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Validity of learning devices of buffer solution material based on dilemma stories to increase students' sustainability awareness

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Abstract. Awareness of protecting the environment continuously or called sustainability awareness should be built through education. This study intent to develop learning devices based on dilemma stories in Buffer Solution subject matter to improve students' sustainability awareness. Through the dilemma stories, students' critical thinking skills and problem solving were trained. The research method used the 4D model. The research subjects consisted of 5 validators and 5 high school students to test readability. Because of the COVID-19 pandemic, the data collection using questionnaire conducted online by email and whatsapp. To test the validity and readability of student worksheet and the dilemma story sheet developed, the CCVLES (Constructivist Chemistry Values Learning Environment Survey) questionnaire and Aiken's content validation sheet were used. Analysis of the data used descriptive. The results showed that the learning devices developed were valid with an average score of validity of 0.93. The criteria for the dilemma stories according to the CCVLES are very good with a score of 84.4. The student worksheet developed was quite interesting. From the results of the research it can be concluded that the learning devices are valid and can be used in learning Buffer Solution Chemistry with the aim of increasing students' sustainability awareness.

1. Introduction

Environmental pollution is a global issue that is increasingly worrying and threatening the lives of humankind. The UN noted that air pollution even killed 800 people every hour [1]. If the number of victims due to diseases such as tuberculosis, malaria and AIDS are combined, then the number of victims due to air pollution is still 3 times greater than the three diseases. The high level of environmental pollution is mostly caused by human activities. According to some research results, the low awareness of the community to protect the environment has to do with the level of knowledge.

The results showed that there is a relationship between the level of knowledge of a person and his/her behavior in managing waste, and attitude toward environment [2] [3] [4]. It shows that increasing awareness of protecting the environment can be conducted by increasing one's knowledge, especially knowledge about the environment. The task of increasing knowledge is one of the responsibilities of educational institutions (schools).

Schools must lead the conversation. Environmental awareness should be a part of the curriculum in all schools. This will encourage young people to engage in protecting their environment and help communities become more environmentally aware. Providing environmental understanding through the presentation of problems and their solutions is one way to teach environmental understanding to students. Accustoming students to dealing with environmental problems that are dilemmatic or



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commonly called *Dilemma Stories* requires the ability to think critically and creatively.

Dilemma stories is a learning approach that promotes contextual learning and relates to the problems of daily life conveyed through stories that create dilemmas [5]. The *dilemma stories* approach creates more meaningful learning and build student character development. Meaningful learning will make students able to understand concepts more deeply and have implications for the application of concepts in everyday life and a more interesting learning process occurs [6].

Students involved in learning using *dilemma stories* will feel the conflict in deciding the dilemma experienced. Some implications for students include the ability to make decisions in problems that pose a dilemma; the ability to convey and negotiate ideas, and an understanding of the chemistry topics taught because they are related to the application of material in everyday life [5].

Some researchers found that *dilemma stories* implemented in learning chemistry give impact on *sustainability awareness*, because the learning process connects with everyday life [5] [7]. The researchers stated that chemistry has an important role in sustainable development, because many products in daily life are related to chemistry. The learning process with a dilemma story makes students learn to care about the environment, know the use of chemicals and be careful in using products that contain chemicals [8]. Research found that problem-based learning that is associated with aspects of life, both social and economic, has been proven to increase students' awareness of sustainability [9].

This research intent to develop a chemistry learning tool based on *dilemmas stories*. Several previous studies have developed *dilemma stories* sheets on the topics of Salt Hydrolysis, Acid Bases, Organic Chemistry, and Environmental Chemistry [6] [7] [8] [12]. In contrast to previous studies, in this study, a dilemma stores sheet was developed on the Buffer solution material with the theme "Carbonic acid in soft drinks", "Detergents", "Preservatives" and "Sea water". The subject matter chosen was Buffer Solution because the application of the Buffer Solution concept is closely related to the environment and environmental problems. It is expected that the learning devices developed are valid and practical.

2. Method

This research applied the Research and Development (R&D) method, which intent to develop chemistry learning devices based on *dilemmas stories* approach to the Buffer solution material, to increase *students' sustainability awareness*. The learning devices developed consist of student worksheet, dilemma stories sheet, and assessment instrument. The development model used was 4D (*Define, Design, Develop, and Disseminate*). Due to the COVID 19 pandemic, the research method was modified, where at the Develop stage only validity and practicality were tested. Because of the difficulty of implementation in the classroom, the practicality test is carried out through the readability test and students' assessment of the *dilemmas story* developed, without carrying out classroom activities.

The research subjects consisted of 5 validators for the validation test and 5 high school students for the legibility test. The research data was obtained using the validation sheet and the *Constructivist Chemistry Values Learning Environment Survey* (CCVLES) questionnaire sheet with a Likert scale.

The data of learning devices validity was analyzed by Aiken's V method, namely:

$$V = \frac{\sum s}{[n(c-1)]}$$

The data assessment of the *dilemmas stories* in the legibility test were analyzed using descriptive analysis techniques. Based on the readability test results, *dilemmas stories* are categorized in the category of Very Good (score 73-90), Good (score 55-72), Fairly Good score (37-54), Poorly Good (19-36) and Very Poor (0-18).

3. Results and Discussion

Assessment of the validity and practicality of the developed learning tools was carried out at the Develop stage. At this stage, validity of the learning devices developed was determined by 5 validators. Meanwhile, the readability test to assess the practicality and attractiveness of the dilemma story sheet and the students worksheet developed was carried out by 5 students. The results of the validation of

the components of the assessment instrument are presented in Table 1.

Table 1. The Validity of Learning Devices

No.	Learning Devices	Average	Category
1	Test instrument for the learning domain knowledge	0.90	Valid
2	CCVLES Instrument	0.95	Valid
3	questionnaire instrument <i>Sustainability awareness</i>	0.95	Valid
4	Dilemma Story Sheets	0.93	Valid
	Average	0.93	Valid

Based on the results of learning devices validity test, it can be concluded that both in general and in terms of each component, the learning devices developed were valid and can be used with a minor revision. The dilemma stories created to trigger conflict and dilemma feelings in students' thinking, were presented in student worksheet. There are four sets of *dilemmas stories* that were developed, namely the dilemma of Carbonic Acid in Soft Drinks, Preservatives, Detergents, and Seawater.

The validity of the *dilemma stories* was assessed using Aiken's method [10]. Assessment indicators for the *dilemma stories* were (a) the dilemma presented in the story is related to daily life; (b) Stories and introduction according to the truth of the chemical concept (Buffer Solution); (c) Stories can motivate students to learn chemistry; (d) Language, plot and content of interesting stories.

All validity indicators received good score from the validators. According to the validators, the stories in the dilemma stories sheet were interesting and were true stories in everyday life. Applying daily life experiences as a problem in learning motivates students to learn [11]. The dilemma problems discussed were also an application of the Buffer solution material, so that students can understand the subject matter better. The application of dilemma stories in problem-based chemistry learning increases in depth chemistry learning. It is also enhances achievement and prevents the formation of alternative conceptions, conceptual difficulties and lack of knowledge [11] [12].

The validity of the instrument that measures students' sustainability awareness was considered as valid by the validators. The questionnaire compiled was clear and appropriate to measure the sustainability of students' awareness. Validators considered measuring sustainability awareness to be very important. Several previous studies found that students' understanding, even the teachers themselves, about sustainability awareness was still very simple. These findings suggested the importance of developing student and teacher understanding of sustainability awareness. Thus teachers can plan effective learning about this sustainability development program through classroom activities [13] [14].

Generally the validity score of the *dilemmas stories* sheet is 0.93, but if it is analyzed on each device, the results of the Dilemmas Stories Sheet validity are as follows.

Table 2. Validation Test Results of *Dilemmas Stories* Sheet

No	Instrument of Dilemma Stories	Average	Category
1	Carbonic acid in soft drinks	0.93	Valid
2	Preservatives	0.93	Valid
3	Detergent	0.95	Valid
4	Sea water	0.90	Valid
	Average	0.93	Valid

Of the four *dilemmas stories* created, the *dilemma story* about Detergents gets the highest response while the story about seawater gets the lowest response. No suggestions for improvement were given by respondents to the dilemma story about Detergents. In contrast to the dilemma story about Sea Water, it was said that the relation of the dilemma story with the concept of a buffer solution is less strong. Therefore a revision of the story of the Sea Water dilemma was carried out by linking it to more concepts of Buffer Solutions. The following is a dilemma story about detergents:

Your mom was a head of the household who makes a living as a laundry worker. Since her divorce from her husband, that was the only thing she can do, because there wasn't much money she had at that time to open a business. Every day she usually gets a lot of shipments of dirty clothes to wash. At that time, not many people had washing machine. Your mom did not have a washing machine either, so she washed herself by hand. Sometimes, her daughter -your sister- helps her to wash the dirty clothes.

Your mom's laundry was very famous for the quality of the laundry which is clean and also smell good. The detergent used was a synthetic detergent which has abundant foam and is very fragrant. Your mom likes to use that detergent because besides it smells good and clean, it's also cheap. A clean and fragrant laundry made many customers come to deliver their dirty clothes for washing. Suddenly, one day your mom's finger skin feels itching and more red rashes appear. The skin of her palms and fingers peels easily. Finally, your mom and you went to the doctor. The doctor stated that your mom had a serious skin allergy. According to the doctor, this was due to the effects of the allergy with detergent. The doctor also suggested your mother to stop washing clothes by using synthetic detergents that are commonly used.

Next, to evaluate the readability of students towards the *dilemma stories*, an assessment using the CCVLES instrument was used, with the following results:

Table 3. Results of CCVLES Assessment

No.	Indicators	Percentage (%)	Category
1	Feelings related dilemma stories	76.0	Very good
2	Contents of dilemma stories	90.7	Very good
3	Teacher Support	86.7	Very good
4	Working together	84.0	Very good
5	Empathy communication	88.0	Very good
6	Contextual chemistry	81.3	Very good
	Average	84.4	Very good

Overall, the *dilemma stories* developed according to respondents were very interesting. Of the six components, "Content of Dilemmas Stories" indicator got the highest response. On the contrary, "Feelings Related Dilemmas Stories" indicator got the lowest response. However, from the students' responses to the questions in the dilemma story, the problem solution given by the students was very good. They also felt that the story presented made them happy, as the following students answer about how the solution of the problem presented in the dilemma story:

"The mothers should not need to use preservatives Sodium benzoate if it is dangerous"

"If you already know this is dangerous please stop immediately the use of preservatives in the ice you sell, whatever happens "

Dialami pd Serta pengetahuan yg diperoleh pd.
 * Menurut saya ~~di~~ belajar seperti ini
 sangat menyenangkan dan disamping itu
 kita makin tambah tahu tentang kesehatan
 bahwa bukan hanya pengawet yg dapat
 merusak tubuh namun soda juga bisa
 dikonsumsi berlebihan.

"I think learning like this is very fun and it makes me know more about health. Excessive use of preservatives can harm our health"

Figure 1. Students' Impressions about learning using Dilemma stories

On the other hand, for the concepts that involve mathematical formulas, learning chemistry using dilemma stories makes the discussion of mathematical concepts become less in depth. Therefore, for chemistry concepts that involve mathematical calculation, instructors can integrate direct instruction strategy to explain mathematical calculation. Direct instruction combined with ethnoscience, is believed to improve critical thinking skills. Direct Instruction also successfully improve student learning outcomes in particular concept [19] [20]. If through dilemma stories, motivation and students' problem solving abilities can be improved, then by integrating direct instruction, students' ability to perform mathematical operations to support problem-solving abilities can also be improved.

4. Conclusion

Based on the results of the study it can be concluded that learning devices based on the Dilemmas Stories approach that have been developed are valid with validity test score of 0.93. From this research, four dilemma stories are applied in learning Chemistry Buffer solution. The dilemma stories sheet developed can be categorized as "very good" with a readability score of 84.4 using CCVLES. The student worksheets developed which contained dilemmas stories can be classified as "very interesting" with a score of 92.3. The results of this study can be applied to improve theoretical chemistry learning into problem-based solving and sustainability awareness of students, which is presented through a dilemma story.

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