Improving students’ higher order thinking skills in thermochemistry concept using worksheets based on 2013 curriculum

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Abstract. Higher order thinking skills could facilitate students' thinking to find a new knowledge from the observation of phenomena or natural phenomena that exists around. The purpose of this research was to improve students’ higher order thinking skills for teaching and learning thermochemistry concept using student worksheets (SWS) based on curriculum 2013. The research and development method developed by Borg and Gall's model was used in this study. The samples were 25 students of grade 11 from a secondary high school and 15 chemistry teachers in Banda Aceh, Indonesia. The higher order thinking skills were measured using the essay test. Based on the results of data analysis, the N-gain value was 79% which is in the high category. It can be concluded that the developed SWS could improve students’ higher order thinking skills. Therefore the developed SWS could be used as the material for teaching and learning of Thermochemistry.

1. Introduction
Associated with the issue of educational development at the international level, Curriculum 2013 in Indonesia is designed with various improvements. One of them is the refinement of assessment standards. Assessment of learning outcomes is done by facilitating learners to improve higher-order thinking because high-level thinking can encourage learners to think broadly and deeply about the subject matter.

The ability to think is a cognitive domain that according to Bloom's taxonomy consists of six levels. In the 2013 curriculum, this domain refers to a form that has been revised by Anderson & Krathwohl. The domain level consists of the ability to remember, understanding, applying, analyzing, evaluating, and creating [1]. Human thinking skills can be classified into two major groups; low-order thinking skills (LOTS), and higher-order thinking skills (HOTS). LOTS consists of first three aspects of taxonomy bloom including remembering, understanding, and applying. HOTS consists of the last three aspects of taxonomy bloom namely analyzing, evaluating, and creating.

The important goal of science education is to improve students’ higher order thinking skills (HOTS) such as critical, reasoning, reflective and science process skills. The students' HOTS enables them to face the challenges of daily life [2]. In the other words to define the problem around them, observe, analyze, hypothesize, experiment summarize, and apply their information. The easiest learning habit is through activities guided by student worksheets (SWS) to train students’ HOTS.

HOTS is thinking level that higher than simply memorizing. HOTS cannot be unmeshed from the levels of learning; they involve interdependent, multiple components and levels. In real life, students will learn content in both community and school experiences. The concepts that they learn in the prior
year will help them to improve HOTS and new content in the next year. Furthermore, HOTS involves a variety of thinking processes applied to complex situations and having multiple variables [3].

Based on the results from the 2017 National Exams (UN) for Senior High School subjects in Aceh, the ability of the students in chemistry, especially in thermochemistry was still low. It is showed by the average score of 54%, which was lower than the acceptable target score [4]. That result indicated to us that the ability of the students to effectively understand the concepts was still low. The participants had difficulties to understand the concepts of chemistry such as thermochemistry because they only calculated problems and used the formulations without any motivation to understand thermochemistry rather than to link those concepts with real life [5].

Teaching and learning activities can be done effectively and efficiently if the learning materials designed by the teachers can support a conducive learning atmosphere. Therefore, teachers are expected to be creative in deciding the model, the method, the media and the learning materials in the teaching and learning processes. The most frequent teaching aid used is SWS. The SWS is one or more sheets of paper that are prepared or provided by the teacher as learning aids to be used by the students. SWS is used to support active learning and to increase students’ enthusiasm to learn, as well as to be used for teacher evaluation. A well prepared SWS will have a positive effect on students’ learning outcome [6].

Student worksheets developed by teacher rarely improved HOTS. As a consequence, students’ thinking skills will be decreased. Based on the description of facts and expectations discussed above, it is necessary to improve students’ HOTS through SWS. The SWS should be developed both theoretically and empirically valid.

2. Methods

The research method used was the Research and Development (R&D) method by adapting Borg and Gall’s model. Type of this research is both quantitative and qualitative. The SWS development was done qualitatively and the result of using the SWS (through pre-test and post-test calculation) was done quantitatively.

Random sampling was used to select the sample for this study. The sample selected was 25 students on grade 11 from one secondary high school and 15 chemistry teachers in Banda Aceh, Indonesia. The higher order thinking skills were measured using the essay test and analyzed by calculating the pre-test and post-test (N-Gain score).

3. Results and discussion

The development of the SWS for learning about thermochemistry to improve HOTS was done based on the model of Borg and Gall [7] as follow:

3.1. Research and information collection

A study of relevant literature was done to find information which could be used as the basis for developing the SWS, which was developed in accordance with the revised 2013 curriculum. In addition, information was gathered about previous researches from various journals, textbooks and teaching materials as material to support the development of the SWS for teaching and learning. The choice of materials was done based on the previous low score results from the 2016/2017 National Examinations (UN). Based on the observations of previous materials used for teaching and learning chemistry, the modules or the SWS did not yet have any material for improving HOTS. As a result, the students did not have the ability to solve the problems which required them to do analysis and evaluation and to use creativity as a part of cognitive domains. These domains are concerned with HOTS. In [8], they have said that the skills improvement in HOTS can be achieved through teaching and learning theory or practice using aspects of analysis, evaluation and creative design.
3.2. Planning
The SWS was prepared in accordance with the syllabus. The thermochemistry material consisted of two basic competencies for the cognitive skills and two basic competencies for the psychomotor skills. Based on those competencies, indicators were prepared with the integration of HOTS. The time allocated in the syllabus for studying thermochemistry was 6 sessions.

3.3. Development of a preliminary form of the product (SWS)
The SWS has developed HOTS for several meetings. Each meeting aimed to achieve one or more indicators in accordance with the syllabus. The various components of the SWS included the cover, the introduction, the content, the summary, the tests and the list of references. These components are shown in Table 1.

| No | SWS components       | Materials included in each component                                                                 |
|----|----------------------|--------------------------------------------------------------------------------------------------------|
| 1. | Cover                | SWS title and drawing connected with Thermochemistry.                                                    |
| 2. | Introduction         | Introduction, contents list, basic competency, indicators, purpose, concept mind-map, and the activity. |
| 3. | Main contents        | Information about HOTS components (analysis, evaluation and creative thinking).                         |
| 4. | Summary              | A Summary of the Thermochemistry material studied.                                                     |
| 5. | Test of understanding| Tests of the Thermochemistry materials based on HOTS.                                                   |
| 6. | References           | Sources of information used in preparing the Thermochemistry SWS based on HOTS.                       |

The SWS which was developed must be able to increase the motivation of the students, one way of increasing motivation is to display drawings which are contextual and interesting so that the students will more easily understand its relevance in daily life [9].

3.4. Preliminary field testing
Components which were evaluated in testing the first draft included the drawings prepared for the SWS, the materials provided, the language used such as correct spelling, the ease of reading and the usefulness of the material for the users of the SWS. The initial testing to validate the SWS was done by two expert lecturers from the Chemistry of the Education and Teacher Training Faculty at Syiah Kuala University and one expert from the Institute for Teaching Quality as independent evaluators. The validity score of the SWS was 89%. This result showed that the SWS was valid to be used after the revisions proposed by the validator.

3.5. Main product revision
The results of the SWS validation by the experts would be valid to use after modifications had been made. Their recommendations for modifications to the SWS draft included how the drawings must illustrate by analogy and be contextual to help student to understand the concepts of thermochemistry in their daily life. The design of the SWS must assist students to expand their thinking ability using HOTS while being in accordance with their needs.

3.6. Main field testing
Field tests were done by giving the SWS to chemistry teachers. The teachers selected for this test were five chemistry teachers from two favorite senior high schools in Banda Aceh. Those two schools were chosen based on similar vision, mission, and level of results in the 2016-2017 National Exams.
Therefore, the feedback from those teachers was used as the material to evaluate the SWS for further improvement.

3.7. Operational product (SWS) revision

The response of the two chemistry teachers from two favorite senior high schools has added extra examples of questions in the column "Let's Practice". In addition, those teachers needed to make the positive (+) and the negative (-) signs clearer in order to avoid misunderstanding of the concepts in the sub-section about changes in enthalpy in exothermic and endothermic reactions. Thus, the revision of SWS product was shown by extra questions in the column "Let's Practice". The signs (+) and (-) were made to show whether the reaction was exothermic or endothermic. While the sign got bigger, it showed larger number of calories generated exothermically for the sign (+) or absorbed endothermically for the sign (-).

3.8. Operational field testing (the SWS)

Trials to further improve of the SWS were done by distributing the revised SWS to various Chemistry Teachers in the Chemistry Teachers Forum in Banda Aceh. The recommendations from these teachers became the final input of the final SWS distribution to schools.

3.9. Final product revision

The revisions of SWS were to provide examples that are more contextual to open, closed and isolated systems, such as chicken eggs get rotten when enclosed in their shell. In addition, at the summary part, it is recommended to add information related the benefits of studying thermochemistry in our lives. This revision was the final step to complete the SWS product to be used in thermochemistry teaching and learning processes. The SWS product is shown in Figure 1, 2 and 3.

![Worksheet based on HOTS (Analyzing)](image)

**Figure 1.** Worksheet based on HOTS (Analyzing)
Figure 2. Worksheet based on HOTS (Evaluating)

Figure 3. Worksheet based on HOTS (Creating)

Figure 1, 2 and 3 show that worksheets were consists of three components of hots including analyzing, evaluating and creating. In the analyzing section, there were images that stimulate students to analyze the system and environment. In the evaluation section, there were images that stimulate students to evaluate how the characteristics of energy and mass transfer occur in closed, open and isolated systems. While in the creating section, there were images that stimulate students to be creative in providing reasons for images that include exothermic or endothermic reactions.

3.10. Dissemination and implementation
The final revision of the SWS was then implemented to one secondary high school in Banda Aceh, Indonesia. The teaching and learning program was run in accordance with lesson plan that had previously been prepared to socialize the SWS product in supporting teaching and learning of thermochemistry.

The quality of this SWS product was evaluated using a questionnaire that accessed three important aspects including (a) compatibility of the SWS with the students, (b) compatibility of the SWS with the aims of the lesson and (c) the technical quality, and those three aspects showed values of 82%, 86% and 85%. These values showed that the SWS product prepared was satisfactory. Furthermore, the
SWS distributed could improve HOTS through the questions being asked and give positive effect on the development of cognitive, affective and psychomotor. The similar finding was supported by the behaviorist theory which said that the process of teaching-learning depends on interaction between the stimulus and the response [10].

The HOTS was measured by using questions in the form of analysis which was included in the SWS. However, before measuring the HOTS, trials were done to check the validity, reliability, and the power differentiation towards the questions difficulty level. The results showed that 10 of the 12 questions were suitable to be used.

Based-on the analysis, N-gain score was at the high-level category with the value of 0.79 or 79%. It means that the test score was increased from pre-test to post-test with the average of 36 to 87 (which was a very good result). Similar finding was found by [11] that students, whom were always given questions which required higher order thinking skills, tended to have high conceptual understanding in accordance with Bloom’s taxonomy. Another study was done by [12], it showed that teaching and learning that could improve HOTS was able to increase the ability in problems solving and critical thinking.

4. Conclusion
The SWS is theoretically and empirically feasibility worthy. This conclusion is based on the high value of N Gain of students’ HOTS. So, it can be concluded that the SWS developed could improve students’ higher order thinking skills. Therefore, this developed SWS could be used as the material for Thermochemistry teaching and learning.

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