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Research Article

Students' learning motivation and cognitive competencies in the PP and PBL models

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ABSTRACT

The learning model is one of the critical factors in boosting student to have good learning motivation (LM) and cognitive competencies (CC). In two academic years (2016-2017), only 19.6% of Senior High School (SHS) students in Samarinda passed minimal competence in Biology subject. This research was conducted to find out a better learning model in Biology subject to replace the conventional learning (CL) model. A quasi-experiment using three learning models, i.e. Problem Posing (PP), Problem-based Learning (PBL), and CL, were conducted in all three 11th grade student classes at Public Islamic SHS (PISHS) I Samarinda in the period of odd semester of 2018/2019 academic year. The LM and CC data were collected by questionnaires, each has 40 and 9 problems, respectively. The LM and CC data were analyzed by ANOVA and ANCOVA continued by comparison test using Bonferroni test (p< 0.05), respectively. The results showed that the CL model could increase the CC, but not improve LM. However, PP and PBL model were significantly more effective (p< 0.05) in increasing both the CC and LM. The PP is superior in improving the LM, while the PBL is superior in gaining the cognitive competence.

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INTRODUCTION

Implementation of curriculum 2013 at primary and high school in Indonesia since 2014, push the transformation of the learning process from the teacher center to the student center. The main reason is that nowadays, learning activities are designed to facilitate the student to explore their ability to be creative, innovative, and able to collaborate (Kementerian Pendidikan dan Kebudayaan Republik Indonesia, 2014). Understandably, there is still not enough academic atmosphere among students in supporting the student-center learning process, so that active effort is needed to create a good environment in helping the student to have dynamic learning with eventually comfortable circumstances. On the other hand, active learning and student-centered pedagogy improved student performance and achievement in Biology subject (Corkin et al., 2017; Derting & Ebert-May, 2010; Mueller et al., 2015). However, this transformation is going to slow because of the lacking of innovations in the school to try new learning models, which can facilitate the student center learning process to take place, including in Samarinda. The impact is the students show low motivation in the learning activity and cognitive competence.

A preliminary study on two academic years (2016/2017 and 2017/2018) of students with majoring in mathematics and science from 6 senior high schools of total 22 senior high schools in Samarinda in year of 2018 (Direktorat Jenderal Pendidikan Dasar dan Menengah Kementerian Pendidikan dan Kebudayaan, 2019), which were randomly observed, showed that level of completeness in learning biology is very low (the average was 19.6%). Based on interviewed, the factor that make student get low score because conventional learning method with teacher as study centre was still used. The learning activities were not varied and monotonous, caused the implication that students showing low attention and motivation during learning activities. Therefore, the application of innovative learning that could increase student motivation needs to be implemented in biology learning.

Problem posing (PP) is a learning model that facilitates the student to explore the discussed subject by developing questions or problems that are to be solved (Rehorek, 2004). The PP is a well-known approach in chemistry (Iriani & Hidayah, 2017), mathematics (Bonotto, 2010), and physic discipline (Rufaida & Sujiono, 2013). However, Jungck (1985) gave a challenge to education practitioners in using the PP approach in biology education to answer the ecological and evolutionary complexity of our problems.

On the other hand, Problem-based Learning (PBL) is promising pedagogy model in science since it performs the value and learning outcomes in which student has the autonomy to understand the nature-of-science, able to collaborate, and can generate knowledge (Allchin, 2013). Several research also showed that PBL could significantly increase students' achievement than conventional learning models in biology class (Kan'an & Osman, 2015; Taşoğlu & Bakaç, 2010).

Despite the benefits of PBL and PP, many teachers in Indonesia still rarely implement this learning model in their biology classes. One potential effort to encourage teachers to implement these learning models is by increasing the number of studies examining the benefits of these two lessons. In fact, studies that examine PBL have been conducted frequently. However, these studies often only examine the different effects of PBL and conventional learning (Kan'an & Osman, 2015; Taşoğlu & Bakaç, 2010). Some researchers also compare PBL with other learning models, such as with project-based learning (Husna et al., 2019; Sari, 2018). In addition, there were no studies that compare PP and PBL on students' motivation and cognitive competence. Therefore, the aim of this study was to determine the effect of the PP and PBL model in Biology subject of Public Islamic Senior High School (PISHS) students on cognitive competence and learning motivation. The student at PISHS has to have 19 subjects, which are six items more than the students at regular Senior High School. This condition makes the students at PISHS feel tired physically and mentally, so they have low motivation in learning biology. Because of that reason, a study on learning motivation at PISHS following the implementation of the student-center learning process will be valuable information in the effort of increasing student learning motivation, especially in Biology subject.

METHOD

A quasi-experiment was conducted on three 11th Classes of PISHS I, Samarinda, in odd semester of 2018/2019 academic year in structure and function of plant tissue subject. Different learning models, i.e., PP, PBL, and conventional, were applied at a different class. The student number of PP and conventional classes were each 36 students, while the PBL class has 37 students. Learning motivation (LM) and cognitive competence (CC) were observed by questionnaire and test, respectively, at the beginning and at the end of the period of learning-subject, which were taught in four class-meeting. The topic taught from the first to the fourth meeting were meristem, leaf structure and function, structure and function of root and stem, and anatomy on monocots and dicot and tissue culture, consecutively.

All of the statements in the questionnaire for learning motivation (40 questions) and test for cognitive competence (9 problems) passed the validity test with the r between 0.484-0.790 and 0.547-0.667, respectively, while r_{table} is 0.344. Both instruments showing an excellent score in the reliability test of 0.956 and 0.711 for the questionnaire of learning motivation and cognitive competence, respectively. The survey and problem for learning motivation and cognitive skills are shown in Table 1 and Table 2, respectively.

The score for the learning motivation (LM) questionnaire is 40 and 200 for a maximum and minimum score, respectively. Data for learning motivation (the gain of LM, score of LM at the beginning of the experiment – score of LM at the end of the test) were analyzed by ANOVA because the data showed significantly different (*p*=0.000) between the three classes. The ANOVA was continued by comparison test using Bonferroni test (SPPS v.22). For descriptive analysis, the LM achievement data were then categorized to a Likert scale of low (1), medium (2), and high (3) for the score of 40-93, 94-147, 148-200, respectively (Sudjana, 2015).

Table 1. Characteristics of learning motivation questionnaire (Indicators and type of statements)

Indicators	Question's number	
	Positive	*Negative*
Persevering in the task	1, 2, 4	3, 5
Not easily discourage	6, 8, 10	7, 9
Showing interest	11, 13, 15	12, 14
Happy to work independently	16, 17,18, 19	20
Quickly bored with routine tasks	21, 23, 24	22, 25
Can depend on his opinion	26, 27, 29	28, 30
Not quickly go of things that are believed	31, 33, 35	32, 34
Happy to find and solve problems	36, 37, 38, 39	40

The statements	
1	I took my Biology assignment seriously
2	I completed the Biology assignment on time.
3	For me, the essential thing in solving the Biology problem or assignment on time without caring about the result that I will get.
4	Every time I have a Biology assignment, I immediately work on it.
5	I am not serious in solving Biology problems or assignments given by the teacher.
6	If my Biology score is terrible, I will continue to study so that the grade becomes good.
7	If my Biology score is terrible, I do not want to study anymore
8	I feel satisfied if I can work on Biology problems and getting good grades.
9	I will not do the problematic Biology problems
10	If I encounter a problematic Biology problem, I will try to work on it until I find the answer.
11	I always listen to the Biology teacher's explanation well.
12	I prefer to talk with friends and do not listen to the teacher when he/she explains
13	I always ask the teacher about the Biology subject that I do not understand yet.
14	I am lazy to ask the teacher about Biology subject that I do not understand.
15	I always answer Biology questions that teachers ask
16	I always do my Biology assignments given by the teacher
17	I copy my friend's answers in doing Biology assignments and questions.
18	I can complete the Biology assignment on my own.
19	I prefer to work on Biology assignments with friends.
20	I never copy a friend's answer because I trust my answers.
21	I enjoy studying Biology because the teacher is diligent in teaching.
22	In my opinion, learning Biology is annoying because the teacher only delivers the materials through lecturing.
23	I enjoy studying Biology because the teacher uses instructional media to explain the subject.
24	I enjoy studying Biology because there is not any tense atmosphere for the teacher.
25	I feel bored in studying Biology because I only take notes while learning.
26	I always give an opinion when there is a discussion in the Biology lesson.
27	If different responses arise, I will respond to them.
28	I stay silent and do not give any opinion.
29	I try to defend my opinion during the discussion.
30	I'm always nervous about expressing my opinion in front of my friends.
31	My friend's answers do not easily influence me.
32	If my answer is different from my friend's, I will change my answer to be the same as theirs.
33	I believe I can get the best score on my Biology assignments because I did well.
34	I am not sure about my answer if my answer is different from my friend's.
35	Every time I'm solving a Biology problem, I have a target above average because I believe I can do it correctly.
36	I was challenged to work Biology problems that were considered difficult by friends.
37	I'm glad to have Biology assignments from a teacher.
38	If there are Biology assignments in the book that haven't been worked on, I will do it.
39	I look for other suitable sources to finish my Biology assignments.
40	I prefer working on easy Biology assignments than difficult ones.

Note: each indicator consists of 5 statements. The answers of the positive comments were 5, 4, 3, 2, and 1 for strongly agree, agree, neutral, not agree, firmly not accept, respectively, while strongly not agree, not agree, neutral, agree, and strongly agree for the negative statements.

The score for cognitive competence is 0-100, which for each question was calculated by equation [1]. Data were analyzed by ANCOVA continued by comparison test using Bonferroni test (SPSS v.22). For descriptive analysis, the CC data were categorised to the Likert scale of very low (1), low (2), medium (3), high (4) and very high (5) for the score of CC < 20, 20 ≤ CC < 40, 40 ≤ CC < 60, 60 ≤ CC < 80, 80≤ CC, respectively (Sudjana, 2015).

Table 2. Questions for cognitive competence

No	Questions	Weight	Score
1	Describe three differences between meristem and permanent tissue	6	0-6
2	Describe three types of meristem tissues according to its location	6	0-6
3	Write down three components of each xylem and phloem	12	0-6
4	Describe the types of an epidermal derivative of the plant below	6	0-6
5	Describe the function of leaf component structure from the top to the bottom	10	0-6
6	Please write down the type of root shape, external structure of a leaf, and part number of a flower of monocots and dicot plants	24	0-6
7	Write down the name of the designated part in the cross-section of the stem	12	0-6
8	Describe the advantages of tissue culture technique in plant nurseries	12	0-6
9	Write down three types of tissue culture that you know and describe each type	12	0-6

Note: the answer to each question consists of six items. The score for each question is 6, 5, 4, 3, 2, 1, and 0 for a solution that has 6, 5, 4, 3, 2, 1, and 0 correct items.

$$\text{The score of each question for cognitive competence} = \frac{\text{Score of answer}}{6} \times \text{weight} \quad .... [1]$$

RESULTS AND DISCUSSION

PBL and PP are innovative models whose application still needs to be optimized in Indonesia. In this study, the two models were tested for their effect on LM and CC of PISHS students. Student-centered learning using PP and PBL models showing suitable and comfortable for the students than the conventional ones. Both learning models significantly (p < 0.05) improve the LM (Table 3) and CC (Table 5) levels. Student-centered learning opens the opportunity of discussion in groups so that the students share ideas or opinions.

Learning models affected significantly (p = 0.001) on the students' LM (Table 3). The PP and PBL increased the number of the student having a high level of LM achievement, while the conventional learning model showed the opposite result. The score of LM achievement form the three classes also emphasize this trend. In student-centered learning, the students are going into groups, which are arranged that students with high academic abilities can help students with low academic skills (Qomariah, 2016). This condition encourages the low motivated students to be more active in the discussion within groups by helping highly motivated students.

The PP and PBL improve the LM with the same power. However, the PP showed more reliable capacity in enhancing the LM. The mean difference between PP and PBL to the Conventional model is 6.917 (p=0.001) and 5.089 (p = 0.015), respectively (Table 4). It means that PP is more effective in improving the student LM in the structure and function of plant tissue subjects. The PP seems to give a more exciting learning environment by the students, as stated by Uno (2011) that someone will be motivated to do activities when he can maintain his sense of pleasure.

PBL is able to present a series of interesting learning activities. By presenting problems at the beginning of learning, students will be challenged to solve these problems. In addition, by working in groups, students will be more motivated to participate in learning. However, if students only listen to the teacher's explanation during learning, students will get bored faster so they will lose their motivation to learn.

Table 3. Effect of learning models on Learning Motivation (LM) of the student in the structure and function of plant tissue subject at 11th class

Level of LM achievement	Problem Posing	Problem-Based	Conventional
At the beginning of the experiment (P) (*n*; %)			
High	7; 19.4	9; 24.3	7; 19.4
Medium	29; 80.6	28; 75.7	29; 80.6
Low	0; 0	0; 0	0; 0
Mean±SD	137.00±1.74	138.46±1.72	136.92±1.77
At the end of the experiment (Q) (*n*; %)			
High	14; 38.9	12; 32.4	5; 13.9
Medium	22; 61.1	25; 67.6	31; 86.1
Low	0; 0	0; 0	0; 0
Mean±SD	141.64±2.03	141.27±1.71	134.64±1.95
Shifting of LM achievement level, Increasing (+) / decreasing (-) (P - Q) (n; %)			
High	+7; +19.4	+3; +8.1	-2; +5.6
Medium	-7; -19.4	-3; -8.1	+2; -5.6
Low	-	-	-

Different from PBL, which is commonly used in Biology education (Mutakinati et al., 2018; Yahya, 2014), PP is very rarely used in Biology education. However, this study demonstrated that the PP is a challenge learning model to be used in Biology education, as suggested by Jungck (1985), especially to improve the students learning motivation.

Motivation is an important factor in the learning process (Gbollie & Keamu, 2017). High motivation correlates with high learning efficacy and student interest in the subjects they take (Daskalovska et al., 2012; Redondo & Martín, 2015). When students are motivated to learn, they will seriously follow and study the material taught in the subject. This condition will optimize students' learning success and academic achievement. Therefore, the significant effect of PBL and PP on LM is expected to be followed up by teachers to implement these two learning models.

Table 4. Pairwise comparison for LM achievement gain

Learning Model (I)	Learning Model (J)	Mean Difference (I-J)	SE	*p*	95% Confidence Interval for Difference	
					Lower Bound	*Upper Bound*
PP	PBL	1.8281	1.77084	0.913	-2.4796	6.1358
	Conventional	6.9167*	1.78293	0.001	2.5796	11.2538
PBL	PP	-1.8281	1.77084	0.913	-6.1358	2.4796
	Conventional	5.0886*	1.77084	0.015	0.7809	9.3963
Conventional	PP	-6.9167*	1.78293	0.001	-11.2538	-2.5796
	PBL	-5.0886*	1.77084	0.015	-9.3963	-0.7809

*Note: Problem Posing and Conventional (Control Class) are each 36 students, while Problem Based Learning is 37 students. Data were analyzed by ANOVA (based on observed means) continued pairwise comparison test. *) The mean difference is significantly different (Bonferroni test at a level of 0.05), SE = Standard Error. PP = Problem Posing, PBL = Problem-Based Learning. LM achievement data were then categorized to a Likert scale of low (1), medium (2), and high (3) for the score of 40-93, 94-147, 148-200, respectively.*

Table 5. Effect of learning models on Cognitive Competence (CC) of the student in the structure and function of plant tissue subject at 11th class

Characteristics	Problem Posing	Problem Based Learning	Conventional
Pre-test			
Min	17	17	17
Max	39	38	38
Mean±SD	24.78±0.75	27.14±0.78	24.00±0.69
Post-test			
Min	77	77	76
Max	92	100	79
Mean±SD	80.86±0.74	84.64±1.13	77.53±0.19
Increasing (+) of CC result level of students (Post-test – Pre-test)			
Min	+60; 353%	+60; 353%	+59; 347%
Max	+53; 136%	+62; 163%	+41; 108%
Mean	+56.08; 226%	+57.50; 212%	+53.53; 223%

The learning models affected significantly (p = 0.000) on students' CC (Table 5). The PP and PBL boosted the CC level higher than the conventional learning model (Table 6). The most effective learning model affected the increase of CC level (Table 6), and the score (Table 7) is PBL, followed by PP and Conventional. The PBL boosted the CC level of the student to a very high level of 75.5%. It is higher than PP that only raised the student CC level to a very high level of 45.4%. The conventional learning model was only able to increase the CC level to a high level (100%). PP improved the CC score in the range of 0.572-6.125 against the Conventional learning model, while PBL enhanced in a variety of 4.316-10.046. The PBL is superior in boosting the CC score than PP. The PBL improved the CC score in the range of 1.017-6.648 against PP. This study demonstrated that PBL is the most effective among the three learning models in structure and function on tissue plant subjects.

Table 6. Distribution of CC level (n; %) in the three different learning model classes

Leve of CC score	Problem Posing		Problem Based Learning		Conventional	
	Pre-test	*Post-test*	*Pre-test*	*Post-test*	*Pre-test*	*Post-test*
Very low	3; 8.3	0; 0	2; 5.4	0; 0	5; 13.9	0; 0
Low	33; 91.7	0; 0	35; 95.6	0; 0	31; 86.1	0; 0
Medium	0; 0	0; 0	0; 0	0; 0	0; 0	0; 0
High	0; 0	20; 55.6	0; 0	9; 24.3	0; 0	36; 100
Very high	0; 0	13; 45.4	0; 0	28; 75.7	0; 0	0; 0

Table 7. Pairwise comparison for CC score

(I) Learning Model	(J) Learning Model	Mean Difference (I-J)	SE	*p*	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
PP	PBL	-3.833*	1.157	0.004	-6.648	-1.017
	Conventional	3.348*	1.141	0.012	0.572	6.125
PBL	PP	3.833*	1.157	0.004	1.017	6.648
	Conventional	7.181*	1.178	0.000	4.316	10.046
Conventional	PP	-3.348*	1.141	0.012	-6.125	-0.572
	PBL	-7.181*	1.178	0.000	-10.046	-4.316

*Note: Problem Posing and Conventional (Control Class) are each 36 students, while Problem Based Learning is 37 students. Data were analyzed by ANCOVA (based on estimated marginal means) continued by pairwise comparison test, *) The mean difference is significantly different (Bonferroni test at a level of 0.05), SE = Standard Error. PP = Problem Posing, PBL = Problem-based Learning. Cognitive competence (CC) data (0-100) were categorised to the Likert scale of very low (1), low (2), medium (3), high (4) and very high (5) for the score of CC < 20, 20 ≤ CC < 40, 40 ≤ CC < 60, 60 ≤ CC < 80, 80≤ CC.*

By the PP learning model, the students experienced to have difficulties in focusing on generating questions in-line with the subject matter discussed, which burdened students in mastering the basic knowledge that they should have. Chin & Kayalvizhi (2002) reported the same cases while implemented the PP learning model so that the teacher should develop the method that can help the student to pose problems and questions. However, Rufaida & Sujiono (2013) showed a different indication on the physic subject, which is the PP learning model showed better performance than learning cycle 5E.

On the other hand, PBL facilitates the students to develop their knowledge based on the problem given to them that in-line with the subject. Many reports show that the PBL can improve the cognitive competence in biology or science subjects effectively (Mutakinati et al., 2018; Ratini et al., 2018; Suciati et al., 2020; Taşoğlu & Bakaç, 2010; Wulansari et al., 2018), besides the PBL can improve the psychometric skills of the students (Sumarni et al., 2016).

The series of learning syntax in PBL is the reason why PBL can optimally empower students' CC. When students are given problems at the beginning of learning, they must use their thinking skills to deal with these problems. Thinking skills have been widely reported as predictors of student cognitive learning outcomes (Miharja et al., 2019; Mite & Corebima, 2017; Wicaksono, 2014; Wulandari, 2018). In addition, group discussion activities will also optimize the cognitive development of students because there is an exchange of knowledge and opinions (Chang & Mao, 2010; Nurulwati et al., 2020). On the other hand, this condition will be difficult to realize when students follow the lecture-based learning method.

CONCLUSION

In the case of Senior High School in Samarinda, especially at Public Islamic Senior High School, PP and PBL models showed superior in increasing learning motivation and cognitive competence in structure and function of plant tissue subject of 11th Class than conventional learning model; however, both learning models have different effectiveness. The PP learning model showed more effective in increasing the learning motivation, while the PBL model showed more effective in improving cognitive competence.

Based on the findings obtained in this study, PBL and PP is recommended to be increasingly implemented in biology learning in various schools in Indonesia. By applying these two learning models, student competencies are expected to be able to develop more optimally. In addition, studies that examine the effect of the PBL + PP combination are also recommended for future research. The addition of other dependent variables based on 21st Century skills also needs to be studied.

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