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Improving Macroeconomics Problem-Solving Skill through Economics Learning Information System Media

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ABSTRACT

The objective of this research was to develop an effective Economics learning information system media to improve students' skill for Macroeconomics problem-solving. It used the research and development method. The Macroeconomics learning information system media was tested by using the quasi experimental research method with before –after design. It was conducted at the Study Program of Economics Education Program, Sebelas Maret University, Surakarta. Its population was 95 students. The findings of the N-Gain showed that the learning result of the experimental group was higher than that of the control group. The criteria of the N-Gain of the experimental group were high gain as much as 3.33%, moderate gain as much as 80% and low gain as much as 16.67%. Meanwhile, the control group did not have a high gain criterion or 0% but moderate gain as much as 46.67% and low gain as much as 53.33%. The score of the calculation on the questionnaire of problem-solving skill of the experimental group students who used the website-based information system media was higher than that of the control group students who did not use such media where the score percentage of the former was 80.61% while that of the latter was 72.18%. With such results, thus, this research was successful in developing a Macroeconomics learning information system media to improve student's problem solving skill.

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1. INTRODUCTION

Some of human resource skills which are required in the 21st century are creativity and problem-solving ability. According to Merrill (2002), problem-solving ability is able to encourage learners to utilize and use the knowledge that they have gained to find solutions when they encounter a problem in addition to attaining knowledge and new experiences. The problem-solving ability is closely related to critical thinking ability, which is translated into assessment, skepticism, alertness to read, rationality, knowledge integration, pure thoughts, and self-reflection form (Moore, 2013). When students are in a learning environment particularly in their daily life, their critical thinking is expected to provide a real encouragement for them in the forms of creativity and problem-solving ability.

According to Sheryl (2009) that Problem Based Learning (PBL) as a learning method, was built with the idea of constructivism and sudent-centered learning approach. When using PBL, teachers help students focus on solving problems in real-world contexts, which will encourage students to think of situations of problem when students try to solve problems [16]. As a model, this learning is done through collaborating of students in small groups; using student-centered learning approaches; teachers acting as facilitators, and using real-life situations as the focus of learning. Students will work in groups to solve real and complex problems that will develop problem solving skill, reasoning, communication, and self evaluation skills through Problem Based Learning. PBL is also a learning model based on the many problems that require authentic investigation of the investigation that requires a real settlement of the real problems (Trianto, 2011). The other findings by Chumsukon (2019) found that the students' problem-solving skills through problem-based learning in Economics in School Course, there were 78% passing the specified criterion out of all students who were higher than the specified standard 70%. The students' satisfaction in problem-based learning overall was in High level (Very Satisfied). It is beneficial for improving social studies teachers to develop future students. The students can continuously learn by themselves; it allows them the opportunity to achieve the goal of life-long learning and to become a person of quality for the 21st century.

In Macroeconomics problem-solving, graphical (curve) and mathematical (proving formulae and calculations) approaches are required. An understanding on the economic concepts and a skill to analyze relations between variables well are needed in employing graphical and mathematical approaches in explaining theory of Macroeconomics. One of the most-recurring problems encountered by students in understanding this is to understand curves. Students consider curves or diagrams to be difficult to understand and often do not know the way to explain curves in a correct and systematic way. In explaining curves, a good mastery of concept, theory, and relation between variables such as mastery in theory of demand, theory of supply, and theory of production is needed. Teachers should realize the role of technology in supporting their students, especially the ever-expanding learning needs (Sharpe et al., 2006).

Likewise, to improve their numeracy skills, students should work on quizzes. The more diverse the answered quizzes will eventually encourage a higher creativity. Mastery of concepts, creativity of thinking, and problem-solving skill are competences that teachers should bear. However, learning outcomes of the students of the Study Program of Economics Education, the Faculty of Teacher Training and Education, Sebelas Maret University, Surakarta who will themselves be teachers of Economics subject matter, especially in Macroeconomics subject matter have not met the satisfactory result. The average final score in Academic Year 2016/2017 reached only 68 (C grade). Several weaknesses shown by the students are considered as urgent to be improved, such as difficulties in understanding the course and in using both graphical and mathematical analysis tool. Researches by Singh & Reed (2001), Ruiz, Mintzer, & Leipzig (2006), Morris (2010), Doig & Hogg (2013), and Tsai & Tang (2017) showed that learning by using online and offline systems (blended learning) can raise students' learning outcomes. Herrington, & Kervin (2007), Dickfos, Cameron, & Hodgson (2014), and Tan & Neo (2015) explained the importance of blended learning, which integrates technology in the success of learning.

Blended learning is a learning method using more than one way in transferring knowledge to students aiming at optimizing learning and reducing learning expenditures (Singh et al., 2011). Doig & Hogg (2013) explained that students of the 21st century have a habit of spending study time through online technology. The online learning experience is considered to be more interesting and beneficial, so that it can improve students' learning outcomes. Blended learning gives many advantages to students, such as time flexibility, ease of access and self-placement in studying, and collaborative learning (Ruiz, 2006). Blended learning provides convenience in integrating traditional way of learning (face-to-face learning) with online learning (e-learning) and is considered suitable to the students' learning needs and teachers' instructional needs. In addition to improving learning outcomes, blended learning encourages students to be self-reliant (Tsai and Tang, 2017) and to be able to provide them with learning opportunities and experience (Morris, 2010). Research by Singh & Reed (2001) presents the way blended learning could increase learning scope and effectiveness and reducing costs; a result was also put forward by Tsai & Tang [8], in which discussions and online interactions can make students learn effectively through teamwork which in turn reduces costs and time.

System of Economics learning presented in this article is developed by making a website facilitating availability of learning resources, such as learning materials on Macroeconomics, PowerPoint presentations of course materials, student's assignments, learning video, and online tests. Resources on Macroeconomics can be downloaded and saved in smartphones, which nearly all students have, so that students can study the course materials anywhere with convenience (useable). All assignments stored are required to be done by students, either individually or in groups.

Based on problems explained above and solutions planned, the questions posed in this research are: How is the design of media development for an effective Economics learning system to improve students' skills in Macroeconomics problem-solving? The objective of the research is to generate a design of media development for an effective Economics learning system to improve students' Macroeconomics problem-solving skill.

2. METHODS

This research was performed to the students of the Study Program of Economics Education, Sebelas Maret University, Surakarta, who were taking Macroeconomics. It employed research and development (R&D) approach by adopting the R&D model of Borg and Gall [12][13]. The procedure of the research included research and information collection, planning, development of preliminary form of product and preliminary field testing.

2.1 Preliminary Study

The preliminary study consisted of three stages, namely: need analysis, product design, and validation.

2.2 Need Analysis.

The need analysis in this research referred to the students' learning results which were not satisfactory yet and the use of learning system media which were still limited although the internet access at the site of the research was adequate for the development of learning system media. The survey of the research was done through field observation by exploring problems, and then identifying the problems based on their priority and appropriateness to the research need. The development of product was aimed at developing information system of website-based Economics learning system media in Macroeconomics course so as to improve the students' problem-solving skill.

2.3 Product design.

This stage referred to the students' weakness in understanding learning material and using graphical or mathematical analysis tools marked by their attained average final score which was below the minimal learning completeness criterion, questionnaire of need analysis, library research which included journals and results of related researches.

2.4 Product validation.

The validation of Macroeconomics learning system product was validated by team of experts (expert judgment). The blueprint of learning system product was validated and assessed a team of experts who know the developed learning system. The feasibility of the learning instruments was validated by one lecturer of the Faculty of Economics and one media expert of the limited liability company of PT. Phicos.

The media assessment used two instruments. The first instrument was used to assess the website-based Economics learning information system media, and the second one was to assess the learning media presented in the website-based Economics learning information system media. The researchers used the same media assessment instrument for learning material, Microsoft power point, and video as they had a similarity in the material assessment. Meanwhile, the instrument of website information system assessment validation did not contain any material assessment element.

2.5 Development of Product

The stage of development of product consisted of four stages, namely: limited testing of preliminary form of product, revision of product, extended testing of revised product, and final revision of product. Each is elaborated as follows:

2.6 Limited Testing of Preliminary Form of Product

The enhanced blueprint or draft of Economics learning information system product was exposed to limited testing to the half of the second semester students of the Study Program of Economics Education (15 students), the Faculty of Teacher Training and Education, Sebelas Maret University, Surakarta.

2.7 Revision of Product

Based on the limited testing of Economics learning information system product, the researchers revised the product according to the feedbacks of the experts i.e. learning media expert, learning material expert, and students who used the product.

2.8 Extended Testing of Revised Product

The revised product was then exposed to extended testing to more respondents, namely: 35 second-semester students of the Study Program of Economics Education, the Faculty of Teacher Training and Education, Sebelas Maret University, Surakarta.

2.9 Testing of Product

Quasi Experimental Research with Before-After Design. The effectiveness of the Economics learning information system media was measured by considering the improvement of the students' learning results prior to and following the use of tutorial video learning media in Macroeconomics course. Thus, in this stage, experimental research method was employed to investigate the improvement of the students' learning result. Its research design was pretest-posttest control group design, meaning that in the testing of product effectiveness, two groups, namely: experimental group exposed to the treatment of Economics learning information system media and control group which was not exposed to the treatment were chosen. Then, the two groups were given a pre-test to investigate their initial ability. At the end of the learning, the two groups were given a post-test to see the improvement and difference of the learning results of the students of both the experimental and control groups.

The descriptive quantitative data analysis technique was used in testing the effectiveness of Economics learning information system media toward improvement of learning outcomes observed from students' Macroeconomics problem-solving skill, in which the data of pre-test and post-test results obtained were then tabulated to tables, and the mean score of experimental and control groups were then compared. This research used gain analysis technique to determine the improvement of student learning outcomes especially in the field of knowledge. Gain was obtained from the calculations of pre-test and post-test score data prior to and following the treatments. The gain score was calculated by using the formula of $SG = (S_{post} - S_{pre})/(S_{max} - S_{pre})$[14]. The learning outcome improvement was then categorized into three categories based on the normalization gain criteria: low gain ($g < 0.3$), moderate gain ($0.3 \leq g \leq 0.7$), and high gain ($g > 0.7$).

2.10 Product Dissemination and Implementation.

After the learning outcome effectiveness following the use of media was known, then product dissemination and implementation were then performed. These steps were conducted to disseminate the new product in form of Economics learning information system media that is feasible to be used by students taking Macroeconomics course, so that the web-based media could be used as new learning media.

2.11 Assessment of Problem-solving Skill through Questionnaires.

In this research, problem-solving skill was observed through two kinds of analysis. The first analysis used N-gain improvement test, while the second analysis was conducted to strengthen the result of the first analysis by using instrument of assessment questionnaires on the problem-solving skill. The questionnaires were divided into two types according to their usage: the first type was used to assess problem-solving skill of the students who used the web-based learning information system media, while second type was used to assess problem-solving skill of the students who did not use it. The data types used in this research were qualitative and quantitative ones. They were obtained through observation, tests, questionnaires, and documentation. Learning devices used were learning materials and information system media. The population of the research was 95 students of the Study Program of Economics Education in Academic Year 2017/2018. Purposive sampling technique was used to determine its samples. The samples consisted of three groups of classes of students as follows: Class A acting as limited testing group with 35 students, Class B acting as control group with 30 students, and Class C acting as experimental group with 30 students.

3. FINDINGS AND DISCUSSION

3.1 Findings

Based on the data obtained in the preliminary study i.e. need analysis and referring to the basics of theory of the literature studies, the preliminary developed product was drafted. Product description. The website-based Macroeconomics learning information system media can be access at the following address http://app.demoo.id/simvideo.

The creation of such media used open source framework code igniter and framework so that it can be accessed online. The website has the following features or menus: (a) *bio data*, this menu is useful for managing the account data of the students of the Study Program of Economics Education who take Macroeconomics course; (b) *material*, this feature has the function to download the learning resources for Macroeconomics course as to enrich students' knowledge; (c) *task*, this feature has the function to download tasks assigned by lecturers as to support their problem-solving skill; (d) *pretest*, this menu is useful for displaying online questions as to measure the preliminary ability of students in macroeconomics learning by using website-based information system media; (e) *posttest*, the function of this feature is the same as that of the pre-test feature, but it measures the students' ability after they have understood and explored the available online materials in the economic learning information system media; and (f) *remedial*, this menu is useful for doing remedial tests online for the students whose learning result is below the stipulated minimal learning completeness criterion.

The collection of learning material draft was done together with the research team, namely: Macroeconomics course lecturers, which included the development of learning media and assessment and the creation of various learning instruments including syllabus, lesson plans, Macroeconomics learning materials, power point of learning material, and Macroeconomics learning video.

In the table of the result of validation calculation on the 45 statement items of three learning media, the average score of each was 3.1 and the total percentage was 78%. Thus, based on the feasibility criteria, the three learning media were classified as the ones with "good" criterion.

The result shows that the average score was 3.4, and the total percentage was 84%. Based on the feasibility criteria, the website-based Macroeconomics learning information system media, learning material, Microsoft power point, learning video were classified as the ones with "good" criterion.

The learning activities of the experimental group used the online Economics learning system media. The use of media facilitated the students to access course material (learning materials, PowerPoint presentation files, and video), integrated assignments (downloading and uploading assignments), and Macroeconomics quizzes. The facilities equipped in the media were considered to be able to improve learning motivation, to encourage students to understand more about the concepts, and to be able to learn better about analysis tools (graphical and mathematic) so that the students' learning outcomes were expected to improve. This is proven by the significant increase of post-test result if compared to the pre-test, in which the post-test learning outcome average score of the experimental group was 78, while that of the control group was 72. The learning activities of control class were conducted offline without using the Economics learning system media. The students in the control group were still obtaining course materials (learning materials and PowerPoint presentation files) and also got assignments and quizzes but with a lower intensity than the experimental group. The results of normality and homogeneity tests obtained through *IBM SPSS Statistics* 22 program were first needed to conduct media effectiveness test, covering difference test of pre-test and post-test average scores, which aims to observe the difference on average pre-test and post-test score between the experimental group and the control group. In addition, gain test was also conducted to understand the improvement on the learning outcomes based on the pre-test and post-test scores between the experimental group and the control group.

This research used the significance level of 0.05. Based on the normality test of the experimental group's pre-test result, it was found that the score of *Kolmogorov-Smirnov* Sig was 0.200 > 0.05 and that of *Shapiro Wilk* Sig was 0.408 > 0.05, while in the normality test of the control group's pre-test result, it was found that the score of *Kolmogorov-Smirnov* Sig was 0.200 > 0.05 and that of *Shapiro Wilk* Sig was 0.460 > 0.05. Both show that the pre-test scores of both group had a normal distribution. Subsequently, in normality test of the experimental group's post-test result, it was found that the score of *Kolmogorov-Smirnov* Sig was 0.200 > 0.05 and that of *Shapiro Wilk* Sig was 0.829 > 0.05, while in the normality test of the control group's post-test result, it was found that the score of *Kolmogorov-Smirnov* Sig was 0.200 > 0.05 and that of *Shapiro Wilk* Sig 0.264 > 0.05. Furthermore, the result of Levene homogeneity test was obtained, showing that the pre-test result had Sig 0.861 > 0.05 and post-test result had Sig 0.220 > 0.05, therefore showing that each group had the same variation, or homogenous.

Based on the gain test result, it was found that the experimental group had a high gain criterionof3.33%, moderate gain criterion of 80%, and low gain criterion of 16.67%. The control group did not have a high gain criterion (0%) but the moderate gain criterion of 46.67% and the low gain criterion of to 53.33%. The result of the difference test of average pre-test scores showed the mean score of the experimental group of 62, and that of the control group of 59. This shows that the experimental group obtained a higher mean score than the control group. A Sig (2-*tailed*) 0.206 > 0.05 of average difference test significance and t_{stat} (1.278) < t_{crit} (2.04) score were obtained, so that H_0 was verified, meaning that that there was not any difference on the average pre-test scores between the students in the experimental group and those in the control group. The result of difference test of average post-test scores showed the mean score of the experimental group of 78, and that of the control group of 72. This shows that the experimental group obtained a higher mean score than the control group. There was a 6-point difference on the mean post-test scores between the experimental group and the control group. A Sig (2-*tailed*) 0.03> 0.05 of average difference test significance and t_{stat} (3.144) < t_{crit} (2.04) score were obtained, so that H_0 was not verified, meaning that there was a difference on the average pre-test scores between students in the experimental group and those in the control group. The existence of differences in the average post-test scores of students show that the specialized treatment of online Economics learning given to the experimental group was able to improve their learning outcomes.

3.2 Discussion

The improvements on the students' Macroeconomics problem-solving skill could be observed from the learning outcome improvements calculated by using N-gain. In addition to N-gain calculation,

the researchers also used questionnaire calculation to support the result of improvements. Based on the calculations of all aspects in the problem-solving skill observed, the students of experiment group, who used Macroeconomics learning information system media, had an average score of 3.2 on 4 scale with the percentage of total average of 80.61%. The average percentage showed that the students' Macroeconomics problem-solving skill grading improved significantly following the use of this media. This supported by the researches by Singh & Reed (2001), Ruiz, Mintzer, & Leipzig (2006), Morris (2010), Doig & Hogg (2013), and Tsai & Tang (2017) that learning by using online and offline systems (blended learning) could improve students' learning achievements in the schools.

This finding also corresponded to the theory of cognitive psychology which states that when students are faced with problems, students will use prior student knowledge to understand and solve a problem (D. Siegler et al, 2014). At the learning stage of Problem Based Learning in the planning part of problem solving, students will be directed to develop their ability to build new knowledge to solve the lesson problems. In the third phase, individual and group research guide phase, students will have the opportunity to use the knowledge they have gained from provided by the teacher acts as a liaison between previous students' knowledge and new knowledge previous experience to solve the problem.

The other study revealed by Simamora et al (2017) showed that the action through implementation of Problem Based Learning model increased learning activities and problem solving skills of students. This problem-solving capability is in accordance with the statement made by Shah which stated that learning problem-solving that basically learning using scientific methods or think systematically, logically, regularly and meticulously were able to improve the ability and cognitive to solve problems rationally, straight forwardly, and thoroughly. PBL with scientific thinking characteristics will train students to improve their thinking skills; every activity in the PBL learning series, is an attempt to train students' skills in solving problems.

Based on the calculations of all aspects in problem-solving skill observed, the students of the control group, who did not use Macroeconomics learning information system media, had an average score of 2.9 on 4 scale with the percentage of total average of 72.18%. The average percentage shows that the students' Macroeconomics problem-solving skill grading also improved following the use of this media, even though the increase was lower than that of the experimental group. In line with the above findings, the research findings by Chumsukon (2019) also found the same results that the students' problem-solving skills through problem-based learning in Economics were mostly passing the specified criterion than the specified standard. The students' satisfaction in problem-based learning overall was very satisfied. It is beneficial for improving social studies teachers to develop future students, since the students can continuously learn by themselves.

4. CONCLUSION

Based on the research conducted, it can be concluded that the website-based Macroeconomics learning information system media produced is feasible to be used. The improvements on the students' problem-solving skill could be observed from the improvement on the learning outcomes and the questionnaire calculation results. Therefore, the research was successful in developing website-based Macroeconomics learning information system media to improve problem-solving skill.

Based on conclusions above, the researchers give these recommendations: to teachers,the teachers should give a deeper knowledge to students on the use of learning information system media facility provided; to other researchers, the researchers who want to research this matter further should develop the learning information system media to be easier to operate so that it can further improve learners' interest and learning outcomes in order to hone their problem-solving skill; to students, the students should be proactive in understanding and utilizing newest learning media as learning source; and to the faculty, the faculty should provide a maximum internet access service so that the information system media can be used by students and lecturers without any hindrance in form of unstable network.

REFERENCES

A. Doig and S. Hogg, (2013) "*Engaging distance and blended learners online*, " vol. 6, no. PARTG. Emerald Group Publishing Limited, 2013.

Borg, W. R. and M. D. Gall, (2089) "*Educational Research: An Introduciton*", Fifthy Edi. New York: Longman, 1989.

B. H. Singh, C. Reed, and C. Software (2001) "A White Paper : Achieving Success with Blended Learning," no. March, pp. 1–11, 2001.

Chumsukon, Montha (2019) The Development of Problem Solving Skills through Problem-Based Learning in Economics in School Course International Journal of Emerging Issues in Early Childhood Education (IJEIECE) Vol. 1, No. 1, May 2019, pp. 33-40

D. Siegler, DeLoache & Eisenberg. (2014). An Introduction to Child Development; How Children Develop: Theories of Cognitive Development. (3rd edition). [On-Line]. Available: http://www.psy.cmu.edu/~rakison/POCDclass1.pdf [May 12, 2017].

Hake, R. R. (1998) "Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," *Am. J. Phys.*, 1998.

H. Y. J. and M. Neo, (2015) "Exploring the use of authentic learning strategies in designing blended learning environments: A Malaysian Experience," vol. 6(2), pp. 127–142, 2015.

J. Ruiz, M. Mintzer, R. L.-A. medicine, and undefined (2006). "The impact of e-learning in medical education," *Journals.Lww.Com*, vol. 81, no. 3, pp. 207–212, 2006.

J. Herrington and L. Kervin, (2007) "Authentic learning supported by technology: Ten suggestions and cases of integration in classrooms," *EMI. Educ. Media Int.*, vol. 44(3), pp. 219–236, 2007.

J. Dickfos, C. Cameron, and C. Hodgson, (2014) "Blended Learning: Making An Impact On Assessment And Self-Reflection In Accounting Education," *Educ. Train.*, vol. 56(2/3), pp. 190–207, 2014.

M. D. Merrill (2002) "First Principles of Instruction," vol. 50, no. 3, pp. 43–59, 2002.

M.-H. Tsai and Y.-C. Tang, (2017) "Learning attitudes and problem solving attitudes for blended problem-based learning," *Libr. Hi Tech*, pp. 00–00, 2017.

N. P. Morris, (2010) "Blended Learning Approaches Enhance Student Academic Performance," *Enhancing Learn. Exp. High. Educ. Int. Conf.*, 2010.

Reynold, M.J. & Hancock, R.D. (2010). Problem-based learning in higher education environmental biotechnology course. Innovations in Education and Teaching International, 47(2), 175–186.

R. Sharpe, B. Greg, and F. Richard, (2006) "Implementing a university e-learning strategy: levers for change within academic schools," *Res. Learn. Technol.*, vol. 14, no. 2, pp. 135–151, 2006

Sheryl MachMath, John Wallace, & Xiaohong Chi (2009, Nov). "Problem-Based Learning in Mathematics: A Tool for Developing Students' Conceptual Knowledge". The Literacy and Numeracy Available http://www.edu.gov.on.ca/eng/literacynumeracy/inspire/research/WW_problem_based_math.pdf [Oct. 4, 2016]

Simamora, Rustam E; Dewi Rotua Sidabutar; Edy Surya (2017) Improving Learning Activity and Students' Problem Solving Skill through Problem Based Learning (PBL) in Junior High School. *International Journal of Sciences: Basic and Applied Research (IJSBAR)(2017) Volume 33, No 2, pp 321-331.*

Sugiyono (2010). Metode Penelitian Bisnis, Pendekatan Kuantitatif, Kualitatif, dan R&D. Penerbit Alfabeta, Bandung.

Trianto (2011) Mendesain Model Pembelajaran Inovatif-Progresif. Jakarta: Penerbit Kencana Prenada Media Group.

T. Moore (2013) "Critical thinking: seven definitions in search of a concept," *Stud. High. Educ.*, vol. 38, no. 4, pp. 506–522, 2013.