Developing Mathematics Module Based on Literacy and Higher Order Thinking Skills (HOTS) Questions to Train Critical Thinking Ability of High School Students in Mojokerto

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Abstract. This research aims to describe the process and results of the developing mathematical module based on literacy and higher order thinking skills (HOTS) to train the critical thinking ability of high school students in Mojokerto that are valid, practical and effective. This research is a development research that uses an adopted Tessmer development model. The subjects of this research were 11th grade students at SMAN 1 Puri Mojokerto. Three students with high, medium and low mathematical ability for the One to One stage. In the Small Group stage, nine students, with the provisions of three students with high mathematical ability, three students with middle mathematical ability, and three students with low mathematical ability. While the field test stage, the research subjects were 30 students with heterogeneous mathematical ability. The students’ mathematical abilities were seen from the first semester of academic year report scores and in each stage. The development process starts from the preliminary stage, which is conducting literature studies about mathematics module based on literacy and HOTS questions, this process then followed by contacting the headmaster and teachers regarding the research schedule. The next stage is the self-evaluation, this stage consists of the analysis and design stages that analyze the students as the subject of this research and material used in the research. The materials used are Mathematical Induction, Linear Program, Matrix and Geometry Transformation, and designing a prototype. The third stage is prototyping, this stage consists of experts review, one to one, small group and field test. In the expert review, a prototype II was produced which were said to be valid. Whereas in the one to one, three students were tested and III prototypes were produced. The small group, a trial was conducted and a prototype IV was produced. Then the field test, testing and produced mathematical modules that met the valid, practical and effective. The results of this study are mathematics module based literacy and HOTS questions to train critical thinking ability that meet the validity criteria with valid categories, fulfill practical criteria with a very
practical level. As well as meeting the module’s effectiveness criteria by having students’ critical thinking ability either high or high.

**Keywords:** Mathematics module, literacy, higher order thinking skills

1. **Introduction**
Mathematics is considered as a very important subject at every level of education in all countries. It is proved by deciding mathematics as the basic competency in PISA (Program for International Student Assessment) which is participated by 540,000 students from 72 countries. PISA is a kind of ability and knowledge evaluation which is designed for 15-year-old students and is held in every three years (OECD, 2016: 25).

The result of PISA in 2015 showed that Indonesia ranked 64 out of 72 countries with the score of 397 for basic reading competencies and 386 for basic mathematics competency’s score. (OECD, 2016: 46). Those scores showed that Indonesia is still far below the average of other countries. The questions used in PISA are not the routine-problem solving questions used to measure critical thinking skills. So that the results of the PISA show that students’ critical thinking skills in Indonesia are still low. The prior statement was also supported by the results of Rahmawati, Hidayat and Rahayu (2016) research which stated that students’ critical thinking skills were very low.

Critical thinking skill is the skill of thinking rationally and reflectively by focusing on the belief and decision to be made (Ennis, 2011). So that the critical students will lead themselves to think critically as well. This is in accordance with the demands of Permendikbud Number 21 of 2016 at the secondary education level (class X-XII) in the formulation of student competencies, they are expected to be able to show critical attitude in solving problems. In addition, Hasruddin (2009) explained that the ability to think is very important for students to solve problems and make decisions based on scientific truth.

Not only the problem of critical thinking that occurs among the students, but the teaching materials which are used in Mojokerto are also not yet optimal in maximizing students’ critical thinking skills, this is due to the lack of test items that support students’ high level of thinking (HOTS). Students will get used to thinking critically and creatively both in decision making and problem solving related to analyzing, evaluating and creating (Anderson and Krathwol, 2001: 79). Meanwhile, according to Brookhart (2010: 14-15) one of the categories of high-level thinking is analyzing, evaluating, and creating. So by using the HOTS items, students’ critical thinking abilities can be trained indirectly. In addition to the HOTS items, literacy also plays an important role in critical thinking skill. This is shown in the results of Makhmudah’s research (2018) which states that with mathematical literacy skills, students can improve their critical thinking skills in mathematics, from understanding to making a decision.

Related to teaching materials used in Mojokerto which are not yet optimal in practicing critical thinking skills, it is therefore necessary to make literacy-based math modules and HOTS items to train students’ critical thinking skill. Due to the existence of modules, knowledge is organized in such a way that activates student participation (Herawati, 2013: 83). According to Daryanto (2013: 1) module is a kind of teaching material that is packed in a whole and systematic way containing a set of learning experiences in a planned and designed to help students master learning material, and evaluation.

Based on the aforementioned background, this research is entitled "The Development of Literacy-Based Mathematics Modules and Questions of High Order Thinking Skills (HOTS) for Practicing the Critical Thinking Ability of High School Students in Mojokerto"
2. Method

This research aims to describe the process and results of developing literacy-based mathematic module and high order thinking skills (HOTS) items to practice the critical thinking skills of high school students in Mojokerto. The research design of this study is research and development. The subjects of this study were the students of XII grade of SMA Negeri 1 Puri Mojokerto in the academic year of 2019/2020 with heterogeneous abilities based on report cards of the previous semester. The report card includes the score of cognitive (knowledge) skill and affective skill. The subject was also taken based on the advice from mathematic teachers at the school especially in students' communication skills.

The research procedure is divided into two main stages namely the preliminary and formative evaluation stages. The formative evaluation stage according to Tessmer (1998: 16) includes self-evaluation, expert review, one-to-one, small group and field tests. In the preliminary stage the researcher determines the place and subject of the research by contacting the school's public relations, the school principal, and the mathematic teachers at SMA Negeri 1 Puri Mojokerto. Next, the researcher prepares the research by arranging the research schedule and preparing the collaboration procedure with the class teacher, and then determines the students who meet the characteristics of the research subjects. In the formative evaluation stage which is self-evaluation, the researchers conduct the preliminary analysis of the study that includes: student analysis, curriculum analysis, and teaching media analysis including modules that have been used at the school and module analysis that will be used later. Next to the Expert Review stage, Prototype I is then given to the expert (expert) to be validated. The experts will examine the substance, construction and language of each prototype.

Responses and suggestions from the validators or experts about the design that has been made, the validator's suggestions are written on the validation sheet as revision material and states that the questions to measure the ability to think at a higher level are valid. The results of the revision are then called Prototype II. Then, the individual test stage (one to one) asked three students with high, medium and low mathematical abilities to work on prototype II. The results of the comments or suggestions regarding the clarity of the prototype will be used as material to revise the literacy-based modules and the matter of Higher Order Thinking Skills (HOTS) which are being developed into prototype III. Continued with the Small group stage, the researcher asked 9 students to complete the prototype of the questions that had been made. Students used as a tester in small groups are students of class XI MIPA with heterogeneous mathematical abilities.

Based on the results of the pilot test and student comments, this product is revised and improved to prototype IV. Then, the stage of field tests, the tested field (field test) to the research subjects are 36 students of class XI with heterogeneous mathematical ability. At this stage, the results of the students' critical thinking skills test will be obtained from the developed question set which is assessed based on the critical thinking ability indicators. The instruments used in this study were questionnaire responses, tests, and interviews. Analysis of the data in this study is practicality, validity and effectiveness. Validity in this study is seen from the results of validation at the expert review stage with valid quality criteria that are valid or very valid. Whereas practicality in this study is seen from the validator which states that the module can be used with minor or no revisions and the results of the analysis of the questionnaire responses with practicality that is practical or very practical. The effectiveness of more than 50% of students meet indicators 4 or 5, on the scoring rubric of critical thinking skills modified from Finken and Ennis (in Zubaidah, 2015).
3. Results
Development of mathematical modules based on literacy and HOTS questions to support students' critical thinking skills according to Tessmer (1998: 16), from the preliminary stage to the formative evaluation stage which includes self-evaluation, expert review, one-to-one, small groups and field tests. In the preliminary stage, researchers conducted a literature study on the legal basis for the implementation of mathematical literacy and HOTS questions and their application in mathematics learning. After conducting a literature study, researchers conducted a research submission to the Principal of SMAN 1 Puri Mojokerto. The reason for choosing this research site is because SMAN 1 Puri Mojokerto is one of the schools that uses the revised 2013 curriculum and is intensively doing literacy activities and using HOTS questions in mathematics learning. Next determine the time of research and students used as research subjects. The time of the study ranges from 11 to 18 July 2019. In the self-evaluation stage, includes student analysis, literature analysis, and design. In the analysis of students, researchers conducted a study of the characteristics of students namely background knowledge of mathematics and mathematical processes that are less mastered by students. As for the background of students' mathematical knowledge, students of class XI have difficulty in mathematics induction material, linear programs and geometry transformations. This is consistent with the statement of Mrs. Siti Rohmah S.Pd. and Mrs. Dhini Marliyanti, S.Pd. While the mathematical process that is less mastered by students is that students have not been able to formulate, interpret and apply contextual problems. In the analysis of the device, the researcher obtained information, namely the Intan Pariwara LKS book and the 2013 Revised Mathematics Mandatory Mathematics book. While the mathematical module design is adjusted to the results of student analysis, literature / device analysis has been carried out, so that the mathematical module based on literacy and HOTS problems is obtained with the material sigma notation and mathematical induction, Linear Program, Matrix and Geometry Transformation. In addition, researchers compile other research instruments such as lesson plans, test grids, test questions, test answer sheets, and validation sheets.

Prototype I that has been designed by researchers is given to 2 validators, namely material expert validator and media expert validator to get an assessment and input or suggestions. Suggestions from material experts are to design modules by adding features from mathematical literacy problems to formulating, applying and interpreting problems in real contexts. In addition, it is recommended to add questions in the HOTS category which includes C4, C5, and C6 in Bloom's taxonomy. While suggestions from media experts are setting footer along with the page, the distance between sentences with the table / image, font size in the title / text. The second evaluation of the validator was analyzed by the module validity data and presented in the following table.

| Table 1. The average results of HOTS mathematics-based mathematics module validation results |
|---------------------------------------------------------------|
| Media Expert Validator | Expert Validator | Presentation Aspect | Aspects of Language Feasibility | Aspects of Literacy Assessment and Higher-Order Thinking |
|------------------------|------------------|---------------------|-------------------------------|-------------------------------------------|
| Average                | 4.11             | 3.58                | 3.7                           | 4                                          |
| Pervalidator average   | 4.11             | 3.71                |                               | 3.57                                       |
| Overall Average        | 3.91             |                     |                               |                                            |

Based on Table 1, it is known that the average validity of mathematical modules based on literacy and HOTS questions to support critical thinking skills has an average of 3.91. According
to the category of quality modules Khabibah (2006), the module math-based literacy and about HOTS to support critical thinking skills that are in a valid category.

Literacy-based mathematics modules and HOTS questions to support critical thinking skills that have been revised from the expert review stage and declared valid, are then tested one to one to 3 students of class XI IPA 1 who are subject to one to one. Researchers conducted interviews and asked the three students to work on critical thinking questions. The results of the interview were students having difficulty in understanding the terms compatible number in the sigma notation material, and understanding the concept of strong mathematical induction. While the results of the subject's work on critical thinking problems are the three subjects have not experienced difficulty in solving problems, but they argue that the problem is not difficult but it takes a thought process to really understand the content of the problem.

In the small group stage, modules that were revised from the previous stage were tested on 9 students of XI Science 1. The researcher also conducted interviews and asked all three students to work on critical thinking questions. The results of the interview are students understanding the contents and terms in the mathematics module, in addition there is only one student who has difficulty completing critical thinking questions number 2. Then in the field test stage, modules that have been revised from the previous stage are tested on 36 students XI Science 2 and completing questionnaire responses regarding literacy-based mathematics modules and HOTS questions to assess the practicality of the module and provide input or suggestions. Inputs given including questions on the module are expected to be not too difficult and the use of words in the module page 21 and funds 36. For the results of the questionnaire analysis the responses of students to the mathematics module are presented in the following table.

| Statement Number | The number of students | Practicality |
|------------------|------------------------|--------------|
|                  | STS | TS | S  | SS |
| 1                | 0   | 0  | 13 | 23 | 90.97 %  |
| 2                | 5   | 21 | 8  | 2  | 62.5%     |
| 3                | 1   | 10 | 18 | 7  | 54.17%    |
| 4                | 0   | 1  | 20 | 15 | 84.72%    |
| 5                | 8   | 14 | 10 | 4  | 50.69%    |
| 6                | 0   | 1  | 13 | 22 | 89.58%    |
| 7                | 12  | 16 | 5  | 3  | 53.47%    |
| 8                | 0   | 2  | 16 | 18 | 86.11%    |
| 9                | 0   | 3  | 25 | 8  | 74.47%    |
| 10               | 3   | 4  | 19 | 10 | 75%       |
| 11               | 14  | 18 | 2  | 2  | 54.17%    |
| 12               | 16  | 17 | 3  | 0  | 53.47%    |
| 13               | 5   | 26 | 5  | 0  | 67.36%    |
| 14               | 0   | 0  | 11 | 25 | 92.36%    |
| 15               | 0   | 0  | 17 | 19 | 88.19%    |
| 16               | 0   | 0  | 21 | 15 | 85.42%    |
| 17               | 6   | 25 | 2  | 3  | 63.88%    |
| 18               | 9   | 22 | 5  | 0  | 61.81%    |
| 19               | 13  | 20 | 3  | 0  | 57.64%    |
| 20               | 5   | 24 | 6  | 1  | 65.28%    |
| 21               | 0   | 0  | 23 | 13 | 84.03%    |
| 22               | 1   | 1  | 8  | 26 | 90.97%    |
| Average          |     | 72.29% |

Table 2. The result of student responses to the mathematics
Based on Table 2, it was found that the practicality criteria of the mathematics module were 72.29% in the practical category. So the math module based on literacy and HOTS questions meets the practicality criteria. While the results of tests of students' critical thinking skills were analyzed using the rubric of Critical Thinking Skills Modified from Finken and Ennis (in Zubaidah, 2015). The results of the critical thinking skills test results at the field test stage are 12 students with low critical thinking skills, and 24 students with high critical thinking skills. So it can be concluded that the mathematics module meets the effectiveness criteria. This is in line with the research by Rofiah, Aminah, Sunarno (2018) which states that modules based on higher order thinking skills (HOTS) improve students' critical thinking skills.

4. Conclusions

Based on the results above, it can be concluded that. (a) The development process starts from the preliminary stage, which is conducting literature studies about mathematics module based on literacy and HOTS questions, this process then followed by contacting the headmaster and teachers regarding the research schedule. The next stage is the self-evaluation, this stage consists of the analysis and design stages that analyze the students as the subject of this research and material used in the research. The materials used are Mathematical Induction, Linear Program, Matrix and Geometry Transformation, and designing a prototype. The third stage is prototyping, this stage consists of experts review, one to one, small group and field test. In the expert review, a prototype II was produced which were said to be valid. Whereas in the one to one, three students were tested and III prototypes were produced. The small group, a trial was conducted and a prototype IV was produced. Then the field test, testing and produced mathematical modules that met the valid, practical and effective; (b) The results of this study are mathematics module based literacy and HOTS questions to train critical thinking ability that meet the validity criteria with valid categories, fulfill practical criteria with a very practical level. As well as meeting the module's effectiveness criteria by having students' critical thinking ability either high or high.

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