The Effectiveness of Subject Specific Pedagogy based on Guided Discovery with E-learning to Improve Students' Problem Solving Skills

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Abstract. This research aimed to know the effectiveness of Subject Specific Pedagogy (SSP) based on guided discovery with Edmodo to improve students' problem solving skills in XI grade of MAN 1 Yogyakarta. The method used was quasi-experimental with pre-test&post-test group design. Two classes were chosen by random sampling techniques and each class consist of 28 students. The data obtained with problem solving skills tests and analyzed by one way Anova. The result of the test shows that the significance value is less than 0.05. It can be concluded that the use of SSP based guided discovery with e-learning has significance impact than conventional teaching.

Keywords: PCK; SSP; Guided discovery; E-learning; Problem solving skills.

1. Introduction

Physics is the most fundamental science and plays an important role in cognitive abilities and practical skills. Physics is not only an ordinary field of research but relates to its ontological and epistemological aspects can be a powerful today to change our intellectual life thoroughly. Physics is a foundation in almost every field including computing, communication, biosciences, and medicine. Given the role of physics is very important, precisely if physics must be taught in school. But today, concerns arise about Physics education especially about the lack of high school students' interest in physics, as well as the number of physics school teachers [1]. Many students think physics is difficult. One factor is many teachers concentrate only on mathematical calculations than to interpret the true meaning of scientific concepts and hence students can’t understand the meaning behind the formula [2]. However, in physics, it should give more illustration of the rules or laws of nature that are simplified to develop beneficial theories for life. In addition, the concepts studied should be linked to the benefits or relevance of the everyday phenomena in order to increase student motivation [3].

Problem solving skills is one of the most important skills to be trained in students in the 21st century. Learning that emphasizes problem-solving has a positive effect on learning achievement of learners compared with conventional learning [4]. Traditional learning tends to cultivate students' dislike toward physics so that it will have an impact on their understanding of physics [5]. Traditional learning is often used by teachers on the grounds that learning with this model will have more physical material delivered. Whereas for effective learning, they must actively work to understand their own concepts and information can’t be easily transferred from teacher to student.

One of the learning models that can improve students' conceptual understanding is Discovery learning. Discovery learning is divided into two, namely pure discovery learning and guided
discovery. Guided discovery more effective for use in learning than pure discovery [6] [7]. Through guided discovery learning, students receive problems to be solved with guidance, direction, training, feedback or modelling to keep students in the desired path while in pure discovery students receive problems to solve with little or no instruction from the teacher.

Teachers as managers and facilitators in learning have an important role in efforts to improve the quality of learning. Therefore, the teacher needs to have knowledge about the material / content and understand how the strategy must be applied so that the content can be conveyed to students. In 1986, Shulman introduced a knowledge that teachers use to facilitate, organize and lead the students to frame the learning situation according to the needs of the students called pedagogical content knowledge (PCK). Pedagogical content knowledge or PCK is described as a combination of understanding of teaching materials (content knowledge) and an understanding of the pedagogical knowledge that a teacher needs to possess [8]. The knowledge of PCK can be developed by teachers over time through experience, on how to teach material content in a specific way. Certain issues or issues that are organized, represented, and tailored to the interests and abilities of learners, and provide instruction to help learners understand the specific content. One way for teachers to develop their teaching skills, in addition to focusing on the content and how the students learn the content, should also involve students actively in learning [9, 10, 11, 12]. In learning, knowledge of PCK can be packaged in the form of learning devices called Subject Specific Pedagogy (SSP). SSP consists of syllabus, lesson plan, worksheet, and assessment instruments [13]. The SSP is structured by considering factors such as the characteristics of learners, the diversity of backgrounds, potentials, facilities and infrastructure in the school, which can be self-designed by the teacher on the need to be more specific and distinctive.

Based on interviews, the teacher compiled his own learning tools consisting of syllabus, lesson plans, teacher books and student books. In the implementation of learning by using learning models that demand the activeness of students can take a lot of time, so evaluation activities at the end of learning are often not done. Therefore, in practice teachers prefer to dominate learning so that the whole material can still be conveyed to students.

With the widespread use of technology in everyday life, technology is thought to be an essential component of teaching support and learning in the classroom. Mishra and Koehler [14] show that good teaching requires an understanding of the technology with the combination of content, pedagogy, and technology to develop appropriate instructional strategies. One of the use of technology in learning is using e-learning. E-learning is an online learning process/internet network that helps teachers to integrate learning materials, provide training and facilitate online discussions [15]. Through e-learning, learning can be done anytime, anywhere, and the learning process can take place efficiently and effectively [16] [17]. In addition, video, simulation, and animation that support learning can also be presented through e-learning. This will certainly help visualize and reduce the level of abstraction of physical matter.

One of the e-learning applications that are widely used in teaching and learning methods is Edmodo. According to Basori [18], Edmodo is an app that appeals to teachers and students with social elements that resemble Facebook. Edmodo comes with some learning activities, such as Quiz, Assignment, and Poll. As for Resources (teaching materials), Edmodo supports teaching materials in the form of Files and Links (URL / Embed media). The use of Edmodo is expected to facilitate online learning. Motivated to create meaningful and effective learning in school, this research develops SSP based guided discovery with Edmodo to improve problem solving skills learners.

The rest of this paper is organized as follow: Section 2 describes the proposed research method. Section 3 presents the obtained results and following by discussion. Finally Section 4 concludes this work.

2. Research Method
This research took place at MAN 1 Yogyakarta on the second semester of academic year 2017/2018. The type of research is quasi experimental using pre-test&post-test control group design (see Table 1).
The Sample was selected using a random sampling technique. There are two sample classes such one as one experimental class (N=28 students) and one control class (N=28 students). Before the lesson begins, the two classes are given pre-test first. After given the pre-test, the experimental class implementing SSP based guided discovery with Edmodo and conventional learning is used in the control class.

Table 1. The Pre-test&post-test Control Group Design.

|          | O1 | X | O2 |
|----------|----|---|----|
| Experiment class |    |   |    |
| Control class    |    |   |    |

The syntax of experimental learning will be presented in the following Table 2.

Table 2: Syntax of guided discovery assisted by Edmodo

| Syntax of guided discovery | Activities |
|---------------------------|------------|
| Stimulation               | Online     |
| Problem statement         | Online     |
| Data collection           | Interface  |
| Data analysis             | Interface  |
| Verification              | Interface  |
| Generalization            | Interface  |

2.1 Validation SSP

Instrument used in this research are syllabus, lesson plan, and student worksheets. Validation of Subject Specific Pedagogy (SSP) used validation sheet by three experts in subject matter, teacher and three peer review. Validation sheet used Likert scale from 1 to 5. Validation result were analyzed using average score by validators. Then, the average score converted based on the Likert scale of 5 criteria to know the criteria [19]. The formula can be seen in the following Table 3.

Table 3. Conversion scale on a scale of 5

| Interval | Average Score | Classification |
|----------|---------------|----------------|
| $X > \bar{X}_i + 1,8 \times sbi$ | >4.2          | Excellent      |
| $\bar{X}_i + 0,6 \times sbi < X \leq \bar{X}_i + 1,8 \times sbi$ | > 3.4 – 4.2  | Good           |
| $\bar{X}_i - 0,6 \times sbi < X \leq \bar{X}_i + 0,6 \times sbi$ | >2.6 – 3.4   | Adequate       |
| $\bar{X}_i - 1,8 \times sbi < X \leq \bar{X}_i - 0,6 \times sbi$ | >1.8 – 2.6   | Failed         |
| $X \leq \bar{X}_i - 1,8 \times sbi$ | $\leq$1.8     | Poor           |

Description:

$X_i$ = ideal mean  
$Sbi$ = ideal deviation standard  
$X$ = total average score

2.2 Empirical test about problem solving skills test

The instrument to measure student’s problem solving skills consist of five essay questions which related with optical devices. The indicator of problem solving skills questions are understanding the problem, physical formulations, carrying out the plan, and looking back. These item has been tested to
72 students of 12th grade to determine validity and reliability. This result was analyzed by QUEST program. Infit Mean Square shows that item fit with Rasch model with interval value 0.77 until +1.30.

2.3 Test Normalized Gain (N-Gain)
Test Normalized Gain (N-Gain) shows an increasing difference between the value of the initial problem solving skills test and the student's final grade (Table 4). N-gain can be calculated by the formula Meltzer [20]:

\[ N - Gain = \frac{postest \ score - pretest \ score}{maximum \ score - pretest \ score} \]

| Gain score | Category |
|------------|----------|
| g ≥ 0.7    | High     |
| 0.3 ≤ g < 0.7 | Medium   |
| g < 0.3    | Low      |

2.4 Analysis with ANOVA
ANOVA (Analysis of Variance) with Tukey test. Before testing the research hypothesis, before the prerequisite test, ie normality test by using Shapiro-wilk test and homogeneity test by using Lavene test with sig. > 0.05. If the sample is not normal, then tested Kruskal.

2.5 Normality Test
The data normality test was analyzed by SPSS program, through the Kolmogorov-Smirnov and Shapiro-Wilk methods. This test is conducted to determine whether the research data is normally distributed or not. Data is normally distributed if the value of sig. > 0.05

2.6 Homogeneity Test
Homogeneity test conducted through Lavene test with the help of SPSS 22 Program. Homogeneity test is intended to show that two or more groups of sample data come from populations having the same variance. If the value of Lavene statistic > 0.05 then it can be said that the data variation is homogeneous.

2.7 Hypothesis Test
Hypotheses in this research are:
H₀ : SSP based guided discovery with e-learning does not influence student's problem solving skills.
H₁ : SSP based guided discovery with e-learning significantly influence student's problem solving skills.
H₀ hypothesis is rejected if significance level is below than 0.05.

3. Result and discussion
This section presents the results used and the proposed discussion

3.1 Result of validation SSP
The SSP developed in this study consists of syllabus, lesson plan, and worksheet. Validation of Subject Specific Pedagogy (SSP) used validation sheet by three experts in subject matter, teacher and three peer review. The results showed that the syllabus categorized excellent, lesson plan categorized good and worksheet categorized good. Thus this SSP has been feasible for use in learning.
3.2 Results of empirical test about problem solving skills test

**Table 5: Infit Mean Square and Reliability**

| Items | Infit Mean Square | Reliability |
|-------|------------------|-------------|
| 1     | 0.71             | 0.92        |
| 2     | 0.86             |             |
| 3     | 0.93             |             |
| 4     | 1.00             |             |
| 5     | 1.00             |             |

Based on Table 5 above that the 5 items tested, the entire item is declared fit with the Rasch model because it meets the criteria that Infit Mean Square is located at the interval value of 0.77 to +1.30. The resulting reliability level is 0.92. This high degree of reliability suggests that the items are reliable to measure the level of problem solving skills.

3.3 N-Gain

Data analysis technique is done in two ways, namely descriptive analysis and statistical analysis. Descriptive analysis describes data based on minimum score, maximum score, mean, standard deviation, and N-Gain. While statistical analysis is done through one way Anova with SPSS 22 data program is presented based on pre-test and post-test value of experiment class and control class (Table 6).

**Table 6. Results of problem solving skills test**

| Category          | Experimental class | Control class |
|-------------------|--------------------|---------------|
|                   | Pre-test           | Post-test     | Pre-test | Post-test |
| Minimum score     | 15                 | 65            | 15       | 50        |
| Maximum score     | 45                 | 90            | 15       | 80        |
| Mean              | 31.43              | 77.86         | 31.43    | 65.36     |
| Std. Deviation    | 6.920              | 7.256         | 6.920    | 8.043     |
| N-Gain            | 0.68               | 0.39          |          |           |

Based on Table 6 it can be seen that the post-test value between the two classes is different. After getting treatment, the post-test average value of both classes has increased from the previous value. The average score of the experimental class pre-test score is higher than the control class. The N-Gain of the experimental class is medium category with score 0.68 while the control class is 0.39 which is in the low category.

3.4 Results test of one way Anova

3.4.1 Result of normality test

**Table 7. Results of normality test**

| Test      | Kolmogorov-Smirnov | Shapiro-Wilk method |
|-----------|---------------------|---------------------|
|           | Exp. Class          | Control class       | Exp. Class | Control class |
| Pre-test  | 0.091               | 0.91                | 0.208      | 0.208         | Normal      |
| Post-test | 0.091               | 0.127               | 0.118      | 0.201         | Normal      |

From Table 7, based on results of normality test with Kolmogorov-Smirnov methods and Shapiro-Wilk, the pre-test and post-test values of both classes are categorized normally. This means that data is normally distributed.
3.4.2 Result of homogeneity test

| Test   | Lavene test | Description |
|--------|-------------|-------------|
| Pre-test | 1.00        | Homogeneous |
| Post-test | 0.719       | Homogeneous |

From Table 8, based on the result of homogeneity test performed with Lavene test, it is known that Lavene statistic has significance above 0.05 so it can be said that the data variance is homogeneous.

3.4.3 Result of Anova test

| Test   | Significance | Conclusion |
|--------|--------------|------------|
| Anova  | 0.000        | H0 rejected |

Based on Table 9, the result of Anova test of problem solving skills shows sig. of 0.000 which means smaller than 0.05. so in this case H0 is rejected and H1 accepted.

3.5 Discussion

Before the learning begins, the experimental class and control class are given a pre-test question first. The pre-test questions were given a number of 5 items related to the optical instruments. The average of the pre-test values from the two classes is the same, which is 31.43. After that, each class was given a different treatment for 3 meetings. The experimental class was taught using SSP based guided discovery with Edmodo and the control class using conventional method learning device treatment. After that, both classes were given the problem solving skills test. The average post-test score in both experimental and control class shows the difference from the pre-test average score. The average post-test grade of the experimental class is higher than the control class post-test score. Based on the N-Gain score, the experimental class has N-Gain higher than the control class, which is 0.68 (medium category) and the control class is 0.39 (low category).

Prior to analysis with one way Anova, first tested the prerequisite normality and homogeneity, the level of significance of the normality and homogeneity test showed sig numbers greater than 0.05. This means that it has met the criteria of normal and homogeneous data. Furthermore, after the data in the analysis with one way Anova, obtained sig value less than 0.05 ie 0.000. This means that the hypothesis H0 which states that "SSP based guided discovery with e-learning does not significantly influence student's problem solving skills" is rejected. So H1 is accepted, which means that the SSP based guided discovery with e-learning has a significant effect on learning. Guided discovery learning is effective to improve the problem solving of learners [21]. The following will describe the learning stages of guided discovery that allegedly can improve the problem solving skills of learners in this research.

The first stage of guided discovery learning is stimulation. At this stage the problem is given by the teacher through images / videos uploaded through Edmodo. Stimulus in this case is intended to hone the ability of students in formulating the problem. This stage is equivalent to understanding the problem in the problem-solving stage. Problem solving also begins with the emergence of an unusual question that will be solved by the learners. Thus, the first stage of guided discovery can facilitate the first phase of problem solving.

The second stage of guided discovery is the problem statement (statement / identification problem). At this stage the teacher guides the students to make the formulation of the problem in the form of hypotheses based on the phenomenon / problem presented. This stage involves problem-solving planning. Through this problem statement, it can hone the probabilistic reasoning ability of the
students by considering all possibilities that can happen. The first and second phase can be done online through Edmodo while the teacher can still monitor the activities of the students through Edmodo.

The third stage of guided discovery is data collection. In the data collection stage students answer the questions and prove true not the hypothesis, thus learners are given the opportunity to collect (collection) a variety of relevant information and observations. This stage is an attempt to solve the problem.

The fourth stage of guided discovery is data processing is to process data and information that has been obtained by the students by connecting the linkage or compare the data obtained with the rationale. Analysis of this data is intended as an effort to solve the problem.

The fifth stage in guided discovery is verification. This stage needs to be done so that the learning process will run well and creatively if the teacher provides an opportunity for students to find a concept, theory, rule or understanding through the examples that he encountered in his life.

The sixth stage in guided discovery is Generalization (drawing conclusions). The generalization stage is the process of drawing a conclusion that can be a general principle and applies to all the same events or problems, taking into account the verification results. Finally formulated with the words the principles underlying generalization. Before generalizing, it is necessary to set up a problem-solving strategy which in this process needs a process of thinking and interacting with others to set up a problem-solving strategy then implementing a problem-solving plan and final stage after running the problem solving is to re-evaluate the strategy that has been taken.

E-learning in this case also play a role in improving motivation in learning. Improvement in student learning motivation has an important effect on the seriousness of students in learning. When learning motivation increases, it will arise curiosity so that in this case can spur students to find the information they need. Various information / knowledge related to optical devices can be presented as reference reading for students through Edmodo. E-learning uses internet technology that can be used to access information and knowledge indefinitely with space and time [22]. Through the library features in Edmodo, material that has been conveyed during classroom learning can be re-uploaded for students to read at any time and add enrichment materials to increase students’ knowledge. Messaging features in the form of private chat are often used by students who wish to consult privately. Students usually ask about the less obvious material or explanations in the class, questions about exercises that they can not do or ask about daily inventions related to optical devices they do not understand. Because during class, not all questions can be answered by the teacher directly because of lack of confidence and time constraints. The assignment feature is used when it will upload the initial task related to the stage of stimulation in the student. Through this feature the time to do the tasks can be set automatically. In addition, the questions in the form of exercise questions can be used as supporting students to better understand in depth the material of optical instruments.

4. Conclusion
Based on result and discussion above, it can be concluded that learning using SSP based guided discovery with e-learning for optical devices can significantly improve problem solving skills.

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References
[1] Blickenstaff, J.C. A framework for understanding Physics instruction in secondary and college courses”. Research paper in education, vol. 25, 177-200 (2010).
[2] Smigiel, E. & Sonntag, “M. A paradox in physics education in France”. Physics Education, 48 (4), 497-505, (2013).
[3] Sya’ban & Wihugjen, I., “Pengembangan SSP zat dan energi berbasis keunggulan lokal untuk meningkatkan literasi sains dan kepedulian lingkungan” Jurnal Inovasi Pendidikan IPA, 2 (1), 66-75,
2016.

[4] Aka, E.I, Guven, E & Aydogdu, M., “Effect of problem solving method on science process skills and academic achievement,” Journal of Turkish science education, 7 (4), 13-25 (2010).

[5] Hake, R. “Interactive-engagement vs. traditional methods: A six-thousand student survey of mechanics test data for introductory physics courses”, American Journal of Physics, vol.66, 64-74, (1998).

[6] Mayer, R. “Should there be a three-strike rule against pure discovery learning? The case for guided methods of instruction,” American Psychologist, 59(1), 14-19 (2004).

[7] Alfieri, L., Brooks, P. J., Aldrich, N. J., & Tenenbaum, H. R., “Does discovery-based instruction enhance learning?” Journal of Educational Psychology, 103 (1), 1–18 (2011).

[8] Shulman, L. S. “Knowledge and teaching: Foundations of the new reform”, Harvard Educational Review, 57(1), 1–22. (1987).

[9] Marton, F., & Booth, S. Learning and awareness. Mahwah, NJ: Lawrence Erlbaum (1997).

[10] Marton, F., & Tsui, A. B. Classroom discourse and the space of learning. London: Lawrence Erlbaum Associates, (2004).

[11] Kullberg, A. “What is taught and what is learned (Doctoral thesis). Professional insights gained and shared by teachers of mathematics”, Gothenburg Studies in Educational Sciences 293, (2010).

[12] Premlatha, K.R, Dharani, B & Geetha, T.V,”Dynamic learner profiling and automatic learner classification for adaptive e-learning environment”, Interactive Learning Environments (2014).

[13] Paimun, Muhsinatun Siasah Masruri. “Pengembangan Subject Specific Pedagogy Tematik untuk meningkatkan Kejujuran dan Kedisiplinan Siswa Kelas I SD,” Jurnal Prima Edukasia, 2(2), 2014.

[14] Mishra, P., & Koehler, M.J. “Technological Pedagogical content knowledge: A framework for teacher knowledge”, Teachers College Record, 108(6), 1017-1054, (2006).

[15] Munir."Pembelajaran jarak jauh berbasis teknologi informasi dan komunikasi”. Bandung: Penerbit Alfabeta, (2009).

[16] Aparicio, M., Baçao, F., & Oliveira, T. (n.d.). (2014). Trends in the e-learning ecosystem: a bibliometric study value focused thinking view project information systems theoretical modulation view project. Retrieved from https://www.researchgate.net/publication/267441431

[17] Darmawan, D. “Pengembangan E-learning Teori dan Desain. Bandung: Remaja Rosdakarya.

[18] Basori. “Pemanfaatan Social Learning Network Edmodo dalam Membantu Perkuliahan Teori Bodi Otomotif di Prodi PTM JPTK FKIP UNS”JIPEK,
Vol. 21, 99-10 (2013).

[19] Widoyo. “Penilaian Hasil Pembelajaran di Sekolah”. Yogyakarta: Pustaka Pelajar. (2014).

[20] Meltzer, D.E. “The relationship between science preparation and conceptual learning gain in physics”, American Journal of Physics, 7(1), 214-221, (2007).

[21] Nurhayati, Yuliani, L., & Mufli, N. “Pola Penalaran Ilmiah dan Kemampuan Penyelesaian Masalah Sintesis Fisika”, Jurnal Pendidikan. Teori penelitian dan Pengembangan, 1(8), 1594-1597, (2016).

[22] Agustini, D., Subagia, I. W., & Suardana, I. N. “Pengaruh Model Pembelajaran Sains Teknologi Masyarakat (STM) terhadap Penguasaan Materi dan Keterampilan Pemecahan Masalah Siswa pada Mata Pelajaran IPA MTs Negeri Patas”, E-Jurnal program pascasarjana universitas pendidikan ganesha, (2013).