Development of STEM-based practicum on making toothpaste from chicken eggs

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Abstract. One challenge in the science learning in industrial revolution 4.0 includes the development of a practical laboratory work that combines science, technology, engineering and through STEM-based learning. This study aims to develop a practical method based on STEM in the manufacture of toothpaste from the chicken in the egg shells as one example of colloid material. Eggshell was chosen because it is regarded as waste material that may create problems on its disposal. However, eggshell contained high amount of calcium, hence it may be utilized as starting material for toothpaste production. The research methods used Research and Development (R&D) comprised of the development of STEM-based worksheet and its validation by experts. Participants of this study were students of class XI, teacher and validator. Data collected included validator sheets and questionnaires responses. This research resulted in the design of a viable practical methods such as lesson plans and worksheets.

1. Introduction
The world is entering the era of industrial revolution 4.0 in which the information technology become a part of human life. Information to be without bounds with the development of internet and digital technology. This will have an impact on human activity case of science and technology and education which is where the human resources will be replaced by the sophistication of the machine that is the result of the industrial revolution 4.0. To deal with the 4.0 era, need to be prepared learning system more innovative and creative like learning curriculum adjustment to technological progress [1].

Chemistry curriculum in 2013, is intended as a process through learning chemistry students are expected to know how to think and behave toward nature, while the chemical as a product that is as the result of learning in the form a literate human science adan technology [2].

The National center for STEM education STEM states that learning can be one of the solution to deal with the industrial revolution 4.0, this is Because STEM develope some disciplines, such as Saint, Technology, Engeneering and Mathematics [3].

The application of STEM indirectly requires teachers and students to think creatively. Teachers are required to be creative in developing the student's ability and creativity the which can be approached through the learning-based STEM. It is a learning that have the characteristics of integrating scince, technology, engineering, and mathematics to solve real problems, so that the implementation of the concept, but rather how students understand and grasp the concepts of scince and its relationship to everyday life [4].
STEM learning can be applied in practical activities which is one of the important learning activities in chemistry. Students will be given the opportunity to learn and work actively as observing the phenomena that occur through practical activities and to improve students understanding of chemistry [5].

The material can be applied in practical activities, one of which is a colloid in the process manufacture of toothpaste, which this material is stressed applications in everyday life and in particular on the KD 4:14 on the colloid material requires students to be able to make a product that uses the principle of colloids. This is very clear competences can be met through practicum and discouraged a means to develop student creativity.

Development of practical activities can be seen from the determination of the equipment and materials in the manufacture of toothpaste. As well as Researchers continue to conduct research on the use of waste to obtain more useful products, new, economical commercial value and can be used by humans. One of the wastes which is found in Indonesia items, namely chicken egg shells. Most of the chicken egg shells containing calcium carbonate is approximately 90%. High content of calcium carbonate that can be used as a basic ingredient of toothpaste manufacturing [6].

However, the result of the analysis where practical guidelines colloid manufacture toothpaste in 5 boxes in class XI high school seniors packages show, the lack of guidelines practicum manufacture toothpaste in colloid material. Therefore, Researchers felt it was important to conduct research and development practicum toothpaste manufacturing of chicken egg shells that can be applied in the colloid materials to enhance students creativity. Therefore, the purpose of this study is to develop the design method based on STEM practicum at making toothpaste from the chicken egg shell is valid, interesting and appropriate to the learning objectives to the colloid material,

2. Experimental Method
This study was conducted involving 20 high school students of class XI as a respondent in a limited test lab worksheet that have been designed. Design studies conducted: (1) analysis of the curriculum, textbook, and journals. The analysis showed that the lack of practical problem-based STEM in the manufacture of toothpaste on the colloidal material, so it can be used as the potential to do a study; (2) optimization of laboratory procedures toothpaste manufacturing of chicken egg shells do to get the format of lab procedures, as ingredients in designing STEM-based worksheets and lesson plans; (3) designing the initial products in the form of worksheets and lesson plans that STEM-based validation test will be conducted to two lecturers are experts in chemistry education department UPI and one high school chemistry teacher. (4) validation of products tailored to the curriculum on colloidal material consisting of material and design. Aspects assessed from validasi material are compatibility between STEM aspects, indicators pencapian with activities in worksheets and lesson plans. Aspects considered in the design of the component such as content, presentation, graphic, and language, while the design aspects of the RPP comprised of format, content and language; (5) improvement of product that is doing the printing products that have been declared valid by the validator; (6) limited testing done to grade students to determine the applicability of the product in practical learning activities; (7) giving a statement on the questionnaire in the form of a list of teachers and students to determine the effectiveness of amenity products, the attractiveness, usefulness,

Data analysis techniques for validation is performed using the calculation of the value of the CVR (Content Validity Ratio) with the assessment criteria "yes" for a weight of 1 and "no" to 0. Determination percent response score performed following equation 1. Questionnaire data processing such as in Table 1 below [7].

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\text{The percentage value (X) } = \frac{\text{real score}}{\text{score maximum}} \times 100\% \tag{1}
\]
Table 1. Interpretation score questionnaire.

| Score (X) | Interpretation  |
|-----------|-----------------|
| 81-100    | Very good       |
| 61-80     | Well            |
| 41-60     | Enough          |
| 21-40     | Less            |
| 0-20      | Very less       |

3. Result and Discussion

3.1. Validation Results: Worksheet

STEM-based practical learning process requires materials such as worksheets and lesson plans. Optimization results used as ingredients in the development of worksheets and lesson plans based on the phases comprising STEM Science, Technology, Engineering, and Mathematics. Worksheets developed refer to the basic competence, competence achievement indicator of colloidal materials, and methods of learning. Worksheets has been developed then validated by a validator is shown Table 2.

Table 2. Worksheets Validation Result

| No | Rated aspect | Total vote "yes" to-validator | Average | Criteria |
|----|--------------|-------------------------------|---------|----------|
|    |              | 1    | 2    | 3   | 4   | 5   |         |          |
| 1  | contents     | 0.90 | 1.00 | 0.90 | 0.30 | 0.90 | 0.80    | valid    |
| 2  | Presentation | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00    | valid    |
| 3  | Graphic      | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00    | valid    |
| 4  | Language     | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00    | valid    |
|    | Overall      |       |       |       |       |       | 0.83    | valid    |

Table 2 shows the results of the validation worksheets with an average overall score of 0.83 where the value of the CVR is greater than the critical value of 0.736 from 5 validator that this case indicating that worksheets is valid so that it can be used in learning activities. The results validate that the contents component with an average of 0.80, which means the contents of the LKS valid component so as to support in the learning lab colloid materials to enhance students' creativity, presentation components, graphical, and language obtain an average value of 1.00 with a valid criteria, which means that the presentation stage of activities in accordance with the purpose of learning and competence achievement indicator. Presentation image, discourse, and the colors on the worksheets can attract students, whereas the meaning of category valid on the language component and the graphics are writing done correctly and can be understood by students as well adapted to the level of students' cognitive [8] LKS declared invalid by the design characteristics of lab-based STEM namely instructional design given to high school students of class XI through practicum manufacture of toothpaste on the colloidal material combines four aspects, namely science, technology, engineering, and mathematics in colloidal material. Science in this lab is a colloid, Technology used is the manufacture of toothpaste to life using a blender and ball mill, ie reverse engineering the particle size of chicken egg shells and mathematics which calculates the exact composition of materials in the manufacture of toothpaste from chicken egg shells.
3.2. Validation Result: Lesson Plans
Lesson plan validation results are provided in Table 3. Table 3 shows that the result validate the STEM-based with three aspects are Considered items, namely the format, content and language with an average of 3.62 that is very valid, so the lesson plan can be used in learning without revision. Aspects of the format in the assessment of this RPP shows the average high with the criteria very valid means of writing lesson plans that have been made complete that contains component RPP such as the identity of the school, learning objectives, materials, methods, learning activities, and assessment, so that aspect of the format does not need to be done revision. Furthermore, the language aspect of average height with very valid criteria means writing lesson plans that have been made already using Indonesian rule is good and true (EYD), so it does not need to be revised. While, to the average content aspect is the most value smaller than the format and language aspects, this indicates a need for revision in the writing of a complete lesson plan includes correspondence between the curriculum, STEM, and creativity with learning activities [9].

Table 3. Lesson Plan Validation Results.

| No | Rated aspect | The average score validator to-votes | Average criteria |
|----|--------------|-------------------------------------|-----------------|
|    |              | 1        | 2        | 3        | 4        | 5       |                  |
| 1  | Format       | 4.00     | 4.00     | 3.50     | 4.00     | 3.50    | 3.75              | Very Valid    |
| 2  | Contents     | 3.60     | 3.60     | 3.20     | 3.80     | 3.40    | 3.52              | valid         |
| 3  | Language     | 3.50     | 4.00     | 3.50     | 3.50     | 3.50    | 3.60              | valid         |
|    | Overall Average |        |          |          |          |         | 3.62              | Very Valid    |

3.3. Teacher And Student Feedback Results
Teacher and students give good feedback to the product development of practical methods of making toothpaste from chicken egg shells, giving the score value of 87.50 (from scale 0-100). Students and teachers assume that the product was motivating, interesting, and easy to apply in the learning of colloidal matters. Teachers also felt motivated to the develop other practical methods that utilize local materials.

4. Conclusion
Based on the results of this study, it can be concluded that: (1) the development of research practicum STEM-base methods produce the form of worksheets and lesson plan STEM-based on colloidal material. In this practical aspect of science that is used is a colloid, teknologi penggunkan tool used is a ball mill, which is in the form of reverse engineering the particle size of the eggshell, and mathematics is to calculate the composition of the material in the manufacture of toothpaste from chicken egg shells; (2) worksheet STEM-base declared eligible to be used as a practical guide on colloid materials with the results of the CVR is; (3) the result of the validation of a lesson plan is 3.62 so it can be used in STEM learning methods in colloidal material; (4) the result of the validation of a lesson plan is 3.62 so it can be used in STEM learning methods in colloidal material.

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