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Automotive engineering chemistry module: Exploring acid base and electrochemistry topic in vehicle context

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Abstract. The research purposed to analyze the characteristics of chemistry module on acid-base and electrochemistry topic based on vehicle context, to analyze the feasibility of module according to chemistry learning experts and to analyze the response of chemistry teachers and students of Automotive Engineering Program (AEP) about this module. This research using mixed methods and exploratory model design. The data collected from expert validation sheets also teachers and students response questionnaire. Technique of data analysis begins by converting qualitative data into quantitative data using Likert scales. Furthermore, the total and average score of each component can be determined from the quantitative data. The result of the average scores were converted into qualitative feasibility criteria according to the rating category. The product of the development was a chemistry module on acid-base and electrochemistry topic based on vehicle context for students in AEP. The experts considered feasibility of the module. This module had assessed by 5 teachers and 10 students. The module assessed by teachers showed a very good response while the module assessed by students showed a good response. Therefore, this module is feasible and can be used as a learning resource for students of AEP to enhance quality of chemistry learning.

1. Introduction

Vocational education more emphasized for students who want to work after graduation. Vocational High School curriculum is more practical than theory. Vocational High School has various programs, student can choose according to interests and talents. Graduates of vocational school ready to work based on their expertise. They learn not only in school but also in workplace.

One of the programs in Vocational High School is the Automotive Engineering Program (AEP). Student of AEP not only accepts subjects that related to automotive engineering skills courses but also gets other general subjects. Chemistry is one of the subjects in Vocational High School that must be followed by teacher especially in AEP.

The aim of the chemistry subject in vocational schools are to prepare the basic skills of vocational students in developing their skills, to support vocational subjects, as a basic knowledge for higher education, and to provide the basic knowledge so that students have good science literacy [1]. In fact, according to vocational school students', chemistry subjects are not important subjects so students tend to underestimate. It is not surprising that many vocational school students in Indonesia do not like chemistry subjects. Many chemistry teacher and science teacher researchers note that chemistry



widely felt by students as a difficult subject at several levels of education [2]. They also assume that the chemistry subject is not beneficial for their next career. Many students are not too interested in the subject matter of school chemistry. They do not understand why they need to know the chemical concepts [3].

Based on the results of interviewed with teachers, chemistry learning was given to vocational students are still very common, it is no different from chemistry learning in senior high school. This is due to not available of chemistry modules for vocational schools especially for AEP. Chemistry modules for vocational high school should be differentiate with chemistry modules for senior high school. The appropriate chemistry module for AEP can be created by developing the chemistry learning that integrated with vocational context. The context-based modules can increase students' motivation intrinsically and can improve students' chemical literacy [4]. The chemistry learning has the potential to increase students' motivation, and can reinforce both the meaning of learning chemistry and its perceptions [5]. The students tend to be more interested in studying big ideas of contextual discipline than basic concepts [3]. Consequently, with this concept, learning outcomes are expected to be more meaningful for students.

Meaningful learning can be gained from connecting subject content to specific contexts. Learning chemistry subjects in Vocational School should be associated with the vocational context. Context-based learning aims to enable students connecting between scientific discourse and real-world contexts to enhance curricular relevance without reducing conceptual comprehension [6]. However, it is still constrained by the limited context-based modules. Some Vocational School teachers say that there is no context-based chemistry module for AEP.

One context that is very close to the students of Automotive Engineering is the vehicle. Every day students of AEP always discuss about vehicle. The vehicles body is influenced by the acid-base factor in the environment. Many acid and base products are used in vehicle maintenance. Solution in battery is an acid which is one of the important components in battery. Battery is an application of electrochemistry cells. Acid base and electrochemistry are chemistry topic that taught to vocational students majoring in Automotive Engineering. In this topic easy to find automotive engineering context. Therefore, this research was concerned to develop chemistry modules that can relate chemistry content to automotive contexts, that is acid-base and electrochemistry based vehicles.

The context-based modules was developed can help students to understanding chemistry topic especially for vocational schools. Context-based modules can be used as student learning resources. Context-based chemistry learning is more meaningful and not boring. The problem of this research are: How the characteristics of chemistry module on acid-base and electrochemistry topic based on vehicle context? How the feasibility of module according to chemistry learning experts? And how the response of chemistry teachers and students of Automotive Engineering Program (AEP) about this module?

2. Method

2.1 Research Design

This research used exploratory mixed methods design. This design was appropriate with it aims because can explore problems and develop products.

2.2 Procedure

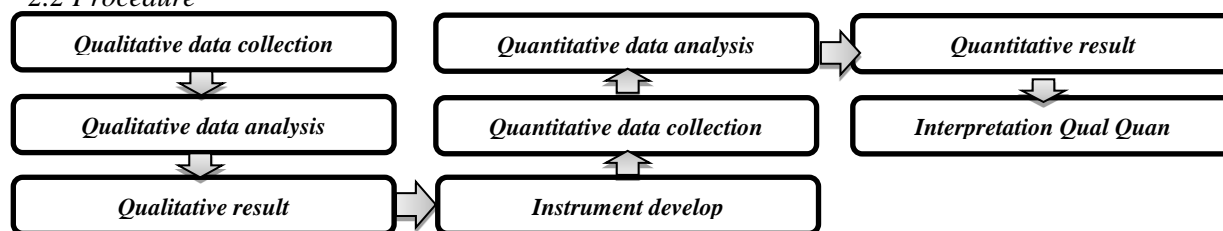


Figure 1. Exploratory design mixed method

Based on exploratory design mixed method that showed on the figure 1 [7], the research procedure can be divided into 4 phase including qualitative, development, quantitative, and interpretation phase. In the qualitative phase, data was collected by analyzing the problems of chemistry learning in AEP, analyzing basic competence of chemistry subject in AEP, and analyzing basic competence of vocational subject that exist in AEP of Vocational School. In the development phase, the first steps were to determine the learning resources to be used as references, make a framework of content, and determine the vehicle context that appropriate with acid-base and electrochemistry topic. Then, arrange the layout and develop the content. In the validation phase was done by feasibility test of experts. The validation was conducted by asking the review of the module in the term of vocational content integration, content feasibility, content presentation, language and grammar toward two experts from chemistry education department. In the quantitative phase, collection of data conducted by responses test of teachers and students. Teachers responses test was conducted by 5 chemistry teachers of Vocational School AEP. Students responses test was conducted by 10 students of Vocational School AEP.

2.3 Research Instrument

The instruments that used to collect the data are validation instrument and qualitative data collection instrument. Validation instrument is chemistry learning expert validation sheets. Quantitative data collection instruments are teachers' responses questionnaire, and students' responses questionnaire. Chemistry learning expert validation sheets were adapted from Education National Standard Agency [8], Programme for International Student Assessment (PISA), and relevant journals. These validation sheets consist of 5 aspect, there are vocational content integration, content feasibility, content presentation, language and grammar aspects. Teachers' responses questionnaire were adapted from Education National Standard Agency [8] and some journals [4] [9-12]. These teachers' responses questionnaire present in the table 1. Teachers' response questionnaire consist of 29 indicators and 5 components. On the other hand, students responses questionnaire was adapted from PISA [13]. Students response questionnaire consist of 18 indicators and 3 components showed in the table 2.

Table 1. Instrument of teachers responses questionnaire

Component	Instruments were adapted	Indicator number	Proposed by
Content Feasibility	Completeness, breadth, Depth, and accuracy of content [8]	1, 2, 3, and 4.	Education National Standard Agency 2012
Content Presentation	Systematic consistency in every chapter, coherency of presentation, suitability the picture with content, addition of question example, addition of concept maps, addition of exercise in every chapter, addition of evaluation question in every chapter, and identity consistency of table/picture [8]	5, 13, 11, 9, 7, 10, 14, and 12.	
	Development of HOT question in evaluation [4]	15	Holbrook, Rannikma and Vaino (2012)
	Student involvement activities [4] [9]	8	Holbrook, Rannikma and Vaino (2012) & Chen and Wei (2015)
Readability	Entirety attraction of module, cover, layout, and font [8]	29, 26, 27, and 28.	Education National Standard Agency
Content Presentation	Completeness of content presentation (content was integrated with context, table of contents, concept maps, core competence and basic competence, glossary, index, and reference) [9]	6	Chen and Wei (2015)
Language	Language use, accuracy of sentences structure, linkages between paragraphs, suitability of punctuation, spelling accuracy, and consistency of terms [8]	16, 17, 18, 20, 19, and 21.	Education National Standard Agency
Vocational Content Integration	Accuracy of integration results with content in module [10]	22	Abualrob and Daniel (2011)
	Suitability of experiment with vehicle/automotive context [11] [9]	23	Ikavalko and Aksela (2015) & Chen and Wei (2015)
	Content application was integrated with context [10]	24	Abualrob and Daniel (2011)
	Accuracy of narrative at the beginning of chapter with context [4] [12]	25	Holbrook, Rannikma and Vaino (2012) & Vos, Taconis, Jochems and, Pilot (2011)

Table 2. Instrument of students responses questionnaire

Component	Indicator Number	Statement
Readability	1	I feel interested when learning acid-base and electrochemistry topic using this module.
	2	I am more excited learning acid-base and electrochemistry topic using this module.
	3	I know the benefits of acid-base and electrochemistry in automotive engineering through this module.
	4	I think easy to understand the concepts of acid-base and electrochemistry using this module.
	5	I know the benefits of acid-base and electrochemistry in everyday life through this module.
	6	I think this module can increase the reading interest about acid-base and electrochemistry topic.
Content	7	I think that acid-base and electrochemistry topic is important to learned because it can be helpful to support my job in future.
	8	I think this module can help the students understanding acid-base and electrochemistry topic in vehicle context.
	9	I know the alternative treatment to respond chemicals (battery, H ₂ gas, etc.) in everyday life.
	10	I think the problem in vehicles related to acid-base and electrochemistry can solved by learning this module.
	11	I can understand acid-base and electrochemistry topic easily using this module.
	12	I think this module appropriate with automotive engineering student needs.
	13	I get some new knowledge about acid-base and electrochemistry from this module.
	14	I think this module can give other knowledge out of major for careers in the future.
	15	I feel motivated to do chemistry practical activity because this module contain practical worksheets integrated with vehicle context..
Content Presentation	16	I think more easy to understand acid-base and electrochemistry topic because there are illustrations and application in this module.
	17	I feel this module can motivate me to discussion with friends because the presentation of module content support to discussed.
	18	I can test my understanding of acid-base and electrochemistry topic through evaluation test in the end of chapter.

2.4 Data Analysis

The assessment result of teachers and students' responses tests were qualitative data and some suggestions. Then, qualitative data was converted into quantitative values with Likert scale while the results in the form of suggestions were used as consideration for revision. Revisions were aimed to improve the modules and increase the quality of modules. Then, quantitative values were analyzed and the average score for each instrument could be determined.

The final average scores were obtained from this quantitative data analysis was used to determine the feasibility category of chemistry module. The results of quantitative data analysis were interpreted with ideal conversion guidelines. The categories that used are very good, good, average, less, very less [14].

3. Result and Discussion

Based on the results of interviews, could be known some problems that occur in the process of chemistry learning in Vocational School AEP. Using basic competence analysis sheets could be gotten acid-base and electrochemistry topic that integrated with automotive engineering vocational basic competence. The analysis result of it was a matrix of integration between chemistry basic competence especially acid-base and electrochemistry topic and vocational basic competence. Based on the matrix, it has been arranged the chemistry module of acid-base and electrochemistry topic for AEP.

Validation result that conducted by chemistry learning expert test were some suggestions. The result of validation by chemistry learning expert, there are some mistakes about chemical nomenclature and some typo, but the experts said that the module have been feasible. The suggestion of validation results was used for consideration of revision.

Quantitative data were gotten from analysis result of teachers and students assessment. Teachers responses of module completely are shown in table 3. In addition, the students' response of module are shown in table 4.

The chemistry module products including cover, introduction, table of contents, introductory sections including a concept map of the integration of chemistry content with the vehicle context, the matrix of integration of chemistry content with the automotive engineering context, content, glossary, indexes, and references. Furthermore, analysis of basic competence of chemistry subject on acid base

and electrochemistry topic and basic competence of Automotive Engineering Vocational subjects in were conducted according to Decree of Director General of Primary and Secondary Education Number 330 / D. D5 / KEP / KR / 2017 [15].

Table 3. Data of teachers responses of chemistry module on acid-based and electrochemistry topic based on vehicle context completely

Component	Teachers					Total Score	Average Score	Maximum Score	Category	Ideals (%)
	1	2	3	4	5					
Content Feasibility	16	14	15	14	16	75	15	16	Very Good	93.75
Content Presentation	43	38	43	37	42	203	40.6	44	Very Good	92.27
Language	24	19	21	18	21	103	20.6	24	Very Good	85.83
Vocational Content Integration	16	14	14	14	16	74	14.8	16	Very Good	92.50
Readability	16	14	16	14	16	76	15.2	16	Very Good	95.00
Total Score	115	99	109	97	111	531	106.2	116	Very Good	91.55

Table 4. Data of student responses of chemistry module on acid-based and electrochemistry topic based on vehicle context completely

Component	Students										Total Score	Average Score	Maximum Score	Category	Ideals (%)
	1	2	3	4	5	6	7	8	9	10					
Readability	18	17	24	19	19	20	20	19	23	19	198	19.8	24	Good	82.50
Content	27	30	36	29	31	29	29	30	36	29	306	30.6	36	Good	85.00
Content Presentation	9	10	12	10	9	9	9	8	12	10	98	9.8	12	Good	81.67
Total Score	54	57	72	58	59	58	58	57	71	58	602	60.2	72	Good	83.61

Based on the analysis of teacher responses on the table 3, an overall average score is 106.2 from a maximum score of 116 is obtained, so it has a very good category with an ideal percentage of 91.55%. Ideal percentage of teachers' responses each component showed on the figure 2.

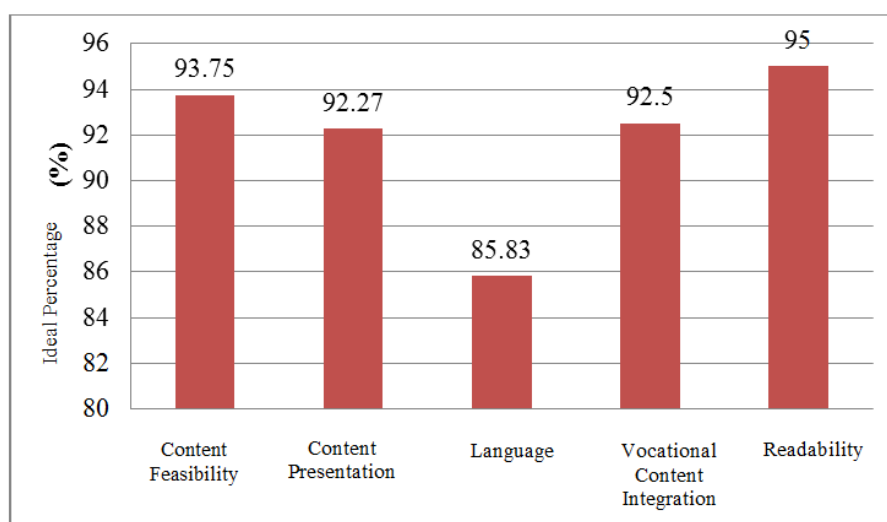


Figure 2. Diagram of Ideal Percentage of Teachers' Responses Teacher responses assessment instrument consists of 5 components

3.1 Components of Content Feasibility

Based on the results of the analysis that showed in table 3, it can be concluded that the components of content feasibility in the module have been very good. The highest average score is in indicator 1 about content completeness while the lowest average score is in indicator 3 and 4 about depth and accuracy of content. In indicators 3 and 4 although the average score is the lowest but it is still in very good category. This shows that of the four indicators in the content feasibility component in terms of completeness, breadth, depth, and accuracy of modules content has been very good.

3.2 Components of Content Presentation

Based on the results of the analysis that showed in table 3, it can be concluded that the content presentation component in the modules has been very good. The highest average score is in indicator 12 about consistency of table/ image identity while the lowest average score is in indicator 8 about student involvement activities. This shows that indicator 12 viewed from the consistency of the identity of the table / picture of the modules have been very good while the indicator 8 about the student involvement activities fall into good category. Other indicators in the content presentation component are also very good because the average score is more than 3.4.

Indicator 8 about student involvement activities has the lowest score because activities in module are less interesting. Activities in modules should encourage students to do something. Other indicator, the development of HOTS questions in modules is very good. One of HOTS (High Order Thinking Skill) realization is able to cultivate critical, creative, and innovative thinking skills [16].

3.3 Component of Language

Based on the results of the analysis showed in table 3, it can be concluded that the language component in the modules has been very good. The highest average score is in indicator 18 while the lowest average score is in indicator 19 and 20. This shows that when viewed from indicator 18 that the linkage between paragraphs of modules has been very good while the indicators 19 and 20 regarding the spelling accuracy and the suitability of punctuation in good categories.

Indicators 19 and 20 have the lowest average score because there are spelling of words in modules that have not complied with general guidelines for Indonesian spelling and the use of some precise punctuation are not exact. Such errors may cause the reader to be unable to understand the content of the module. Sentences become ineffective.

The indicator 21 viewed from the consistency of term also got a low score. Some terms in the module have not been consistent. There are the use of foreign words and Indonesian words on the same terms. It must be used only foreign terms or Indonesian terms only, not both.

3.4 Components of Vocational Content Integration

Based on the results of the analysis showed in table 3, it can be concluded that the component of the integration of vocational content in modules has been very good. The highest average score is in the indicator 24 about content application while the lowest average score is in the indicator 22, 23, and 25 about accuracy of the integration result, suitability of experiment, and the accuracy of the beginning narrative of the chapter. The indicators are 22, 23, and 25 although the lowest average score is still in very good category. This indicates that of the four indicators in the vocational content integration component have been very good. The context-based modules designed to capture students' intrinsic motivation and increase chemical literacy to become fast-response students [4]. To develop competence in an area of inquiry, student must understand fact and ideas in the context of conceptual framework and organize knowledge in ways that facilitate retrieval and application [17]. The vocational content integration component of modules is so good that the modules are expected to increase the motivation of vocational students in AEP to study chemistry.

3.5 Components of Readability

Based on the results of the analysis showed in table 3, it can be concluded that the components of readability in modules have been very good. The highest average score is in indicator 26 about cover of module while the lowest average score is in indicator 28 about font type. In indicator 28 even though the lowest average score but still in the very good category. This shows that when viewed from the cover and the font type of modules are very good. Other indicators in the readability components that are indicators 27 and 29 seen from the layout and entirety attraction of the modules have also been very good.

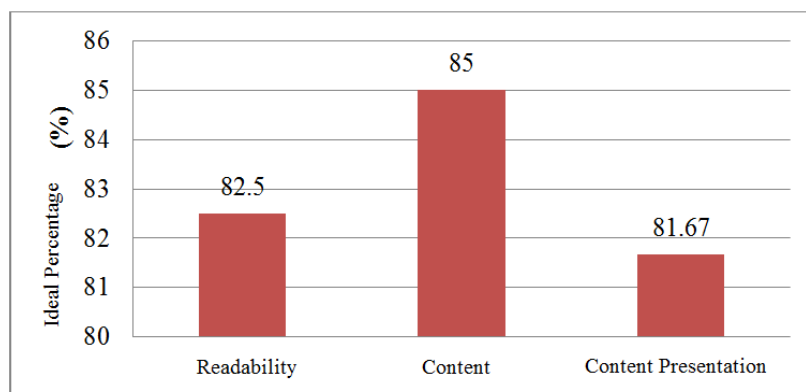


Figure 3. Diagram of Ideal Percentage of Students' Responses

Based on the results of data analysis showed on table 4, obtained the overall average score is 60.2 from a maximum score of 72 so that it has good category with an ideal percentage is 83.61%. Thus, it can be concluded that students' responses to module are good. Ideal percentage of students' responses each component showed on the figure 3.

4. Conclusion

Based on the research, the chemistry module has a characteristic, that is the module was the result of integration between basic competence of chemistry subject on acid-base and electrochemistry topic and basic competence of Vocational Automotive Engineering subject. Based on chemistry learning expert, this module is feasible to be tested to students of AEP but with some suggestions. Based on teachers' responses, this module is included in very good category. Based on students' responses, this module is included in good category. Hence, the module should be used as a learning resource for students of AEP in order to support the learning of chemistry.

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