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Research Article

Enhancing Scientific Argumentation Skills Through Electronic Worksheets Based on Research Oriented Collaborative Inquiry Learning

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Abstract.
This study aimed to develop and determine the feasibility of an electronic worksheet based on Research Oriented Collaborative Inquiry Learning in a course on chemical equilibrium. The development model of this research was Research and Development. It follows the 4D model by Thiagarajan. The 4D development model consists of four research and development steps: define, design, develop and disseminate. The instruments in this study were questionnaires used to obtain input data for products and quantitative scores as the value of media feasibility. The results showed that the components of the e-worksheet on the aspects of the materials, learning, visual display, and software engineering were suitable for use by students. The percentage of assessment by chemistry teachers was 92.50%, peer reviewers were 90%, and students' rating was 87%. Therefore, the electronic worksheet based on Research Oriented Collaborative Inquiry Learning (REORCILEA) is worthy of being used as a learning medium in the course on chemical equilibrium to improve scientific argumentation skills. The electronic worksheet has the advantage of being more practical and effective in learning.

Keywords: electronic worksheet, collaborative inquiry learning, chemical equilibrium

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1. INTRODUCTION

The use of technology in the learning process makes learning media suitable for use as an innovation in industrial revolution 4.0 and 21st-century learning [1]. In line with this, now circulating about the Society 5.0 era where people use sophisticated technology, the internet of things, robots and artificial intelligence such as Augmented Reality (AR) which are actively used in the fields of health and education. In the field of education, information and communication technology has changed the way students learn by obtaining various information and interpreting it. In addition, this development encourages the creation of creative innovations such as the concept of electronic

learning. Innovative learning and the application of technology are needed to support learning in the 21st century [2].

Based on the implementation of the learning plan, a worksheet is a means to facilitate the learning process. Worksheet not only contains questions or tasks that must be done by students, but the worksheet is needed to guide students in carrying out learning activities according to the objectives to be achieved. Worksheet functions as teaching materials that can minimize the role of educators but activate the role of students to make it easier to understand the material provided. Interactive worksheets, as a whole part of digital education, thereby encouraging informed teacher intervention as part of the individual student learning process [3]. Electronic worksheet as student exercise in digital form can be carried out systematically and continuously for a certain period of time [4]. Electronic worksheets are suitable for use in chemistry learning because they can improve students' creative thinking skills [5].

It has been and still difficult to improve students' scientific argumentation skills. Based on the research showed that students are weak in the construction of scientific arguments with valid concepts [6–8]. The involvement of students in scientific argumentation enhances their conceptual, epistemological, and methodological understanding of science and supports the enculturation of students into the practice of science [9]. Argumentation in science education is defined as the relationship between claims and data through justification or evaluation with empirical or theoretical evidence [10]. The argumentation aspect consists of three key elements, namely claim, evidence, and reasoning or explanation.

The context of argumentation is relevant for science classes because it acts as knowledge justification and argumentation as persuasion. Through argumentation which is a process of inquiry, students can produce a complete understanding, so that scientific argumentation is the main and basic thing that every student must have [11]. However, most research on argumentation in science has documented the myriad flaws in student argumentation, and the difficulties teachers have in organizing productive arguments in the classroom [12]. Therefore, special strategies and media are needed to increase the involvement of students in arguing. Combining different methods by strategy and media development can increase students' understanding of chemistry subjects, especially chemical equilibrium material so that it can help students overcome their misconceptions.

One of the most effective ways to help students build scientific knowledge is through the use of inquiry. Scientific inquiry is key to the development of knowledge and has cross-disciplinary value as a way of studying science where explanations result from

evidence [13]. Inquiry is important for teaching and learning because it represents how valid and reliable knowledge is in the construction of science. A collaborative inquiry approach is suitable for teaching science in secondary schools that promotes a number of desired learning outcomes as a result of the active participation of students [14]. Inquiry learning that provides opportunities for students to participate in collaborative discourse based on research is the Research Oriented Collaborative Inquiry Learning (REORCILEA) Model. REORCILEA is a student-centered learning model, which integrates the principles of scientific inquiry into a collaborative environment and is supported by research-oriented learning elements [15]. The REORCILEA model consists of a series of learning activities; (1) Initiating, (2) Hypothesizing, (3) Experimenting, (4) Writing, (5) Evaluating and Reflecting. The research after using the REORCILEA model in chemistry learning showed that there was an increase in critical thinking scores, science process skills and scientific attitudes. Based on the research, by combining electronic media with learning strategies, it indicates students to be able to develop their argumentation skills. The objective of this study was to develop and determine the feasibility of an electronic worksheet based on Research Oriented Collaborative Inquiry Learning (REORCILEA) on chemical equilibrium to improve students' scientific argumentation skills.

2. RESEARCH METHOD

This development research refers to the 4D development model which consists of 4 research and development steps, namely define, design, develop and disseminate [16]. The defined stage contains activities to determine what products will be developed along with their specifications. The design phase contains activities to create a design for a predetermined product. The development phase contains the activities of making the design into a product and testing the validity of the product until the product is produced in accordance with the specified specifications. The last stage, namely the dissemination stage, contains activities to disseminate products that have been tested for use. The 4D stages used refer to Thiagarajan research and development as shown in Figure 1.

Electronic learning media developed in the form of electronic worksheet compiled using professional flip pdf software. The choice of this software as a medium for the worksheets is because it is easy to operate and modify the content contained in the form of videos, images, or animations used. The products that have been finished are then reviewed by two experts, namely media experts and matter experts. Media experts were lecturers who have experience in the field of research in the development of learning

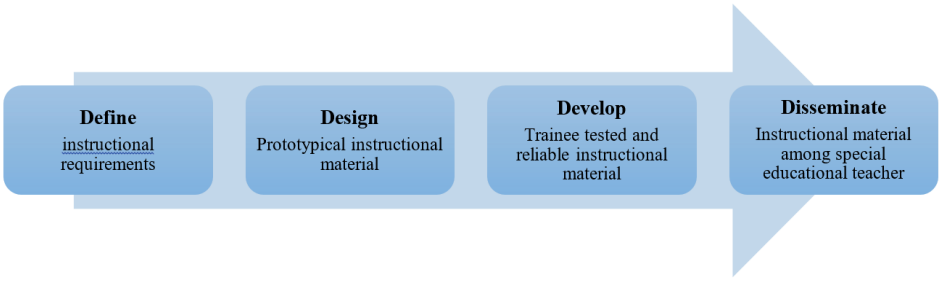

Figure 1: The 4D stages used refer to Thiagarajan research and development.

media. Aspects assessed by expert judgement of media were aspects of visual audio display and software engineering. Matter experts were lecturers who were experts and mastered the material in the field of chemistry, especially those related to chemical equilibrium. Products that have been validated by matter experts and media experts are then revised based on the comments and suggestions given, then the products are given an assessment by high school chemistry educators and peer reviews in terms of materials and media. The criteria for high school chemistry educators are educators who already have an understanding of chemistry and good media quality standards for teaching materials.

The study took SMA located in Yogyakarta as the research site and took the representatives located in the district of Sleman. The trial subjects consisted of a limited scale trial sample of 57 high school students. The limited-scale trial aims to determine the legibility level of the developed electronic worksheet. The instruments used in this study were non-test instruments in the form of media expert validation sheets, material expert validation sheets, questionnaire responses for students and educators. The questionnaire was used to measure the feasibility of REORCILEA-based electronic worksheets on chemical equilibrium materials during the limited-scale trial process. Assessments of validators, students, and educators are averaged and the percentage of assessment results is interpreted in Table 1.

TABLE 1: Media assessment criteria.

Score Range (i)	Criteria
$\overline{X}\,\overline{X}$ > Mi + 1.5 SBi	Excellent
Mi + 0.5 SBi < $\overline{X}\,\overline{X}$ ≤ Mi + 1.5 SBi	Good
Mi – 0.5 SBi < $\overline{X}\,\overline{X}$ ≤ Mi + 0.5 SBi	Average
Mi – 1.5 SBi < $\overline{X}\,\overline{X}$ ≤ Mi – 0.5 SBi	Below average
$\overline{X}\,\overline{X}$ ≤ Mi – 1.5 SBi	Poor

Note: $\overline{X}\,\overline{X}$= average score; Mi = ½ (ideal max score + ideal min score); SBi = ideal standard deviation

Media scores provided by chemistry teachers, peer reviewers, and learners then calculated the percentage ideal to find out the overall REORCILEA-based electronic worksheet assessment. The formula for calculating ideal percentages is:

$$Ideal\ percentage = \frac{research\ score}{ideal\ maximum\ score}\ x\ 100 \quad (1)$$

3. RESULT AND DISCUSSION

The initial analysis at the define stage is in the form of a preliminary study which shows that learning chemistry in schools is only facilitated by teaching materials in the form of a revised edition of the 2013 curriculum chemistry book. Teachers rarely make other teaching materials due to limited time and energy. The results of observations at one high school in Yogyakarta showed that the activeness of students in learning chemistry was not optimal, students tended to just listen without any feedback on the delivery from the teacher. In addition, the use of media is still minimal, and there are no worksheets that facilitate students to be actively involved in learning.

The use of technology-based learning media is able to attract the attention of students in the learning process. In addition, by using electronic media students can learn independently because it has been equipped with a coherent learning stage and there are learning videos. Learners can actively participate with electronic media where they can improve their ability to think and learn independently [17]. The use of e-learning media focuses on the needs of students in conveying knowledge in the digital era more effectively [18].

The design phase begins with the contracting criterion-referenced test which uses a media validation instrument consisting of 4 aspects of assessment, namely visual display, software engineering, learning, and material. The initial design of the electronic worksheet was developed based on the REORCILEA learning step. Electronic worksheet components consist of cover, introduction, content, and closing. The initial design of REORCILEA-based electronic worksheet can be seen in Figure 2.

The development stage is in the form of developing an electronic worksheet using a professional flip pdf program. The advantage of using a professional flip pdf program is that it can create dynamic content, easy to use, responsive on all devices, equipped with videos and other interactive links. According to Sriwahyuni et al., the benefits of using a professional flip pdf application are that you can create e-books in the form of flip books and equipped with several types of multimedia such as animation, video, and audio [19]. The features available in the flip pdf professional program can combine

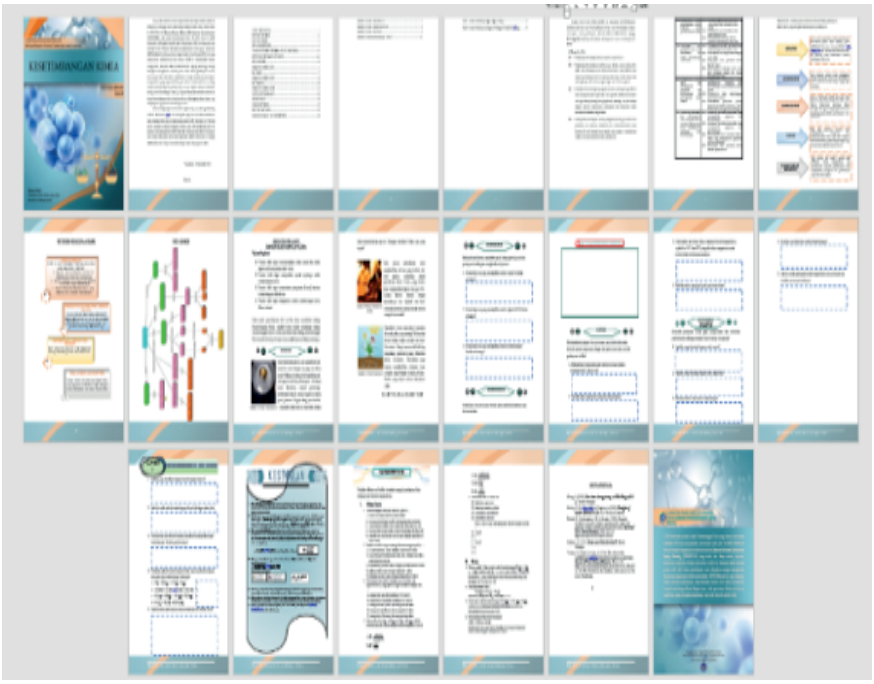

Figure 2: Initial design of REORCILEA-based electronic worksheet.

several files such as pdf, animation, audio visual, images, videos, youtube and hyperlinks [20]. Electronic media created using this program can be applied to PCs (computers or laptops) or smartphones (Android or IOS). The display of electronic worksheet on PCs and smartphones can be seen in Fig. 3 and Fig. 4.

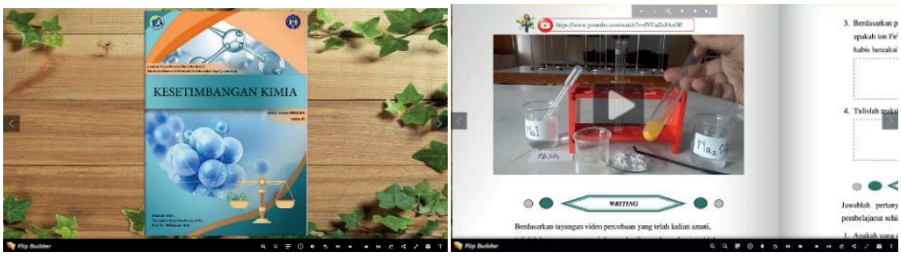

Figure 3: Display of electronic worksheet on PC.

The media assessment by expert lecturers obtained an average score of 3.82 with excellent category, but expert lecturers gave input and suggestions to improve the media such as: 1) The table should not be cut off by one page, if possible only one page, 2) Writing symbol of K_c and K_p needs to be corrected with italic notation and index, 3) Correct the standard/latest terms according to chemical terms. After the media was revised, its feasibility was tested by chemistry educators and were tested for feasibility by peer reviewers. The average score obtained from chemistry educators is 3.7 and is in the excellent category. While the media feasibility assessment from peer reviewers obtained an average score of 3.6 with excellent category. Based on the assessments

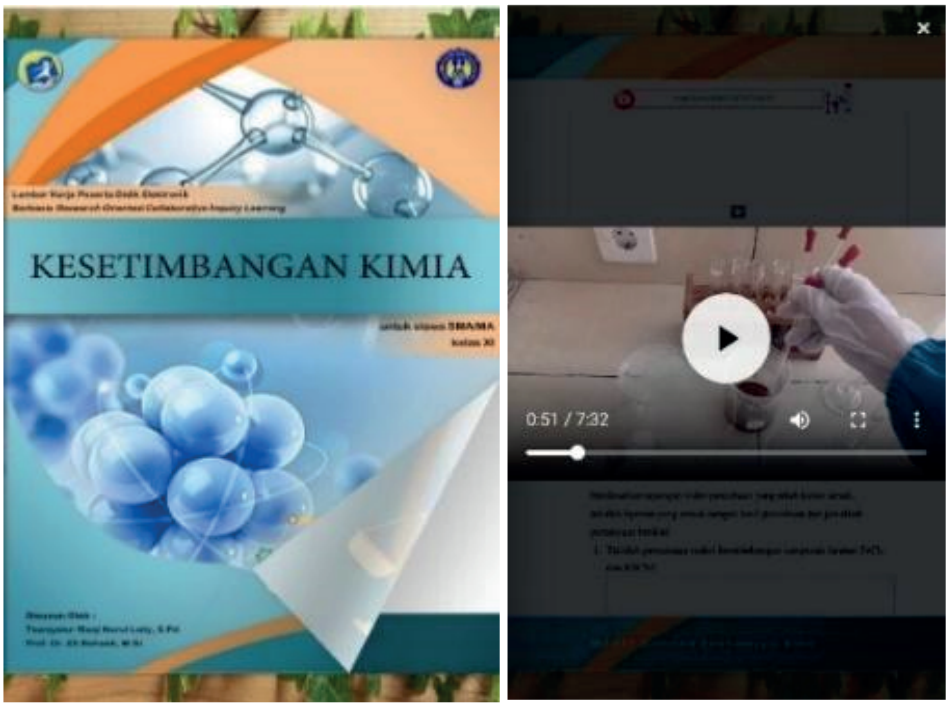

Figure 4: Display of electronic worksheet on smartphone.

of expert lecturers, chemistry educators, and peer reviewers, the media is ready for use with minor revisions. After the media was revised, it was then tested for readability by students. The readability test was carried out by 57 students. The improvement of the media is carried out based on input and suggestions from students as material for media revision. The results of the readability assessment by students are 3.48 and get excellent category. Improvements are made to produce products that are superior in terms of appearance and learning content [19] The data for assessing the feasibility of learning media includes the results of assessments from expert validation, chemistry educators, peer reviewers and learners which can be seen in Table 2.

TABLE 2: Feasibility assessment of electronic worksheet.

Evaluator	Average score	Category
Expert Lecturer	3.82	Excellent
Chemistry Educator	3.70	Excellent
Peer Reviewer	3.60	Excellent
Learners	3.48	Excellent

The ideal presentation for the REORCILEA-based electronic worksheet as a whole was 89.8% so that it included an excellent category. Based on the results of the study, the REORCILEA-based electronic worksheet is worthy of being used as one of the learning media for chemistry equilibrium in senior high school. A graph obtained for

the total score of media assessment obtained from chemistry teachers, peer reviewers, and learners can be seen in Figure 5.

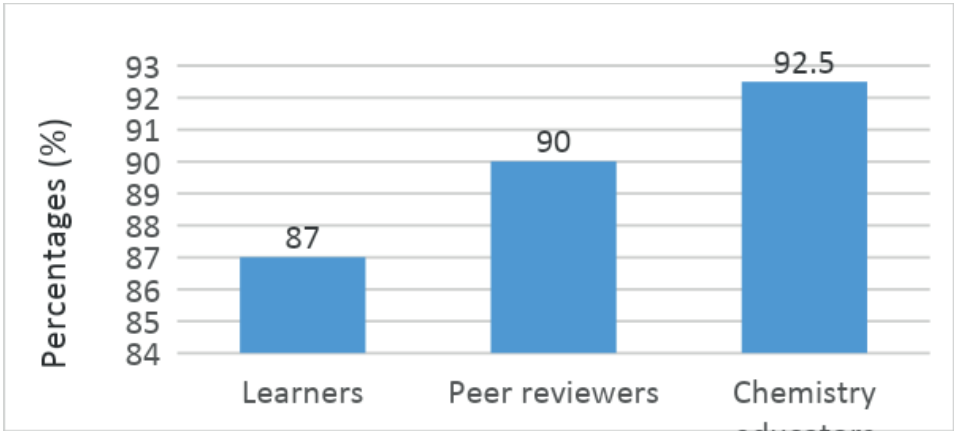

Figure 5: Average score percentage graph.

REORCILEA-based electronic worksheet that has been developed combines the use of media and learning models at the same time. According to Demircioğlu combining different methods can increase students' understanding of chemistry subjects, especially chemical equilibrium material so that it can help students overcome their conceptual errors [21].

Several studies have shown the positive effect of learning using electronic media based on students' insights [22–24]. For example, learning with electronic media makes it possible to observe many flexible ways of learning, students can gain deeper insight into information through activities carried out with interactive video facilities [25]. Learners can have a systematic lesson because it provides content and supported exercises in the form of animation, sound, and video.

The results of research using electronic worksheets show that electronic worksheets are very effective in overcoming the lack of understanding of students on a particular topic in science class. Practice questions on interactive worksheets can explain how students relate data based on graphs and symbols so that they can use it in the problem solving process [26]. In addition, electronic worksheets are effective for improving students' critical thinking skills [30].

The dissemination stage is carried out by distributing products that have been developed, namely electronic worksheets based on Research Oriented Collaborative Inquiry Learning. Dissemination is carried out by providing the electronic worksheet website address to chemistry teachers and students so that they can be accessed for further learning. In addition, dissemination is also carried out through journal publications and seminars related to the results of product implementation in chemistry

learning. Dissemination is not a one time activity, but a process that involves a long-term relationship with users and partners. Continuous feedback helps researchers appraise the effectiveness of their messages, such as what method or approach worked best or which method was most effective [27].

4. CONCLUSION

Based on the results and analysis of the scientific process skills test, it can be concluded that students' scientific process skills on simple harmonic oscillation is still low, with the average score being 50. Percentage of each scientific process skills aspect in less category. The aspect with the lowest percentage is concept applying, 45% in less category. Followed experiment planning aspect and communicating aspect with a percentage 46% in less category, observing aspect with a percentage 48% in less category, interpreting aspect with a percentage 56% in less category, and predicting aspect with a percentage 58% in less category. Thus, the next research needed to find out the learning design that is effective to improve students' scientific process skills and easy to implement in the school under normal or pandemic conditions as now.

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