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THE DEVELOPMENT OF ELECTROLYSIS CELL TEACHING MATERIAL BASED ON STEM-PJBL APPROACH ASSISTED BY LEARNING VIDEO: A NEED ANALYSIS

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ABSTRACT

This study attempts to explore teachers' and students' needs on the development of electrolysis cell teaching materials assisted by a learning video. Data were obtained through open question questionnaires and close-ended questions given to 15 teachers and 15 students of senior high school in East Java province. What teachers need of interactive learning media is both in knowledge and thinking skills and adds insight to students' conceptual understanding. Besides, it can apply 4C skills (Communication, Collaboration, Critical Thinking, Problem Solving, Creativity, and Innovation). Chemistry learning materials that students want are interactive instructional video media integrated with information technology. The level of teacher and student confidence in learning chemistry in schools on the topic of voltaic cells was carried out based on STEM-PjBL education assisted by learning videos of 78.6 and 89.2. Therefore, it is necessary to develop teaching materials with appropriate approaches and methods that can support chemistry learning on the topic of electrolysis cells in the form of STEM-PjBL-based textbooks assisted by learning videos featuring triple representative.

Keywords: need analysis; electrolysis cell; STEM-PjBL; learning video

INTRODUCTION

One of the goals of 21st-century education is to develop students' critical thinking skills in learning so that they can solve problems encountered in real life (Hikmah et al., 2017). Rosen et al. (2020) contended that the 21st century requires students to have collaboration and communication skills to compete in the workplace (Rosen et al., 2020). The success of students in constructing their knowledge is not only from achieving predetermined learning goals (Nessa et al., 2017), but students must also be able to apply the concepts of knowledge obtained at school to solve problems faced in everyday life in a relevant, meaningful, and contextual way (Khairunnufus et al., 2019).

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Job opportunities in technology are currently increasing on the industrial scales. Nevertheless, there is still a gap between the skills of job seekers with the competencies needed by the industries. Based on the data from the Indonesian Institute of Sciences in 2016, the education level of the workforce in Indonesia with elementary school education is below 44% compared to other ASEAN countries (Adam, 2016). Referring to the 2010 Central Statistics Agency data, unskilled laborers (as many as 88 million) still dominate Indonesia's human resources, and it is predicted that by 2020 there will be a 50% shortage of workers to fill vacancies in the employment structure (Jauhariyyah et al., 2017). Therefore, it is necessary to increase human resources through education.

Education is a crucial factor for humans in supporting the improvement of the quality of

human resources. Through education, humans attempt to develop themselves following the advancement of science and technology to support sustainable development (Burbules et al., 2020). Therefore, education issues need more attention and better handling regulations related to its quality and quantity (Zamista, 2018). Education quality that can support future development should also be able to develop students' skills. One of the classroom subjects that can support future development is chemistry.

Chemistry covers scientific experiences from laboratories and applicable sciences useful for the future (Karpudewan & Kulandaisamy, 2018). Explanation of chemistry as a product and process of scientific work related to the existence of practicum in the laboratory (Saharsa et al., 2018). However, this subject entails one complicated topic for students to understand, which is the electrolysis cell. According to Asih et al. (2018), static visualization can make it easier for students to achieve an understanding of the electrolysis cell topic because it illustrates an unobservable level (Asih et al., 2018). This visualization will aid students in understanding reactions in the electrolysis process that occurs in practicum. The low ability of students to think formally causes difficulties in understanding submicroscopic aspects so that there is the potential for misunderstanding (Asih & Ibnu, 2018). However, most students are still confused about the concept of electrolysis and cannot compare and determine substances that have experienced a reduction or oxidation in electrolysis. Thus, errors often occur in answering questions about the material. To overcome such a problem, creating effective teaching materials are of paramount importance.

Teaching material serves as a learning resource for students to understand the concept of learning. Teaching materials used can be in the forms of printed or non-printed documents. Printed teaching materials include textbooks (teacher book and student book), worksheets, modules, handouts, and leaflets (Cloonan & Fingeret, 2020). One form of teaching material that can support independent learning is the student book. The student book contains learning material in the form of concepts constructed by students through the problems contained therein and arranged based on the approach. Therefore, students need student books as learning resources to achieve expected competencies. However, student books generally used in the classes are not well-designed and well-implemented (Hidayat et al., 2020).

Science, Technology, Engineering, and Mathematics (STEM) is an approach formed based on a combination of several scientific disciplines (Salampessy & Suparrman, 2019). Collaboration or interconnection of knowledge will assist students in collecting, analyzing, and solving problems that occur and be able to understand the relationship between a problem and other problems (Siong & Osman, 2018). STEM-based education forms human resources (HR) who can reason and think critically, logically, and systematically, so that they can face global challenges and to improve the country's economy (Wang et al., 2020). STEM refers to the ability of individuals to apply an understanding of how intense competition works in the real world, which requires four interrelated domains (Li et al., 2020; Nugroho et al., 2019; Parno et al., 2020). In the mathematics domain, the impact on learning with the help of embedded types promises much knowledge-gain in the fields of technology and engineering. The application of STEM in teaching and learning can be carried out at all levels of education, from elementary schools to universities. The consideration is that aspects of STEM implementation, such as creativity, intelligence, and design ability do not depend on age. The STEM approach in its implementation employs the type of Project Based Learning (PjBL) learning model. Also, in electrolysis cell topic, one learning model that matches the characteristics of the material is Project Based Learning.

Project-based learning is a student-centered learning model and provides meaningful learning experiences for students (Dinis-Carvalho et al., 2019). Student learning experiences and concept acquisition are built based on the products produced in the project-based learning process (Barienti et al., 2017). The application of PjBL in learning science from the results of the research can improve cognitive learning outcomes (Khamidah et al., 2019), shape attitudes and behaviors that care about the environment, science process skills, and effective learning (Safaruddin et al., 2020 ; Ismayani, 2016).

The application of the STEM approach (Science, Technology, Engineering, and Mathematics) in Project-Based Learning is not without obstacles. There are some obstacles in using PjBL in the learning environment: 1) failure to realize experiments due to spatial limitations and temporal capacity, 2) capacity to use resources available at the risk of injury to participants, 3) expensive equipment or materials causing the inability to complete some activities, and 4) repetition of

some significant experiments and a related high financial burden (Pellas et al., 2017). We can utilize the advance in digital technology to overcome the obstacles so that it can configure activities with the expected goals. One tool that can be used is a learning video.

Besides, learning also influences attention to the student psychologist. At the beginning of the learning, the educator creates a sense of comfort by playing music so that the students feel relaxed. After that, educators can give positive suggestions that can bring up the confidence of students in participating in learning. Learning video tools have a unique strength compared to ineffective texts. The video can visualize concepts to students more efficiently and interactively (Gowasa et al., 2019; Rokhim et al., 2020). This video was developed to overcome time constraints because it can be watched anywhere and anytime. Students are convenient, and there is a synergy to trigger their enthusiasm for learning (Degeng et al., 2017).

The application of the STEM-PjBL approach in chemistry learning is to provide the knowledge and skills needed in this era of globalization. The characteristics of an electrochemical cell are 1) each half cell consists of a metal rod dipped in a solution of its ion; 2) the half-cell reaction that occurs at the anode is called the half-cell oxidation reaction, while what occurs at the cathode is a half-cell reduction reaction; 3) two half-reactions always coincide; 4) the anode captures electrons so that it is negatively charged, while the cathode loses electrons so that it is positively charged; 5) Electrons flow from anode to cathode and current flows from cathode to anode. The technique deals directly with real-world problems. It provides a useful context for illustrating other concepts that may be difficult for students to visualize. Likewise, the integration of the STEM-PjBL approach in this student book becomes more meaningful. Education is not just memorizing numbers and formulas but can be implemented in everyday life. Technological aspects can be used to overcome various existing problems. Also, the need for multidisciplinary knowledge will complement each other and make it more tangible to be widely used by the community. The purpose of this study was to analyze the need for teaching materials based on the STEM-PjBL approach on the topic of video learning assisted electrolysis cells.

METHODS

Our study lies in the framework of descriptive research, which aims to capture and present facts, realities, symptoms, and events that want to be raised appropriately (Raco, 2010). We recruited 15 chemistry teachers and 15 senior high school students in East Java Province, Indonesia.

The research procedures carried out are illustrated in Figure 1.

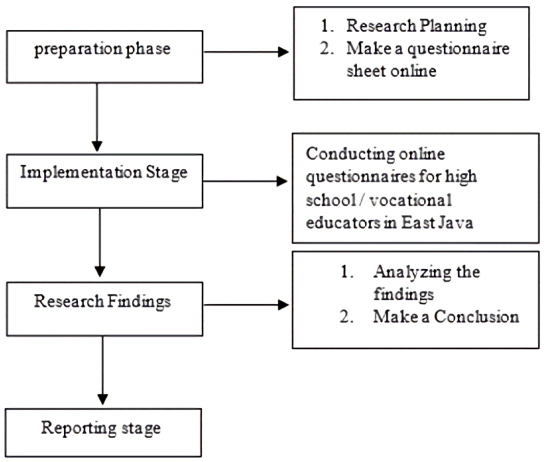

Figure 1. Research Procedure

They were asked to fill in an online open and close-ended questionnaire that seeks to construe what aspects are necessary for the teaching of electrolysis cell topics in chemistry classes as well as the implementation of learning electrolysis cell material by teachers and students in their classes. Open questionnaire in the form of questions for teachers consisting of 7 questions and questions for students consists of 6 questions, while for closed questionnaire for teachers consists of 3 questions and for students consists of 3 questions. The instruments used were questions in the form of explanatory answer questions and multiple choice answer questions.

The data collected were then analyzed using descriptive statistical analysis techniques. Descriptive statistics are statistics to describe or give an idea of the object to be examined through data samples or populations as they are in this descriptive statistic without conducting analysis and making conclusions that apply to the public. There are several data prescriptions in descriptive statistics that can be used, such as ordinary Tables, frequency distributions, graphs, and data group explanations through mode, median, average values, group variations, and standard deviations.

RESULTS AND DISCUSSION

The development of electrolysis cell book as teaching material aims to help improve the

quality of learning resources available at school, facilitate students in obtaining lessons, improve critical and creative thinking, and add learning media for teachers in conducting learning activities in the classroom and strive to increase knowledge and students' understanding of chemistry subjects on the topic of electrolysis cells with the approach of Science, Technology, Engineering, Mathematics-Project Based Learning or abbreviated as STEM-PjBL. In this study, our need analysis serves as a preliminary investigation.

Open-Ended Questionnaire

Based on questions from the open questionnaire by the teacher and students obtained answers related to the need for teaching materials on the topic of electrolysis cells. These results can be seen in table 1.

Table 1. The Need Analysis of Teachers' Responses

No.	Questions	Teachers' Responses
1.	Based on the views and observations while learning the electrolysis cell, how do students react to the learning process?	-Seven teachers provide answers with the conclusion that students are happy and enthusiastic about the topic of electrolysis cells due to simple experiments and are related to daily life. -Four teachers provide answers with the conclusion that students have difficulty in the topic of electrolysis cells because students have difficulty distinguishing reactions that occur at the cathode and anode. Also, students have difficulty because they only memorize concepts because of the lack of supportive teaching materials. -Three teachers provide answers that learning takes place naturally.
2.	What are the obstacles to learning electrolysis cells?	Some obstacles in learning the topic of electrolysis cells revealed, including how to determine the elements of anion ions and cations. Students only memorize, distinguish electrolysis cells and electrolysis cells. They lack ability in calculations and application examples. Students do not understand the basic redox reactions. Teaching materials are inadequate, lack of media to visualize electrolysis cell submicroscopic, and limited practical material.
3.	How is the learning model applied to the study of the electrolysis cells?	The learning model that has been used by 14 respondent teachers includes cooperatives, environment-based learning, induction learning, guided inquiry. While the method used in the form of experiments, lectures, informative discussions, exercises.
4.	What are the teaching materials that were used on learning electrolysis cells?	-textbooks -practicum tools -worksheet -module -flash media -PowerPoint -student worksheet -articles and the internet
5.	What do you think about the application of 21st-century skills or 4C (Communication, Collaboration-on, Critical Thinking, Problem Solving, Creativity, and Innovation) integrated into teaching materials?	All respondents gave positive responses that can help students in helping students understand the concept of the electrolysis cell.

6.	What is your opinion if the electrolysis cell topic is developed with interactive teaching materials?	All respondents answered with a good response because it can support the process of teaching and learning activities in school in a fun and more comfortable way for students to understand the concept of the electrolysis cell.
7.	In your opinion, can the development of interactive teaching materials on the electrolysis cells increase insight into students' understanding of concepts?	All respondents gave answers that could add insight and of students' understanding of concepts.

Table 1 of questions 1 and 2 presents the teachers' views as respondents regarding the need for teaching materials on electrolysis cell topics. Based on Table 1, students encounter difficulties in understanding the reactions that occur at the anode and cathode, which are unseen for its displacement. The type of cathode and anode mainly influences the difficulty in determining the elements of anions and cations, and in the case of electrolysis cell faraday calculation, the use of inert and non-inert electrodes is presented. It occurs since the teaching material used is less supportive. Besides, students' numerical ability becomes an obstacle, as well as the visualizing submicroscopic performance. This finding corresponds to the research carried out by (Asih et al., 2018), revealing that submicroscopic representation of submicroscopic visualization that occurs in electrolysis cells can facilitate students' understanding of the electrochemical phenomena. Also, it is easier to provide a picture of the flow of electrons in the electrolyte solution migrating from the anode to the cathode through a closed-circuit (cable). In this context, students cannot differentiate and understand electrolysis cells based on the use of electrodes. In line with the two studies conducted by Haryati et al. (2019) and Fani et al. (2016), students also experience difficulties with the type of electrolysis, the use of electrolysis, and Faraday's Law. The reason is that students understand the reactions to the voltaic cell process that occurs in practicum, and the low ability to think formally causes difficulties in understanding the submicroscopic aspects, so there is potential for misunderstanding. So that it can be improved by using learning media that displays visual and auditory; students can learn lessons quickly.

Table 1 (points 3 and 4) also indicates that the learning models used by the teachers included cooperative, environment-based learning, induction learning, guided inquiry, experiments, lectures, informative discussions, and practice-based exercises. Meanwhile, the teaching materials employed were textbooks, practical tools, worksheets, modules, flash media, power points, worksheets, articles, and the internet. Strategies and teaching materials are used to support interactive and exciting teaching and learning enactment. These results are supported by previous studies contending that instructional media are well-responded by the students since these media can improve their learning outcomes (Arsanti, 2018; Pangesti et al., 2017; Salampessy & Suparrman, 2019). On another report, Riswanto et al. (2018) found that students' problems include difficulties in understanding chemical materials, especially in the electrolysis cell topic due to the use of ineffective instructional. Teaching materials should be as intriguing as independent learning resources to facilitate the learning process.

On point 5, this study captures that the application of 4C (Communication, Collaboration, Critical Thinking, Problem Solving, Creativity, and Innovation) integrated into teaching materials is beneficial for students in teaching-learning processes. The application of 4C is also to increase students' creativity, insight, and mindset. Students are required to have various competencies in supporting their personal lives and professionalism (Bezanilla et al., 2019). It is in line with research done by Dinis et al. (Dinis-Carvalho et al., 2019), arguing that teachers who apply critical thinking to students' daily practice and integrate with a variety of skills help them better understand the world in the context of the subjects. It can increase students' conceptual understanding and interests (Loyola et al., 2020).

On points 6 and 7, the finding suggests that the use of interactive teaching materials can add insight and understanding of concepts and learning motivation on the topic of the electrolysis cell. These results are in line with research carried out by (Santana et al., 2019), uncovering that interactive teaching material tends to employ the most of information technology. This teaching material provides positive responses to student understanding. According to Jahnke and

Liebsher (Goodsett, 2020), develop information-based virtual literacy learning practices that can gather creative ideas and make students think critically.

Aside from presenting teachers' responses, we also document students' answers (Table 2).

Table 2. The Need Analysis of Students' Responses

No.	Questions	Students' Responses
1.	What learning resources do you use to study changes in electrolysis cell material in redox and electrochemical learning?	Most of the student answers are related to learning resources used between other textbooks, online learning applications, worksheets, UKBM, youtube.
2.	What learning resources do you want to support the learning of electrolysis cells?	The source of learning that respondents want is that lots of practice exercises, fun and impressive pictorial animations, exciting learning games, learning videos, and discussion questions. Tthere are summaries of learning points.
3.	What are the learning strategies applied to the redox and electrochemical reactions of electrolysis cell topics?	Learner strategies that have been used are based on exercises, practice, using donkey bridges (abbreviations), and independent learning.
4.	Are the learning resources that you use today accompanied by (pictures, videos) exciting and easy to understand?	A total of 8 respondents said they had used material (pictures, videos) in the learning process, but still, not all activities in the class and video images were less exciting and boring. The remaining seven respondents said they had not applied the material.
5.	What do you think about the application of information and communication technology (ICT) if integrated into teaching materials?	Fourteen respondents said they agree if information and communication technology (ICT) if integrated into teaching materials so that it is interesting, and one respondent does not agree with the use of ICT.
6.	What is your suggestion for the development of teaching materials so that it is easy to understand the topic of electrolysis cells in the study of redox and electrochemical reactions so that the topic becomes more interesting?	Most of the respondent revealed suggestions for developing instructional materials by adding interactive videos, supporting images, adding games to learning, moving animation, teaching materials integrated with the internet and android, practicum, making donkey bridges, practice exercises, e-modules.

Based on table 2, the results obtained related to the need for teaching materials from the student's perspective that learning resources for the topic of voltaic cells have been using worksheets, modules, internet media, youtube, online education applications. Students' learning strategies and approaches are still in the form of practice-based questions, practice, using donkey bridges (abbreviations), and independent learning. One respondent contended that the teaching materials used were not integrated with specific learning models but only used as handbooks and explanations from the teacher. Also, other respondents shared that the need for ICT integration to facilitate visualizing the electrolytic concept is necessary. These findings are reinforced by (Gan et al., 2015), who stated that the use of ICT could increase student learning interest so that it has an impact on learning outcomes and student achievement. Besides, it can foster student creativity and interaction between teachers and students to add insight (Jahnke & Liebscher, 2020). The digital media can enhance the quality of learning by utilizing online sites. This learning supports students to learn collaboratively and conveniently. Active learning can facilitate students to construct concepts and increase learning retention. Besides, students can gain new learning experiences. In line with that, according to (Rahayu et al., 2019), online chemistry learning remains to improve learning outcomes because student motivation increases. It can be an

indicator of the success of the learning process experienced by students (Thibaut et al., 2018). Motivation becomes an essential aspect of increasing motivation to learn based on information and technology programs.

Close Ended Questionnaire

Based on questions and closed questionnaires by the teacher and students obtained answers related to the need for teaching materials on the topic of electrolysis cells. These results can be seen in table 3.

Table 3. The Results of the Questionnaire Covered the Analysis of the Requirements of Electrolysis Cell Teaching Material

No	Questions	Average Score	
		Teachers	Students
1	The level of trust is one way of integrating learning using technology and information	88.2	87
2	The level of implementation of the use of IT-based teaching materials for learning chemistry in schools so far effectively	54.9	61
3	The level of confidence in the learning of chemistry in schools on the topic of electrolysis cells is carried out based on the STEM-PjBL-based approach assisted with video learning.	77.5	85.3

The average results of the closed questionnaire are interpreted as the discussion refers to the requirements analysis requirements according to the rules of educational and cultural standards. The value provisions obtained are 88 <N≤100 and are categorized as very good, for the value of 76 <N≤88 is categorized as good, for the value of 65 <N ≤76 is categorized as sufficient, and value of <65 is categorized as insufficient. Based on Table 3, the results of teacher and student analysis showed that the level of confidence in how to integrate learning with technology, information, and communication was in both categories of 88.2 for teachers and 87 by students. It means, aspects of integrating learning using technology generally take place well. Meanwhile, the level of implementation of the use of teaching materials based on technology, information, and communication for learning chemistry in schools is categorized as less than 54.9 by teachers and 61 by students. It is possible because of the lack of facilities to support the availability of learning technology and the lack of teaching skills to use learning technology. However, the results of the analysis on the level of confidence in chemistry learning in schools on the topic of electrolysis cell carried out based on the STEM-PjBL assisted approach to learning videos are categorized both in the implementation of 77.5 by teachers and 85.3 by students, meaning that the respondents' prefer the learning process based on the STEM-PjBL approach aided with learning videos.

The results of this study serve as a reference in developing teaching materials with approaches that can support the process of learning chemistry in the classroom, in the form of student books with the STEM-PjBL approach assisted with learning videos. Teaching materials developed are tailored to the needs and characteristics of students. Teaching material is vital to support the teaching and learning process. The preparation of ideal teaching materials to optimize student involvement and knowledge transfer is based on understanding student needs (Cloonan & Fingeret, 2020). Teaching materials are useful for teachers and students in carrying out teaching and learning activities so that students more easily understand the concept of the material. Teaching materials become a significant part in terms of meeting the demands of standards in the fulfillment of advice and infrastructure in schools. One of the teaching materials that can support learning is the student handbook. Student handbooks are books that contain material and are compiled with the needs of the existing curriculum. Besides, this book can be used to study independently at home. In addition to the use of teaching materials, educators are also required to use specific approaches that are following the current material needs. One of the approaches that are suitable for the era of globalization and welcome the industrial revolution 4.0 is STEM-based learning. STEM is learning that can train students' ability to solve problems in a project that integrates various disciplines.

Thus, providing real-life based learning experiences (Li et al., 2020). Many developed countries have applied the application of this learning model (Pellas et al., 2017). STEM can be adopted and integrated with project-based learning. This approach is suitable for use in the topic of electrolysis cells. This project will pro-

duce innovations that can benefit the wider community. Some examples of applications are the use of electrolysis to reduce pollutants in polluted water, synthesis of biodiesel using the electrolysis method, the development of renewable energy through electrolysis technology, the manufacture of catalysts. This research can be used as a material for consideration for other researchers related to the development of student books based on the STEM-PjBL approach to chemistry learning topics on electrolysis cells.

CONCLUSION

This study has attempted to reveal both teachers' and students' needs on electrolysis cell teaching materials in their chemistry classes. What teachers need of interactive learning media is both in knowledge and thinking skills and adds insight to students' conceptual understanding. Besides, it can apply 4C skills (Communication, Collaboration, Critical Thinking, Problem Solving, Creativity, and Innovation). Chemistry learning materials that students want are to use interactive instructional video media integrated with information technology. The level of teacher and student confidence in learning chemistry in schools on the topic of voltaic cells was carried out based on STEM-PjBL education assisted by learning videos of 78.6 and 89.2. Therefore, it is necessary to develop teaching materials with appropriate approaches and methods that can support chemistry learning on the topic of electrolysis cells in the form of STEM-PjBl-based textbooks assisted by learning videos featuring triple representative.

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