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Organizing Exercise Items in Mathematics Learning

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Abstract: ***Mathematics exercises items are very essential for students to really understand the concept learned in order to internalize all the knowledge. The more exercises done on the mathematics concepts, the more the concepts understood and mastered. The study was aimed at describing the procedures or steps of organizing web-based mathematics exercises items and the evaluation on tests results. Subjects of the study were the first year students of Digital Telecommunication Network Study Program of the State Polytechnic of Malang, academic year of 2013/2014. Web-based mathematics exercises items are organized to facilitate students to do practices based on their competence levels, namely level 1 (low), level 2 (medium), and level 3 (high). Mathematics exercises items are designed in blocks, in whicheach block starts from the easiest to the most difficult by web-based organization. Web-based organization of the exercises items considers: the role of the learners, individual differences between learners, feedback provision, and the implementation of knowledge and skills in real situation. The evaluation is designed to observe students' activities through tracking the frequency of students doing the practices as well as students' record of activities, including the completed exercises items, time of doing the practices, and thegained scores.The results of the study show thatthere was an increase learning outcomes by 42%.***

Keywords: Mathematics exercises items,mathematics learning, evaluation, competence levels

1. Introduction

Mathematics learning is very important since mastering this subject is essential in daily life. Although mathematics is considered very important to master, a lot of students found difficulties in mastering mathematics. The learning of mathematics, especially in the State Polytechnic of Malang, needs to be given more attention. This urgent need is more essential considering that mathematics is also one of essential supporting subjects at the Digital Communication Network Study. It was identified that the number of class sessions of mathematics course was not adequate for students to master all the targeted materials. Furthermore, the academic system in the State Polytechnic of Malang does not allow students to retake the course for better understanding the materials or getting a better score. Therefore, there should be attempts made to provide students with learning facilities and additional chances to learn the materials out of the class. This could be done through providing web-based learning facilities. Web-based learning facilities were considered an appropriate solution sinceit allowed students to learn mathematics outside classroom without strict limitation of time and space.

Mathematics concepts can be implemented when they are well internalized. The internalized concepts, then, need to be used often so that these concepts can retain longer in the students' memory and that students do not easily forget the concepts (Hudojo, 1988: 115). One attempt that can be implemented to internalize the concepts is by giving a lot of exercisesitems. The more practices done on the concepts, the better the concepts understood.

1.1 Purpose of the Study

This study was aimed at:
1. Describing the steps in organizing mathematics exercises items
2. Describing the design of the evaluation on the exercises items

1.2 Scope of the Study

This study was conducted within the scope of the learning materials of differential and integral calculus. Furthermore, the web-based exercises items were implemented in the Digital Telecommunication Network Study Program of the State Polytechnic of Malang.

2. Literature Review

2.1 The Learning of Mathematics

The development of learning strategies needs to be done in order to improve students' learning outcome. Direct observation in the field confirmed the fact that students often need to repeat learning the materials and, thus, need to be facilitated with learning strategies that can be done through organizing exercises items. One potential technology that can be used to organize exercises items is computer software (Smaldino, 2005:38).

In this advanced technology era, there are possibilities to have a virtual class without the attendance of both the teacher and the students in the classroom. Using internet, students can access learning resources even when they are outside the class. Learning media and technology haveinfluenced the advancement of education, and internet has also affected the teaching and learning process. The use of internet in the learning of mathematics is expected so that students could have more motivation and have positive attitude towards the learning of mathematics. Previous studies show that the use of web as learning media can improve students' motivation and performance in learning mathematics.(Nguyen, 2005).

2.2 The Development of Learning Media

Technology and learning media play a lot of roles in the learning process. When learning is centered on students, technology and learning media are the essential support for learningperformance . In the student-centered learning, students are expected to be the main user of the technology and media. Learning support can also be provided without the presence of the teacher. Using internet, students can access learning resources even though they are not in the classroom (Smaldino, 2005:11).

3. Methodology

This study was conducted regarding the implementation of web-based exercises items on the learning of Basic Mathematics, namely differential and integral calculus. The topics of differential and integral calculus were selected because these topics were pre-requisite for the next course, differential equation and fourier series. The organization of exercises items was based on Suppes's study (1969). Steps of organizing the mathematics tests include providing facilities based on students' levels of competences comprising level 1 (low), level 2 (medium), and level 3 (high) while the tests are designed in the order of levels of difficulty. Tests items consisted of two blocks, namely differential calculus and integral calculus. Each block always started with the easiest tests and ended in the most difficult tests. Determination of students' level of competence was based on the pretest results. The organization of web-based tests considered students' active roles, learners' individuality, the giving of feedback, and the implementation of knowledge and skills in real life.

Stages of designing the application programs referred to ASSURE Model developed by Smaldino, Lowther, and Russel (2005), which consists ofAnalyze learners; State standards and objectives; Select strategies, technology, media, and materials; Utilize technology, media, and materials; Require learner participation; Evaluate and revise. Validation in the study was conducted on the content, the material development, and the application. Validators were experts in the field. The organized design of exercises items was uploaded in the website of the study program. Students needed to log in and entered their students' ID number. Results of the exercises items were scored and all data were inputed. The frequency of doing the exercises items and the scores were reviewed by the lecturer in charge.

Data of the study were: (1) students' scores from pre-test, practices item no –i, and post-test; (2) results of observation during the learning process, which was the frequency of the exercises items done by the students.

4. Results and Discussion

Competence to solve problems plays a very important role in learning mathematics. Problem solving competence related to mathematics assignments is potential in developing students' intelligence in improving understanding in mathematics. Studies by Widjajanti (2010, 2014) shows that taking extra courses of calculus outside the class could improve students' performance. Guidance in doing exercises items could improve students' skills and understanding of the mathematics topics learned.

Mathematics is hierarchy.It means that learning mathematics should be in an order. With the consideration that exercises items are very important and plays the primary role in learning mathematics, one essential point in arranging tests items is the well organization of the exercises items (Resnick& Ford, 1981). Exercisesitemsorganizer should pay attention on how to arrange tests items, should be good in deciding which exercises items should be learned first and which should be learned later.

To identify students' need, the researcher of the current study gave a set of questionnaire of 24 students. However, there was one student who did not fill in the questionnaire, making the total number of the respondents were 23 students. Results of the questionnaire are presented in Table 1.

Table 1: Identification of Students' Need

NO.	Statements	Agree (%)	Disagree (%)
1	I think I am not skillful enough to complete test items on derivatives.	75	25
2	I think I am not skillful enough to complete test items on integral.	75	25
3	I think I do not have adequate time to complete mathematics exercises items in the class.	75	25
4	I need additional facilities to do mathematics exercises items outside in-class activities.	79.17	20.83
5	I am glad if I am provided with extra facilities that I can access outside in-class activities to do mathema-tics exercises items.	79.17	20.83
6	I am glad if I am provided with extra facilities to do exercises items plus discussion.	87.50	12.50
7	I am glad if the learning mathematics is suited to students' levels of competence.	91.67	8.33

Based on the questionnaire of identification of students' needs, it was identified that 75% of the students believed that they were not skillful enough to complete tests items on derivatives and integrals. This makes them hard to complete test items on differential equation and fourier series because these test items use derivatives and integrals. About 80.36% of the students stated their agreement to the provision of learning facility that helps students to learn outside the in-class activities with learning materials that are suited to students' levels of competence.

Steps to organize test items included:
a. Test items were organized in the concept of n-block
b. Each concept block consists of the same type of tests and there were test items which were the same
c. Each concept block presented three levels of difficulties, namely level 1 (L1), level 2 (L2), and level 3 (L3). The higher the level, the more difficult it was. Test items of different levels of difficulty were provided as based on students' competences.
d. Every student started at a certain level determined based on the result of the pretest.
e. If the pretest result showed scores between 0% and 39%, the students would do test items level 1; if the pretest result showed scores between 40% and 64%, the students would do test items level 2; if the pretest result showed scores between 65% and 100%, thestudents would do test items level 3. This is shown in Table 2:

Table 2: Criteria for Different Levelling

Pretest to Exercises Items	From Exercise Item i to Exercise Item i+1		
Percentage of Correct Answers (T)	Levels of Exercise Items	Percentage of Correct (C) of the –i^{th} of Exercises Items	Assignments for the –$(i + 1)^{th}$ of ExerciseItems
0≤T<40	1	0≤C<60	Exercise Item of the the level below
40≤T<65	2	60≤C<80	Exercise Item of the the level
65≤T≤100	3	80≤C≤100	Exercise Item of the the level above

Notes:

a. The level of difficulty of the–$(i+1)^{th}$ exerciseitem was determined the scores of the–i^{th}exerciseitem.

b. When students' score of the –i^{th} items was below 60%, they had to do the –$(i+1)^{th}$ item which was less difficult. When students could do correctly between 60% and 79%, they would do the –$(i+1)^{th}$item of the same level. When students' score of the –i^{th}item was 80% or above, they could do the –$(i+1)^{th}$ item of more difficult level. This is presented in Figure 1 (Sarosa, 2015).

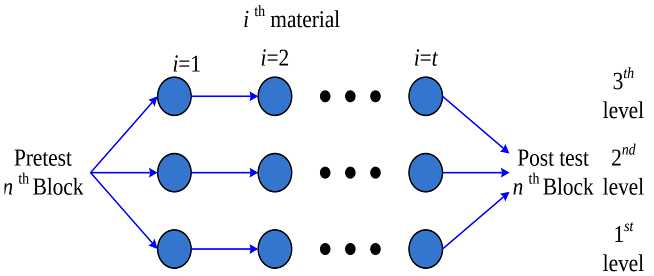

Figure 1: Organization of Exercise Item

Main points in the designing the application of items organization:

a. If the given answer was wrong, computer would report that the answer was wrong and would give students other chances to answer.
b. Within a certain period of time, if there is no inputted answer, the computer screen would show guidingstep by step instructions to comlete the exercise independently.
c. Instruction was given step by step to provide students adequate opportunities to develop the instruction has been received.
d. When the provided time to complete a certain item ended and the student had not input the answer yet, the computer would give a message encouraging the student to work in a proper speed.
e. The number of exercise items provided was more than the number of exercise items students could finish so that items could be presented in random order and students could not memorize the answer of the exercise.

The organization of mathematics exercise items was made based on the materials presented in Table 3 and Table 4 (Purcell, 2003), including staging (i) and branching (C) the items.

Table 3: Organization Diagram of Mathematics Exercise Item in Differential Calculus (n=1)

Pretest Material	i^{th} Item Material			Post Test Material
	i=1	i=2	i=3	
• Basic rule • Trigonome-tric function • High-level derivation	Basic rule • Trigonome-tric function High-level derivation Logarithmic function Natural logarithmic function Exponential function Hyperbolic function	• Chain rule • Implicit function	• Derived application on the function graph • Maximum-minimum derived application	• High level derivation • Trigonometric function • Logartihmic function • Natural logarithmic function • Exponential function • Hyperpbolic function • Chain rule • Implicit function • Derived application on function graph • Derived application

Table 4: Diagram of Mathematic Exercise Item in Integral Calculus Material (n=2)

Pretest Material	i^{th} Item Material			Post Test Material
	i=1	i=2	i=3	
• Basic formula • Substitution method integral	• Basic formula • Substitution method integral • Trigronometric function integral	• Partial integral • Rational function integral • Trigonometric function substitution integral	• Integral application	• Substitution method integral • Trigronometric function integral • Partial integral • Rational function integral • Trigonometric function substitution integral • Integral application

The materials were sequenced in rows and columns. The pretest material was selected based on the students' experience of learning mathematics at their senior high school level. As in the example for the differential calculus material, the pretest material was the derived basic formula, trigonometric function and high level derivation. The material referred to the mathematics curriculum for senior high school. The pretest result was used for determining the level of the i-nth item material. The material began from column $i = 1$, namely with the basic rule order, trigonometric function, high level derivation, logarithmic function, natural logarithmic function, exponential function and hyperbolic function. After completed the exercise item in column $i = 1$, the student continued to column $i = 2$. Material $i = 3$ contained derived application items, namely maximum-minimum graphic function and application on practical problems. This organizing was conducted so that the students could gain adequate knowledge to deal with the new materials because the tasks in columns $i + 1$ were more complex than those in column i. Resnick & Ford (1981) state that giving mathematics problem exerciseitems is important to train the learners' calculation competence. Researches proved that the exercise itemaffected better results if it was given frequently in relatively smaller number than that given in low frequency in high number.

On each i-nth column there was branching based on the students' competence, namely L1 (low level), L2 (moderate level), and L3 (high level). According to Vygotsky, learning takes place when assistance is given at *Zone of Proximal Development* (ZPD), in which the implementation requires guidance (Tharp & Gallimore, 1988:41 in Murata, 2006). The guidance referred in this research was the item completion. If student makes an error in doing the item, he will be given a chance to redo the item with a clue in the form of formula summary. If he still makes an error, he will be given step by stem guidance to complete the item. An example of guidance to do items in differential calculus is as follows:

Problem

First derivation from $y = \ln\left(\frac{1-x}{1+x}\right)$is …

A. $-\frac{x}{1-x^2}$

B. $-\frac{2}{1-x^2}$

C. $\frac{2x}{x^2+1}$

D. $\frac{x}{x^2+1}$

E. $\frac{1}{x^2-1}$

Solution:

Given that:

$$\ln\left(\frac{a}{b}\right) = \ln a - \ln b \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\frac{d}{dx}\left(f(x) \pm g(x)\right) = \frac{d}{dx}f(x) \pm \frac{d}{dx}g(x) \ldots\ldots\ldots\ldots (2)$$

$$\frac{d}{dx}(\ln x) = \frac{1}{x} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\frac{d}{dx}\ln u(x) = \frac{1}{u(x)}.\frac{d(u(x))}{dx} \ldots\ldots\ldots\ldots\ldots (4)$$

Thus,

$$\frac{dy}{dx} = \frac{d}{dx}\left(\ln\left(\frac{1-x}{1+x}\right)\right)$$

$$\frac{dy}{dx} = \frac{d}{dx}(\ln(1-x) - \ln(1+x)) \ldots\ldots\ldots\ldots \text{formula (1)}$$

$$\frac{dy}{dx} = \left(\frac{d}{dx}\ln(1-x)\right) - \left(\frac{d}{dx}\ln(1+x)\right) \ldots\ldots \text{formula (2)}$$

$$\frac{dy}{dx} = \left(\frac{1}{1-x}.\frac{d}{dx}(1-x)\right) - \left(\frac{1}{1+x}.\frac{d}{dx}(1+x)\right).\text{formula (4)}$$

$$\frac{dy}{dx} = \left(\frac{1}{1-x}(-1)\right) - \left(\frac{1}{1+x}(1)\right)$$

$$\frac{dy}{dx} = \frac{-1}{1-x} - \frac{1}{1+x}$$

$$\frac{dy}{dx} = \frac{-1(1+x)-1(1-x)}{1+x-x-x^2}$$

$$\frac{dy}{dx} = \frac{-1-x-1+x}{1-x^2}$$

$$\frac{dy}{dx} = -\frac{2}{1-x^2}$$

Answer: B

The step by step solution show the guidance given to facilitate the students to understand the solution steps. The guidance given to the solution item is in the form of clues given in steps. If the student makes an error, the computer will display an instruction for him to do the item again with a clue in the form of material summary. At this stage, the student is supposed to actively find the solution by himself. If the student still makes an error, the clue will be given comprehensively. The clue should be provided if the student thinks that the task given is difficult enough (Bell, 1981).

The detailed design of problem item organizing application is shown through a flowchart (Figure 2) (Sarosa, 2015). This facility is downloadable from the Digital Telecommunication Network Study Program webpage, State Polytechnic of Malang, namely ***www.jtd.polinema.ac.id*** on the menu **Akademik** and sub menu **LatihanSoalMatematika**.

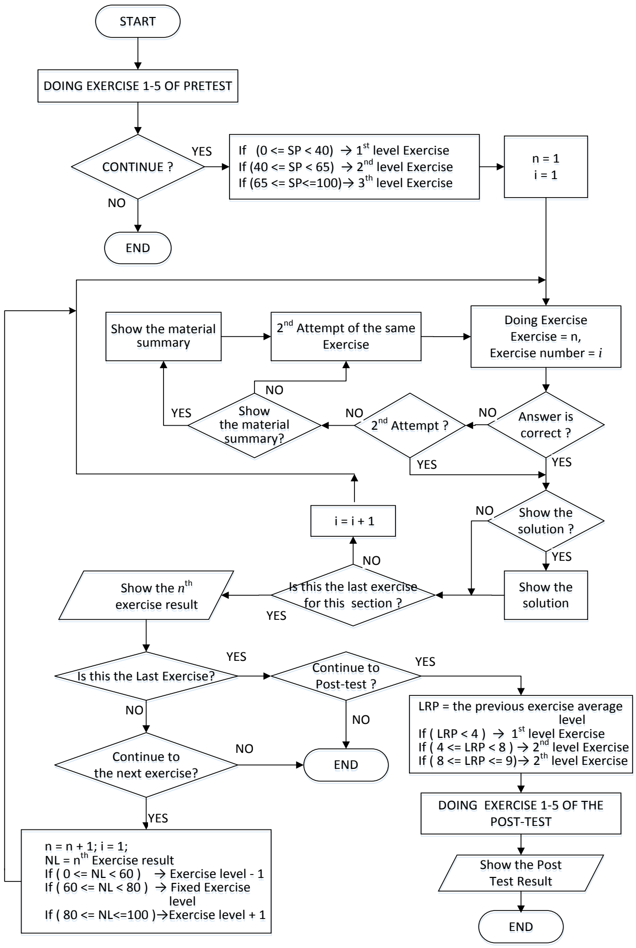

Figure 2: Flowchart of problem item organizing application

The evaluation design was conducted by observing the students' activities. The students' activities were monitored through their frequency of doing the problem items and their scores in each exercise.The frequency s shown through the bar chart to facilitate the lecturer in monitoring the student activity frequency as a whole.The students' activities record includes thecompletedexercise item material , date of completion, time of completion (hour:minute:second), and their scores. The students can browse any material and scores they get in the end of each exercise. It is intended to motivate the students. According to Sardiman (2008), the score in the form of numbers is the representation of the learning activity. The students normally expect that the scores that they get are higher and higher from one exercise to another. It is indicated by the repetition in each of the learning material. If the score is high, it will serve as a strong learning motivation. The item is given in the form of multiple choice with 5 choices; they are A, B, C, D, and E. Many choices are adapted to the general form used as the multiple choice items for item solution in Indonesia. The scores are displayed in the form of presentation.

The observation on the students' activity was done by two observers who are also the researchers. The score was given based on the descriptor appearance, namely observation on the students activities based on the students frequency in accessing the exercise item through the web. Score 1 means "not available", Score means "available, but poor". Score 3 means "available and good enough". And Score 4 means "available and good". The students activity was seen from the students activity in accessing the exerciseitem. The student activity descriptors were seen from the student access frequency. The observation result data are analyzed with the following percentages;

The percentage of the score average (SA):

SA= (total score/maximum score) x 100%
Level of Mastery:
90%≤SA≤100% : very good
80%≤SA≤90% : good
70%≤SA≤80% : moderate
60%≤SA≤70% : poor
0%≤SA<60% : very poor

Table 5: Data of the Results of the Students Activity Observation

Descriptors	*Observer Score 1*	*Observer Score 2*	*Observer Score 3*
Accessing pretest	4	4	4
Accessing exercise 1	4	4	3,5
Accessing exercise 2	3	3	3
Accessing exercise 3	3	3	3
Accessing post test	3	3	3

The students' activity is good if the score average of all the assessed aspects belongs to the good or very good category. The score average of the students activity observation was 3.3 or 85% (Table 5), or it is in good category.

In learningmathematics, learners are expected to work with the lecturer in various situations either in or outside the classroom (Bell, 1981:467). The teacher's role in giving guidance to the students provides assistance to the students when they face difficulties with mathematics problem items, directs and acts as a consultant to the learners, helps learners prepare for the test, and provides learning facilities outside the class. The role of the lecturer outside mathematics classes is a part of professional responsibility.

The internalized conceptof the materials they have learnt should be often reviewed so that the students do not forget the learnt concepts through repeated exercises (Hudojo, 1988:115). According to constructivists (Grouws in Hudojo, 2005:142), learning is intended to help students construct a concept with their own ability through an internalization process so that the concept is reconstructed. The guide given to the students takes account of the students' ability. The basic constructivistic assumption is that the learner should be active to build their knowledge and skill (Hitipiew, 2009:88).

The results of the web-based exercise item are directly displayed so that the students can look up the correct answers and check whether they have mastered the given learning materials, learn again the section they have not mastered yet for improvement, strengthen the section they have mastered correctly as self-motivation for further learning, and identify the difficult section in order to master. For the lecturer, the students' scores provide the level of the students' mastery on the learning material given, help deciding whether he or she continues to the following learning materials as the previous learning material is the prerequisite of the following, and give the overall description of the mastery level on the given learning materials (Lambas, 2004:28-27). Improvement of student's learning outcomes obtained by comparing scores between before and after participating in organized exercises. The results of the study showed there was an increase learning outcomes by 42%.

4. Conclusion

1. The support to learning mathematics covers the completion of the mathematics problem items by paying attention to the students' activities. The support can also be gradually-structured direction to complete the problem items.
2. The organizationof the mathematic problem items covers the math problem items construction that is structured hierarchically from the lowest, moderate, to the highest level of difficulty.
3. The application design of the exercise program is constructed in the level of difference and hierarchical fashion. a) Level of difference consists of three levels. They are Level 1 (low), Level 2 (moderate), and Level 3 (high). (b) Hierarchical fashion implies that the students learn a material after completing the previous one hierarchically (in sequence).
4. The evaluation design is conducted by observing the students' activities of a) the students' frequency to do the exercise item and b) the students' activity record that covers the completedexercise item, dates of completion, duration (time) of completion (hour:minute:second), and the students scores.
5. The results of the study showed there was an increase learning outcomes by 42%.

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