Peer Assisted Learning Strategy for Improving Students’ Physiologic Literacy

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Abstract. Research about the implementation of the Peer Assisted Learning (PAL) strategy in Plant Physiology lecture has carried out, in which it aims to improve students’ physiologic literacy. The PAL strategy began with a briefing by the lecturers to the students tutor about pretest questions, followed by the interaction between student tutors with their peers to discuss response problems, terminated by answering responsiveness questions individually. This study used a quasi-experimental method, one - group pre-test post-test design. This design includes a group of students observed in the pre-test phase (tests carried out before PAL treatment) which is then followed by treatment with PAL and ends with post-test. The other students group (control) was given the pre-test and post-test only. The results showed that the PAL strategy can increase student’s physiologic literacy significantly. One of the weaknesses of students’ physiologic literacy is that they have not been able to read the graph. The faculties are encouraged to begin introducing and teaching material using a variety of strategies with scientific literacy aspects, for example teaching research-based material. All students respond positively to the PAL strategy.

1. Introduction
Until now plant physiology concepts are considered difficult for students [1; 2] and teachers [3; 4], thus causing misconception [1; 5; 6; 7; 8; 9]. Some ways to overcome this are through the implementation of inquiry based demonstration interactive [10], dual mode teacher training [3], development of teaching materials based on deep dialogue/critical thinking [11], use of conceptual attainment model [8], and conceptual change text-oriented instruction [1; 5].

The scientific literacy must contain context, competencies and knowledge about [12], so that students are not enough to master knowledge only, even if those are still considered difficult. Furthermore, the scientific literacy aspect consists of role of science, scientific thinking and doing, science and society, mathematics and science, science motivation and beliefs [13].

Physiologic literacy aspects in this study lead to scientific thinking and doing, and mathematics and science [13], but the content and context adapted to Plant Physiology course materials as part of Biology. Science literacy especially physiologic literacy skills should be procured in the lecture as a learning innovation. Learning innovations that can be structured in the classroom and monitored directly by the teacher, or even not limited by time and place, is learning involves peer tutoring, namely peer assisted learning (PAL) [14; 15]. The PAL implementation has proven to increase the scientific literacy ability of the pre-service Biology teachers on Plant Morphology lecture [16] and
their anatomic literacy ability [17]. PAL program earlier studies indicated that the presence of peer tutors were helpful in the success of Plant Physiology lab works [18], involving students as lab assistant also supports the improvement of lab works quality, such as in Botany Phanerogamae [19], Plant Physiology [20; 21; 22], Plant Anatomy [22], and Plant Morphology course [20; 22; 23]. Application of PAL also can increase students’ concepts mastery of Plant Embryology subjects [24]. Scientific studies through research on the application of PAL in the fields of biology, both nationally and internationally, over the years has not revealed its influence on the improvement of physiologic literacy ability. Therefore, based on the successful implementation of PAL in the earlier study, this study will revealed the application of PAL strategy to improve students’ physiologic literacy in Plant Physiology course. In addition, this research was particularly carried out to improve the pre-service Biology teachers’ physiologic literacy, in which PAL implementation can be done outside of class schedules.

2. Experimental Method
The method used in this study was experimental method, with quasi experimental pre and posttest design. This design includes a group students that observed in the pretest phase (tests carried out before PAL treatment) which is then followed by treatment with PAL and post-test (the post-test items are different with the pretest items, but same in the content). Another group students (control group) were taken the pretest and posttest data only.

The research subjects were students of Biology Education Study Program of class 2012 and 2013 enrolled in Plant Physiology courses in 2014. The research instruments were questionnaire to solicit tutor, a set of pretest in a form of essay questions about growth, development and plant hormones which contain aspects of scientific literacy, a set of essay questions about growth, development and plant hormones that contains the same aspects as in that of the pretest but contains different discourse. Another research instruments were a set of posttest questions in a form of multiple choice questions to confirm the response results in PAL in which these questions have the same discourse as that of the pretest, and also a questionner to solicit students’ response towards PAL program.

PAL program were preceded by discussions between Plant Physiology lecturers with the head of the group (tutor who have previously been selected based on the highest academic achievement and class sociogram results) about pre-test results and its expected answers. Lecturers was not directly informed the tutors about the expected response from the pretest questions, but rather encompass most correct answer from the tutor and indirectly led the tutor to the expected answer. This stage is also a PAL that occurs between the lecturers and tutors.

The next phase was the interaction between the tutors with their tutee, in which they discuss about problem solving test based on lecturer-tutor discussion results, with the smallest lecturers’ intervention possible, in which lecturers were merely observing tutors-tutee interaction from a distance. After PAL was executed, all students were assigned to answer a set of test problem solving . Multiple choice-questions postest was then performed to confirm PAL’s results. All questions used as an instrument of this research mostly include aspects of the ability of scientific thinking and doing, and mathematics and science [13] and distributed according to various levels of cognitive level of Marzano’s new taxonomy [26]. The pretest and posttest data was tested statistically using the t test [27]. To determine students’ physiologic literacy improvement, normalized test-gain (N-gain) was calculated and categorized using Hake’s formula [28].

3. Result and Discussion
From Table 1 it appears that prior to the PAL (pre-test), the average students’ physiologic literacy in Plant Physiology subjects is still low, which only amounted to 29.3 in experimental group and 33.2 in control group. The pre-test of both group is not different significantly with t value = 0.997< t table = 2.000 (α = 0.005). The highest physiologic literacy ability in experimental group pre-test were in analysing research results, predicting and analysing hypothesis, with 56.8, 54.4 and 51.5 score, respectively. The ability to analysing research results, which solicited through an item in which
discussed about the properness of a plant being categorized as long day plant (the plant in question was stored in high temperature treatment followed by long day and short day treatment, in which it could not produce flower). But if this plant was stored in low temperature followed by long day treatment it can produced flower, whereas if it followed by short day treatment it could not produce flower. According to Marzano’s new taxonomy, this capability is classified in analysis cognitive level, especially analysing errors. Similarly, another item contain the ability to analyse the hypothesis of results research graph which based on soybean hypocotyl growth research (soybean was administered with auxin then also given kinetin without giving hormones). The question is about the possibility of epicotyl growth that is not too different from the controls when kinetin was given early. 

It turns out half of all students realize that plants parts hypothesized (epicotyl) is different from the plants parts observed in the graph (hypocotyl). Therefore, based on the questions of the analysis, the ability of the students showed near enough. In contrast to the level of analysis, on other physiologic literacy aspects, the ability of students is still very low, even in terms of giving examples categorized as retrieval according to Marzano’s new taxonomy, i.e. only 7.4 from a scale of 100.

The highest ability of physiologic literacy in the control class in pretest are determining independent variable and determining research purposes with each scores 57.8. The ability of determining independent variable is obtained from the item which questioned about independent variable in the research that is if the plant was kept at high temperature and given the treatment of long day or short day, the plant is not flowering. Another case when the plant is kept at low temperatures and given a long day treatment, the plant is flowering, but if it is given short day treatment, the plant is still not flowering. The ability of physiologic literacy in the control class which is the highest among other is determining a research purpose which is collected from item which questioned the purpose of research based on the graphic display of the research result.

From the pretest datas, the level of students’ physiologic literacy based on scaffolding teaching theory through the Vygotsky’s ZPD theory (the zone of proximal development) [29] only reached 29.3 and 33.2 (Table 1), which is achieved when students learn individually. These findings are consistent with the results of other scientific literacy studies in senior high school students in Bandung that it were still low [30], even in junior high school students in Sumedang district, also it were very low [31]. As well as the results of other biology literacy studies among students are still low [16; 17].

After PAL implementation, students’ physiologic literacy ability, especially in the ability of scientific thinking and doing increased dramatically (Table 1), which reached an average of 82.7 from a scale of 100. This indicates that all students have reached the maximum ZPD (the zone of proximal development) due to scaffolding through PAL from tutor to their peers, amongst tutors and amongst peers, even from tutee to tutor.

The highest aspect of this response was obtained in terms of the ability to determine independent variables (Figure 1) which includes the level of understanding (integration), and compiling the data in the form of a table that also included the level of understanding, but it included as symbolization in the new taxonomy Marzano. In both these aspects all students can master it very well, followed by the ability to analyze the hypothesis, deduce and determine decisions. Response results showed that the ability which was still in the poor category is constructing a hypothesis (58.8), while the ability to overcome problem (66.2) and considers effective variable (73.5) were sufficient. The response was carried out immediately after PAL happens in the classroom and the students answer the response based on an agreement through serious discussion, so that answers tend to be uniform.

In contrast to the physiologic literacy skills obtained from the response after the PAL, physiologic literacy ability obtained from the posttest still relatively low, which reached an average of 40.2 on a scale of 100 in experimental group and 34.9in control group (Table 1), although there are a different significantly between experimental group and control group with t value = 2.545>t table = 2.000 (α = 0.005). When traced from the item’s format, pretest items are about the same with problem solving items test, in which the differences were only in terms of its discourse and graphs. The discourse of posttest items were same with pretest but different only in terms of its items form. The form items in pretest were essay, while the form items in posttest were multiple choice. The most aspects which the

![Image](image-url)
students’ mastered in the posttest is the ability to analyze hypotheses and to determine the independent variables (Figure 1) that was both at 67.1 in experimental group and in control group was at 65.6 and 56.2 scores respectively (Table 1).

The most interesting things in the posttest, among others, was on aspects closely related to the ability to compile the data in tables/graphs, especially in reading charts contained in item posttest no. 10. On this item, students were asked to count coleoptile growth of wheat sprouts which only given ABA alone, which directly can be seen in the graph of growth hormone –treated with a concentration of 0 um. Of all the students who responded, only about 12% - 16% can answer correctly, most choose another option which involves the administration of hormones. Apparently the ability to create a table is not always in line with the ability to read charts, although both carry the aspect of symbolization.

Table 1. Learning results summary

| Physiologic Literacy Aspects                     | Level of Thinking                        | Student’s Mastery Score | Pretest PAL | PST | Posttest PAL | Control Pretest | Posttest Control |
|-------------------------------------------------|------------------------------------------|-------------------------|-------------|-----|-------------|-----------------|------------------|
| Determining independent variable                | Comprehension (Integrating)              | 47.1                    | 100         | 67.1| 57.8         | 56.2            |                   |
| Determining parameter                           | Comprehension (Integrating)              | 40.6                    | 89.7        | 43.6| 31.3         | 28.5            |                   |
| Arranging data into table                       | Comprehension (Symbolizing)              | 49.7                    | 100         | 15.7| 43.8         | 12.5            |                   |
| Constructing concept from research results      | Analysis (Generalizing)                  | 40.15                   | 87.5        | 27.6| 32.8         | 21.2            |                   |
| Analysing research results                      | Analysis (Analyzing errors)              | 56.8                    | -           | -   | 39.1         | -               |                   |
| Predicting                                      | Analysis (Specifying)                    | 54.4                    | 75.6        | -   | 48.4         | -               |                   |
| Analysing hypothesis                            | Analysis (Analysing Errors)              | 51.5                    | 97.1        | 67.1| 42.2         | 65.6            |                   |
| Drawing conclusion                              | Analysis (Generalizing)                  | 25.3                    | 97.1        | 43.4| 32.8         | 40.6            |                   |
| Determining research purposes                   | Metacognition (Specifying Goals)         | 14.1                    | 79.4        | 18.6| 57.8         | 18.7            |                   |
| Composing alternative treatment                 | Knowledge Utilization (Decision Making)   | 10.3                    | 77.9        | 31.4| 35.9         | 31.2            |                   |
| Determining decisions                           | Knowledge Utilization (Decision Making)   | 19.4                    | 91.2        | 25.7| 25.0         | 15.6            |                   |
| Considering effective variables                 | Knowledge Utilization (Decision Making)   | 16.2                    | 73.5        | 44.3| 17.2         | 18.8            |                   |
| Constructing hypothesis                         | Knowledge Utilization (Experimenting)     | 21.8                    | 58.8        | 10.0| 18.8         | 15.6            |                   |
| Determining methods to prove a hypothesis       | Knowledge Utilization (Experimenting)     | 16.2                    | 75.9        | 39.3| 34.4         | 32.8            |                   |
| Problem Solving                                 | Knowledge Utilization (Problem Solving)   | 17.6                    | 66.2        | 38.6| 29.7         | 43.7            |                   |
| Giving example                                  | Retrieval (Recalling)                    | 7.4                     | 82.6        | 37.3| 21.1         | 40.0            |                   |
| Average                                         |                                          | 29.3                    | 82.7        | 40.2| 33.2         | 34.9            |                   |
| N-gain                                          |                                          | 0.15                    | 0.02        |     |              |                 |                   |

Another interesting aspect is the decisive decision explored by item posttest showing that the ability of students is very low (25.7) in which this result are very different for the same aspects of the item response results in which showed very high ability (91.2). This item posttest asked students to decide the most appropriate treatment from the two alternatives to obtain optimal α-amylase activity in wheat germ coleoptile, based on some graphs of various phytohormone effect on the growth and activity of wheat germ α-amylase coleoptile. The desired answer is GA, but in posttest answers, the majority of students answer Kinetin - ABA which means Kinetin treatment only.
On the item of problem solving test that ask almost the same thing, students are asked to choose one of the most appropriate treatment alternatives as the act of decision-making in order to get the high number of shoots based on a bud formation graph. The majority of students can answer it correctly. This very noticeable difference is due to students’ very low ability to read charts, because there were 6 graphs in one item. Of all the tutors interviewed, sayed that they are very less trained in reading charts and have not even been discovered science literacy problems like this before, so they felt difficult when answering questions. Actually, create the chart at this point can be done by entering data aided by a computer program, and students are used to create the chart. On the other hand the ability to read charts from other data sources is unfamiliar to students. In addition, the student mastery of the course material also affects the views of students on reading the graph.

![Figure 1. Students’ physiologic literacy ability.](image)

The results of test posttest statistically show that PAL strategy can improve students’ physiologic literacy skills significantly, although the increase is low with N-gain of only 0.15 in experimental group and 0.03 in control group. This finding is somewhat different from the study results that showed moderate score of student’s anatomic literacy after PAL implementation [17]. The implementation of PAL also can improve significantly student’s scientific literacy on Plant Morphology lecture with moderate category(N-gain 0.4) [16]. This finding is also somewhat different from the results on Plant Embryology course [24], that the implementation of PAL can improve student mastery of concepts with N-gain of 0.76, although not directly related to science literacy skills. Similarly, with a series of PAL research in the lab, showed that PAL is facilitated by a lab assistant contribute to the success of the lab and improve the students’ N-gain for Morphology of Plants and Plant Anatomy lab works from low to medium, both from the test phase to the implementation phase.
of the program [20; 21; 22; 23]. Despite the many advantages of PAL strategy either directly related to academic achievement, it seems that students’ physiologic literacy is still low, but this was not due to PAL itself but rather to the lack of scientific literacy learning frequency in general.

The low ability of physiologic literacy of pre-service biology teacher students corresponds to other scientific literacy abilities at the same level of education and at lower levels. At the university level, the science literacy of prospective teachers in West Java was also low [32], as well as its quantitative literacy skills [33; 34] and microbiological literacy [35; 36]. Therefore it is not surprising that scientific literacy capabilities of students at senior high school and junior high school are extremely low as evidenced by PISA outcomes [37], and from other studies using the scientific literacy assessment (SLA) [30; 31]. Even according to [38], students in Southern Trinidad who have high academic achievement, their science literacy were relatively low.

It is very likely that learning activity in school and university emphasizes on concepts’ mastery, the students less sharpen thinking related to scientific literacy aspects. The students may already good at developing and implementing mini research design which loaded with scientific method, but they are still poorly trained in analyzing the research of others. Therefore, the most appropriate action is to start promote scientific literacy as early as possible. According to questionnaires and classroom observation results, all students like the application of PAL as an appropriate step to deepen the mastery of the course material. The reason the students liked the application of PAL is, among others, the students become more understanding of the material, there was discussion among the students in a more relaxed/comfortable atmosphere, shared understanding among students, the perception, language better understood by peer tutors, and students feel more intimate with their classmates. Disadvantages experienced by students are they generally less experienced in examining research results and had never answered the questions of research-based course material.

4. Conclusion
The Peer Assisted Learning (PAL) strategy which is carried out in Plant Physiology course to improve physiologic literacy of students significantly, began with a briefing by the lecturers to the students tutor about pretest questions discussion, followed by the interaction between student tutors with their peers to discuss response problems, terminated by answering responsiveness questions individually.

The PAL strategy has a potential to improve students’ physiologic literacy. In order to increased students’ physiologic literacy, the faculties are encouraged to begin introducing and teaching material using a variety of strategies with scientific literacy aspects, for example teaching research-based material. Learning evaluation tools are also expected to demand aspects of scientific literacy, not just a concept charged.

Because the instrument used in this study mostly only about scientific thinking and doing and mathematics and science, this study needs to be followed up by research on other aspects of scientific literacy, i.e. the role of science, science and society, and affective aspects contained in the components of science motivation and beliefs.

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