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SOCIO SCIENTIFIC ISSUES-BASED LEARNING FOR INCREASING ARGUMENTATION AND CONCEPT MASTERY LEVEL ON GROUNDWATER PURIFICATION TECHNOLOGY

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Abstract

The purpose of this study was to increase the argumentation and concept mastery level of socio-scientific issues (SSI) on groundwater purification technology. The argumentation is based on Toulmin Argumentation Pattern. The number of samples is 100 students. SSI is focused on West Kalimantan groundwater purification technology which has a high iron content. Students have been able to provide solutions to purify groundwater/ponds/wells from high iron content, oily, smell, and taste with 3 verified methods, namely deposition/settling methods, filtration, and a combination of deposition and filtration. SSI-based learning has increased the level of argumentation skills and concept mastery. Before the implementation SSI based learning, among 100 students no student has the highest level. After the implementation SSI based learning there are 25 students had the highest level of argumentation skills and 20 students have the highest level of concept mastery.

Keywords: Argumentation level, Concept mastery level, Groundwater purification technology, Socio-scientific issue.

1. Introduction

Toulmin's Argumentation Pattern 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 [1]. In physics or science learning, an argument is needed for scientific communication. Argumentation must be supported by scientific concepts or facts or data. The ability to argue involve the components of Toulmin's argumentation (claim (statement), ground (data), warrant (guarantee/proof), qualifier (quality), backing (supporting), and rebuttal (refutation)) [2-4]. Many phenomena in society can be studied scientifically, which is termed the Socio-Scientific Issue (SSI). SSI is a contemporary controversial issue arising from the advancement of science and technology. Learning using SSI is learning that displays controversial social issues related to science [5-7]. Problem-solving of SSI requires understanding the concept and expressing it requires argumentation skills. SSI can be used as a learning theme for problem-solving. This study raised the theme of underground water purification technology. This research is done by implementing SSI-based learning to increase the level of Argumentation Skills and Concept Mastery.

2. Literature Review

2.1. Argumentation skill

The argumentation skill assessment is based on the Toulmin argumentation level rubric (level 1 to level 5). Level 1 is arguments that only consist of claims. Level 2 is arguments that consist of claims and evidence. Level 3 is arguments consisting of claims, evidence, and warrants. Level 4 is arguments consisting of claims, evidence, warrants, and backings. Level 5 is arguments consisting of claim, evidence, warrant, backing, qualifier, and rebuttal [1-4].

2.2. Concept mastery

A person's ability to interpret (construct) an existing concept based on the basic knowledge possessed by using one's own words and being able to make connections with new knowledge [8]. Concept mastery level is the level of concept mastery consisting 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). Level 1 is no understanding or 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 is scientifically incorrect answers, differences in concepts that are believed to be true but contradict the concepts held by scientists. Level 3 is some of the answers given to show the correct understanding of the concept, but some of the answers still contain misconceptions. Level 4 answers contain parts of scientifically accepted concepts. Level 5 is the answer that contains all the correct and complete understanding of the concept [9].

2.3. Clean water

The physical requirements of clean water are the requirements of water that can be sensed whether by the sense of sight, smell, or taste [10]. Water should be clear,

clean, colourless, smelly, and tasteless. Iron is one of the elements that are the result of weathering of parent rocks that are found in many common glasses of water, iron compounds in water are generally in the form of ferrous salts or ferrous salts with the 2nd-valence. Iron content in water can cause water to be brown-reddish or yellow-rusty, cause a fishy smell, and form an oil-like coating [13-14].

3. Methods

The sample in the implementation of SSI-based Learning was 100 students in the Department of Mathematics and Natural Sciences of STKIP Singkawang, Indonesia. The ability of argumentation is assessed by giving the problem of SSI to the student and they answer the problem by giving a solution based on Toulmin Argumentation Pattern. The issue is about west Kalimantan groundwater purification technology which has a high iron content. The argumentation ability assessment is carried out by referring to the Toulmin argumentation level rubric [1]. Argumentation should be supported by concept mastery for scientific reasoning. This research also measured the level of concept mastery that using in their argumentation based on the rubric for concept mastery level [9].

4. Results and Discussion

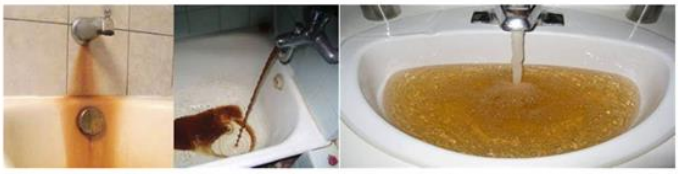
SSI is about The West Kalimantan Groundwater having a high iron content level. In SSI-based Learning, students are given a problem to be solved by themself. The solution is presented with Toulmin Argumentation Pattern that is supported by concept and data. Then their argumentation is analysed to the argumentation level. The SSI problem is given in Fig. 1. Students' answers to provide solutions to groundwater with high iron content and turbid yellow and odorous water are summarized in Table 1. Based on Table 1, 3 methods of water purification are settling, filtration, and a combination of settling and filtration.

In the settling method, students explained that by dissolving the water lime in the storage tank and stirring until evenly distributed, allowed to stand/precipitate for approximately 1 h, it has purified well water with high iron content. The disadvantage of this method is that it still leaves a precipitate but does not leave yellow rust hard stains.

The second method is the filtering method. Students explained that draining the well water in a filtration system with an arrangement from top to bottom foam, sand, charcoal, stone, and thatch purified the water. The disadvantage of this method is that the filtration system must be made high, and each array must be high/thick to get maximum results.

The third method is a combination of settling and filtering. Students explained that by dissolving the water lime in the well water storage tank and stirring until evenly distributed, let it stand/precipitate for 1 h, then the water is filtered through a filtration system with the arrangement from top to bottom is sand, coax and stone, it produces water that is much clearer than the filtration method. The disadvantage of this combination method is a long process due to 2 processes (settling and filtering) and the infrastructure that must be built is multilayer. The upper level is the settling system. The lower level is a filtration system. With the nature of water flowing from high places to low places, the infrastructure built must have a

significant difference in the height between the system of settling, filtration, and installation of pipes that drain water into the house.



The West Kalimantan area is an area where the iron content on the soil is very high. Often if you make well/pond water by digging the ground or by drilling the ground up to several meters, you will get a source of groundwater that is rusty yellow and surfaced water like there is shiny oil. If the water is stored in a shelter such as a ceramic/cement bathtub or plastic drum, the surface of the wall will stick yellow dirt and at the bottom of the floor there will be yellow deposits from the iron hard sheet contained by the water. If water is used for washing, the white clothes will be dirty yellow. If water is used to wash dishes, it will also leave yellow stains on the dishes. If water is used for bathing, the water smells and the skin feel perverted. Seeing this phenomenon what can you do in providing a clean water solution that comes from the well/pond water or drilled well above? Conduct experiments to purify the water, and so that the water does not smell and is tasteless. Argue your solution based on the Toulmin Argumentation Pattern (TAP).

Fig. 1. The SSI problem on groundwater purification.

Table 1. Distribution of student solutions to the SSI problem.

Student Solution	Solution Description	Students Percentage	Physical quality of water
Deposition /settling	Dissolve the water lime on the holding tank and mix evenly. Let it stand/precipitate for 1 hour and then the water is ready to flow into the house.	20%	clear, non-greasy, slightly smelling of lime, tasteless, leaving little sediment but not a yellow stain of iron rust
Settling and Filtering	Dissolve the water lime in the well water storage tank and mix thoroughly. Let stand/precipitate for 1 hour. Then the water is filtered through a filtration system with the arrangement from top to bottom is sand, thatch, and gravel.	30%	Clear, non-greasy, odorless, tasteless, and no precipitate
Filtering	Flow well water in the filtering system with an arrangement from top to bottom is foam, sand, charcoal, gravel, and thatch	50%	Clear, non-greasy, odorless, tasteless, and no leaves precipitate

Because it is high, the pump machine must have a large pressure, economically this is inefficient. It is recommended to use the filtration method only (the second method) to purify the water. The deposition/settling Method with water lime is not recommended because it still leaves stain deposits even though it is not an iron-yellow rust stain. In Fig. 2, the results of water purification before and after being filtered by the layered filtration method (porous cotton, sand, charcoal, stone, and thatch) are given.

Student arguments based on the Toulmin Argumentation Pattern already exist that show the maturity of understanding concepts such as thinking to create an effective filtration system to produce clean water. In Fig. 2., students are already able to filter water from the initial turbid, yellowish, oily, and odorous conditions to clear, non-greasy, and smelly. Based on the results of the experiment/investigation, students were able to explain that a layered/tiered filtration system with an arrangement of porous cotton, sand, charcoal, stone, and coax has filtered the water flowing slowly. The porous cotton at the top layer plays a role in roughly filtering out water deposits even in the yellow direct foam layer which indicates that there is filtered iron content. To filter further, it is slow-filtered through a thick, dense network of sand. At the top of the sand surface, it appears yellow which indicates that something is micro-filtered. Next, the water flows into the charcoal layer. Charcoal, which is activated carbon, serves to lower metal levels (Hg, Pb, Cd, Fe, Mn) by adsorbing it. Rock layers such as gravel interact chemically for purifying the water and eliminating its odor and taste. The bottom layer of the filtration system is a coax that functions as a fine sand holder so that it does not fall/collapse on the bottom which is the final container of water after filtering that is ready to be distributed through the tap and so that the tap is not entered by sand which hinders the circulation of water when flowing in household pipe installations. Based on the student's explanation, it has indicated that the student has 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 Table 2.

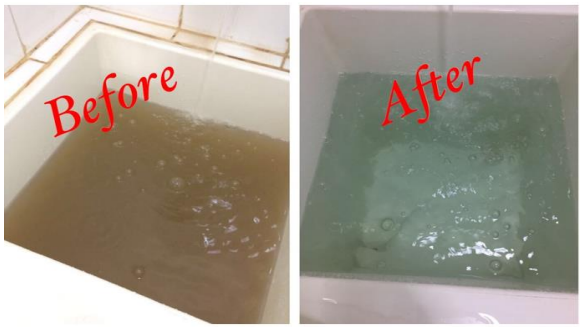


Fig. 2. Well water before and after filtering by multistage filtration method.

Based on Table 2, the level of students' argumentation skills increases after the SSI-based learning is held. 15 students are 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. Students are given freedom in thinking and creativity in

conducting experiments to find solutions to the problem of groundwater quality with high iron content.

Table 2. Distribution of students based on Toulmin argumentation level.

Level	Category	Number of students (person)	
		Before treatment	After treatment
5	Arguments consist of claim, evidence, warrant, backing, qualifier, and rebuttal	0	25
4	Arguments consist of claims, evidence, warrants, and backings	5	30
3	Arguments consist of claims, evidence, and warrants	25	30
2	the argument consists of claims and evidence	45	10
1	the argument only consists of a claim	25	5

The quality of argumentation is strongly supported by the level of understanding of students' concepts [8, 14]. It appears that none of the students with the highest level of argumentation (level 5) before the synchronous treatment with none of them having an understanding of the concept of the upper level (level 5). More complete levels of understanding of students' concepts are given in Table 3.

Table 3. Distribution of students by category of concept mastery level.

level	Category	Number of students (person)	
		Before treatment	After treatment
1	no understanding	10	0
2	specific misconception	30	10
3	partial understanding with a specific misconception	40	20
4	partial understanding	20	50
5	sound understanding	0	20

Based on Table 3, the level of concept mastery increased before treatment and after treatment with SSI-based learning. After learning implementation, there were 20 students in the highest-level category, from before the treatment no one was at this level. The SSI-based learning has developed students' thinking skills because the learning setting is student-centred, active students, based on group discussions for problem-solving that require them to have arguments [15, 16]. Thinking skills are explored which leads to understanding the concepts [27]. The students themselves find the concepts and it is appropriate level [18, 19]. The concept mastery level after the SSI-based learning is implemented. Thus, it increases. A person's argumentation ability is strongly supported by an understanding of the concepts that exist in him. 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 ability [20, 21]. 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 [22]. decisions consciously and pay attention to the consequences of the decisions they make [18, 19]. Arguing is often coloured by debates and arguments [18, 23]. For each person's opinion or views to be taken into account, he must have good argumentation skills [20, 21]. Any views, opinions, or claims submitted by him 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 [23]. 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 unfavourable to the existing situation/problem and has not answered the problem. 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. Related to science 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.

5. Conclusion

SSI-based learning has increased the argumentation and the concept mastery level on SSI, especially on the technology of purifying groundwater. Students can provide solutions to purify groundwater/ponds/wells from high iron content, oily, smell, and taste. Before education treatment, no student has the highest level. After treatment, 25% have the highest level of argumentation skills, and 20% have the highest level of concept mastery.

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