The development of student worksheet by using discovery-based approach: a case study in learning media course

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Abstract. With regard to the national curriculum for the primary and secondary school, the Department of Mathematics of Universitas Negeri Surabaya through Indonesian National Qualification Framework (KKNI) has tried to accommodate the demands of the National Curriculum 2013. The department proposed an innovation through Learning Media course. This study aims at producing student worksheet which had been developed by students themselves by using a discovery-based approach. It adopted Plomp’s model of developmental research. Thirty-eight students participated in this study. Research instruments used were validation sheet and student worksheets. This study produced 11 student worksheets for junior high school and eight student worksheets for senior high school. The results showed that discovery activity matched learning objectives and student worksheet involved students’ initial knowledge. Furthermore, it revealed that discovery stage matched student’s cognitive development. The finding also showed that discovery activity guided students to make a conclusion and the answers for student worksheets were correct and matched the worksheets. However, student worksheet still had several grammatical errors; therefore, revision was needed.

1. Introduction

Learning is a process of interaction between students and teachers using some resources in one environment. It is a process to help students to learn well. The process will lead to the learning achievements. It will be effective when it is supported by students’ learning motivation and teacher’s creativity. The use of learning media can improve students’ interest, passion, motivation and stimulation [1,2,3]. At the beginning of learning process, the media will improve the effectiveness of the learning process and deliver the messages and content of lessons. Hence, learning objectives can be achieved optimally. The learning process in primary and secondary school is regulated through the Regulation of the Minister of Education and Culture No. 22 of 2016 [4] concerning a Process Standards, which contains the basic concept of the learning process. Students are viewed as subjects who have the ability to actively search, process, construct, and use knowledge. In line with this view, learning should be concentrated upon giving the learners opportunities to construct knowledge in their cognitive processes. Furthermore, in order to truly understand and be able to apply knowledge, they need to be encouraged to work, to solve problems, to find everything for themselves, and strive to realize their ideas.

In line with the basic concepts and principles of learning, scientific approach or a scientific-based approach is used in the national curriculum. In order to strengthen the scientific approach, it is necessary to apply discovery/inquiry learning. In addition to the scientific approach, other learning models, such as discovery learning, project-based learning, problem-based learning, and inquiry...
learning, can be applied. In regard to the curriculum development in high school, the Department of Mathematics at one of the universities in Surabaya through KKNI Curriculum has tried to innovate and accommodate the demands of national curriculum, one of which is by setting up innovative learning course II. This course is intended to develop students’ understanding of such learning models with a scientific approach as problem based learning, project-based learning, inquiry-discovery learning, and contextual learning as well as their application in task-based and IT-based learning simulations. In the course, students learn about learning theories, learning characteristics and learning syntax by using the aforementioned models and develop learning instruments that are relevant to those models. Based on the evaluation, it was found that many students in Innovative Learning II course still lacked ability to develop student worksheets for discovery learning.

As a continuation of Innovative Learning II, students can take Learning Media course. The objective of this course is that students understand the definition, type/classification, functions, basic development of learning media as well as apply them in learning process as their learning strategies. Up to now, students are only requested to develop contextual (manipulating the environment component) and ICT-based learning media. Among the media students can develop is student worksheet (specifically based on discovery). To develop various kinds of learning media is one important element a teacher candidate must possess in order to improve his/her competency as a professional teacher.

A successful use of learning media is for improving learning outcomes depends on the content of the message, how it is delivered, and the characteristics of the message recipients. Thus, in choosing and using the media, it is necessary to consider three factors. If the three factors can be delivered through learning media, optimum results will certainly be achieved. Student worksheet is a part of visual media [1]. There are several types of student worksheets: 1) one which helps students to find a concept, 2) one which assists students to apply and to integrate the various concepts that have been found, 3) one which serves as a learning guide, 4) one which serves to strengthen, 5) one which serves as a practical guide.

One important aspect that must be considered by the lecturers of Learning Media course is students’ ability to develop various kinds of learning media. It is because students must have this competence when they start teaching at schools. A good teacher is one who can design a good learning, design learning instrument, implement learning with appropriate learning methods or models, and assess the implementation of learning.

2. Research methods
This research is categorized as developmental research, aiming at developing student worksheet for junior and senior high school levels. The students who took Learning Media course developed the worksheets. This research was conducted in the Department of Mathematics at a university in Surabaya. The subjects were all students in year 2015 who enrolled in Learning Media course. The research was conducted in the second semester of 2016/2017 academic year involving 38 students.

Two research instruments were employed in this research, namely validation instrument and student worksheets that had development tasks. An analysis was also conducted and used to answer the research question. In analysing the data, initially the resulted student worksheets for junior and senior high schools were grouped. Next, the results of task development were validated. This included some activities such as: 1) determining the suitability of the established indicators to the type of selected student worksheet, 2) determining the suitability of the established indicators to the tasks assigned; 3) conforming the activities in student worksheet to students’ cognitive development ; 4) conforming the activities developed in the student worksheets to discovery activities, 5) conforming the discovery tasks to the possibility of eliciting alternative solutions, 6) conforming the activities in student worksheet to selected learning model, 7) matching the student worksheets with their answers, 8) checking the correctness of the answers, and 9) checking the adequacy of the language used.
3. Results
This research used developmental research model as proposed by Plomp [5]. It consists of five phases: 1) Initial Investigation Phase, 2) Design Phase, 3) Realization Phase, 4) Test, Evaluation, and Revision Phase, and 5) Implementation Phase. Unfortunately, this research was conducted only until the fourth phase. Because of limited time, the implementation phase cannot be conducted. Each phase needed to be revised until the classification was valid. It can be described in detail as follows:

3.1. Initial investigation phase
The initial investigation phase was undertaken to determine the teaching materials needed in developing student worksheet. At this stage, theoretical analysis, curriculum analysis, student analysis, and teaching material analysis of the student worksheets were conducted by collecting and analysing the supporting information in order to determine the next plan. The four stages can be explained as follows:

i. Theory supporting the development of student worksheets
To support the creation of student worksheets in accordance with discovery activities, the researcher investigated some literature to study the theories of student worksheet development and its application in learning [6,7,8,9,10].

ii. Curriculum analysis
At this stage, the curriculum used in junior and senior high schools especially in Surabaya was a reviewed. The researchers focused on the national curriculum 2013 (K-13). The curriculum would be implemented simultaneously throughout Indonesia commencing from 2018-2019 academic years. In addition, interviews were conducted with some junior and senior high school teachers in Surabaya to find out the benefits of student worksheet in the on-going math learning. The results of the interviews indicated that the student worksheets were still needed to enable students to understand mathematical concepts. The student worksheets available so far contain exercise questions.

iii. Student analysis
Students were investigated to examine their characteristics in accordance with the design of student worksheet with discovery-based approach. The students’ characteristics investigated included their background knowledge of mathematics, their initial ability they had already possessed, and academic ability.

iv. Analysis of teaching materials
Analysis of teaching materials was intended to select, define, itemize and systematically compile teaching materials relevant to the development of student worksheets for junior and senior high schools. In the analysis of teaching materials, researchers mapped out K-13 materials in accordance with discovery activities. Teaching materials were selected by considering the conformity of the concept and the content of the material to the discovery activities. Based on the results of teaching material analysis, the researchers determined the appropriate junior and senior high school materials for discovery activities. There were 19 materials for junior high school and 10 materials for senior high school [11,12].

3.2. Design phase
At this stage, every student designed a prototype of student worksheet based on discovery-based approach for junior and senior high schools. Along with these activities, a research instrument, which consisted of student worksheet validation sheet and Development Task, was also developed.

The validation sheet focused on a) the suitability of the established indicators to the tasks assigned; b) the suitability of activities in student worksheet to the cognitive development of students; c) the suitability of the activities developed in student worksheets to the discovery activities, d) the
suitability of the discovery tasks to the possibility of eliciting alternative solutions, e) the suitability of discovery activities in student worksheet to the selected learning model, f) the suitability of student worksheets and the answers, g) the correctness of answer, and h) the adequacy of language used.

The Development Task contains assignment that students must complete. It asked each student to develop a student worksheet with discovery-based approach. Students selected one of the mapped materials suitable for discovery activities.

3.3. Realization phase
In this phase, the college students tested the worksheets by assigning them to other college students enrol in Learning Media course. The students were from class 2015A. Each of them identified the topics that can be developed by using discovery-based approach in junior or senior high schools. They developed 19 student worksheets consisting of 11 worksheets for junior and 8 worksheets for senior high school. The student worksheets in this phase were referred to as the first prototype student worksheets.

3.4. Revision phase
Prototype student worksheet 1 was validated by three lecturers of mathematics education. The result of validation showed that a) the discovery activity in student worksheets matched the predefined indicators, b) the prototypes had integrated students’ initial knowledge, c) the discovery stage was based on students’ cognitive development although it had not been sequenced, d) discovery activities led students to conclude the findings, e) discovery activities that elicited alternative solutions were still less than 50%, f) Student worksheet answers were correct and suitable for the student worksheets, g) Some directions were still confusing, requiring a slight improvement.

After the validation, the students had to revise the first prototype, resulting in what was called prototype 2. Furthermore, it was found that student worksheets compiled by the students could help learners find a concept [1]. The developed student worksheets were in accordance with predetermined indicators. This shows that the students had been able to determine the materials that could be learned through the discovery activities. The student worksheet provided student-centred activities to construct knowledge. In addition to their compliance with the indicators, the worksheets were already developed by considering the characteristics of students as the recipients of the message. These characteristics included the students’ initial knowledge, level of cognitive development, and language adequacy.

The developed student worksheets showed that the students were able to develop learning media in accordance with predetermined learning strategies (especially discovery-based approach). The results indicated that the worksheets could develop students’ competence in developing learning media in addition to the already-existing contextual and ICT-based learning media.

4. Conclusion
Based on the data analysis, it can be summarized that initial investigation phase gave a foundation for the development of student worksheets so as to implement national curriculum 2013. There were 19 materials suitable for discovery activities. At the next stage, every student developed student worksheet with a discovery-based approach. The student selected one of the mapped materials which were suitable for the discovery activity. In the realization stage, the students developed 11 student worksheets for junior high schools. Based on the validation results, it was found that 82% of the student worksheets developed by the students were highly relevant with the indicators; 45% of the tasks given were highly relevant with the indicators; 55% of the tasks given were relevant with the indicators; 64% of the activities were highly suited to learners’ cognitive development; 36% of the activities were suited to learners cognitive development; 91% of the activities developed in the student worksheets were categorized as good and excellent discovery activities; 27% of the invention tasks leading to alternative solutions were categorized as good, very good, and excellent tasks, while 72% of discovery activities lacked alternative solutions; 100% of student worksheet answers were appropriate
and correct; 55% of the language used was very appropriate; and 45% of the language used was in suited to the students’ level of cognitive development.

In the initial investigation phase of the development of student worksheets for senior high school based on Curriculum 2013, there were 10 materials suitable for discovery activities. At the next stage, every student developed student worksheets with discovery-based approach. They selected one of the mapped high school topics suitable for discovery activities. At the realization stage, the students developed 8 student worksheets. Based on the validation, 86% of student worksheets were very suitable for discovery-based approach student worksheet; 71% of the tasks were highly relevant with the indicators; and 29% of the tasks were relevant with the indicators; 86% of the activities were very suited to learners’ level of cognitive development; and 14% of the activities were consistent with the level of learners’ cognitive development; 91% of the activities developed in the student worksheets were discovery activities with good and very good criteria, 27% of the invention tasks leading to alternative solutions were categorized as good and excellent, while 72% of discovery activities lacked alternative solutions; 100% of student worksheet answers were appropriate and correct; 86% of the language used was very consistent with the learners’ level of cognitive development; and 14% of the language used was suited to learners’ level of cognitive development.

Regarding the findings, we suggest that other researchers develop students’ worksheets that are suitable for implementing project-based and problem-based learning for other mathematics topics as regulated in Kurikulum 2013.

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