The effect of peer assisted learning (PAL) on anatomic competencies of prospective student’s biology teachers

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Abstract. Research about the effect of Peer Assisted Learning (PAL) strategy on Plant Anatomy Course, which aims to improve anatomic competencies of prospective student’s biology teacher, has been done. This study used a quasi-experimental pre-test post-test control group design. The draft includes a group of students who were given a pre-test which is then followed by observing the PAL treatment process and post-test. The other students group (control) was given the pre-test and post-test only. The PAL program began with a discussion between the lecturer and the tutor about the pretest results and then discussion between the tutors and their tutees in the class about the responses items. After that, all students were assigned to answer a set of response items, and then did the posttest. The results showed that the PAL strategy can increase student’s anatomic literacy significantly and can increase student’s anatomic lab skills no significantly. Thus the PAL strategy implementation has a potential to improve student’s anatomic competencies. The generally students weaknesses were they lack practice in interpreting of research results in the graphs form and rarely shared about anatomic lab skills. All students respond positively to the PAL strategy.

1. Introduction
Understanding plant anatomy is not only fundamental to the study of plant systematics and palaeobotany, but is also an essential part of evolutionary biology, physiology, ecology, and the rapidly expanding science of developmental genetics [1]. So, plant anatomy is one of the compulsory courses for students of Biology Education and as a prerequisite course for the next course. On the other hand, the achievement of Biology teacher candidates in plant anatomy is still low [2], so it needs to be addressed immediately.

One way to improve the anatomical competence of prospective student’s biology teachers, especially plant anatomy that includes anatomic literacy and lab skills, is to involving peer tutors called peer assisted learning (PAL). The anatomic competence of prospective student’s biology teachers needs to be developed, because in the future they have to teach it through aspects of science literacy to students by the application of lab skills.

The anatomic literacy as a part of the anatomic competence in this study refers to scientific literacy aspects by [3], like the role of science, scientific thinking and doing, science and society, and mathematics in science, but the contain and the context were adapted to the material of Plant Anatomy course [4]. Laboratory activities are very important on science, because they can generate motivation to learn science, develop basic skills in conducting experiments, as learning tools for scientific
approach, and support for understanding of subject matter [5]. Therefore, lab skills are one of the
decisive factors in supporting the ability of science literacy, in this case anatomical literacy. The lab
skills in this study include the dominant and specific science-process skills of the Plant Anatomy lab,
i.e. identification, interpretation and classification.

The PAL application in some lecture can improve the learning quality and learning outcome of
Biology students [6,7], and can increase student’s learning motivation [8]. The application of PAL can
support the successful of various Plant Biology lab works [9], can improve the concept mastery of
students in Plant Embryology course [4], and can increase student’s scientific literacy in Plant
Morphology course [10]. Thus the application of PAL strategy is very possible for the occurrence of
scaffolding on anatomic competencies of prospective student’s biology teachers. So far this is rarely
published by research.

2. Methods
The research method shown in this article is only about the influence PAL on lab skills, the effect of
PAL on anatomical literacy refers to previous studies [4]. The research design, the subjects, the PAL
treatment and the instrument are similar to previous studies [4], the different on the lab skills are the
research subject and pretest posttest items.

The method used in this research is quasi experimental with nonequivalent control group design.
One group of students was given lab skills pretest (tests conducted before PAL treatment) followed by
observing the PAL process and ending posttest. Another group of students (control) were only given a
pretest and ending posttest, without PAL treatment.

The research subject are students of Department of Biology Education in 2015, consisted of class A
which amounted to 36 students (as control class) and class B (as PAL class) which amounted to 38
students, who was contracting the Plant Anatomy course in the second semester of 2016/2017. The
research instruments included questionnaires to encompass tutors and pretest posttest items of
anatomical lab skills. The instrument used in the PAL implementation was a set of lab skills items (the
problem solving /response items) about matter and skill aspects almost same with pretest posttest
items. The next instrument is a questionnaire for students about their response to the PAL program.

The PAL program began with a discussion between the Plant Anatomy lecturer and the tutor
students about the pretest results and the expected pretest answers [4]. The lecturer confirms the
correct answer from the tutors and leads indirectly to the expected answer. This stage was a PAL
lecturer - tutor. The next PAL program stage was a discussion between the tutors and their tutees (PAL
tutor – tutee) in the class about the problem solving (response) items, according to the result of PAL
lecturer - tutor. After the PAL has been done, all students were assigned to answer a set of response
items, and then did the posttest. All of the quantitative data including pretest and posttest results
between the PAL class and the control class were tested statistically. To reveal the increased of
student's anatomic literacy and student's lab skill, the Normalized-gain (N-gain) test was calculated.

3. Result and Discussion
Table 1 and Table 2 show that before the learning taken place (pretest), the average anatomic
competence of prospective student’s biology teachers in the Plant Anatomy course is very low, both
on anatomic literacy and lab skills. The pretest score of anatomic literacy is 35.5 in the control class
and 34.5 in the PAL class [4], while the pretest score of lab skills is 2.3 in the control class and 2.7 in
the PAL class. The pretest of anatomic literacy in both of classes (PAL and control) are not different
significantly with t count values = 0.276 < t table = 2.000 (α = 0.05) [4]. Similarly, the pretest of
anatomical lab skills in these two classes are not different significantly with the t count value = 0.895<
table = 2.000 (α = 0.05). The low initial ability of anatomical literacy in prospective student’s
biology teachers is consistent with other literacy abilities at the same educational level [10,11,12,13],
and at lower educational levels [14,15,16]. The low value of pretest anatomy lab skills in prospective
student’s biology teachers is considered reasonable, because they have not elaborated the lab
activities.
Table 1. Recapitulation of student anatomic literacy [4]

| Anatomic Literacy Aspects                  | Student’s Mastery Score (%) |
|-------------------------------------------|----------------------------|
|                                           | Control Class              | PAL Class                       |
|                                           | Pre-test       | Post-tests | pre-test | PST  | post-tests |
| Scientific thinking and doing             | 46.2          | 49.4       | 66.3     | 70.0 |
| Mathematics and science                   | 21.3          | 26.8       | 56.0     | 38.4 |
| The role of science                       | 12.0          | 13.0       | 81.0     | 58.8 |
| Science and society                       | 20.2          | 15.8       | 79.8     | 69.3 |
| Average                                   | 35.5          | 34.5       | 72.1     | 59.7 |
| N-gain                                    | 0.14          | 0.38       |          |      |

PST: Problem Solving Test

Table 2. Recapitulation of student anatomic skills

| Anatomic Skill Aspects                      | Student’s Mastery Score (%) |
|--------------------------------------------|----------------------------|
|                                           | Control Class              | PAL Class                       |
|                                           | Pre-test       | Posttest  | pre-test | PST  | Posttest |
| Identification, classification, relation   | 3.7            | 6.0       | 84.9     | 47.9 |
| structure – function of parenchyma         |               |           |          |      |
| Identification parts of the cell           | 0.4            | 0.0       | 50.0     | 46.9 |
| Identification characteristics, cell parts | 5.6            | 6.8       | 76.8     | 30.0 |
| & tissue collenchyma                       |               |           |          |      |
| Identification, relation structure –       | 1.5            | 3.0       | 90.8     | 35.0 |
| function of sclerenchyma                   |               |           |          |      |
| Listing of slide-making material           | 0.0            | 0.0       | -        | 43.1 |
| Identification characteristics, cell parts & tissue epidermis | 4.9 | 2.6 | 100.0 | 38.4 |
| Average                                    | 2.3            | 2.7       | 82.5     | 43.3 |
| N-gain                                     | 0.38           | 0.42      |          |      |

PST: Problem Solving Test. *: No data.

The highest anatomic literacy in pretest is in the aspect of scientific thinking and doing, with a value of 46.2 (from scale 100) in the control class and 49.4 in the PAL class (Table 1) [4]. The lowest anatomic literacy in this pretest is in the aspect of the role of science, with 12.0 and 13.0 of the control and PAL classes respectively (Table 1). Identifying and connecting between the structures with the function of collenchyma is the highest student’s lab skill indicator, with values of 5.6 (from scale 100) in the control class and 6.8 in the PAL class (Table 2). The lowest lab skill indicator of Biology teacher candidates on pretest is listing of slide-making material with a value of 0.0 in both classes (Table 2).

During the PAL of anatomic literacy (PAL tutor-tutee) taken place, all students including tutors and tutee are very enthusiastic in discussions about the most appropriate answer from the problem solving/response items [4]. The tutors tried to share ways of thinking in answering problem solving questions, based on the results of discussion in PAL lecturer - tutor. In the PAL between the lecturers with tutors, the lecturer guided the most appropriate answers of pretest items based on the tutor’s answers; the expected answers are not stated by the lecturer. When the PAL tutor-tutee was implemented in lab skills, the interaction between the tutors with their tutees are insufficient, discussion occurred only when a tutee asked to the tutor. Most of tutor and tutee are busy themselves answering the question of response items. It seems that most of tutee are less tutors empowering, although the lecturer provided these opportunities.

From the results of the responses when the PAL was done showed that student's anatomy competence in general increased significantly, with t count value on anatomical literacy = 13.625 > t table = 3.460 (α = 0.001) [4], and t count on anatomic lab skill = 5.452> t table = 3.460 (α = 0.001). The highest anatomic literacy of student in the responses is the aspect of the role of science and the
aspect of science and society (Table 1). The highest student lab skills in the responses are on indicators about identification of characteristics, cell parts and tissue of epidermis, and on indicators of identification and connection between the structures with the function of sclerenchyma (Table 2).

![Figure 1. Improvement of student anatomic literacy (N-Gain) [5]](image)

| Anatomic Literacy Aspects     | Control | PAL |
|-------------------------------|---------|-----|
| 1: Scientific thinking and doing | 0.38    | 0.48|
| 2: Mathematics and science    | 0.32    | 0.44|
| 3: The role of science        | 0.35    | 0.46|
| 4: Science and society        | 0.34    | 0.47|

On the items of anatomical literacy responses about the aspects of science and society, especially on the validity of the sources of scientific reports, examined students' beliefs about the media that revealed the application of *Andrographis paniculata* plant as an anti-diabetes mellitus (DM). There is 85% of students can answer correctly on this item, that information about human health which has been published in the mass media cannot be trusted reliably, but it must be supported by other information to confirm the results of a study [4]. The lowest anatomic literary aspects of students in the responses is mathematics and science (Table 1), which asked students to read the graph of the research results about *Lactuca* tissue culture in inductive medium. Only about 56% of students can answer the question, meaning that the student has not been able to interpret the graph that gives rise to some independent variables [4]. This quantitative literacy was also experienced by almost all prospective students’ biology teachers [13].

On the items of the lab skill responses about the identification of characteristics, cell parts and tissue of epidermis, all students can answered these correctly (Table 2), that the outermost primary tissue is the epidermis. Another indicator of the lab skills responses that can be mastered by students is identification and connection between the structures and the function of sclerenchyma. This result is in accordance with previous studies that almost all students who have been doing practicum about plant tissue can draw, identify and describe the characteristics of sclerenchyma [17].

In the posttest results, all aspects of the anatomical literacy of prospective student’s biology teachers increased, except the science and society aspects decreased in the control class (Table 1). The average enhancement of student’s anatomical literacy in the control class is still low (N-gain 0.14) whereas in the PAL class is moderate (N-gain 0.38) (Table 1). The t test result of pretest anatomical literacy data of both classes, showed a significant difference based on t value = 5.278 > t table = 3.460 (α = 0.001) [4]. The anatomical literacy enhancement in the PAL class which includes moderate is almost same as scientific literacy enhancement of prospective student’s biology teachers in Plant Morphology course [4].

Unlike the anatomical literacy, all lab skill indicators of students increased in posttest (Table 2), with a higher score in the PAL class than the control class, although not different significantly. Result
of statistic test to posttest lab skills data from both classes, show t value = 1.084 < t table = 2.000 (α = 0.05). The posttest score of anatomical lab skills is still low, i.e. 43.3 in the PAL class and 39.1 in the control class (Table 2). The low score of posttest of anatomical lab skills suggests that students have difficulty in Plant Anatomy learning by lab work. Making slides and identifying plant anatomy structures are difficult authentic tasks for Biology students [17]. The essential skills competences of the ecology lab in Biology students are also low [18].

After PAL accomplishment, the highest increasing of anatomical literacy is on the aspects of science and society with an N-gain of 0.64, followed by aspects of the science role with a 0.53 N-gain value (Figure 1). In lab skills, the most elevated indicator after PAL accomplishment is identifying the cell parts, with an N-gain of 0.47 (Figure 2). The high increase in anatomical competence is likely due to the scaffolding that occurred during the PAL, from a tutor alone who is competent in certain aspects will transmit such competence to fellow tutors and will extend to almost all peers [4].

![Figure 2. Improvement of student anatomic lab skills (N-Gain)](image)

1: Identification, classification, relation structure – function of parenchyma
2: Identification parts of the cell
3: Identification characteristics, cell parts & tissue collenchyma
4: Identification, relation structure – function of sclerenchyma
5: Listing of slide-making material
6: Identification characteristics, cell parts & tissue epidermis

Anatomy lab skill enhancement through PAL application is in the moderate category. In the previous study also showed that prospective student’s biology teachers have improved lab skills through PAL implementation in moderate category [19]. Although PAL application did not provide a significant improvement in anatomical lab skills, but PAL can be viewed as one of the potential strategies for improving lab skills. On the other hand, this activity-based learning is one of the best strategies for dealing with students' difficulties in studying biology [20]. The survey results stated that the plant anatomy lab skills are categorized as "Prior Knowledge" and even "Essential" [21].

Overall improvement of anatomical competence capability of prospective student’s biology teachers which in the moderate category, in accordance with the research results of spatial thinking of students Biology education after having experience through framing based learning in the Plant Anatomy course [22], and other scientific literacy even at lower levels of education with various treatments [23]. The finding that the application of PAL can improve student learning outcomes is supportive of PAL research in the course of Plant Embryology [4], in various Plant Biology lab works [9,19], in teaching genetics [7] and in undergraduate medical programs [24].

So far Plant Anatomy Learning which is dominated by the concept discovery through lab work, lack practiced about the anatomical literacy, its theoretical studies were less experimental based but
more descriptive, rarely discuss about the concept of Plant Anatomy application in determining policy and in daily life [4]. Therefore the student's anatomical literacy has not achieved the expected results.

Factors that affect the low literacy of anatomy in these students, possibly due to the effect of education level previously [4]. There are differences in the learning goals in the curriculum with PISA goals as one of the international science literacy assessments [25]. The low scientific literacy is due to the learning patterns in schools (including in the Higher Education) which still emphasized mastery content not through the scientific process [26].

Some potential learning alternatives to increasing science literacy generally involve student activity [27], as well as in this Plant Anatomy course which is dominated by lab activities and presentation rather than theory, and at the end of semester the student in groups and independently assigned to conduct research inquiry based [4]. To increase science literacy should be gradual and last a lifetime [27]. This suggests that to improve the ability of anatomical literacy cannot be done instantly only in the Plant Anatomy course alone, but can be traced to the next related course [4].

The anatomical literacy indicator in the instrument of this study has not yet covered all the scientific literacy indicators and the composition of the items from every aspect is uneven [4]. In addition, the material of Plant Anatomy on the items of anatomic literacy includes other Biology subject matter such as Plant Physiology, Ecology, and Molecular Biology which are still "foreign" for students, so that the lecturer must explained first about these related biological material [4]. This is done because one's literacy is largely determined by previous content knowledge [28]. These are the main research obstacles, anatomical literacy that must involve various aspects of life contradict to the nature of plant anatomical characteristics that tend to be stable while recent research is almost always molecularly [4].

In addition, differences form of items between the responses with posttest items, causes scoring and assertion of different judgments. The individual answer of the response items are exact same on each group, so there are still passive students and they only followed the agreement of their group without understanding the essence of the answer [4].Thus the drastic increasing from pretest score to responses score, decreased again in the posttest. This occurs in anatomic literacy and lab skills.

Another weakness of PAL tutor - tutee students, is the limitations of the tutor competencies so that the tutee was less satisfied with the tutor answers on discussion, and the tutor was only busy with some particular tutees, consequently the other tutee works individually. Collaborative learning weaknesses are classified as ‘postponed support’ if students in groups with busy leaders may have experienced delays in assistance from their group leaders, whereas leaders in other groups were constantly available for helping anyone in need of learning support (classified as 'invisible helper'), the lack of immediate feedback (classified as ‘absent feedback’), and group leaders teasing or ignoring group mates because of their slower rate of learning (classified as ‘conflict-oriented collaborative process’) [28]. Even long-term effects of peer-teaching during medical school remain poorly understood [24].

According to the results of questionnaires and classroom observations, all students agree that the PAL strategy is essential for improving anatomical competence, because discussions among students can improve each other’s weaknesses in a more enjoyable atmosphere; the language and cognitive level of tutors are more accepted by peers. The generally students weaknesses are they lack practice in interpreting research results in the graphs form and never practiced answering subject matter items based on literacy science aspects [4]. Students also expect the PAL application on the lab skills of other Plant Anatomy material, not only just on cell, epidermis, parenchyma, collenchyma and sclerenchyma lab materials.

4. Conclusion
The implementation of PAL strategy in Plant Anatomy course has a potential to improve the anatomical competence of prospective student’s biology teachers in the "moderate" category. The PAL strategy included of tutors training by confirming answers of pretest questions, the interaction between tutor and tutee to discussed responses items, and ending by answering responses items individually.
To more enhance the student's anatomical competence; in finding the concept besides through experiential experience is also through research-based and associated with the actual phenomenon in the daily life. In addition, the implementation of PAL should do more regularly especially the responses about the interpretation of observations and identification data. Thus to improve the ability of students' anatomic literacy, it is necessary to do further research on the development of learning and its equipment like an evaluation tool that load all the science literacy indicators and various lab skills with its responses.

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