Development of student worksheet for enhancing of graphical and mathematical construction of physical phenomenon of pre-service mathematics teacher in basic physics lecture

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Abstract. The preservice math teacher needs to have the competence of his mathematical literacy. According to NCTM (2014) the competence of mathematician teacher candidates must have problem solving abilities, communication, logic inference reasoning, connections and representations. Basic physics courses can be providers to equip the ability of graphical and mathematical representation of a physical phenomenon for math teacher candidates. Unfortunately, physics lectures for mathematics teacher candidates have been viewed more as a form of knowledge than as a form of thinking or a method of investigating in mathematical literacy. This is what causes the results of physics lectures have not shown significant significance to the competence of math teacher candidates. The researcher develops the structure of lectures, teaching materials, student worksheets, appropriate instruments and lecture methods to equip the graphic and mathematical representation capabilities of a physical phenomenon for mathematics student candidates. The method to be used in this research is mixed methods method with embedded experimental model design. In this paper the researcher will describe the achievement of the development stage of the student worksheet which is oriented to the ability of construction of graphic and mathematical representation of a physical phenomenon in basic physics lecture for preservice math teacher.

1. Introduction

Physics should be viewed as a way of thinking and how to solve problems for prospective math teachers. During this time, physics lectures for mathematics teacher candidates are only positioned as a form of knowledge. This can be seen from the lecture activities that have been done centrally to the lecturer, and less to provide an opportunity for students of mathematics teacher candidates to develop their way of thinking. This is what causes the impression of lack of utilization of physics lecture for prospective math teacher [1]. From the preliminary research conducted in 2013 it was revealed that the ability of interpretation of data of mathematics teacher candidate students in private universities "x" Cirebon is in low category that is equal to 47.1 percent [2]. Of all the first grade students, only 34.8 Percent of students who have been able to solve the problem of C4 level for thinking skills Analysis is a physics concept that is tested [3]. The low average achievement score obtained by mathematics student candidates in a private university in Cirebon city in 2016 in answering the question of understanding kinematic graphs...
need to be serious attention from the researcher [4]. For that need a thought and development of a special course of physics given to the student candidate math teacher in an effort to meet the mathematical literacy.

One of the competencies of a mathematics teacher candidate is the ability of the mathematical thinking process. This program aims to improve the achievement of one of the skills of mathematical thinking process that is mathematical representation and graph [5]. For that was developed a student worksheet that trained the ability to construct graphs and mathematical equations of a presentation of physical phenomena. This Student Work Sheet (LKM) is structured based on the syntax developed by the researcher including the activities (1). Presentation of Physical Phenomena (2). Problem identification (3). Creating Hypotheses, (4). Conducting Investigations and Data Collection, (5) Creating Conjectures, (6) Creating Representation and Interpretation of the results of investigation and data collection, (7) Generalization. This activity process is facilitated by practitioner-based virtual animation media with computer media. Through this medium makes students can interact with computers that have been equipped with learning software that contains simulations or practicum virtual specific teaching materials. Through the simulation or virtual practicum students are guided to find conclusions about the material being studied [6]. The outline of the learning steps outlined in this LKM can be explained in Figure 1 below on the general overview of the PPFBKRMG program for mathematics teacher candidates.

Desain Physics Lecture for preservice math teacher

Physical probability training for prospective teachers has been conducted by kaniawati [7] which is the improvement of the ability of symbolic language and mathematical modeling ability of physics teacher candidate through inquiry learning. Muslim [8] reveals that it has successfully developed a program of school physics lectures oriented argumentation to improve the ability of argumentation and understanding of the concept of physics teacher candidates. In addition, Ismet [9] also conducts research to equip the physics skills of prospective teachers in mechanical recovery based on multiple representations and effects of spatial visual intelligence.

Figure 1. Overview PPFBKRMG (program development of physics-oriented lectures on construction of mathematical representations and graphs) For Preservice mathematics teacher
Considering the importance of the ability to construct graphic and mathematical representation as the fulfillment of the competence of mathematics teacher candidate, the researcher develops student worksheet (LKM) which facilitate the activity to train the construction ability of graphic and mathematical reposes of a physical phenomenon. With this LKM the math teacher candidate can train one of the mathematical thinking ability that is representation in observing and studying a physical phenomenon presented. The physical phenomena presented are physical phenomena that can represent the representation of linear, squared, exponential, parabolic, circular, logarithmic and trigonometric functions.

2. Method
This research is conducted in the framework of the development of student worksheet oriented graphic and mathematical construction Skills of a physical phenomena for prospective math teacher. This development is based on the needs of basic physics courses in the fulfillment of the competence of mathematics teacher candidate in the form of mathematical thinking process which is one of the skills of representation [10]. This development process is done through several stages of activity, among others, preliminary study; then the literature study stage in designing the LKM, then the LKM design stage and the LKM's development stage followed by the expert validation stage and the LKM implementation phase test in the process of basic physics lecture [11]. Flow chart research can be seen in Figure 2.

Figure 2. Product development model student worksheet used in research.

The development stage is done by creating, validating and testing the design of student worksheets with the ability to construct graphic and mathematical representations in accordance with the designs that have been made [12]. Feedback for improvement of student worksheets is obtained through expert validation and limited testing of students. The validation of experts involved to provide validation of student worksheet rancagan amounted to three people from the lecturer at one lecturer LPTK in Bandung. Qualified experts consist of two experts who have expertise in physics and physics education and one expert in the field of mathematics education. In assessing, the three experts were asked to provide corrections and comments that would be used to refine the student worksheets with graphic and mathematical constructions for mathematics teacher candidates.

3. Result and discussion
3.1. The design and making of the beginning of the student worksheets the ability of construction of graphic and mathematical representation oriented for mathematics teacher candidate
Early student worksheets were created for every physics concept that represents a mathematical function that can be practiced. Due to the limited time limit of the initial twelve student workbooks composed of
linier function worksheets for ohm law concepts, hooke law and hydrostatic pressures, quadratic functions for free fall motion, trigonometric functions for harmonic spring and bandunl motion as well as alternating current voltages bali, exponential function in the concept of capacitor filling and damped harmonic motion, parabolic function in bullet motion, circular functions in rotation of objects and logarithmic functions on the concept of light intensity. Each student worksheet is made with reference to the design that has been made. An example of a student worksheet developed can be seen in table 1 and figure 3.

Table 1. Graphic and Mathematical Construction Graphic Design Student Worksheet For Student Candidate Math Teacher.

| Experiments way (through investigation and data collection) | Activity step | Student Activity |
|-------------------------------------------------------------|---------------|-----------------|
| Preface                                                     | Students listen to the lecturer's explanation of the competencies that must be completed after the lecture |
|                                                            | Students form groups. |
| Presentation of Physical Phenomena                          | Students listen and observe the physical phenomena presented by the lecturer |
| Stage 1. Identification of Problems                         | Students Identify problems to investigate |
| Phase 2 Creating Hypotheses                                 | Students Submit predictions Hypotheses based on the results of the identification and formulation of problems they have compiled. |
| Stage 3 Conducting Investigation and data collection        | Students receive LKM divisions and conduct investigation and data collection activities guided by the LKM. |
| Step 4 Create Conjecture                                    | Students formulate relationships between physical levels involved based on the results of investigations and observations. |
| Stage 5 Representation and Interpretation                   | Students Make Mathematical Representations and graphs after searching for the relationship between the physical quantities involved and interpreting them |
| Generalization                                              | Students reveal the general conclusions of the results of investigation and data collection. |
| Explanation of Physical Phenomena                           | Students listen to the lecturer's explanation of physical phenomena and its relation to the results of the investigation. |
| Reflecting on the outcome of the investigation              | Students and lecturers evaluate the process and results of the investigation |
| Closing activities                                          | Students listen to corrections / lecturers' reinforcement of the material being studied |
|                                                            | Students ask questions to lecturers. |
|                                                            | Students collect student worksheets |
|                                                            | Students listen to follow-up and assignment from lecturers |
Figure 3. Sample of student worksheet developed.

3.2. Validate student-oriented construction ability worksheet graphic and mathematical representation for student prospective math teachers

Before the student worksheet oriented to the ability of the construction of graphic and mathematical representation was tested in lecture activities, then the first worksheet of this student is rated by three experts in the field of physics education and mathematics education to ensure the feasibility of its use in basic physics lectures for mathematics teacher candidate. Table 2 summarizes the results of expert validation on student worksheets-oriented capability of construction of graphic and mathematical representation for mathematics teacher candidates.
Table 2. Recapitulation of Expert Validation Result on Student Worksheet with construction-oriented representation of mathematical graph for mathematics teacher candidate.

| Aspect of Assessment | Assessment Indicators                                                                 | Rating result                                                                                                                                                                                                 |
|----------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Construction of      | Systematics, Physical Phenomena and Guidelines meet the adequacy and facilitate the  | The three validators stated that the stages on the student worksheet have reflected the phases of the ability to construct graphic and mathematical representations for mathematics teacher candidates. |
| Student Worksheet    | preparation of the ability of representational construction                           |                                                                                                                                                                                                               |
| (LKM)                |                                                                                       |                                                                                                                                                                                                               |
| Virtual Lab and      | Conformity Themes, Images and Animations support and fulfill sufficiency in data      | The three validators state that virtual labs and image media meet the adequacy and provide support for the data retrieval process on virtual practice activities.                                                  |
| Picture Media        | retrieval to practice the ability of representational construction capabilities        |                                                                                                                                                                                                               |
| Content of Physics   | Empirical, based on concepts, in accordance with mathematical functions and avoid      | The three validators stated that the phenomena presented are related to many mathematical functions and are suitable for the fulfillment of the competence of the mathematics teacher candidate.                               |
| Content              | errors                                                                                 |                                                                                                                                                                                                               |
| Grammar              | Word behavior, Simple and easy to understand, not ambiguous, interactive communicative, to the rules, typing errors | The three validators stated that the grammar used in the student worksheet oriented graphics and mathematical constructs for mathematics teacher candidates is already in good criteria and can be used. |
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