A PROBLEM-BASED LEARNING MODEL IN BIOLOGY EDUCATION COURSES TO DEVELOP INQUIRY TEACHING COMPETENCY OF PRESERVICE TEACHERS

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Abstract: This study was aimed to: 1) develop a problem-based learning model in the Biologyy education, and 2) obtain the expert evaluation on the appropriateness of the developed model. The model was developed using the instructional design system approach based on the analysis of Biology teachers' needs, and literary study on the characteristics and process of the problem-based teaching. The evaluation of the model was done by two experts at Biology education. The data obtained from the evaluation were analyzed descriptively. The structure of the developed model in the courses of Biology Teaching Strategies, Micro Teaching, and Teaching Practicum consisted of the following stages: identification of the problems, plan of the problem solving, implementation of the problem solving, presentation of the problem solving result, and reflection of the problem solving. Those five stages were carried out repeatedly in several cycles. The result of the expert evaluation showed that the developed model was in accordance with the characteristics of the problem-based teaching and was appropriate to be used to develop the inquiry teaching competency of preservice teachers.

Key words: ***PBL model, biology education courses, preservice teachers, inquiry teaching competency***

MODEL PEMBELAJARAN BERBASIS MASALAH PADA MATAKULIAH PENDIDIKAN BIOLOGI UNTUK MENGEMBANGKAN KOMPETENSI PEMBELAJARAN INKUIRI

Abstrak: Tujuan tahap awal penelitian pengembangan ini adalah: 1) mengembangkan model pembelajaran berbasis masalah (PBM) pada matakuliah pendidikan biologi, dan 2) memeroleh penilaian ahli terhadap ketepatan model PBM. Model PBM dikembangkan menggunakan pendekatan sistem desain instruksional berdasarkan analisis kebutuhan kompetensi guru biologi, serta kajian literatur mengenai ciri dan proses pembelajaran berbasis masalah. Evaluasi model PBM dilakukan oleh dua pakar pendidikan biologi. Selanjutnya data evaluasi dari pakar dianalisis secara deskriptif. Struktur model PBM yang dikembangkan pada matakuliah Strategi Pembelajaran Biologi, PPL I, dan PPL II terdiri atas tahap identifikasi masalah, perencanaan pemecahan masalah, pelaksanaan pemecahan masalah, penyajian hasil pemecahan masalah, dan refleksi pemecahan masalah. Kelima tahap tersebut dilaksanakan berulang dalam beberapa siklus selama semester. Hasil penilaian pakar menunjukkan bahwa model PBM sesuai dengan ciri pembelajaran berbasis masalah dan tepat digunakan untuk mengembangkan kompetensi pembelajaran inkuiri calon guru.

Kata kunci: ***Model PBM, matakuliah pendidikan biologi, calon guru, kompetensi pembelajaran inkuiri***

INTRODUCTION

Future world development in the globalization era demands human resources with certain competencies in order to be able to adapt on it. The National Education Standard (2010) formulated competencies needed to encounter the world development in 21th century. They are critical thinking and problem solving skills, communication and collaborative skills, ability to create and innovate, literacy in communication and information technology, contextual learning, and literacy in media and information. Developing these competencies requires educational system improvement.

The government has already made efforts to improve the educational system through the implementation of the 2013 Curriculum which is a reform of the previous school-based curriculum. The 2013 Curriculum began to be implemented gradually in schools from the 2013/2014 academic year. It is expected that all learning processes in the 2013 curriculum use the scientific approach (Permendikbud Nomor 103 Tahun 2014). The scientific approach includes five learning phases, namely observing, questioning, exploring, associating, and communicating. The five phases are interrelated as foundations to develop students' skills, attitudes, and knowledge. In science education, including biology, the learning process with the scientific approach is similar to the essential characteristics of the inquiry approach (Chiappetta & Koballa, 2015). The five essential characteristics of inquiry are posing inquiry questions, conducting inquiry, explaining evidence to answer questions, explaining connection between evidence explanation and scientific knowledge, and communicating explanation.

The implementation of the scientific or inquiry approach on biology learning of the 2013 Curriculum at schools demands teachers and preservice teachers who own the competency of the inquiry teaching. The Inquiry teaching competency can be defined as the ability to plan and conduct subject matter learning through the inquiry approach. The definition was based on the combination of teacher pedagogic aspects and professional aspects in *Permendikbud Nomor 16 Tahun 2007 tentang Standar Kualifikasi Akademik dan Kompetensi Guru.* The combination is in accordance with the concept of pedagogical content knowledge from Shulman (1986). In pedagogical content knowledge, pedagogy knowledge is not separated from the subject matter or content knowledge. Understanding the content and the thinking process related to the content becomes a part of the pedagogical aspect development i.e. planning and conducting instruction.

Efforts to improve the biology teacher competency in implementing the inquiry teaching has been done through trainings. Since 2013, institutions of teacher education have already been involved in socializing the national standard approach of the 2013 Curriculum through PLPG activities. However, the program should also be followed by improvement efforts in the internal teacher education institutions. A case study on preservice biology teachers at Faculty of Teacher Training and Education of Bengkulu University showed that the competency of the inquiry teaching was not mastered by most of them, esspecially the ability to guide student thinking as a part of the inquiry teaching competency.

The inquiry teaching competency involves the ability to solve problems in analyzing, planning, and conducting the inquiry teaching. The problem solving ability through the use of knowledge is a part of Indonesian National Qualification Framework (*Peraturan Presiden Nomor 8 Tahun 2012 tentang KKNI*) on levels 6 and 7 for teacher education graduates (Dikti, 2012). The problem solving skill is the most complex cognitive learning (Gagne, Wager, Golas, Keller, 2004). According to Dick, Carey, & Carey (2015), that skill equals to the analytical, evaluation, and creation ability on the cognitive learning taxonomy of Bloom. The problem solving skill equals to the analytical ability if the problem solved is well defined, and equals to the evaluation and creation ability if the problem solved is ill-defined. Arends (2008) limits an ill-defined problem as a complex problem that has many solutions, and cannot be solved by simple answers.

In order to develop the inquiry teaching competency of presevice biology teachers through problem solving, there is a need to change the instruction model of pedagogical content knowledge courses in the teacher education institution. The courses are both in the category of teaching process skill courses and subject matter courses. In the core curriculum of teacher education (*Ditjen Dikti, 2012*), the first category courses are about theory and practice in the teaching process. These courses include courses of Biology Teaching Strategy. The subject matter courses category is related to the content about academic competency on the primary subject matter including courses of Field Experience Program I and II. Instructional model of those courses should be reformed into more active learning that provides an opportunity for preservice teachers to develop their inquiry teaching competency. An emphasis on active learning is in accordance to teaching standard in higher education (*UU Nomor 12 Tahun 2012 tentang Pendidikan Tinggi*). One active learning model in higher education recommended to be implemented is problem-based learning or PBL (USAID, 2010).

Based on literature review, the development or implementation of the PBL model was already done on courses for biology preservice teachers. PBL model implementation on biology courses include General Biology (Setiawan & Susilo, 2015), Invertebrate Zoology (Rusyana & Rustaman, 2011), Population and Environmental Education (Safryadi, Ali, & Nurmaliah, 2013), Genetics and Evolution (Darmawati & Mahadi, 2014). The PBL model development and implementation on general education courses and biology education courses were conducted on courses of Science Teaching (Fakhriyah, 2014), Introduction of Education (Redhana, 2013), Teaching Planning (Saguni, 2013), Biology Teaching Strategy (Sugiharto, Prayitno, & Suciati, 2011), and Science Teaching Methodology (Brears, MacIntyre, & O'Sullivan, 2011; Thomas et al., 2013). The PBL model on those courses was not yet developed specifically and continuously on related courses, for example between the Biology Teaching Strategy courses and Field Experience Program to strengthen the inquiry teaching competency of preservice teachers.

Based on the problem description above, this study was done to: 1) develop a PBL model on courses of Biology Teaching Strategy, Field Experience Program I, and Field Experience Program II; and 2) to describe expert evaluation of the developed PBL model. This study can contribute to enrich knowledge on the PBL model in higher education, especially on preservice science teacher education. Practically, the developed PBL model can be used later as an effort to improve the inquiry teaching competency of preservice science teachers.

PBL was defined by Howard Barrows and his team, as the early designer of PBL at McMaster University Medical School Canada in 1970, as a student-centered teaching approach using the real world problem and its solution as learning stimuli of students in small groups (Borhan, 2014; Karakas, 2008). The real world problem called an authentic problem is a problem occurring in a certain context in a society (Arends, 2008; Tan, 2004). In the context of the teacher profession, an authentic problem is a problem related to teaching and learning, for example a problem of various student learning styles (Karakas, 2008), class management, learning assessment, building relationship between the teacher and students' parents (De Simone, 2014). Tan (2004) did not limit problems in PBL only on real world problems but also on simulated problems which are designed as authentic problems. Real world or simulated problems on PBL have unstructured and complex characteristics (Arends, 2008; Tan, 2004). An ill-defined or unstructured problem is a problem that cannot be solved with a simple answer and there are various solutions to it. The process of getting the solution to those problems requires learners to study prerequisite knowledge on several fields or interdisciplinary fields. Knowledge and information are acquired through several resources. According to Loughran (2006) and Collins & Gillespie (2009), real world problems on learning at school should be included in courses for preservice teachers in order for them to understand the relevance of their study and their future profession.

PBL is suitable to help learners develop higher thinking skills, problem solving skills, and attitudes required in real life such as being active, independent and also cooperative (Arends, 2008; Tan, 2004). PBL has already been implemented in many courses for preservice teachers to improve metacognitive aspects (Brears, MacIntyre & O'Sullivan, 2011; Setiawan & Susilo, 2015), critical thinking (Fakhriyah, 2014; Redhana, 2013; Rusyana & Rustaman, 2011), concept understanding (Sugiharto, Prayitno, & Suciati, 2011; Safryadi, Ali, & Nurmaliah, 2013), science teaching skills (Thomas et al., 2013), problem solving skills (Darmawati & Mahadi, 2014; Redhana, 2013; Saguni, 2013: Temel, 2014), and positive attitudes on group work (Mohamed, 2015). Research on PBL implementation conducted by Borhan (2014) showed that the model could develop skills needed by future teachers which include critical thinking and problem solving skills; teaching skills and reflection; self-regulation skills and social skills. Moreover, the PBL model also develops knowledge on pedagogy, subject matter, and basic teaching.

The PBL process is oriented on problems solved in groups by learners and is ended on self-reflection to improve the next problem solving. Arends (2008) developed PBL syntax in five phases i.e. problem orientation, organization of learners, independent and group investigation, problem solving development and presentation, and evaluation of the problem solving process. This PBL syntax (Arends, 2008) was implemented by Fakhriyah (2014), Darmawati & Mahadi (2014), and Redhana (2013). Tan (2003) also developed similar PBL syntax in cycles i.e. problem posing, problem analysis, discovery and reporting, solution presentation and reflection, integration and evaluation. Safryadi, Ali, & Nurmaliah (2013) implemented PBL syntax including contextual problem presentation, conducting investigation, developing investigation result, finding solution, and evaluation. The PBL phases implemented by Barron (2013) were school problem identification, collaborative problem solution, presentation, evaluation, and reflection.

Solving problems on PBL is conducted actively by students through an independent, cooperative, and collaborative learning process (Tan, 2004). Students are encouraged to regulate themselves and to be responsible to the group learning process. It is expected that a dialogue and colllaborative problem solving occurs in groups, including basic knowledge learning, role and work sharing in solving problem and presenting solution. According to Arends (2008), a student group is a small group which can only consist of two learners. The role of the instructor as a facilitator is one characteristic of PBL. As a facilitator or tutor, the instructor has responsibilities of guiding instead of lecturing students, determining groups and rule and roles in groups, creating conducive learning conditions, guiding interactions with academic attitudes among students, encouraging the use of information resources including the Internet, monitoring work progress periodically, guiding in creating presentation of the problem solving result, guiding reflection of the problem solving process and result, evaluating group performance and giving constructive feedbacks on it (Fry, 2009). Arends (2008), De Simone (2014), and Tan (2004) argued that a facilitator should also able to present complex problems that need higher thinking to solve as a basis of PBL. A facilitator should encourage each individual in groups to contribute on solving the problem and be responsible on his or her own role as a leader, secretary, or a member (Baron, 2013). Moreover, it is emphasized that the role is conducted interchangeably by individuals in the group. Guidance of the problem solving process is provided by circulating from one group to another group as needed (De Simone, 2014). Guidance then is gradually decreased in accordance to group independence development (Brears, 2011; De Simone, 2014). Baron (2013) and Tan (2004) suggested the use of a guide sheet, instruction, and probing questions in guiding students. In addition to guidance and feedback, availability of learning resources and the guidance on using them can stimulate student active involvement (De Simone, 2014).

METHOD

This study is a research and development design using instructional design system approach by Dick, Carey, & Carey (2015). According to Gall, Gall, & Borg (2003), this approach had been used mostly in educational research and development. The development of the PBL model in this study consists of seven from ten components of the approach, including: 1) instructional goal identification, 2) instructional analysis, 3) learner and context analysis, 4) objective performance formulation, 5) assessment instrument development, 6) instructional strategy development, 7) selection and development of instructional materials. At the sixth component of the approach, characteristics of PBL from literature study were referred to develop the PBL model on courses of Biology Teaching Strategy, Field Experience Program I, and Field Experience Program II.

Formative evaluation on the developed PBL model is the eighth component of the instructional design system approach which was conducted by experts on subject matter and instruction (Dick, Carey, & Carey, 2015). Evaluation is needed to obtain assessment and suggestions for the improvement of the developed PBL model. The developed PBL model was evaluated based on model description on the three biology education courses with their operational description on the syllabus, the teaching activity unit, work guidance sheets, and the inquiry teaching competency assessment. The experts who evaluated the developed PBL model were two biology education professors at Surabaya Public University.

The two experts evaluated the developed PBL model of the three biology education courses using an assessment instrument. The instrument consists of two parts, a closed-ended assessment part and an open-ended assessment part. The closed-ended assessment part was in the form of scales with the scores ranging from 1 to 4 for each item of the PBL model aspects, with a score 1 as poor, 2 as fair, 3 as good, and 4 as very good. The assessment scale was developed based on the five aspects of the instructional model from Joyce, Weil, & Calhoun (2011) consisting of the model structure (syntax), social system, instructor role, supporting system, and instructional effects.

The evaluation data from the experts were analyzed descriptively (Borg, Gall, & Gall, 2003). The quantitative descriptive analysis used the average score for each and overall aspects of the developed PBL model. An identification was done on the similarity of aspect items assessed on the score category below the very good category by both experts, and on similar and specific suggestions from the open-ended evaluation.

RESULT AND DISCUSSION

PBL Model on Courses of Biology Teaching Strategy, Field Experience Program I, and Field Experience Program II

The developed PBL model on the three biology education courses is described based on the teaching model aspect from Joyce, Weil, & Calhoun (2011), the characteristics of the PBL process according to Arends (2008); Brears, MacIntyre, O'Sullivan (2011); De Simone (2014); Fry, Ketteridge, Marshall (2009); and Tan (2004). The five aspects of the developed PBL model are the instructional effect, model structure (syntax), social system, instructor role, and the supporting system.

The instructional effects of the PBL model on the three biology education courses were formulated in the beginning of the model development in the form students' competency standard. The competency standard formulation was based on *KKNI* (*Peraturan Presiden Nomor 8 Tahun 2012*), the teacher competency standard (*Peraturan Menteri Pendidikan Nasional Nomor 16 Tahun 2008*), and the preservice teacher competency elements of the teacher education curriculum (*Dikti*, 2012). The competency standard on Biology Teaching Strategy (BTS) course was the student ability to develop the inquiry biology strategy design to solve inquiry learning problems for achieving the learning goals. In the courses of Field Experience Programs (FEP) I and II, the competency standard was the student ability to make a plan and conduct inquiry biology teaching to solve inquiry learning problems for achieving learning goals.

The competency standard on each course was specified into the basic competency on attitude, knowledge, and skill aspects. The basic competency on Biology Teaching Strategy (BTS) courses was: 1) having the attitude as an inquiry teacher including being diligent, independent, able to collaborate, creative, and being critical; 2) understanding the inquiry teaching strategy in the 2013 Curriculum; 3) being able to analyze the inquiry biology teaching strategy to overcome inquiry learning problems that hinder the achievement of learning goals.

The basic competencies on FEP I and FEP II are: 1) having attitudes as an inquiry teacher including being diligent, independent, able to collaborate, creative, and being critical; 2) creating and implementing the inquiry biology teaching plan to overcome inquiry learning problems. The basic competencies of the two field experience programs are similar because the courses mainly comprise teaching practice. The difference between the two courses is that the teaching practice on FEP I is a simulation teaching, whereas that on FEP II is a real teaching in schools.

The structure or syntax of the developed PBL model on the three biology education courses

Table 1. PBL model syntax on BTS course

PBL Syntax	Cycle/Content	Session
Problem Identification → Problem Solving Planning → Problem Solving Excecution	– I : Discovery – II : Inquiry – III : Problem-based learning – IV : Project-based learning – V : Scientific	2 – 3 5 – 6 8 – 9 11 13
→ Problem Solution Presentation → Problem Solving Reflection (→ back to Problem Identification)	– I : Discovery – II : Inquiry – III : Problem-based learning – IV : Project-based learning – V : Scientific	4 7 10 12 14 – 16

Table 2. PBL syntax on FEP I dan FEP II course

PBL Syntax	FEP I		FEB II	
	Cycle	Session	Cycle	Session
Problem Identification → Problem Solving Planning	I II	2 – 4 10 – 11	I II III	2 4 6
→ Problem Solving Excecution, Problem Solution Presentation → Problem Solving Reflection (→ back to Problem Identification)	I II	5 – 9 12 – 16	I II III	3 5 7

consisted of five phases i.e. problem identification, problem solving planning, problem solving execution, problem solution presentation, and problem solving reflection. The five phases were conducted repeatedly on several improvement cycles during the course activity. In the BTS courses, PBL model phases were conducted in five cycles (Table 1). In FEP I and FEP II, the third and the fourth phases were combined in the teaching practice activity. The PBL model in FEP I was done in two cycles, whereas that in FEP II was conducted in three cycles during guided teaching practice (Table 2).

Problems identified on the three biology education courses were related to inquiry biology teaching at schools. The problems as the learning basis were formulated in questions. In the BTS courses, the problems were: 1) How good was the example design of the inquiry biology teaching strategy to overcome students' problem during inquiry learning problem; 2) How was the design of the inquiry biology teaching strategy to overcome students' problems during the inquiry learning? The first problem, with a different teaching model, was solved by each group from Cycles I to IV. The content of each teaching cycle was related to the learning process standard in the 2013 Curriculum which consisted of discovery, inquiry, problem-based learning, and the project-based learning model (Table 1). The problems on students' inquiry learning were unreal but authentic based on the previous observation of inquiry biology teaching at schools. Problem solving in Cycle II was an improvement of the process in Cycle I, and so forth. The second problem of PBL in the BTS courses was solved in Cycle V. Each group of preservice teachers created a design of an inquiry teaching strategy in the form of the scientific approach to solve students' problems in the inquiry learning. The inquiry learning problem ins the fifth cycle was based on the observation during FEP II at schools.

In FEP I and FEP II, the problems as the center of learning activity were: 1) How was the design of the inquiry biology teaching strategy to overcome students' problems during the inquiry learning? 2) How was the execution of the inquiry biology teaching strategy design to overcome students' inquiry learning problems? The student problem in the inquiry learning in FEP I was a simulated problem based on the previous instructor observation on the inquiry biology teaching. The problem solving was conducted in two cycles with two simulated teaching by each preservice teacher (Table 2). In FEP II, the inquiry learning problem was an authentic problem observed directly by preservice teachers from the previous inquiry biology teaching by teachers at schools. Three inquiry biology teaching cycles were conducted by each preservice teacher during the guided practice session.

The social system of the PBL model on the three educational biology courses included students-instructor interaction, student interaction in and between groups. During the course activity in the semester, student-instructor interaction time was less than student interaction. Student-instructor interaction was conducted especially in the phases of problem identification and reflection. Student interaction in groups happened during the discussion on the phases of problem solving planning and problem solving execution, whereas interaction between groups happened in the phase of problem solving presentation.

In the BTS course, each group of preservice teachers discussed and worked cooperatively to solve: 1) four problems related to the analysis of the design of the inquiry biology teaching strategy to overcome students' inquiry learning problems, and 2) one problem in designing the inquiry biology teaching to overcome students' inquiry learning problems. Each group consisted of 4 to 5 preservice teachers. The interaction among groups of preservice teachers happened in the phase of problem solving presentation. The groups were encouraged to criticize each other about their solution to the problem.

In FEP I and FEP II courses, the groups of preservice teachers discussed and worked cooperatively in the planning phase to create a design of inquiry biology teaching to overcome students' inquiry learning problems. The groups consisted of two preservice teachers. In the execution and presentation phases, an individual preservice teacher practiced inquiry biology teaching. The partner in each group acted as an observer. After the teaching practice, the preservice teacher was asked to reflect on his or her own teaching based on the peer and instructor observation, and self-observation of the recorded teaching, An observation by a school teacher should also be included for reflection on FEP II. The teaching reflection was suggested to be used by preservice teachers for revising and improving the next design and implementation of the inquiry biology teaching.

The instructor role in the PBL model was as a facilitator and a tutor. As a facilitator, the instructor determined the content of the course and the activity schedule, assigned groups, provided written guidance for solving problems, and provided media and learning resources. The learning resources provided were content course power point, inquiry biology teaching films, and the 2013 Curriculum documents. The written guidance for group work was provided to direct the learning activities. As a tutor, the instructor was actively guiding the work of preservice teachers rather than lecturing. The guidance was decreased gradually through the PBL cycles in order for the preservice teachers to develop their work independence. The subject matter power points were used as learning resource supplements during group and class discussions.

The three biology education courses using the PBL model needs a supporting system in the form of learning media, facilities, and learning resources such as biology teachers and the real biology teaching process at schools. The learning media include examples of the inquiry biology teaching plan. These teaching plan examples were analyzed for their appropriateness on each model phase and on their accuracy in solving the inquiry learning problems. In the BTS courses, the interview with biology teachers and the observation of biology teaching at schools by preservice teachers during the internship program became the resources for identification of students' inquiry learning problems. The internship program is a one-week program for preservice teachers to make an observation on the learning process at schools, and learn about the curriculum and evaluation. At the end of the semester, the preservice teachers would develop and present a design of an inquiry biology teaching strategy to solve inquiry learning problems.

The general syntax of the developed PBL model on the three biology education courses was similar to the PBL syntax from Arends (2012) and Barrons (2013) in the presence of planning, conducting, and evaluation-reflection of problem solving. The difference was that each phase of the developed PBL model was more specific on the PBL characteristics and its problem solving process. Therefore, the learning phases were consecutively described as problem identification, problem solving planning, problem solving execution, problem solving result presentation, and problem solving reflection. In addition, the phases of the PBL model were conducted in several improvement cycles.

According to the expert evaluation, the developed PBL model was appropriate for developing the inquiry biology teaching competency of preservice teachers. The inquiry biology teaching competency formulated as the basic competency on courses of the Biology Teaching Strategy course, FEP I, and FEP II was considered as indicators of the problem solving skill. According to Dick, Carey, & Carey (2015), high level thinking skills of Bloom's taxonomy i.e. analyzing, evaluating, and creating were equal to Gagne's problem solving skills as described in Gagne et al. (2004). The problem solving skill was an important instructional effect of the PBL model (Arends, 2008; Tan, 2004).

The problems as the basis on the three biology education courses, which were related to the implementation of the scientific approach as generic approach of the 2013 Curriculum, were a current issue at schools. Therefore, the problems could be considered as authentic problems. According to De Simone (2014) and Karakas (2008), authentic problems in a teaching profession context were problems related to teaching at schools. The problem selected was also in accordance to the recommendation of Loughran (2006) and Collins & Gillespie (2009), that is, to include real teaching problems at schools in courses for preservice teachers so that they could understand the relevance of what is learned and their future profession.

The social system and the instructor role in the developed PBL model activity, which was in the form of group and class discussions facilitated by the instructor, were consistent with the PBL characteristics. The combination of group and class discussions in the PBL was also implemented by Barron (2013), Etherington (2011), Lee (2014), Redhana (2013), Sugiharto, Prayitno, & Suciati (2011), Tan (2004), and Temel (2014). Through group discussions, members of groups learn to depend on each other with the purposes of solving the problem. A class discussion on the phase of the presentation of the problem solving result encouraged the development of open-mindedness attitude and reflective thinking to revise meaning when needed (Tan, 2004). The provision and guidance in using learning resources could support student active involvement (Brears, MacIntyre, O'Sullivan, 2011, De Simone, 2014; Fry, Ketteridge, Marshall, 2009).

Expert Evaluation on the Developed PBL Model

The evaluation from biology education experts showed that the overall developed PBL model on the three biology education courses was categorized as very good with the average score of 3.7 from the maximum score of 4. The average score of the PBL model aspects categorized as very good was 72%. Five aspects of PBL model were evaluated as not yet optimal even though they were categorized as very good and good. The average score on the syntax, supporting system, and the teaching effect aspect was 3.8 conscutively whereas that on the social system aspect was 3.7, and that on the instructor role was 3.5.

In the syntax aspect of the PBL model, the appropriateness with principles of gradual learning and learning through contextual problem solving was evaluated as not yet optimal because it was not explicitly described in the scenario in the teaching activity unit plan. Therefore, it was suggested that the teaching steps in each course session should be described in each course plan. The tables of the developed PBL syntax were suggested to be improved for easier understanding. The experts had the opinion that the developed PBL model was a simulation of preservice teachers work when they became teachers. Understanding the construction of the inquiry teaching strategy through those course activities would have a high level of retention.

The teaching activity to encourage individual or group interaction with the instructor in the social aspect was also evaluated as not yet optimal by the two experts. The social aspect of the developed PBL model was related to the instructor role. Preservice teachers' interaction with the instructor and among themselves was suggested to be described in detail in the teaching activity unit plan. In addition, for each basic competency indicator, its interaction activity and teaching strategy should also be described.

In the supporting system aspect, the teaching media availability should be improved. An expert suggested that the film that would be accessed by preservice teachers from the Internet needed to be accommodated by providing the complete website addresses. Supporting textbooks should also be added with biology book as subject matter references.

In the aspect of the instructional effect, the developed PBL model on the three biology education courses generally was evaluated as very good. According to the experts, the PBL model could develop learning outcome emphasized on problem solving skills including critical and creative thinking skills. The critical thinking was developed during the process of analyzing the inquiry biology teaching scenario and the inquiry biology teaching practice. The creative thinking was developed when preservice teachers developed the inquiry teaching scenario. The assessment strategy and instrument of the teaching effect on affective, knowledge, and skills needed some improvement to conform to the basic competency indicators in the syllabus. The course purposes of the course activity unit were recommended to be formulated in more detail and comprehensive in accordance with the basic competency.

Several PBL model aspects which were evaluated as not yet optimal by experts indicated that the developed PBL model should be improved. According to Dick, Carey, & Carey (2015), the recommendation by experts can be used to improve the model before trying it out on the three biology education courses.

CONCLUSION

This study produced a PBL model design on the three biology education courses, i.e. Biology Teaching Strategy, Field Experience Program I, and Field Experience Program II to improve the inquiry teaching ability of preservice biology teachers. The PBL model structure of the courses consisted of five phases i.e. problem identification, problem solving planning, problem solving implementation, problem solving result presentation, and problem solving reflection. Those PBL model phases were conducted repeatedly in the improvement cycle of problem solving during the course semester. The PBL model was generally evaluated as very good by experts even though some parts of the model design needed to be improved. The improvements needed were in some parts of the five aspects of the developed PBL model i.e. are the syntax, social system, instructor role, supporting system, and the formulation of instructional effects reflected in the syllabus, course activity unit, and the course materiel including assessment instruments of the preservice teachers competency on the inquiry biology teaching. The development of the PBL model should be adjusted with certain course goals and students' characteristics. The model design would be revised continuously for a better result through try out, and the revision result then wouldbe re-evaluated by experts.

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