A Study of Pre-Service Teachers' Critical Thinking on the Cell Biology Learning

Pramudiyanti, Herawati Susilo, Utami Sri Hastuti, Ummie Lestari
Universitas Negeri Malang, Indonesia
yanti711@yahoo.com

Abstract: This study is a survey seeking to investigate critical thinking skills of university students in Cell Biology learning. The aim is to obtain explanation regarding pre-service teachers' critical thinking skills from their learning process conducted during the even semester in the Academic Year of 2014-2015. The data were gathered by distributing a questionnaire and a critical thinking test. The questionnaire given to the students consists of items related to the learning process conduct, including model, media and learning strategies used. On the other hand, the test is made of three simple essay questions regarding the material discussed which is protein synthesis. The data from both the questionnaire and essay test were analyzed using simple descriptive. The findings from the survey have shown that a) the teaching and learning has used cooperative learning approach; b) it has used learning media such as books, animation, and Power Point slides; and c) the mean of the critical thinking test is 42.4. The critical thinking skills were based on the following indicators: (1) explanation 36.7; (2) analysis 58.8; and (3) drawing conclusions 31.7. The findings suggest that the critical thinking skill of the students is relatively low.

Keywords: critical thinking skills, cell biology, cooperative learning.

The teaching and learning in the 21st century is a profession requiring skills for student teacers. To mention, one of the skills includesbeing able to design learning involve students' thinking process. In order to achieve such skill, it is vital to prepare student teachers with learning which trains them to think. Liliasari (2001) asserts that to win the global challenge of the 21st century it is important to improve higher order thinking skills of student teachers, paticularly critical thinking skill.

Critical thinking, according to Elder (2012: 2),*critical thinking is that mode of thinking about any subject, content, or problem-in which the thinker improves the quality of his or her thinking by skillfully analyzing, assessing, and reconstructing it.*This definition refers to critical thinking which means that it is a mode of thinking – about any subject, content, or problem with that the thinker makes an attempt to enhance the quality of his thought by skillfully analyzing, assessing, and reconstructing it.

The aims and purposes of assessing critical thinking are as follows: (1) to diagnose the level of student's critical thinking. If a teacher wants to focus on learning, it would be best to start from the position of student's critical thinking. A test is helpful in identifying the weaknesses and strengths, for example the skill of identifying assumptions, (2) to give feedback on the proficiency of student's critical thinking. Knowing the weakness can lead a student to better focus on improving it, (3) to motivate students in order to be a better critical thinker (Ennis, 1993).

Biology cell, as a learning material, has its own uniqueness compared to other learning materials. It is unique in its point of view in discussing the material which includes the structure and organ functions of cell in both prokaryota and eukaryota. This particular material encompasses anatomy, mechanics, and physiology, thus it engenders difficulty in students for

this material is abstract and hard to analogize with other objects in the surrounding. Similarly, Martomidjojo (2011) and Lukitasari (2013) propose that Cell Biology is an abstract and complicated learning material. Such characteristics of the material become one of the causes of difficulty experienced by students in learning it.

Schmid and Farquhar (2010) further explain that: 1) Biology cell is fundamental for identifying organel of the cell, along with its structure and functions; 2) it is a field of science requiring multidisciplines to be able to learn it; 3) it is needed to untie the complication of human diseases; and 4) Biology cell is defined as encompassing membrane traffic, cytoskeleton diynamic; cell-matrix interaction, signal transduction, and the structure and function of nucleus.

One of the materials being regarded as hard and abstract is that of myosin response after tying calcium ion (Ca^{2+}). The structure of myosin protein resembles the cord of a rope. When the rope is unbound, it will make two ropes. When myosin protein bindscalcium ion, the cord of myosin protein will unbind which making it two cords of protein in parallel and changing the conformation of myosin head, made it open and ready to receive ATP molecules, thus the movement of cellular muscle will be activated.

To comprehend such example requires the process of transferring the prior knowledge by attempting to understand the new one. In this mode of thinking high critical thinking is required, particularly the critical thinking at explanation aspect with its ideal category that is being able to provide explanation and integrate important information into the context of discussion, which not everyone can do it (Zane, 2013: 37).

Some profiles of student teacher's critical thinking is still low in several places. The result of a critical thinking test administered to students of Biology Cell in Kuningan – West Java shows the score of 6,16 (21%)in the first group, and of 7,2 (24 %) in the second(Martomidjojo, 2011:385). Low level of critical thinking is also found in student teachers in Pontianak regarding the concept of Biological Diversity in Mangrove Forest by the score of 57,88, in student teachers in Lampung regarding the concept of Metabolism by 37,25 and in student teachers in Semarang regarding the concept of Biodiversity by the score of 57,87 (Sudargo et al.,2010).Such low critical thinking is also found in student teachers in Malang on the concept of Evolution shown by the score of 7,63 (31,8%) in the first group and 6,97 (29,0%) in the second group (Suciati, 2015).

The data described above delineate the low critical thinking skills of student teachers. This state is in contrary with the challenge being faced which is to implement the teaching and learning that can improve the thinking skills (Liliasari, 2001). The teaching and learning conducted in the class should be able to make students think (Corebima, 2009).Paul and Elder (2006: 4) state that *yet the quality of our life and that of what we produce, make, or build depends precisely on the quality of our thought. Shoddy thinking is costly, both in money and in quality of life. Excellence in thought, however, must be systematically cultivated*. It means that the quality of our life and what we make or produce depends on the precision of our quality of thought, thus thinking is a fine investment both in the quality of financial and life. A qualified thought should be empowered and this empowerment can be initiated in the classroom.

This study aimed to investigate: 1) How is the critical thinking state of student's on the learning of Biology Cell in Lampung; 2) Can the critical thinking skills of student's on the learning of Biology Cell in Lampung be improved by cooperative learning; 3) How is the learning that is capable of improving the student's critical thinking skills.

THE THEORY

Critical thinking, according to Paul and Elder (2006: 4), is the art of analyzing and evaluating thinking with a view to improving it. Facione (2013:6) describes critical thinking as

referring to cognitive skills and disposition. Disposition means the tendency of attitude while cognitive skill means the mental capability. Facione divides cognitive skill into interpretation, analysis, evaluation, and self regulation. Ennis (1993) states that "critical thinking is reasonable reflective thinking focused on deciding what to believe or do". Critical thinking depends on the precision of reasoning; therefore one would have the faith to act. Facione (2013: 6) adds that critical thinking skills are defined not only as thinking critically (Disposition) but also cognitively skilled (cognitive skill).

Being cognitively skilled comprises explanation, interpretation, inference, analysis, evaluation, and self regulation (Facione, 2013:6-7). Zane (2013:37-47) develops a measurement rubric of critical thinking as in the following: a) Explanation consists of arguments and description; b) Interpretation is of quality of questions, clarifying questions, comprehension and finding links and patterns; c) Inference is making conclusions; d) Analysis is consisted of categorization, comparing and finding differences, and information selection; e) Evaluation is comprised of accessing data or source of material and the use of standard and criteria; and finally f) Self regulation is of self monitoring, reflection, and self correction (self introspection).Each of the aspect above is given score of 1 to 4 with the categories of *Well below expectation* (scored 1), *Below Expectations* (scored 2), *Meets Expectations* (scored 3), dan *Exceeds Expectations* (scored 4).

Study findings which are relevant with critical thinking is that of Chaijaroen,et al.(2012), report that problem based learning, resources, discovery learning, scaffolding, collaborative learning, and guidance can encourage students to think and find answers. CAM learning model and practice can improve student's critical thinking skills (Martomidjojo, 2011; Sudargo, 2010). Furthermore, PBL learning model and inquiry can also enhance critical thinking skills (Suciati, 2015). King (1995) mentions that teaching the technique of formulating questions can help studnts think critically and learn easier. Yang, et al. (2005) also adds that the implementation of ADF (*Asynchronous Discussion Forum*) learning and *Socratic* questioning method can help students express high level of critical thinking. Gunawan (2012) also confirms that Socratic questioning method can improve critical thinking skills. Khoshneshin (2011) reports tat the use of Socratic questions through online discussion on WWB *(Web Based Bulletin)* can help improve critical thinking skills. De Waelsche (2015) proposes that assigning students to make questions can trigger their critical thinking.

The concept of protein synthesis is included in "Chapter of Nucleus" and "Chapter of Ribosom and Protein Synthesis". The two chapters are arranged in three meetings. Several concepts are learned here, such as the concept of DNA, RNA, Replication, Transcription, and Translation. The expected competences include: 1) students are able to understand the structure and function of nucleus; 2) students are able to analyze the process of Replication, Transcription, and Translation. The following figure summarizes the concept of protein synthesis.

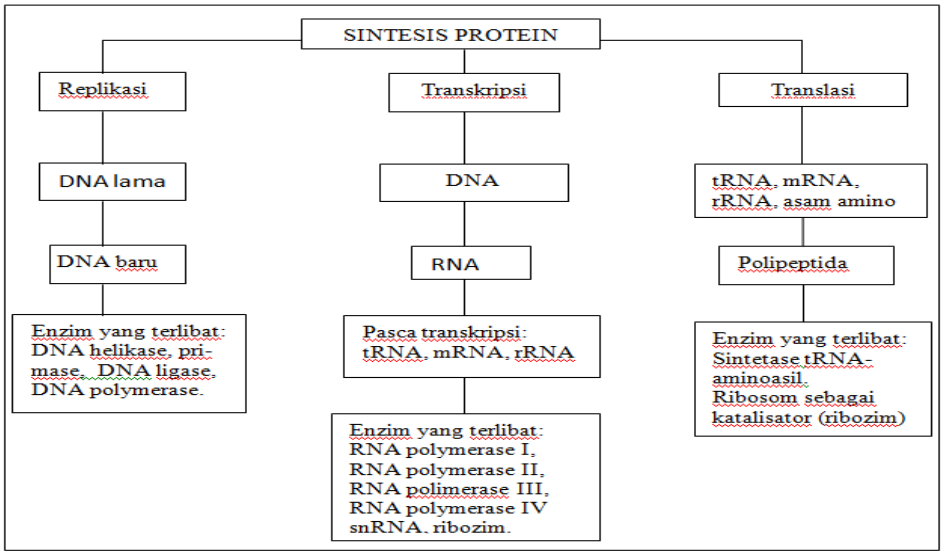

Figure 1 The Scheme of Protein Synthesis

DNA (*deoxyribo nucleic acid*) is that of genetic material own by prokaryota and eukryota. Studies have proven that DNA is the genetic material inherited to the generation. Evidences have shown that: a) DNA can transform bactery from non-pathogen into pathogen; b) DNA virus can program cell by infecting a cell and taking over its metabolic device;c) before the occurrence of mitosis, DNA will self replicate, and distribute the DNA the same amount to the other cell; d) The DNA composition differs among species, but is similar in the ratio of the four nitrogen alkali, namely Adenin, Guanin, Timin, and Citosin (Campbell et al., 2002: 298-301).

Each nucleotide unit is polymer of nitrogen alkali, sugar, and fosfat group. Phosphate of one nucleotide bound to sugar of the following nucleotide in a series. Ribose sugar is known as a composer of ribo nucleic acid or RNA, and contains four kinds of alkali, A, U, G, and C. Deoxyribo nucleic of sugar (position 2' hydroxyl (OH) occupied by hydrogen) is known as deoxyribo nucleic acid or DNA, and contains for alkali, A, T, G, and C (Albert; 2003: 82).

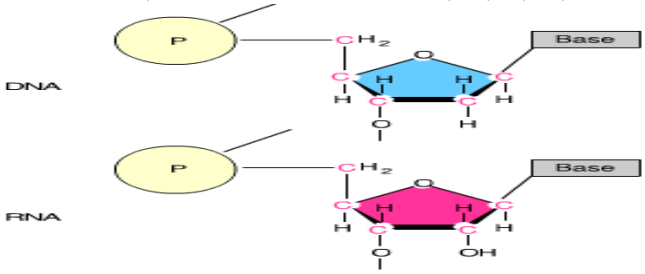

Figure 2 the Structure of Nucleotide Molecule of DNA and RNA

The concept of DNA replication.

DNA Replication becomes one of the evidences that DNA is that of genetic material. Replication process has been observed in prokaryota and eukryota. This process of replication includes several phases, such as: 1) Replication is initiated when the initiating protein identifies centari area (*origin of replication*) of the DNA and starts forming replication "bubbles"; 2) elongation of new DNA chain. Elongation of new DNA is catalyzed by the DNA enzyme of polymerase. The energy source ini this phase is nucleocyde triphosphat (Campbell et al., 2002: 308).

Based on the direction of the formation of new DNA chain, the terms *leading strand* and *lagging strand* are introduced. The two terms are distinguished by the existence of okzaki fragment. Okazaki fragment is formed to deal with the adversative replication direction with the opening direction of replication fork. The role of DNA helicase Single-stranded DNA-binding proteins (SSBs), and primase at the replication fork. Helicase moves along the DNA chain. When it is unbound and bound by SSBs in order not to twist (stay straight). Primase together with helicase synthesize RNA primer to start the okizaki fragment. RNA Primer will substitute into DNA by other DNA polymerase. DNA ligase will combine Okazaki fragment to the increasing chain (Karp, 2010: 542)

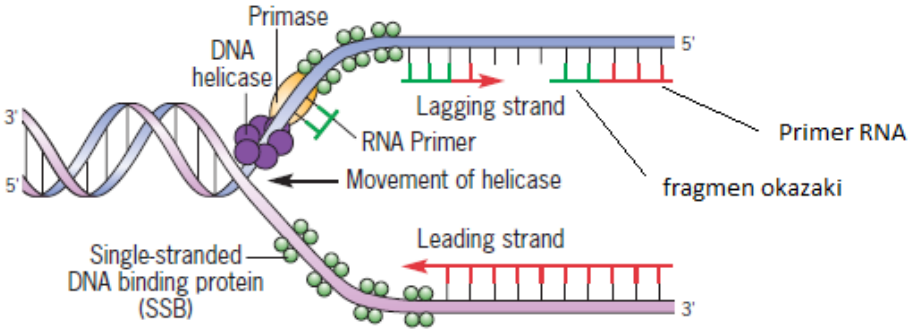

Figure 3. The DNA Replication Fork (modified from Karp, 2010:542)

METHOD

The study took time during the even semester of the Academic Year of 2014/ 2015. It employed survey method. The object of the study was students who were taking the course of Biology Cell in class A and B totaling 81 students. Data were gathered using a questionnaire and three essay questions with the minimal structure (Ennis, 1993). The questionnaire covers questions regarding the model of learning and assignment during the teaching of Biology Cell, which was distributed to both lecturer and students. The following questions were addressed to the students: (1) during the teaching of Biology Cell, did you raise a question? Yes, because… Never, because…; (2) during the teaching of Nucleus, Protein Synthesis, and Replication, some learning media were used, namely…; (3) during the teaching Nucleus, Protein Synthesis, and Replication some learning activities were implemented, among others: (discussions, lectures, exercises, mention others); (4) Did you help a friend in your group who had not understood the learning material? Yes, describe the material you explained to your friend… No, because…: (5) did you divide the task with friends when working with a group assignment? Yes, explain a sample of the task and how you distributed it.

Questions that are proposed to measure the critical thinking skills comprise three simple questions, such as the first question is used to measure the critical thinking skill by the indicatorsof analyzing the subindicator, comparing and finding differences, and selecting information. The second one is used to measure the critical thinking skills by the explanation indicator. The third one is used to measure the critical thinking skills by making conclusions.

The assessment guide for critical thinking refers to Zane Rubric (2013) using the scale of 1 to 4. The data obtained using the questionnaire and test is analyzed using simple descriptive.

FINDINGS AND DISCUSSION

Based on the questionnaire, it is known that the learning of Biology Cell has been conducted using cooperative learning. Cooperative learning is characterized by the presence of

student-student, teacher-student, and student-teacher communication (Rusman, 2012: 203).The conduct of teaching and learning is delineated in Figure1.Several characteristics of cooperative learning that were visible are the occurrence of task division among groups, information sharing from one student who has said to have understood to another who has not. Besides, the existence of discussion also shows that the learning has focused on the students, while the students' raising questions shows that the two-way interaction between the lecturer and students really existed.

The implementation of learning in this study has opened up chances for students to improve their thinking ability through sharing information with groups. The use of learning media such as animation and PowerPoint slides is expected to encourage the student's learning ability. Nonetheless, it is known from the score of critical thinking test that the student's thinking ability is not yet optimal. Taking an example, the student's responses (60%) during the learning in raising questions is essentially because they were expecting further clarification to make them comprehend the learning material, only one student was observed rasing a question with the expectation to know further regarding the material learnt. In fact, the question expected here is that of curiosity and comes truly from the student (*true question*) (Walsh and Sattes, 2011:113). This way, such curiosity will elicit a deeper question, instead of a question asking for clarification from teacher and friend.

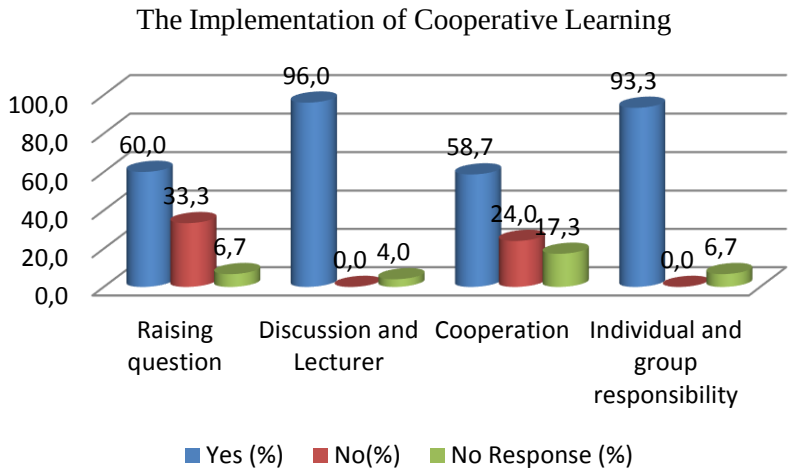

Figure 4 The Learning of Cell Biology Using Cooperative Approach.

Cooperative learning done here has proven capable of improving the student's learning behavior, particularly of making them responsible individually and in groups, allowing them to share information from a knowledgeable student to a non-knowledgeable one, cooperating, and interacting with the lecturer. Furthermore, this learning approach is better designed to improve the learning attitude by improving the way of thinking. As proposed by Corebima (2007), Paul and Elder (2006: 4), Facione (1990: 4)that thinking (critically) is very crucial in learning, and that this way of thinking should be taught to students all the time in order to improve their quality of thinking.

The profiles of student's critical thinking are described as follows: the mean of test score for critical thinking skills is 42.4. The profiles of critical thinking skills are as: (1) explanation 36.7; (2) analysis 58.8; and (3) making conclusions 31.7 (Table 1). Of the three aspects, the two (explanation and making conclusions) include in the *well belowexpectation*categorywhile the other one (analysis) is found in the *below expectation* category.

The test score shows that the students have the potential to analyze problems provided by the teacher. Analyzing is indicated by the student's ability to identify adversing differences. In the concept of DNA and RNA the students could successfully find the difference between the molecule structure of DNA and RNA. Meanwhile, some of the students still found difficulties in selecting information, particularly of all information presented regarding the structure of DNA and RNA, resulting in answers like memorization, not selecting information which is actually needed from the question.

Table 1. The Pre-Service Teacher's Critical Thinking Score Based on Some Indicators and Their Descriptions.

Indicators of Critical Thinking	Test Score	Score	Criteria	Descriptions of Critical Thinking	Ideal Description (Scored of 4)
Explanation	36,7	1,1	Very low *(Well below expectation)*	Not having information to support explanation	Detailed important information explaining the content that readers might not integrate to the text.
Analysis	58,8	2,35	Low *(Below expectation)*	• Assessing/ reviewing data/ facts. • Finding differences	• Selecting and organizing data/ facts to support texts or arguments. • Comparing "or" comparing generally or fundamentally.
Making conclusions	31,7	0,95	Very low *(Well below expectation)*	Making conclusions	Describing conclusions*).

*Ideal descriptions for Conclusions used the description with the score of 2 from Zane (2013)

A sample of answering form is not selecting information Figure 5. The question addressed is: "See the figure (Figure 2), find differences of DNA and RNA molecules by circling and provide a reason".

Positively, the answer shown in the figure above is conceptually true only if no figure attached to the question; however, seen from the critical thinking of the student it can be inferred that the corresponding student has not performed any information selection in order to provide the intended answer to the question. The intended answer is that the student could find the differences between ribose sugar (having OH^-) as a constituent of nucleotide, shown in the figure. Meanwhile, the alkali constituents of DNA and RNA are different in Timin and Urasil alkali, yet in the "questioned figure" such thing is not supposed to be the context of discussion. All this makes the answer given has not been selected yet.

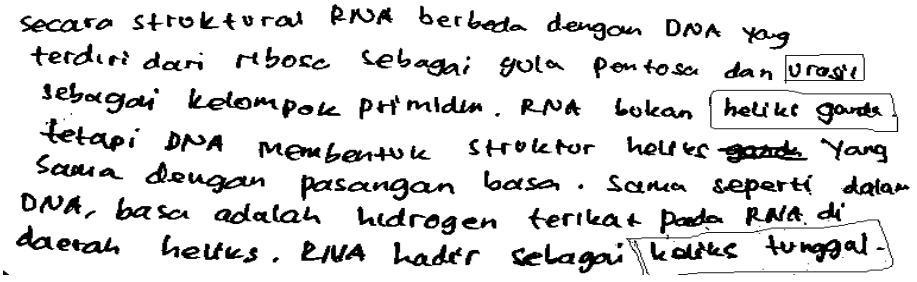
secara struktural RNA berbeda dengan DNA yang terdiri dari ribose sebagai gula pentosa dan urasil sebagai kelompok pirimidin. RNA bukan heliks ganda tetapi DNA membentuk struktur heliks ganda. Yang sama dengan pasangan basa. Sama seperti dalam DNA, basa adalah hidrogen terikat pada RNA di daerah heliks. RNA hadir sebagai heliks tunggal.

Figure 5 A Samples of The Student's Answer in Analyzing the Structure of DNA and RNA.

In accordance with the findings of this survey, an optimal cooperative is required in order to be able to improve the student's critical thinking skills. Hasan et al, (2013) have reported that cooperative learning is capable of improving student's critical thinking skils. Acording to Ennis (2003), moreover, developing critical thinking skills is not supposed to coplete all aspects at a time but step by step. It is suggested to first identify the weakness of criical thinking of every student with which any suitable strategy can be arranged to cope aftewards.

Teaching based on *Lesson Study* (LS) is an alternative to optimize cooperative learing. Through LS, strategies can be proposed to make a better learning (Doig and Groves, 2011; Lewiset al., 2004; Lewis, 2011; Subadi, 2013: 105), one of which is by improving the student's learning attitude through observation on their learning speed (IDCJ, 2012:26-61).

Findings from studies implementing LS have proven positive in improving the quality of learning in the study program of Biology Education (Marhamah, et al.: 2014; Pramudyanti: 2011; Lukitasari: 2014). Zukmadini (2014) suggests that implementing LS can improve student's critical thinking.

CONCLUSIONS AND SUGGESTION

To conclude based on the results of the survey conducted here, that (1) cooperative leanring has been done during the teaching of Biology Cell; (2) the student's critical thinking skills in learning Biology Cell is relatively below expectation and requires improvement; (3) cooperative learning can be used to improve critical thinking skills through the implementtion of LS.

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