Integrated vocational context in chemical teaching materials for vocational school

S Haryani*, S H Dewi, S Wardani, and K I Supardi

Department of Chemistry, Faculty of Mathematics and Natural Science, Universitas Negeri Semarang, Indonesia

*Corresponding author: haryanikimia83@mail.unnes.ac.id

Abstract. Chemistry learning in vocational schools is included in the field of specialization, but the context of chemistry learning is in vocational schools has not been linked to the vocational field. Therefore it is necessary to research to compile chemical teaching materials vocational schools that integrate the vocational context. In addition to teaching materials related to the vocational context, this study also aims to integrate character education and religious aspects (chemireligiousa). This teaching material development model adopts the 4D model by Borg & Gall. The preparation of teaching materials is based on a literature study and rational considerations to find the characteristics of learning planning in the form of teaching materials and worksheet, as well as an assessment to measure HOTS. The validation of teaching materials in terms of aspects of chemical content material, vocational context material, as well as the suitability of the chemical content with the vocational context. The results obtained by validated acid-base teaching materials are related to aspects of the vocational context and religious aspects. The results of this study have been able to develop teaching materials so that they fit the vocational context. It is necessary to do an in-depth basic competence (BC) analysis of Chemical in general and vocational so that it can be applied to contextual vocational chemical.

1. Introduction

Vocational high schools (vocational schools) are educational institutions that aim to equip students with knowledge and skills as life skills. This educational institution is expected to prepare graduates as a workforce that can compete competently in the world of work [1]. There are 9 types of areas of expertise in vocational secondary education. These areas of expertise include Technology and Engineering, Energy and Mining, Information and Communication Technology, Health and Social Work, Agribusiness and Agro-technology, Maritime Affairs, Business and Management, Tourism, and Arts and Creative Industries. Each of them is further classified into expertise and skill competency programs [2].

The 2013 curriculum divides subjects in vocational schools into three groups, namely groups A, B, and C. Chemistry subjects are included in group C, namely the content of vocational specializations, one group with vocational subjects. This further confirms that the objectives of chemistry subjects are used to strengthen subjects or competencies in vocational schools. Chemistry learning in vocational schools should be directly linked to vocational learning [3]. Thus, chemistry learning in vocational schools should be relevant to vocational subjects or following the vocational context in supporting the achievement of student competency skills [4]. In fact, until now, chemistry learning in vocational schools has not been integrated with the vocational context. This is one of the reasons vocational school
students think that chemistry is not an important priority compared to vocational subject [5]. Besides, they also think that there is no connection or relationship between chemistry subjects and vocational interests. Generally, vocational school students prefer vocational subjects because they place more emphasis on practical work competencies than non-vocational subjects [6].

Based on the results of observations in six vocational schools in the city of Semarang, it is clear that chemistry teachers in vocational schools have not conducted chemistry learning that is integrated into the vocational context. The six vocational schools include SMK Negeri Jawa Tengah Semarang, SMK Negeri 3 Semarang, SMK Negeri 4 Semarang, SMK Negeri 8 Semarang, SMK Muhammadiyah 2 Semarang, and SMK Texmaco Semarang. The main reason is that there are no books or supporting teaching materials available. Some of the vocational school chemistry teaching materials Curriculum 2013 on the market are generally not under the vocational context [7]. The context in vocational school learning is an integration of the basic characteristics of the vocational subject, the conditions in which learning takes place, the goals and desired outcomes that are adjusted to the specifications of the qualifications of vocational school [5,8,9]. Thus chemistry teachers in vocational schools need an overview of how to integrate the material in chemistry with the material provided in vocational competencies according to student interests [6,10].

School as the second institution after the family plays an important role in instilling the values of life in individuals. In school, individuals learn how the values of life must be realized in everyday life. Students spend more time at school than anywhere else. Therefore, the school is a place for character building for students [11]. Character education is a system of instilling character values to school members. The components are in the form of knowledge, awareness, or willingness and actions to carry out these values. Character education must be socialized from an early age at all levels of education. Educational institutions must appear as educational pioneers in building the character of students who are moral and moral, dynamic, and visionary [12].

To obtain teaching materials that are following the demands of competencies that must be mastered by students, analysis of CC and BC are required, analysis of learning resources, and determination of the type and title of teaching materials. Even though the BC has written is still general, the government has sorted it out according to the needs of the field of expertise. There are 142 skill competencies in vocational schools with 9 types of expertise. Extra thought is needed if the government has to make BC which is integrated with the vocational theory for all types of skill competencies. This study aims to develop chemistry textbooks that are integrated into vocational contexts for vocational schools in the fields of expertise of Automotive Engineering, Construction, and Property Engineering and Electronics Engineering.

2. Method

This study include research and development (R&D) which is conducted to develop teaching materials with several aspects such as chemireligiousa, integrated character education, representative multilevel, and the vocational context in vocational school chemistry materials. The teaching material products developed are then analyse their meaning, especially in the vocational context. In this study, the product of teaching materials is still limited to 3 materials with certain vocations. Sources of data collected in this study were obtained through interviews, observation, documentations during the study, and the results of expert validation. The validation of teaching materials is used to determine the level of validity of teaching material products based on expert judgment. The validation of teaching materials includes aspects of material accuracy (chemical content and vocational context), suitability between chemical content and vocational context, and conformity with indicators of critical thinking skills.

The character education integrated chemireligiousa teaching material development model adopts the 4-D model by Borg & Gall (1983), which includes four stages, namely define, design, development, and disseminate. The research design from define to model implementation is presented in Figure 1.
3. Discussion

Skill competencies in vocational school, based on Perdirjen Dikdasmen No. 06 /D.D5 /KK /2018 of 2018 (regulation of the minister of education), concerning the Vocational High School Expertise Spectrum, the number of vocational schools' competency skills which originally amounted to 142 skill competencies has increased to 146 skill competencies. Furthermore, Perdirjen No.464 of 2018 accommodates the Core Competencies (CC) and Basic Competencies (BC) of the 4 new skills competencies that have been mentioned above and at the same time replaces the previous regulation, namely the Decree of the Director-General of Primary and Secondary Education No. 330 / D.D5 / KEP / 2017 in 2017. In Permendiknas No. 22 of 2006, states that the curriculum preparation of vocational school subjects is divided into three groups, namely normative, adaptive, and productive groups. The adaptive group focuses on understanding and mastering the concepts and basic principles of science and technology that can be applied in everyday life.

Facts in the field show that the application of chemistry as an adaptive material has not been linked to Skilfull Competence. Well done. This is based on the results of the analysis of several vocational school chemistry textbooks on the market and interviews with several teachers. Likewise for the vocational school chemistry textbook [13,14]. According to the narrative of some vocational school teachers who take advantage of textbooks as well as the research results of the chemical package books used in vocational school are not specific books for their expertise competence, but chemistry books for vocational school in general [3,10,14]. The chemistry book used is "Chemistry for high school / vocational school ". This statement shows that the application of chemistry as an adaptive material has not been implemented well. As an example of a chemistry textbook "Chemical Technology and Engineering for vocational school " This book is a general chemical support book for vocational school, especially in the fields of technology and engineering expertise, in which it has nothing to do with the problem of Light Vehicle Engineering Skills Competency both in the presentation. Material sample questions, and practicum. However, it contains more basic chemical materials in general as in the high school. The same is true of books with certain publishers. The next question is how to integrate the vocational context into teaching materials. For this, it is necessary to analysis of BC for various vocations major.

The types of BC were divided into 2 groups, namely technology and engineering as group 1 and group 2. Group 1 consists of The Technology and Engineering Spectrum, which consists of Construction and Property Engineering, Geometrics and Geospatial Engineering, Electrical Engineering, Mechanical
Engineering, Aircraft Technology, Graphic Engineering, Industrial Instrumentation Engineering, Industrial Engineering (Production Control Techniques), Textile Technology, Chemical Engineering, Automotive Engineering, Shipping Engineering, Electrical engineering, and Mechanical Engineering. While group 2 consists of 2a) Energy and Mining Spectrum as well as Information and Communication Technology, and 2b) Agribusiness and Agro technology, as well as Health and social work, and 2c) Maritime [1,2,13,15].

Chemistry in high school begins with the essence of chemistry, in vocational school it begins with analysing Material change and mixture separation ended in analysing the technical process of separating petroleum fractions and their uses, while Group 2 BC started with understanding the role of chemistry in life, and ended by applying simple mixture separation techniques. Materials that are not included in the Technology and Engineering Spectrum are thermochemistry, reaction rates, chemical equilibrium, hydrolysis, buffers, colloids, collective properties, and elemental chemistry.

Meanwhile, the energy and mining spectrum, as well as Information and Communication Technology, have the same BC starting with all BC from both groups have BC associated with acid-base material. Technology and Engineering spectrum group evaluating the properties of the solution based on the concepts of acid-base and pH of the solution, for group two added by understanding the properties of acid, base, and salt solutions with several indicators. BC in the spectrum of group 2a begins with Understanding the role of chemistry in life and ends with applying the calculation of solution concentration (%), molarity, and ppm). Meanwhile for 2b. Starting with analyse the change of matter and separation of mixtures and ending with analyse the manufacture of various colloid systems with the materials around us. Finally, 2c) the maritime spectrum begins analyse the properties of matter and its transformation and ends with applying simple mixture separation techniques.

Even though the basic competencies stated are still general in nature, the government has nevertheless sorted them out according to the needs of the areas of expertise. Although the basic competencies listed are still general in nature, the government has sorted these basic competencies according to the needs of the areas of expertise. There are 142 skill competencies in vocational schools with 9 types of expertise. Extra thinking is needed if the government has to create basic competencies that are integrated into the vocational context for all types of skills competencies. On the subject matter of material change and separation of mixtures, vocational school textbooks that are often used by teachers only contain theoretical material. When this material is taught, additional information can be given about the application in the vocational field of students. For example, automotive engineering students are given...
information that the emission test on motorized vehicles is one way of separating the mixture, namely smoke.

One of the chemical contents that applies to vocational programs in automotive engineering is petroleum content. There are several basic competencies in automotive engineering vocational subjects that require a good basic knowledge of petroleum content. These basic competencies include understanding the gasoline fuel system, understanding diesel fuel, explaining the lubricants used in the hydraulic system and their contents, and understanding the contamination of the fuel, oil, and body according to environmental standards. Based on the basic competencies in automotive engineering vocational, the chemical content that can be taught includes the concept and use of petroleum fractionation, the quality of fuel in vehicles, the ratio of fuel to air in vehicle engines, the impact of fuel combustion, and ways to reduce its impact [1,17]. The integration of the basic vocational competencies of computer and network engineering with the basic competences of corrosion is presented in Table 3.

Based on Tables 1 and 2, teaching materials can be prepared according to the vocational context. It is hoped that the integration of chemistry materials with vocational subjects is expected to teach chemistry, which originally only aims at mastering chemistry, will turn into chemical knowledge and understanding of vocational subject matter knowledge. Students can master vocational subjects by basing the aspects of other scientific buildings that support them. Based on the basic competences in automotive engineering vocational, the chemical content that can be taught includes the concept and use of petroleum fractionation, the quality of fuel in vehicles, the ratio of fuel to air in vehicle engines, the impact of fuel combustion, and ways to reduce its impact [10]. The physical and chemical properties of corrosion contained in vocational subjects in computer and network engineering can be supported by chemical materials, namely changes in material, the physical and chemical properties of corrosion. To study chemistry, corrosion has metal physical properties and chemical content which contains a lot of rust. For all BCs of the various spectrum are BC related to acid-base material. Next will be discussed the development of acid-base teaching materials that represent various spectrums and vocations.

Table 1. Integration of basic Competencies of Automotive Engineering Vocational Competencies with Basic Competencies of Petroleum

| Basic competencies Chemistry | Basic Automotive Engineering Vocational Competencies that Can Be Integrated with Chemistry Learning | Chemical Content Context Vocational Engineering Automotive |
|------------------------------|--------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| BC Knowledge                 |                                                                                                  |                                                          |
| Analysing the technical process of separating petroleum fractions and their uses | Applying the maintenance of the lubrication system | Oil characteristics and quality |
|                              | Applying the maintenance of conventional gasoline/carburettor fuel systems | The process of forming petroleum fractionation |
|                              | Applying the way of caring for the fuel injection fuel system (EFI)                             | Characteristics and quality of gasoline                  |
| BC Skills                    |                                                                                                  |                                                          |
| Presenting the technical process for the separation of petroleum fractions as well as its uses | Diagnosing damage lubrication system | Process, benefits and impact of oil recycling in the automotive sector |
|                              | Diagnosing damage gasoline fuel system conventional / carburettor | Combustion reaction gasoline and its effects |
|                              | Diagnosing damage gasoline fuel system injection (Electronic Fuel EFI) | How to overcome negative impact burning gasoline         |

Based on the results of chemical analysis in vocational schools, the first teaching material to be developed in this research is acid-base material. Acid-base materials are chosen because they have almost any direction or spectrum on vocational schools studies the topic. Just like other materials, acid-base material is also not adaptive and the material content is still the same as acid-base material in high
school. To fix this, basic competency analysis and achievement indicators were carried out, as well as material content to suit the vocational context.

Table 2. Integration of basic competences in computer and network engineering with basic competences in corrosion

| Basic Chemical Competencies | Basic Computer Network Engineering Vocational Competencies Integrated with Chemistry Learning | Chemical Content Vocational Context of Computer Network Engineering |
|----------------------------|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| **BC Knowledge**           | 1. Describe the incidence of corrosion and chemical applications in appropriate technology | 1. Corrosion formation process                                      |
| 3.9 To analyze the symptoms of the gilding process and the factors that influence the occurrence of corrosion | 2. Analyze the factors that cause corrosion                                         |
|                            | 3. Analyze the impact of corrosion                                                            | 3. The impact of corrosion                                           |
|                            | 4. Describe electroplating                                                                   | 4. Gilding (electroplating)                                         |
|                            | 5. Analyzing the electroplating process                                                       | 5. The electroplating process on the motherboard                     |
| **BC Skills**              | 1. Describe the incidence of corrosion and chemical applications in appropriate technology |                                                                     |
| 4.9 Proposing ideas/ideas to overcome the corrosion process based on the factors that influence it in everyday life through the experiments carried out | 2. Analyze the factors that cause corrosion                                             |
|                            | 3. Analyze the impact of corrosion                                                            |                                                                     |
|                            | 4. Describe electroplating                                                                   |                                                                     |
|                            | 5. Analyzing the electroplating process                                                       |                                                                     |

The second stage is the preparation (design stage) of chemical acid-base teaching materials. Design starts with making a display storyboard for producing a prototype. Some of the prototypes can be seen in Figure 2. After all the parts are arranged, then the validation process is carried out.

![Figure 2. Teaching material prototype](image)

The validation stage is the development stage. The validation process is carried out by material experts and media experts to determine the validity of teaching materials. The instrument in this stage is based on Badan Nasional Standar Pendidikan (BNSP), the national institutions that regulate the quality standards of education in Indonesia [16]. Statistically, the teaching material obtained a valid category and the decision was feasible to use with a few revisions. Valid criteria with a validity level of 3.78 in the very good category. Some of the revised results include religious content. The religious content in the prototype is not yet visible so it is necessary to add an introduction with religious content. The religious content here uses Islamic teachings more specifically. The display before validation can be seen in Figure 3, and Figure 4 shows the revised results. Also, the revisions made are in the form of grammar and grammar, but in terms of content, it is following the prevailing concept without experiencing significant revisions.

The next stage is the trial stage on limited subjects or small-scale trials. The results of small-scale trials that have been carried out are analysed to determine the effectiveness of teaching materials in improving critical thinking skills and the proportion of student completeness. From the results of the analysis, it can be seen that the average pre-test value is 61.25 with the proportion of completeness of 11.11%. Meanwhile, the average post-test score was 82.71 with the proportion of completeness of
86.11%. It can be seen directly that there is an increase in the value of the pre-test and post-test results by 35%. The analysis was continued using the N-Gain test. From the results of these calculations, it can be seen that the normalized N-Gain score with high criteria was obtained by 9 students and moderate criteria as many as 27 students. The average N-Gain score in this class is 0.55 with moderate criteria. To see whether the increase was significant or not, the test was continued using the Paired Sample t-Test. The t-test results show that the price of \( t = 25.15 \) is greater than \( t (0.95) (35) = 2.03 \). Because \( t \) is greater than \( t \) in the table and \( t \) is located in the rejection area of \( H_0 \), it can be concluded that there is a significant increase in the value of the pre-test and post-test results. Then the integration of vocational context to chemical teaching material can improve student’s understanding and knowledge [12,14,15,17].

Teaching materials are said to be effective if they can improve critical thinking skills and fulfill the proportion of student completeness by 85% with the average posttest results classically reaching \( \geq 80 \). From the analysis previously described, we already know that there is a significant increase in the pretest and posttest scores and the proportion. Completeness reached 86.11%. Besides, the mean posttest results classically also met the indicators of success, with a mean of 82.71. This information can be used to state that acid-base teaching materials that are integrated into vocational contexts are effectively used in learning.

4. Conclusion
The analysis result of integrated acid-base teaching materials in the vocational context to improve students’ critical thinking skills, the following conclusions can be drawn: 1) the acid-base teaching materials integrated with the vocational context meet the valid criteria with a validity level of 3.78 in the very good category. 2) Teaching materials achieve effective criteria to improve critical thinking skills with the conditions that have been met, namely the average critical thinking skills test results increased by 35%, the N-Gain score reached 0.55 with moderate criteria, and the proportion of student completeness reached 86.11% with the mean post-test results of students' classical critical thinking skills of 82.71.

References
[1] Corrigan, D., and Fensham, P. 2002. The roles of chemistry in vocational education (Amsterdam Kluwer Academic Publishers) 125
[2] Mahirda, K., and Wahyuni, H. 2016 Rev Econ Stud. 9 28
[3] Acar, B., and Yaman, M. 2011 Hacettepe univ. eczac. fak. derg. 40 1
[4] Rintala, H. and Nokelainen, P. 2020 Educ. Train. 72 250
[5] Smith, E., 2010 Int. J. Train. Dev. 14 54
[6] Misbah, Z., Gulikers, J., Dharma, S., and Mulder, M. 2019 J. Vocat. Educ. Train. 7 28
[7] Broman, K., Bernholt, S., and Parchmann, I. 2018 Int. J. Sci. Educ. 40 1176.
[8] Brunello, G. and Rocco, L. 2017 SERIEs 8 315
[9] Broman, K., Bernholt, S., and Parchmann, I. 2018 Int. J. Sci. Educ. 40 1176
[10] Wiyarsi, A., Pratomo, H., and Priyambodo, E. 2020 J. Turkish Sci. Educ. 17 147
[11] Çiğdemoğlu, C., Arslan, H., & Cam, A. 2017 Chem. Educ. Res. Pract. 18 288
[12] Nainggolan, B., Simamora, M. and Hutabarat, W. 2019 J. Pendidik. Kim. 11 3 67–78
[13] Wiyarsi A, Pratomo H and Priyambodo E. 2017 Proc of 3rd Int. Sem. of Sci. Educ. (Yogyakarta: Yogyakarta State University) 3 359-366
[14] Ariyani, N. 2019 JISE 8 516-524
[15] Febrianto, A. Wiyarsi, C. F. Partana, and B. Sulistyö 2019 J. Phys.: Conf. Ser. 1156
[16] Rogalski S. 2006 Vocational education and training in the chemical industry in Germany and the United Kingdom (Geneva : International Labour Office)
[17] Ningrum, L. S., Supardi, K.I., Jumaeri, J., and Haryani, S 2018 J. Innov. Sci. Educ. 7 114