasible to use. The reliability test shows that this multiple-choice test has a reliability score of 0.85 and is declared valid and reliable. Thus, this instrument is reported to have met the reliability criteria by using Cronbach's Alpha coefficient.

3.3. Data Analysis

In general, the data collected in this study were analyzed using a quantitative approach. Data from observations of learning implementation and student activities from lecturers or observers were analyzed to determine the average score. If the cumulative average score has been found, it is compared with the practicality category table in table 1.

Table 1. Practicality criteria for learning devices

No	*Score Interval*	*Category*
1.	$3.6 \leq M \leq 4.0$	*Very practical*
2.	$2.6 \leq M \leq 3.5$	*Practical*
3.	$1.6 \leq M \leq 2.5$	*Less practical*
4.	$M \leq 1.5$	*Not practical*

Furthermore, the pretest and posttest data regarding the state of students' conceptions were then calculated for the decrease in the number of misconceptions. The level of decline in student misconceptions can be calculated by the formula by (Hake, 1999) proposed using an equation based on the adaptation of the inverse of the normalized gain value. The formula used in calculating the rate of decline in misconceptions is:

$$\Delta M = \frac{\%M_I - \%M_{IV}}{\%M_I - \%M_{ideal}}$$

Information:

AM= decrease in the number of students who have misconceptions

MI= number of students who have misconceptions in the posttest session

MIV= number of students whose misconceptions in the pretest session

After finding the score using the formula above, then the results of the calculation are compared with the table of criteria for the effectiveness of this CCT-assisted POE learning tool. The effectiveness criteria used in this study can be seen in table 2.

Table 2. Criteria for the effectiveness of learning tools

Quantity M (%)	*Criteria of effectiveness*
AM ≥ 70	*High*
30 ≤ AM < 70	*Moderate*
AM < 30	*Low*

4. RESEARCH RESULTS

4.1. Practicality of CCT Assisted POE Learning Tools

Results of Observation Analysis of Learning Implementation

During the trial process, the researcher asked for the help of 3 observers to observe the learning process taking place. The observation process was carried out for four meetings for the electrical and magnetic material. In general, the results of the analysis of the implementation of the learning are presented in table 3.

Table 3. The results of the observation of the implementation of learning

No	Observed Aspects	The meeting			
		P1	P2	P3	P4
I	**Preliminary activities**				
1.	*The lecturer checks the completeness of the tools/materials/PR assigned to students.*	4.0	4.0	4.0	4.0
2.	*The lecturer displays a discrepant event and prepares an experiment or science phenomenon in a simple demonstration, picture, or question.*	4.0	4.0	4.0	4.0
3.	*Lecturer distributes SIPF (Student Individual Prediction Form) or initial worksheet to students*	4.0	4.0	4.0	4.0
II	**Core activities**				
4.	*Lectures begin by the lecturer by asking questions/activities that lead students to make predictions with reasons, level of confidence in the answers (initial assignment)*	3.7	4.0	4.0	4.0

5.	*The lecturer collects the students' initial assignments. After some time has passed.*	4.0	4.0	4.0	4.0
6.	*Divide students into groups and ask them to sit in their respective groups*	4.0	4.0	4.0	4.0
7.	*The lecturer shows some additional facts about the context of the problem or a statement that predicts the answer*	3.0	3.3	4.0	4.0
8.	*Lecturers distribute Student Activity Sheets (SAS) so that students make observations and complete SAS assignments*	4.0	4.0	4.0	4.0
9.	*The lecturer prepares each group of student representatives to report the results of the activity/discussion*	3.3	3.7	3.7	4.0
10.	*Lecturers observe the process and results while students are doing SAS.*	3.0	3.3	3.7	4.0
11.	*Lecturers explain and evaluate students' predictions and help them evaluate their understanding*	4.0	4.0	4.0	4.0
III	***Close Activity***				
12.	*Lecturers and students conclude the lecture material*	4.0	4.0	4.0	4.0
13.	*Assign tasks for the next meeting*	4.0	4.0	4.0	4.0
	Score Average	3.77	3.87	3.95	4.0

From table 3 above, it can be concluded that as a whole (4 meetings), the results of observations indicate that this learning tool is stated to be very practical. This can be seen from the results of the average score, which reached more than 3.5 of the maximum average score of 4.0. At the first meeting, the average score of the observation results of the implementation of learning was 3.77, while at the second meeting, it was 3.87. Likewise, meetings 3 and 4 obtained an average score of 3.95 and 4.0. This very practical category is determined based on the achievement of an average score in the range of 3.5 M 4.0 as determined in the research methods section.

Result of Student Activity Observation Analysis

The practicality of this learning device is also determined by the results of observations of student activities. Observers assess student activities during the learning process by evaluating three main aspects: predict, observe, and explain. Overall, the results of the analysis are presented in Table 4.

Table 4. Results of student activity observations

No	***Observed aspects***	***Score at the Meeting***			
I	***Predict***	***P1***	***P2***	***P3***	***P4***
1.	Predicting an event correctly	2.3	3.0	3.3	3.7
2.	Answer questions with reasons	2.7	3.0	3.7	4.0
3.	Connecting variables correctly	2.3	3.3	3.7	4.0
4.	Make forecasts based on data patterns	2.7	3.0	3.3	3.7
II	Observe				
5.	Take measurements with appropriate tools	2.7	3.3	3.3	3.7
6.	Distinguish relevant/irrelevant facts.	2.7	3.3	3.3	3.7
7.	Making similarities/differences to something	2.7	3.0	3.3	3.7
8.	Record observations	2.7	3.3	3.7	3.7
III	Explain				
9.	Explain the relationship between the observed variables.	2.7	3.3	3.3	3.7
10.	Explain the results of observations systematically	2.7	3.0	3.3	4.0
11.	Using the right concept	2.7	3.0	3.3	4.0
12.	Changing misconceptions	2.7	3.0	3.7	4.0
	Score Average	2.61	3.14	3.44	3.81

From the table 4, it can be concluded that the results of observing student activities fall into the "practical" and "very practical" categories. At the first meeting, the average score of student activity observations reached 2.61, with a maximum average score of 4.0. Furthermore, the average score for the second meeting was 3.14, the third meeting was 3.44, and the fourth meeting was 3.81. In conclusion, the average score of the 1st, 2nd, and 3rd meetings is in the practical category because it is in the score range of 2.6 M 3.5. For the fourth meeting, the average score of 3.81 was included in the "very practical" category because it was in the range of scores of 3.6 <M <4.0.

4.2. Effectiveness of CCT-assisted POE Learning Tools

To determine the effectiveness of this learning device, the learning outcomes test is used at the beginning and after the learning process. In summary, the results of the learning test are presented in table 5.

Table 5. Effectiveness of CCT-assisted POE learning tools

No.	Sub-content/Content	Pretest			Posttest		
		KI	TMK	M	KI	TMK	M
1.	Static electricity	28.89	33,33	34.44	77.78	4.17	16.67
2.	Electrical circuits	28.89	46.67	41.11	78.33	9.17	15.56
3.	Magnetism	27.78	28.33	34.44	78.89	6.67	12.22
	Sub-material Average	28.52	36.11	36.66	78.33	6.67	14.82
	Overall Material	25.67	40.00	33.00	78.33	8.00	13.33

Table 5 above shows that the number of students who have progressed in understanding progress is very significant, both for each sub-material (static electricity, electric circuits, and magnetism) and the whole material. If you look closely, it appears that, on average, the number of students who have a scientific conception (KI) has increased almost three times in the posttest session when compared to the pretest results for the three tests sub-materials (increased from 28.5% to 78.3%). The increase was more than three times for the overall test material, from 25.67% to 78.33% in the posttest.

Furthermore, from the table, it can also be concluded that there has been a decrease in the number of students who experience misconceptions, both for each sub-material (static electricity, electric circuits, and magnetism) and the whole material. The average number of students with misconceptions decreased by two times to 2.8 times in the posttest compared to the pretest. The number of students who have misconceptions in the posttest is around 0.35 to 0.5 of the number of students. They have misconceptions in the pretest. In other words, the average student who experienced misconceptions decreased to only 14.8% from the original 36.7%).

5. DISCUSSION

Based on the research results, this CCT-assisted POE learning tool proved to be practical and effective. This learning device is proven to have high effectiveness in minimizing the number of students who experience misconceptions in the basic science concepts course, especially in electricity and magnetism. This is in line with (Stepans, 2011) statement, which states that the key to the success of a conceptual change approach in minimizing initial misconceptions lies in the success of the conceptual confrontation stage in diluting the belief in the initial conception of someone wrong.

Another study by (Hilario, 2015) supports this finding by stating that POE strategies can improve classroom practice by recognizing lesson conceptions and considering the meaning of certain laboratory phenomena. This strategy can be used individually or in groups to help students explore their ideas and justify them at the prediction stage (Karamustafaoglu & Mamlok-Naaman, 2015). In line with these two findings, another study stated that this strategy could help teachers discover students' knowledge before the material is taught to find sustainable solutions to overcome misconceptions (Phanphech & Tanitteerapan, 2017).

The POE strategy is considered essential to be used in science learning, especially in understanding scientific concepts. (Ayvaci, 2013) even asserts that the POE strategy is stronger in impact when compared to science training related to other general approaches. This is based on the main feature of the POE strategy, which provides students with the use to support their predictions through their knowledge and experience with similar everyday events they encounter every day. In fact, given the positive impact of the POE strategy, (Kibirige et al., 2014) call for the need for educators and curriculum developers to include various elements of POE in the curriculum as a learning model for a conceptual change in teaching.

The POE strategy used in minimizing student misconceptions does not stand alone but is combined with CCT techniques.

The CCT technique is essential because it is designed to change students' alternative conceptions to promote conceptual change by generating dissatisfaction and a reasonable explanation(Ozmen & Naseriazar, 2018). In addition, CCT techniques are also effective for creating conceptual change, promoting meaningful learning and overcoming misconceptions (Aygun & Tan, 2021).

In other fields of science, CCT techniques are also widely applied in dealing with misconceptions. Duez (2020) states that the use of meta-conceptual questions using CCT can promote conceptual change. Another study in the field of science was also conducted by (Rohmawatiningsih et al., 2018) which found evidence that most students' conceptions of the properties of air changed from misconceptions to scientific concepts. The CCT technique can also be used in social sciences related to the evolving concepts about the constitution, independence, republic, democracy, government/state and others (Dagdelen & Kosterelioglu, 2015).

Many studies have proven that this CCT technique has advantages compared to other conventional methods. (Caycı, 2018) states that the CCT technique, which consists of four components, has proven to be effective in reducing the level of student misconceptions. In line with this study, (Cetin et al., 2015) have demonstrated through their research that this technique has a better effect than traditional learning, especially in understanding ecological concepts. For this reason, the CCT technique becomes more effective in changing students' misconceptions if under the following conditions: (1) students are not satisfied with existing conceptions, (2) students must find new conceptions so that they were understood, (3) students must assume the new conception makes sense, and (4) students must find new conceptions that lead to new insights (Yurukk & Eroglu, 2016).

Of the many studies related to the CCT technique, some studies have been identified as contradicting the previous findings. Some studies find that this technique does not have a significant impact on changing students' concepts. (Onder, 2017) found no significant difference between the two groups in terms of understanding the concept of electrochemistry at school. However, the number of studies stating that the CCT technique has a significant positive impact on changes in conception is more than the other way around. This indicates that lecturers/teachers need to try to apply the POE strategy with the help of CCT techniques in learning, especially in natural sciences.

6. CONCLUSION

In achieving the learning objectives that have been set, a lecturer must also develop learning tools to make it easier for students to understand the learning material. This study is part of the research and development process intending to know how far the practicality and effectiveness of CCT-assisted POE learning tools minimize student misconceptions. The results showed that the developed learning tools were practical and effective after going through several stages of testing. This learning device is declared practical based on several observers' observations during the learning process. In the learning outcomes test, both in the pretest and posttest sessions, results were obtained that proved that this device was declared effective in minimizing students' misconceptions about the concepts of electricity and magnetism. Lecturers at universities can develop learning tools to reduce misconceptions experienced by prospective elementary school teacher students regarding basic science concepts (especially electricity and magnetism).

7. REFERENCES

[1] Acarsesen, B., & Mutlu, A. (2016). Predict-observe-xxplain tasks in chemistry laboratory: Pre-service elementary teachers' understanding and attitudes. *Sakarya University Journal of Education*, *6*(2), 184–208. https://doi.org/10.19126/suje.46187

[2] Adebayo, F., & Olufunke, B. T. (2015). Generative and predict-observe-explain instructional strategies: Towards enhancing basic science practical skills of lower primary school pupils. *International Journal of Elementary Education*, *4*(4), 86–92. https://doi.org/10.11648/j.ijeedu.20150404.12

[3] Afacan, Ö., & Gürel, İ. (2019). The Effect of Quantum Learning Model on Science Teacher Candidates' Self-Efficacy and Communication Skills. *Journal of Education and Training Studies*, *7*(4), 86–95. https://doi.org/10.11114/jets.v7i4.4026

[4] Aufschnaiter, C. Von, & Rogge, C. (2010). Misconceptions or missing conceptions? *Eurasia Journal of Mathematics, Science & Technology Education*, *6*(1), 3–18. https://doi.org/10.1016/0002-9416(79)90031-9

[5] Aydin, S. (2012). Remediation of misconception about geomatric optic using conceptual change texts. *Journal of Education Research and Behavioral Sciences*, *1*(1), 1–12.

[6] Aygun, M., & Tan, M. (2021). The impact of mass on action-reaction forces during a collision: Using a conceptual change yext or traditional expository text to overcome missconception. *Pamukkale University Journal of Education*, *51*(1), 65–91. https://doi.org/10.9779.pavefd.690966

[7] Ayvaci, H. (2013). Investigating the predict-observe-explain strategy on teaching photo electricity topic. *Journal of Baltic Science Education*, *12*(5), 548–565.
[8] Balci, C. (2006). *Conceptual change text oriented instruction to facilitate conceptual change in rate of reaction concepts*. School of Natural and Applied Sciences of Middle East Technical University.
[9] Banawi, A., Sopandi, W., Kadarohman, A., & Solehuddin, M. (2019). Prospective primary school teachers' conception change on states of matter and their changes through predict-observe-explain strategy. *International Journal of Instruction*, *12*(3), 359–374. https://doi.org/10.29333/iji.2019.12322a
[10] Caycı, B. (2018). The impacts of conceptual change text-based concept teaching on various variables. *Universal Journal of Educational Research*, *6*(11), 2543–2551. https://doi.org/10.13189/ujer.2018.061119
[11] Cetin, G., Ertepinar, H., & Geban, O. (2015). Effects of conceptual change text based instruction on ecology, attitudes toward biology and environment. *Educational Research and Reviews*, *10*(3), 259–273. https://doi.org/10.5897/err2014.2038
[12] Cetingul, I., & Geban, O. (2011). Using conceptual change texts with analogies for misconceptions in acids and bases. *H.U. Journal of Education*, *41*(1), 112–123.
[13] Cinici, A., & Demir, Y. (2013). Teaching through cooperative poe tasks: A path to conceptual change. *The Clearing House*, *86*(1), 1–10. https://doi.org/10.1080/00098655.2012.712557
[14] Costu, B., Ayas, A., & Niaz, M. (2012). Investigating the effectiveness of a poe-based teaching activity on students' understanding of condensation. *InstrSci*, *40*(1), 47–67. https://doi.org/10.1007/s11251-011-9169
[15] Dagdelen, O., & Kosterelioglu, I. (2015). Effect of conceptual change texts for overcoming misconceptions in "people and management " unit. *International Electronic Journal of Elementary Education*, *8*(1), 99–112.
[16] Duda, H. J., & Adpriyadi, A. (2020). Students' misconception in concept of biology cel. *Anatolian Journal of Education*, *5*(1), 47–52. https://doi.org/10.29333/aje.2020.515a
[17] Durmus, J., & Bayraktar, S. (2010). Effects of conceptual change texts and laboratory experiments on fourth grade students' understanding of matter and change concepts. *Journal of Science Education & Technology*, *19*(5), 498–504. https://doi.org/10.1007/s109566-010-9266-9
[18] Eggen, P. D., Kauchak, D. P., & Garry, S. (2004). *Educational psychology* (P. Prentice, Ed.).
[19] Gernale, J. P., Aranes, F. Q., & Daud, V. (2015). The effects of predict-observe-explain (poe) approach on students' achievement and attitudes towards science. *The Normal Lights*, *9*(2), 1–23.
[20] Gurel, D. K., Eryilmaz, A., & McDermott, L. C. (2015). A Review and Comparison of Diagnostic Instruments to Identify Students' Misconceptions in Science. *Eurasia Journal of Mathematics, Science and Technology Education*, *11*(5), 989–1008. https://doi.org/10.12973/eurasia.2015.1369a
[21] Hake, R. R. (1999). *Analyzing change/gain scores*. http://www.physics.indiana.edu/-sdi/Analyzing
[22] Hilario, J. S. (2015). The use of predict-observe-explain-explore (poee) as new teaching strategy in general chemistry-laboratory. *International Journal of Education and Research*, *3*(2), 37–48.
[23] Joyce, C. (2006). *Predict, observe, explain (poe)*. https://arbs.nzcer.org.nz/strategies/poe.php.
[24] Karamustafaoglu, S., & Mamlok-Naaman, R. (2015). Understanding electrochemistry concepts using the predict-observe-explain strategy. *Eurasia Journal of Mathematics, Science and Technology Education*, *11*(5), 923–936. https://doi.org/10.12973/eurasia.2015.1364a
[25] Kibirige, I., Osodo, J., & Tlala, K. M. (2014). The effect of predict-observe-explain strategy on learners' misconceptions about dissolved salts. *Mediterranean Journal of Social Sciences*, *5*(4), 300–310. https://doi.org/10.5901/mjss.2014.v5n4p300
[26] Kuczmann, I. (2017). The structure of knowledge and students' misconceptions in physics. *AIP Conference Proceedings*, *1916*(December), 1–6. https://doi.org/10.1063/1.5017454
[27] Mancuso, V. J. (2010). *Using discrepant events in science demonstrations to promote student engagement in scientific investigations: An action research study*. University of Rochester, New York.
[28] Marks, J. B. (2014). The predict-observe-explain technique as a tool for students' understanding of electric circuits. *The International Conference of Physics Education: Active Laerning in a Changing World of New Technology*, 1–11.
[29] Martin, R. E., Sexton, C. M., & Gerlovich, J. A. (2001). *Teaching science for all children*. Allyn and Bacon.
[30] Neolaka, F., & Corebima, A. D. (2018). Comparison between correlation of creative thinking skills and learning results, and correlation of creative thinking skills and retention in the implementation of predict observe explain (poe) learning model in senior high schools in Malang, Indonesia. *Educational Process: International Journal*, *7*(4), 237–245. https://doi.org/10.22521/edupij.2018.74.2
[31] Nieveen, N. (1999). Prototyping to Reach Product Quality. In T. Plomp, N. Nieveen, K. Gustafson, R. M. Branch, & V. Den Akker (Eds.), *Design Approach and Tools in Education & Training*. Kluwer Academic Publisher.
[32] Ojose, B. (2015). Students' misconceptions in mathematics: Analysis of remedies and what research says. *Ohio Journal of School Mathematics*, *72*(1), 30–34.

[33] Onder, I. (2017). The effect of conceptual change texts supplemented instruction on students' achievement in electrochemistry. *International Online Journal of Educational Sciences*, *9*(4), 969–975. https://doi.org/10.15345/iojes.2017.04.006

[34] Ozkan, G., & Selcuk, G. (2013). The use of conceptual change texts as class material in the teaching of "sound" in physics. *Asia=Pasific Forum on Science Learning & Teaching*, *14*(1), 1–22.

[35] Ozkan, G., & Selcuk, G. S. (2015). Effect of technology enhanced conceptual change texts on students' understanding of Buoyant force. *Universal Journal of Educational Research*, *3*(12), 981–988. https://doi.org/10.13189/ujer.2015.031205

[36] Ozmen, H., & Naseriazar, A. (2018). Effect of simulations enhanced with conceptual change texts on university students' understanding of chemical equilibrium. *Journal of the Serbian Chemical Society*, *83*(1), 121–137. https://doi.org/10.2298/JSC161222065O

[37] Pandiangan, P., Sanjaya, I. G. M., & Jatmiko, B. (2017). The validity and effectiveness of physics independent learning model to improve physics problem solving and selfdirected learning skills of students in open and distance education systems. *Journal of Baltic Science Education*, *16*(5), 651–665. https://doi.org/10.33225/jbse/17.16.651

[38] Phanphech, P., & Tanitteerapan, T. (2017). The development of a model to promote predict, observe, explain strategies for teaching about electric circuits in virtual environments. *The Asian Conference on Technology in The Classroom 2017*.

[39] Queloz, A. C., Klymkowsky, M. W., Stern, E., Hafen, E., & Köhler, K. (2017). Diagnostic of students' misconceptions using the biological concepts instrument (bci): A method for conducting an educational needs assessment. *PLoS ONE*, *12*(5), 1–18. https://doi.org/10.1371/journal.pone.0176906

[40] Rini, A. P., Suryani, N., & Fadhilah, S. S. (2018). Development of predict observe explain (poe)-based thematic teaching materials. *International Journal of Educational Research Review*, *4*(1–7), 206–215. https://doi.org/10.15548/jt.v25i3.464

[41] Rohmawatiningsih, W., Sopandi, W., & Surtikanti, H. K. (2018). The students' conceptual change using poe strategy assisted by air properties-experimental kit. *International Conference on Elementary Education*, *September*, 625–634.

[42] Setyaningrum, V., & Sopandi, W. (2015). Pengaruh teks perubahan konseptual terhadap pemahaman siswa pada materi suhu dan kalor. *Prosiding Seminar Nasional Fisika 2015 Mataram Lombok*, 1–6.

[43] Soeharto, Csapo, B., Sarimanah, E., Dewi, F. I., & Sabri, T. (2019). A review of students' common misconceptions in science and their diagnostic assessment tools. *Jurnal Pendidikan IPA Indonesia*, *8*(2), 247–266. https://doi.org/10.15294/jpii.v8i2.18649

[44] Sreerekha, S., Arun, R. R., & Swapna, S. (2016). Effect of predict-observe-explain strategy on achievement in chemistry of secondary school students. *International Journal of Education & Teaching Analytics*, *1*(1), 1–5.

[45] Stepans, S. (2011). *Targeting students' science misconception: Using the conceptual change model*. Saiwood Publications.

[46] Sudarminata, J. (2002). *Tantangan dan permasalahan pendidikan di Indonesia memasuki milenium ketiga dan transformasi pendidikan*. Rajawali Press.

[47] Suparno, P. (2005). *Miskonsepsi perubahan konsep dalam pendidikan fisika*. Grasindo.

[48] Teo, T. W., Yan, Y. K., & Goh, M. T. (2016). Using prediction-observation-explanation-revision to structure young children's learning about floating and sinking. *The Journal of Emergent Science (JES)*, *10*(1), 12–23.

[49] Thiagarajan, S., Semmel, D. S., & Semmel, M. I. (1974). *Instructional Development for Training Teachers of Exceptional Children*. Indiana University.

[50] Yurukk, N., & Eroglu, P. (2016). The effect of conceptual change texts enriched with metaconceptual processes on pre-service science teachers' conceptual understanding of heat and temperature. *Journal of Baltic Science Education*, *15*(6), 693–705.