



## CHARACTERISTICS OF CHEMISTRY TEACHING MATERIAL VOLTAIC CELLS ON STUDENTS' CREATIVITY AND CONCEPT MASTERY

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**Abstract.** There is no mapping of the characteristics of teaching materials needed by vocational high schools, especially in Sukabumi district. This study aims to find the characteristics of chemistry teaching material used by 16 teachers on the concept of voltaic cells in vocational high schools. The characteristics of teaching material accommodate 21st-century learning which includes the accuracy of the contents, the accuracy of the scope, the updating of the material, the comprehensibility of the text, the use of the language, and the use of the illustrations. The research identifies student competency profiles that are indispensable in 21st-century learning, namely creativity and concept mastery. The subject of the research is teaching material used by 16 chemistry teachers in 16 vocational high schools with 95 students studied. Data were collected using observation sheets, product creativity questionnaires, and tests of students' concept mastery. The data obtained were analyzed using a quantitative descriptive method. The results show that the teaching materials used in learning had not used an approach that encouraged creativity and learning outcomes for students. This resulted in low creative-thinking ability at a rate of 27.03% and in low mastery concept showed from the mean of learning outcomes at a score of 22.4 from a maximum score of 100. The study concludes that the characteristics of chemistry teaching material voltaic cells are not under the demands of the characteristics of 21st-century learning in the aspect of the content.

**Keywords:** Teaching material, STEM, Creativity, Concept Mastery

**Abstrak.** Pemetaan terhadap karakteristik bahan ajar yang diperlukan sekolah menengah kejuruan khususnya di kabupaten sukabumi belum ada. Penelitian ini bertujuan untuk menemukan karakteristik bahan ajar kimia yang digunakan oleh 16 guru pada konsep sel volta di sekolah menengah kejuruan. Karakteristik bahan ajar mengakomodir pembelajaran abad 21 yang meliputi kecermatan isi, ketepatan cakupan, kemutakhiran materi, ketercernaan naskah, penggunaan bahasa dan penggunaan ilustrasi. Penelitian mengidentifikasi profil kompetensi siswa yang sangat diperlukan dalam pembelajaran abad 21, yaitu kreativitas dan penguasaan konsep. Subyek penelitian adalah bahan ajar yang digunakan oleh 16 guru kimia di 16 SMK dengan sasaran siswa sebanyak 95 orang. Data dikumpulkan dengan menggunakan lembar observasi, angket kreativitas produk dan tes uji penguasaan konsep siswa. Data yang diperoleh kemudian dianalisis secara deskriptif kuantitatif. Hasil penelitian menunjukkan bahwa bahan ajar yang digunakan dalam pembelajaran belum menggunakan pendekatan yang mendorong kreativitas dan hasil belajar. Hal ini berakibat pada kemampuan berpikir kreatif siswa yang rendah, pada angka 27,03% dan penguasaan konsep siswa juga relatif rendah, rata-rata nilai hasil belajar sebesar 22,4 dari skor maksimal 100. Simpulan penelitian bahwa karakteristik bahan ajar kimia materi sel volta belum sesuai dengan tuntutan karakteristik dalam pembelajaran abad 21 pada aspek konten.

**Kata kunci:** Bahan Ajar, STEM, Kreativitas, Penguasaan Konsep

## INTRODUCTION

The 2013 Curriculum (K-13) is expected to be implemented in 21st-century learning. This is to address the demands of an increasingly competitive era. 21st-century learning should reflect four things in teaching materials; critical thinking skills, creativity, communication, and collaboration (Trilling & Fadel, 2009). Learning chemistry to develop 21st-century skills should have characteristics that can integrate various scientific fields, such as integrating science, technology, engineering, arts, and mathematics (Wilcox, et al., 2017; Ridwan & Rahmawati, 2017). The need for teaching materials that can foster students' ability to have creativity learning becomes an important prerequisite for achieving 21st-century skills.

To teach students to have 21st-century skills, learning must be oriented to 21st-century learning, and one of the principles is the student-centered learning approach and the way students get their knowledge constructively (Ah-nam & Osman, 2017; Redhana, 2019). One of the learning approaches that can accommodate these learning characteristics is the Science, Technology, Engineering, and Mathematics approach or called STEM and modeling instruction. The learning approach adopted must be integrated into presenting teaching material.

Learning with the STEM approach and modeling instruction needs to be supported by representative teaching materials. Based on various literature studies, the criteria of 21st-century teaching materials include the accuracy of the content, the accuracy of the scope, the updating of the material, the comprehensibility of the text, the use of the language, and the use of the illustrations. Specifically, in vocational high schools, the important point in teaching material is the accuracy of the scope and the updating of the material (Depdiknas, 2008). Specifically, the teaching materials needed must contain student activities to design and create products according to the learning topic. The teaching materials that accommodate modeling must contain activity that stimulates students to do activities so that they find concepts in the topics being studied (Prins, *et al.* 2018). The successful use of teaching material on the students' concept mastery depends on the clarity of the content.

Concept mastery and creativity are two essential things in 21st-century learning. Students who master the concepts correctly and adequately are expected to appear creative ideas from within themselves (Yeh, et al., 2019). Creativity is the ability to develop, implement, and convey new ideas to others; being open and responsive to new and different perspectives. Concept mastery is the foundation of creativity. Creativity is also defined as a person's ability to create new mergers. Creativity will depend very much on one's creative thinking, the process of one's intellect in creating new ideas. Creativity can encourage producing concept findings as evidence of innovative learning (Levin-goldberg, 2012). There are many ways to increase creativity, including the inquiry learning model (Zarisa & Saminan, 2017; Ramdani & Artayasa, 2020), the Problem Based Learning model (Oktaviani et al., 2017), the learning with virtual laboratories (Muzakkir, et al., 2015) and the development of teaching materials in the form of modules (Lahra et al., 2017). Concept mastery is a prerequisite for the formation of skills for students in vocational schools that will determine the success of the graduates in the world of work, so it is very important to be strengthened through innovative learning.

The vocational school graduates are still the highest contributor to unemployment compared to the graduates from another level of education. In February 2019, the unemployment rate reached 8.63% of the 136.18 million people (BPS, 2019). The number of unemployed is due to the low competency. The low competence is because, during learning, students do not have good concept mastery so that creative ideas do not emerge. This is because vocational students are instructed as implementing staff who work only according to standard operating procedures (SOP) (Putra, et al., 2018). The reason for this

low concept mastery is the unavailability of adequate teaching materials that match the competency needs of the expertise (Supriadi & Suparno, 2020). Following up on problems with the quality of the graduates, this study did an observation to find the learning facts that became the starting point of the graduate quality concerns.

The observation on the use of teaching materials used by vocational teachers in Sukabumi showed that there is no data analysis of teaching materials used by vocational teachers. Analyzing teaching material is crucial to do immediately because if the teaching materials used are not under the demands of 21st-century learning, it will impact on the lack of students' learning creativity. Analyzing the students' creativity profile is also important to do because this is one indicator of whether the teaching material that has been used can significantly increase creativity and concept mastery or not.

Good teaching materials should be contextual, under the expertise competencies of vocational students, as research by Yustin & Wiyarsi (2019) that has developed contextual chemistry teaching materials that are oriented towards mastering concepts on the topic of petroleum and how the reactions are involved in motor vehicles. Criteria for adequate teaching materials should be able to integrate various subjects (Ningrum, et al., 2018). Finally, adequate chemistry teaching materials must be tested for eligibility through limited testing (Azmy, et al., 2018; Hasibuan & Silaban, 2017). There is a considerable gap between the conditions of teaching materials in various schools with the ideal conditions of teaching materials that are under the criteria for learning in the 21st-century. If the conditions in the school have not been conducted the analysis, whether the teaching materials used are contextual or not, or the teaching materials used have been integrating various fields of science or not, so that the analysis needs to be done for making the school policy (Yasmin, et al., 2016; Wulandari & Sudrajat, 2019).

The purpose of this study was to analyze the characteristics of the chemistry teaching materials used by teachers at 16 vocational high schools in Sukabumi and analyze the creativity and students' concept mastery on the topic of voltaic cells. The characteristics of teaching materials in this study are limited to the aspect of the content, which includes the accuracy of the content according to basic competencies, the updating of the content under the times, relating to the situation, accommodating meaningful learning and STEM approach. The teaching material is limited to the topic of voltaic cells in increasing the creativity and concept mastery of vocational students. Analysis of students' creativity is limited to the creativity of thinking and concept mastery is limited to the concept of voltaic cells under the expertise competencies of the students.

## METHOD

This study uses a quantitative descriptive method that refers to Sugiyono (2017) to describe, explain, or summarize the various conditions including teaching materials used by teachers in vocational schools. The research stages include; introduction, determination of research methods, data collection, and data analysis. The preliminary stage was through background exposure and the formulation of the research problems. Further, the stage of determining research methods includes determining the type of the research method, determining the participant and sample that will be the subject of the research, compiling the research instruments, determining data collection techniques, and determining data analysis techniques. The data collection stage can be carried out online or directly to the population and the data analysis stage is the last activity before drawing the research conclusions.

The participants of the study were students of grade XI vocational schools who had obtained voltaic cell material learning and vocational chemistry teachers in Sukabumi. The number of students was 95 students from 2 schools and 16 chemistry teachers from 16

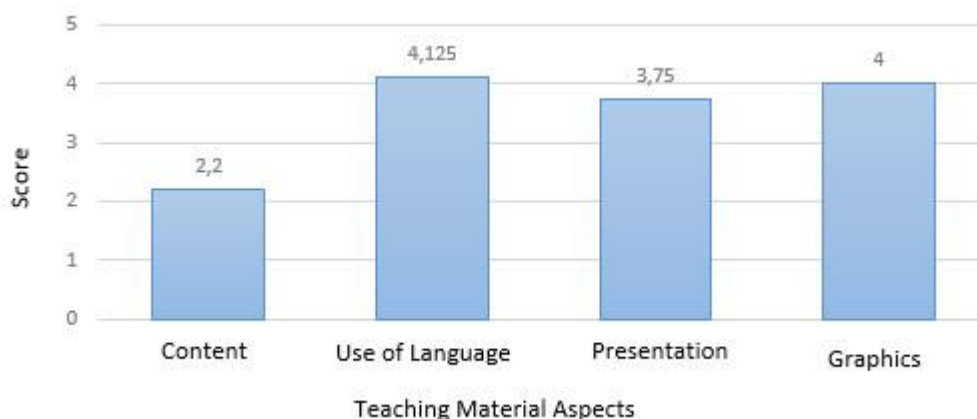
schools. The students were taken by purposive sampling technique and collected using the concept mastery test and thinking creativity test on the topic of voltaic cells. The teachers were taken by a random sampling technique to determine the intensity of student products and the conditions of teaching materials used at the time through the study of teaching materials in online activities using Google Form.

The teaching materials analyzed were collected using the observation sheet of teaching materials. Four aspects were observed, namely the aspect of the content, the use of the language, the presentation, and the graphic. The data obtained are a score with a Likert scale. Data is analyzed by calculating the mean score of each aspect and then performed characterization. In addition to knowing the characteristics of the teaching materials whether it is capable of encouraging creativity or not, the teachers were given a questionnaire that contains about how often students produce a learning product in one academic year arranged.

Students' creativity and concept mastery are measured using written tests using the google form application. The aspects of creativity that are used based on the category of Munandar (1999). There are four aspects measured; the aspect of flexibility, originality, elaboration, and fluency. The concept of voltaic cells tested consists of the concept of an oxidation-reduction reaction, analyzing the anode-cathode, analyzing the direction of electron flow and electrical current, determining the cell notation, calculating the  $E^0$  theoretical cell and the argument of voltaic cells. The data of creativity and concept mastery is in the form of a numeral, then analyzed by determining the mean of the score. The data obtained is then analyzed in a quantitative descriptive method.

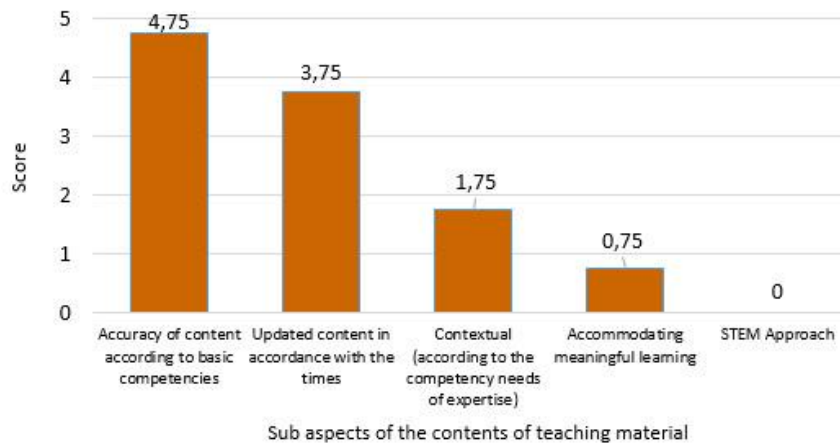
## RESULTS AND DISCUSSION

The analysis results of teaching materials used by 16 teachers in 16 different schools in Sukabumi show that the teaching material is good enough generally, as represented in Figure 1. In general, the teaching materials used by the teachers were relatively good, with a mean score of 3.52. However, there is one aspect of teaching materials which has a relatively low score, that is the content aspect of the teaching material (a score of 2.2 from a scale of 5). There are five indicators of the content aspect of the teaching materials analyzed; the accuracy of the contents according to the basic competence, the updating of the content under the development of the era, contextual (according to the needs of expertise competence), accommodating meaningful learning and the approach of STEM as displayed in Figure 2.



**Figure 1.** Analysis of Chemistry Teaching Material for Vocational Schools in Sukabumi

In Figure 2, it shows the low of the third indicator of the content aspect. This is because there are still a few adaptive books and modules that fit the expertise competencies. Even the books and teaching materials that are in the component of the content tend to be the books for high school students. The analysis of teaching materials on the content component is presented in Figure 2.



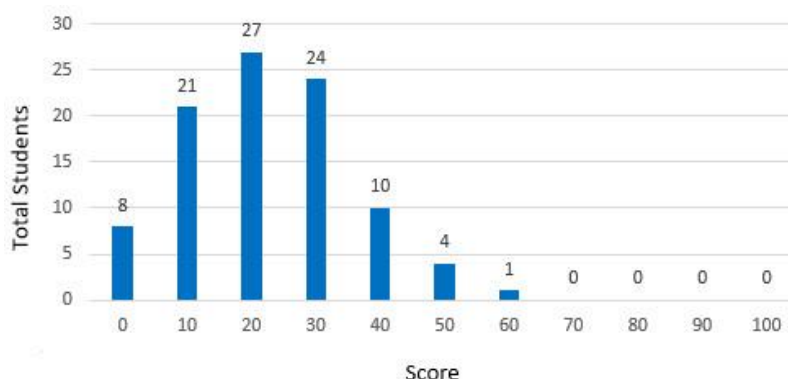
**Figure 2.** Analysis of Teaching Material on The Content Component

The ability of students' thinking creativity is shown in Table 1. In general, the level of students' thinking creativity is low, with a mean score of 27.03. The lowest aspect is the flexibility and the highest aspect is the originality. The result of thinking creativity in this study are presented in Table 1.

**Table 1.** Thinking creativity of Vocational Students in Sukabumi

The aspects of thinking creativity	Creativity score (scale 0-100)
Flexibility	19.70
Originality	36.82
Elaboration	24.20
Fluency	27.40

Of the 9 teachers who have taught chemistry product-based, there are 4 types of products maximum. Some of the products produced by the students include; making key chains of resin, making electrolyte testing equipment, making water filters, and making soap, dishwashing soap, aromatherapy candles, ice cream, *congklak* media of the skin for electron configuration. This fact shows the low creativity of both thinking and student products. The reasons are that the teaching materials used have not facilitated to use creative thinking skills and the teachers have not taught product-based chemistry.



**Figure 3.** The Result of Concept Mastery Test by Vocational Students

The result of the students' concept mastery test is very low (fig. 3). This is because the students have forgotten about the voltaic cell material, while the test was implemented 6 months after the study. The data of the students' concept mastery in this study is presented in Table 2.

**Table 2.** Concept Mastery of Voltaic Cell Material by Vocational Students in Sukabumi

Indicators	Concept Mastery (%)
The concept of the oxidation-reduction reaction	12.75
Analyzing the anode-cathode	25.63
Analyzing the direction of electron flow and electric current	19.55
Defining cell notation	20.00
Calculating $E^0$ theoretical cells	26.60
The argument of voltaic cells	36.80

The result shows that the students in learning are merely memorizing the material without understanding them whereby understanding, the concepts will be long stored. Another factor that causes low concept mastery is that the teachers do not design contextual learning according to students' expertise competencies (Padwa, et al., 2019; Pursitasari, et al. 2019). It also causes students to easily forget (Krathwohl, 2002). Chemistry learning is contextually necessary for students to solve problems in the field of work (Surdin, 2018; Susilaningih, et al. 2019; Suryawati & Osman, 2017). The low concept mastery in vocational students certainly impacts the expertise skills that demand the prerequisite of good concept mastery.

The low flexibility aspect shows that most of the students have not been able to produce ideas, answers or statements that vary as well as students cannot yet see a problem from a different point of view. The creativity of student products is measured by asking teachers, whether or not students are making products, and how often teachers are teaching product-based chemistry. Of the 16 teachers from different schools, only 9 teachers (56%) who have been teaching product-based chemistry, while the rest have never been at all. It is quite a concern for the vocational school level because there are still 7 teachers who have taught theory only in learning.

The research findings indicate that the learning conducted cannot support the expertise competencies of each major, considering the different needs of vocational school teaching material from high school. The books and modules are also still few

accommodating meaningful learning, while there are not many books and modules that facilitate students to experience what they are learning. This resulted in learning as one way and only centered on the teacher. Good teaching books must certainly be able to awaken student-centered learning (Czajka & Mcconnell, 2019; Rahmatillah, et al., 2017). The highlight indicator is that no teaching material used the STEM approach. This is due to the least information about the creation of STEM-based teaching materials in Sukabumi. Thus, it can be said that the material of the voltaic cells used by the teachers at 16 vocational schools in Sukabumi has not been under the demands of 21st-century learning which one of them uses various approaches that put students as a learning center.

In detail, the students' low concept mastery of each indicator is presented in Table 2. The lack of concept mastery is because the use of learning methods chosen by the teachers is not appropriate. Although the 2013 Curriculum has been rolled out almost 7 years, many teachers still use conventional methods in learning, centered on the teacher and minimal product. In learning, vocational teachers are required to implement learning methods that produce creative products (Basri, et al. 2019). In particular, the low concept mastery in the concept of the reduction reaction is because, on the material, there are certain parts in this concept that are abstract, and it is required an alternative method so that something abstract can be shared by modeling (Jackson, et al. 2007; Prins, et al. 2018).

Learning with modeling instruction has been successfully conducted on physics lessons as performed by Jumadin & Hidayat (2017) and Cullen (2015) on a chemistry lesson, so it is necessary to try to teach the material of the Voltaic cells by modeling instruction. Another thing that causes low concept mastery is the idea of the standard operational procedure (SOP). This idea suggests that vocational students only work based on SOP so that concept mastery is not so important. It also affects the lack of creativity because students become afraid to do other things outside the SOP.

This study finds that the characteristics of teaching material have not been under the demands of 21st-century learning and not used various approaches that put students as a learning center. The good teaching material according to the demands of 21st-century learning is capable of making students as a learning center (Czajka & Mcconnell, 2019; Rayens & Ellis, 2018; Rahmatillah, et al., 2017). This condition will make students not develop creativity or concept mastery. The findings also show that existing teaching materials have not adopted a contextual approach, so it has an impact on less supporting expertise competencies for vocational students (Supriadi & Suparno, 2020). Any subjects in vocational schools should be able to support the main competencies in the school, so the main competence will be stronger in concept mastery. Strong concept mastery is expected to increase the creativity and competency of each student.

## CONCLUSION

After mapping the characteristics of the chemistry material voltaic cells at 16 vocational schools in Sukabumi, it shows that the teaching material has not been under the demands of the characteristics in 21<sup>st</sup>-century learning on the aspect of the content. This results in low thinking creativity with a score of 27.03, the low product creativity with 56%, and the low students' concept mastery with a score of 22.42 from a scale of 100.



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#### Keywords

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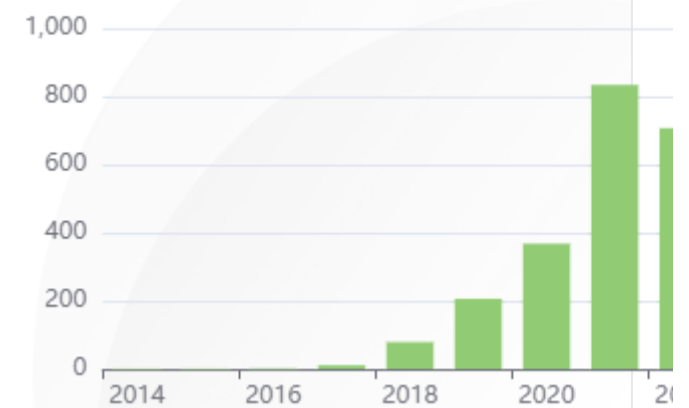
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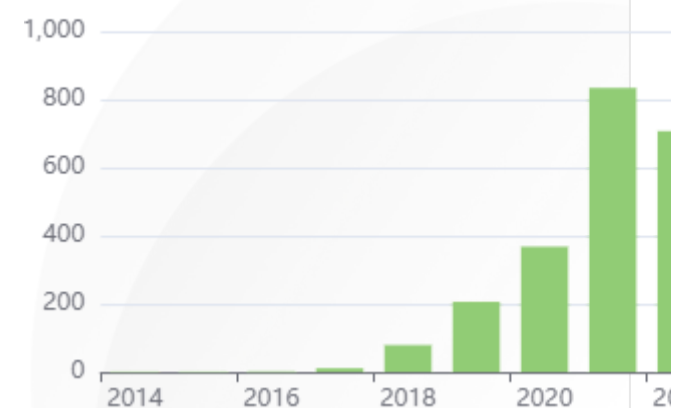
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