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PHYSICS ARGUMENTATION-BASED COMPUTER-SUPPORTED COLLABORATIVE HYBRID LEARNING TO INCREASE CONCEPT MASTERY AND ARGUMENTATION SKILLS

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ABSTRACT

This study aims to increase the level of concept mastery and argumentation of senior high school students in Singkawang City, West Kalimantan Province, Indonesia. The Physics Argumentation-Based Computer-Supported Collaborative Hybrid Learning (PABCSCHL) model in Socio-Scientific Issues (SSI) especially on the topic of the forest fire on the peatlands has been developed with good validation categories by three pedagogical validators and three assessment validators and been implemented to 200 students. Their argumentation skill levels are measured based on Toulmin Argumentation Pattern. The syntax of the PABCSCHL model is Reading (online), Concept Building, Discussing and Debating (offline), Experiment Designing (online), and Experiment Doing (offline). The core of this model is student collaboration in arguing, debating, and experimenting. From this research, most student solution to anticipate the fire forest on peatlands is burning and waiting until the fire is extinguished perfectly (70 students), monitoring periodically that the fire is completely extinguished (60 students), and limiting the burned area by digging trenches around the site (50 students). Student solutions describe students' understanding of solving problems posed in group discussion sessions and debates and prove their arguments with experimental data. Before implementing the model, no student has the highest level of argumentation and concept mastery. After that, 23 students have the highest level of concept mastery, and 25 students have the highest level of argumentation. The PABCSCHL model can increase the level of concept mastery and argumentation skills. This model is a new alternative hybrid learning in the post COVID-19 pandemic. Many more SSI can be learning topics to be implemented in this model.

Keywords: argumentation; concept mastery; socio-scientific; hybrid learning

INTRODUCTION

Toulmin's Argumentation Pattern (TAP) is an argumentation pattern that begins with the submission of a claim to a fact, a claim can be supported or refuted by submitting data, but the data needs to be collected validly. For scientific argumentation, empirical data is needed resulting from experimental or investigation activities (Erduran, 2015; Chen, 2016; Arias, 2017; Fishman, 2017; Erduran, 2018; Osborne, 2019; Lazarou, 2021). Indonesia and all countries in the world are currently in the era of the COVID-19 endemic which has an impact on the world of education. Learning that is done face-to-face (offline learning) turns into learning in a network (online learning) or a mixture of both in blended learning or hybrid learning (Chen, 2014; Jamison, 2014; Hwang, 2018; Aristika, 2021; Mettis, 2021; Guppy, 2022; Latifi, 2023; Zheng, 2023).

In hybrid learning, the composition of online and offline learning is presented in a balanced, independent manner (clearly separated between online and offline), and alternately re-

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gularly (offline-online-offline-online) (Tan, 2017; Aristika, 2021; Mettis, 2021; Latifi, 2023; Zheng, 2023). This study choose hybrid learning because in the COVID-19 endemic era, if a new case of COVID-19 occurs which requires learning to be done online, then hybrid learning is a solution. The implementation of Hybrid learning requires a computer/laptop that is connected to the internet (Tan, 2017; Wallon, 2018; Lin, 2020; Noroozi, 2020; Aristika, 2021; Mettis, 2021; Latifi, 2023; Zheng, 2023).

By using computers and the internet, it is easier to communicate that is not limited by space and time during learning interactions that require students to actively collaborate with other students (Lin, 2017; Hwang, 2018; Wallon, 2018; Aristika, 2021; Mettis, 2021; Raes, 2022; Guppy, 2022; Akbari, 2023). More specific communication in learning physics or science is an argument that is supported by scientific concepts or facts (McNeill, 2013; Cetin, 2014; Crowell, 2014; Bathgate, 2015; Batlolona, 2018; Murphy, 2018; Sengul, 2019).

Kalimantan Island is the largest island in the country of Indonesia. The largest province in Kalimantan is West Kalimantan. Kalimantan's soil is dominated by peat soil. Almost every year there are fires in this peatland as a result of land clearing by the community by burning the land (Eilenberg, 2022; Hayasaka, 2020). By looking at this, the attitudes and arguments of students in this phenomenon can be explored. For this reason, it is very interesting to bring this phenomenon into learning, for example in Physics Learning. Forest fires are closely related to physics, especially in the content of "substance, temperature, and heat". By bringing the topic of forest fires into the context of student discussion and then students debating on this topic, it has presented contextual and meaningful learning for students. These discussions and debates will involve students' argumentation skills and students' conceptual understanding skills. Regional characteristics are raised and included in learning, it is interesting to study the impact of student learning and student skills on argumentation skills and understanding concepts (Ozden, 2020; Sadler, 2021; Sakamoto, 2021; Sparks, 2022; Durak, 2023).

Arguments based on an understanding of the concept will be a strong foundation for arguing. Many phenomena in society can be studied scientifically, which is termed the Socio-Scientific Issue (SSI) and can be used as a learning theme for students' problem-solving (Sadler, 2017; Batlolona, 2018; Ozden, 2020; Sadler, 2021; Sakamoto, 2021; Sparks, 2022; Durak, 2023; Ouyang, 2023).

The demands of 21st-century life require humans to have the skills to be able to collaborate, argue, solve problems, and make decisions (Kaufman, 2013; Larson, 2013; Geisinger, 2016; Häkkinen, 2017; Van Laar, 2017; Batlolona, 2018; Fang, 2019; Khosravi, 2019; Sparks, 2022; Latifi, 2023; Ouyang, 2023). Learning Physics is expected to provide skills but based on the results of interviews with physics teachers at ten high schools in the city of Singkawang, West Kalimantan, Indonesia, it is obtained information that students are less able to explain science concepts. However, students are better able to solve mathematical problems. The impact is that during learning interactions that require students to answer teacher questions orally, it appears that students' argumentation skills are still low because they convey answers or arguments without evidence or reasons to strengthen their answers. This means that there is a problem with low student argumentation skills in involving data, evidence, or reasons.

The results of other interviews are that the student concept mastery is still low. This is the main factor that hinders argumentation because it argues without a scientific basis or knowledge, only claims without conceptual support as a basis for argumentation. It is also found that collaboration, problem-solving, and decision-making skills are felt by teachers to be lacking in teaching physics. From here, 21st-century learning requires a collaborative learning process between students, and after COVID-19 which requires learning to be held online and offline learning, collaborative learning in blended or hybrid learning is important to be designed and implemented by teachers (McNeill, 2013; Tan, 2017; Giri, 2020; Guppy, 2022; Raes, 2022; Ouyang, 2023; Zheng, 2023). This study choose hybrid learning because it has a balanced composition between online and offline meetings, while blended learning is still dominated by offline learning. Previous research has not been carried out in a fully collaborative manner, there is still a lot of blended learning, has not raised the local wisdom of SSI for learning topics, and has not integrated argumentation-based learning as a whole which involves claims, evidence, warrants, backing, qualifier, and rebuttal (Häkkinen, 2017; Spark, 2022; Xu, 2023).

Collaborative learning and argumentation are very possible to be implemented simultaneously. Collaborative learning settings in group discussions and debates between groups discussing SSI, arguing in groups, and refuting other groups in debates, followed by proving arguments by conducting experiments, are an appropriate form of debriefing to equip students' argumenta-

tion skills and understanding students' concepts. This study offers the implementation of the Physics Argumentation-Based Computer-Supported Collaborative Hybrid Learning (PABCSCHL) model which is developed by the researchers themselves to increase the Level of Understanding of Concepts and the Level of Argumentation of students in Making Decisions on Socio-Scientific Issues in a society related to the topic of Forest Fires in Kalimantan's Peatlands.

METHODS

Before the PABCSCHL model treatment, it was found that students' understanding of concepts was still low, seen from the final test of the material with an average score in the range of 30-60 out of a maximum score of 100. There were always students who were remedied because they did not pass a passing grade of 60. The implementation of physics learning in schools had not has provided arguments involving data, evidence, guarantees of belief in the correctness of opinions, scientific support, and refutations. Learning using the debate method that had taken place in schools until now had not been followed by proving group claims, for example, proving by conducting an experiment.

This research aims to determine how student learning in the PABCSCHL model on Socio-Scientific Issues (SSI) is, how the increase of students' argumentation skill levels based on the Toulmin Argumentation Pattern (TAP), and also how the increase of concept mastery levels after model implementation. Post COVID-19 requires learning that can collaborate online and offline learning, one of which is hybrid learning. Hybrid learning in schools has not been programmed properly and has not found the right method/ model or pattern following the characteristics of learning physics. For this reason, PABCSCHL is a hybrid physics learning solution.

Based on the aims above, this research used a pre-experimental design in a specific one-group pretest-posttest design following the flow of research methodology from Creswell (2018), in which a single group of research participants or subjects was given a pretest, treatment with the PABCSCHL model implementing as the dependent variable for increasing the level of argumentation and the concept mastery as the independent variable, and posttest as the end of the study to determine the differences between argumentation and concept mastery levels before and after implementation of the model. The sample of this research was 200 students from 10 senior high schools in Singkawang City, West Kalimantan Province, Indonesia. The PABCSCHL model developed and implemented as the new learning model on 21st-century learning required a collaborative learning process between students, and after the COVID-19 pandemic or in the new normal era which required learning to be held online and offline learning. Collaborative learning in hybrid learning was important to be designed and implemented by teachers (Giri, 2020; Guppy, 2022; Raes, 2022). This study chose hybrid learning because it had a balanced composition between online and offline meetings.

SSI in the model implementation was related to how to anticipate and solve the forest fire on peatlands. The forest fire topic was chosen because it was an existing local-wisdom phenomenon caused by human error so it was a very contextual topic in students' daily life. PABCSCHL model had been developed with the good validation categories by three pedagogical validators and three assessment validators (Professor, Senior Lecturer, and Senior Teacher), including the validation of pretest and posttest questions regarding the level of understanding of concepts and the level of student argumentation, with high reliability.

The components of TAP were claim (statement), ground (data), warrant (guarantee/ proof), qualifier (quality), backing (supporting), and rebuttal (refutation) (Erduran, 2018; Osborne, 2019; Lazarou, 2021). The syntax of the PABCSCHL model was Reading (online), Concept Building, Discussing and Debating (offline), Experiment Designing (online), and Experiment Doing (offline). The core of this model was student collaboration in arguing, debating, and experimenting.

The argumentation skills were observed continuously by observers through observation sheets during group discussions and debates. The TAP level rubric contained: Level 1: arguments only consist of claims; Level 2: arguments consist of claims and evidence; Level 3: arguments consist of claims, evidence, and warrants; Level 4: arguments consist of claims, evidence, warrants, and backings; and Level 5: arguments consist of claim, evidence, warrant, backing, qualifier, and rebuttal (Erduran, 2018; Osborne, 2019; Lazarou, 2021).

The last aim was The Concept Mastery Level, which consisted of Level 1: no understanding, Level 2: specific misconception, Level 3: partial understanding with a specific misconception, Level 4: partial understanding, and Level 5: sound understanding. The level of concept mastery was measured using an essay test that re-

quired verbal and picture responses. The concept mastery level rubric was based on the Concept mastery Level by Abraham (2013) with Level 1: blank answers, answers in the form of repeating questions, answers that are irrelevant or unclear, and do not provide explanations for answer choices; Level 2: scientifically incorrect answers, differences in concepts that are believed to be true but actually contradict the concepts held by scientists; Level 3: some of the answers given show the correct understanding of the concept, but some of the answers still contain misconceptions; Level 4: answers contain parts of scientifically accepted concepts; and Level 5: answers contain all the correct and complete understanding of the concept. Before the PABCSCHL model treatment, it was found that students' understanding of concepts was still low, seen from the final test of the material with an average score in the range of 30-60 out of a maximum score of 100. There were always students who were remedied because they did not pass a passing grade of 60. The implementation of physics learning in schools had not has provided arguments involving data, evidence, guarantees of belief in the correctness of opinions, scientific support, and refutations. Learning using the debate method that has taken place in schools until now has not been followed by proving group claims, for example proving by conducting an experiment.

Post COVID-19 requires learning that can collaborate online and offline learning, one of which is hybrid learning. Hybrid learning in schools has not been programmed properly and has not found the right method/model or pattern following the characteristics of learning physics. For this reason, PABCSCHL is a hybrid physics learning solution.

Concept understanding level data and argumentation level data were analyzed using descriptive statistics.

RESULTS AND DISCUSSION

The syntax of the PABCSCHL Model is Reading (online), Concept Building, Discussing and Debating (offline), Experiment Designing (online), and Experiment Doing (offline). The core of this model is student collaboration in arguing, debating, and experimenting. The SSI in this research is about The West Kalimantan Forest Fire (Figure 1) and how to solve it. In PABCSCHL, students are given a problem to be solved by themself. The solution is presented with Toulmin Argumentation Pattern that is supported by concept and data. Then their argumentation is analyzed to the argumentation level.

Figure 1. Screen-shoot of the SSI Problem

The SSI problem is given in Figure. 1. Students' answers to provide solutions to solve the forest fire are summarized in Table 1.

Table 1. Students' Solutions to the SSI Problems

Student Solution	Number of Students	Percentage
Opening plantation land not by burning the land	10	5%
Burning and waiting until the fire is extinguished perfectly	70	35%
Monitoring periodically that the fire is completely extinguished	60	30%
Limiting the burned area by digging trenches around the site	50	25%
Needing permission to open the land officially according to state regulations	10	5%

Based on Table 1, there are 5 methods of the student solution to anticipate the fire forest on peatlands. The methods are opening plantation land not by burning the land (5%) and needing permission to open the land officially according to state regulations (5%). If there is a forest fire during land clearing, before this happens, it must wait so that the fire does not spread to other areas and the fire has been extinguished perfectly (35%), limiting the burned area by digging trenches around the site (25%), and monitoring periodically that the fire is completely extinguished (30%).

The following is a summary description of the students' arguments in the case of forest fires that have been given. Peatland fires are events that are difficult to predict. It is caused by complex peat soil characteristics and other natural factors such as wind direction, vegetation status, and water content in peat soil. When entering the dry season, the water content in the peat soil will decrease, so the potential for fires will be higher. Peat soil becomes dry in the dry season, triggering fires (Hayasaka, 2020; Ningrum, 2020; Eilenberg, 2022). In conditions where peat soil is degraded due to land clearing and drainage, peat water will easily flow out so that the peat soil becomes dry. Dry peat soil makes peat soil a potential fuel that is highly flammable. In its development, the fire spreads vertically and horizontally in the form of a smoke bag with smoldering combustion so that only white smoke appears above the surface (Eilenberg, 2022).

Hayasaka et al. (2020) find that peat fires occur in three stages, namely surface fires, shallow peat fires, and deep peat fires. The characteristic of peat depth is a major factor in estimating carbon stocks in peatlands. This peat soil can absorb water which is related to the availability of carboxylic and OH-phenolic groups (Ningrum, 2020). Climatic conditions or rainfall that occur will also be closely related to the water level contained in it. The incidence of fires will be very low when the rainy season has stabilized when it rains almost every day. In this condition, forests and peatlands will be inundated by water so that the peat soil has a high-water content and is difficult to burn (Hayasaka, 2020; Ningrum, 2020; Eilenberg, 2022).

Based on the results of the analysis, it is found that the efforts to prevent and control land fires that had been carried out by the community and the Fire Care Community group before the fire occurred are (1) making water reservoirs (canal blocking, holding ponds, etc.); (2) when a fire occurs, it is to look for water to extinguish a fire and (3) after a fire occurs, it is law enforcement. The cause of forest and peatland fires is believed to be 90% due to human activities, and the remaining 10% due to natural events. The fire disaster on peatlands has an impact on the occurrence of smoke disasters which widely cause environmental damage in the form of air pollution and ecosystem damage, as well as economic and social losses that also threaten public health. Fires in peatlands do not only burn the ground on the surface but also spread and are difficult to control within the peat soil itself (Hayasaka, 2020; Ningrum, 2020; Eilenberg, 2022).

Based on the student's explanation, it has indicated that the students have good argumentation skills supported by a good understanding of the concept as well. Furthermore, the level of student argumentation in full based on the Toulmin Argumentation Pattern is summarized in Figure 2.

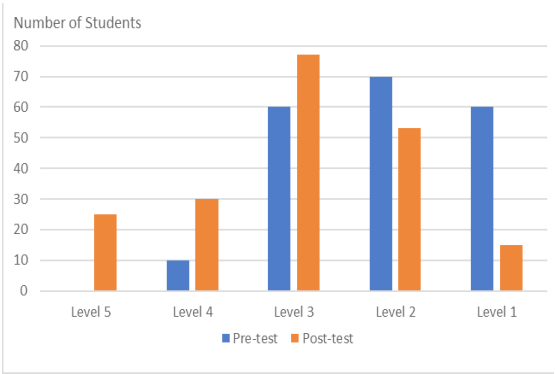

Figure 2. Students' Argumentation Level based on TAP

Based on Figure 2, the level of students' argumentation skills increases after SSI-based learning is held. There are 25 students at the highest level after learning treatment. Before treatment, no one of the students was at this level. The learning process of SSI should be able to increase the level of argumentation skills because the topic or theme of SSI is very relevant to the real world, daily life, contextual, and concrete not abstract (Sadler, 2016; Sadler, 2017; Ozden, 2020; Sadler, 2021; Sakamoto, 2021; Arslan, 2023; Banihashem, 2023; Chan, 2023; Durak, 2023; Mou, 2023). Students are given the freedom in thinking and creativity in conducting experiments to find solutions to the problem of forest fires in the peatlands.

The quality of argumentation is strongly supported by the level of understanding of students' concepts (Cetin, 2014; Wicaksono, 2017; Batlolona, 2018; Murphy, 2018; Anwar, 2019; Arslan, 2023; Banihashem, 2023; Chan, 2023; Mou, 2023; Noroozi, 2023). It appears that none of the students with the highest level of argumentation (level 5) before the synchronous treatment and none of them had an understanding of the concept of the upper level (level 5). More complete levels of student concept mastery can be seen in Figure 3.

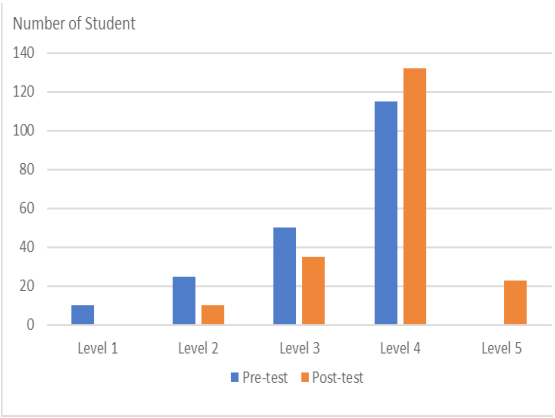

Figure 3. Students' Concept Mastery Level

Based on Figure 3, the level of concept mastery increases before treatment and after treatment with SSI-based learning. After learning implementation, there are 23 students in the highest-level category, from before the treatment no one was at this level. SSI-based learning has developed students' thinking skills because the learning setting is student-centered, active students, based on group discussions for problem-solving that require them to have arguments so that thinking skills are explored which leads to understanding the concepts (Cetin, 2014; Batlolona, 2018; Murphy, 2018; Fang, 2019; Khosravi, 2019; Giri, 2020; Sparks, 2022; Buseyne, 2023; Durak, 2023; Jensen, 2023; Mou, 2023; Nielsen, 2013; Ouyang, 2023). The students themselves find the concepts and it is appropriate level (Wicaksono, 2017; Anwar, 2019; Chan, 2023; Jensen, 2023). The concept mastery level after implementing SSI-based learning increases.

A person's argumentation skill is strongly supported by an understanding of the concepts that exist in him/her. For the argument to be strong, it needs to be based on a correct understanding of the concept. Therefore, the level of understanding of a person's concept is very influential on the level of argumentation skill (Batlolona, 2018; Murphy, 2018; Anwar, 2019; Osborne, 2019; Sengul, 2019; Lazarou, 2021; Arslan, 2023; Banihashem, 2023; Chan, 2023; Mou, 2023). Argumentation skills play a role in determining decision-making to solve problems or SSI that occur in society because argumentation provides the foundation for decision-makers, helps decision-makers to choose the best decision options from all available decision alternatives to solve problems, and make decisions (Durak, 2023; Ouyang, 2023). It helps a person make decisions consciously and pay attention to the consequences of the decisions they make (Häkkinen, 2017; Batlolona, 2018; Fang, 2019; Khosravi, 2019; Sparks, 2022; Arslan, 2023; Chan, 2023; Ouyang, 2023).

Arguing is often colored by debates and arguments (Crowell, 2014; Arias, 2017; Fishman, 2017; Lin, 2017; Özdem, 2017; Erduran, 2018; Osborne, 2019; Sengul, 2019; Buseyne, 2023; Chan, 2023). For each person's opinion or views to be taken into account, he must have good argumentation skills (Berland, 2013; Bathgate, 2015; Chen, 2016; Arslan, 2023; Banihashem, 2023; Chan, 2023). Any views, opinions, or claims submitted by him/her must be supported by valid data and evidence. If it is not supported by strong data or evidence, the opinion may be considered mere nonsense and tends to justify rather than prove it (Khishfe, 2013; Msimanga, 2013; Erduran, 2018; Osborne, 2019; Sengul, 2019; Lazarou, 2021; Chan, 2023). In a debate, sometimes you have to refute other people's opinions, so the rebuttal must be accompanied by data/facts that show the other person's opinion is wrong and unfavorable to the existing situation/problem and has not answered the problem (Buseyne, 2023; Ouyang, 2023). For someone to be able to show data as evidence, they need expertise in collecting the data or evidence. If the data is empirical then it must be collected through experiments or investigation activities (Häkkinen, 2017; Batlolona, 2018; Lazarou, 2021; Buseyne, 2023; Ke et al., 2023). Related to scientific learning, investigations or experiments need to be carried out to collect the data to be used to support or refute a claim in the frame of scientific argumentation (Buseyne, 2023; Ke et al., 2023).

CONCLUSION

The Physics Argumentation Based Computer Supported Collaborative Hybrid Learning (PABCSCHL) model in Socio-Scientific Issues (SSI) on the forest fire topic in West Kalimantan has been implemented in the students and has increased the level of the argumentation skill and the concept mastery. Students have been able to provide solutions or methods to anticipate the fire forest on peatlands. The PABCSCHL with SSI is very easy to be implemented because it is very local wisdom, concrete, and contextual to the students. Students are very interested and excited in the debate session. They argue and refute the opinions of others freely without pressure and coercion. Their ideas and thoughts are more explored and elaborated. The PABCSCHL model is implemented not only in the topic of the Forest Fire on the "Substance, Temperature, and Heat". Teachers and even lecturers can implement the PABCSCHL model in all physics topics. All physics topics can be taught in hybrid learning, discussion, debate, and experimentation.

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