Research Article

The critical thinking skills of biology teacher candidates toward the ethical issues

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ABSTRACT

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The critical thinking skills are needed by biology teacher candidates to deal with the nowadays ethical issues arisen among society. The aim of this research was to observe the critical thinking skills of biology teacher candidates toward the ethical issues especially in genetic field through online discussion. The subjects of this experimental research were 104 biology teacher candidates who took the Genetics Course in an institution in West Java. The subject were devided into three groups consisted of two experimental groups and one control group which conducted online discussion by using Gen-21cs application. The experimental groups discussed the topics given by the both instructor and students, while the control group only discussed the topics given by the instructor. The topics discussed were cell cloning, Genetically Engineered Products, stemcell and inbreeding. The online discussions have been done for four weeks. The biology teacher candidate responses were measured using the cri tic thinking measurement developed by Facione. The critical thinking scores gained were analyzed using descriptive statistic in term of mean. The results showed that the critical thinking skills of the biology teacher candidates tended to increase in each discussion sessions. Online discussion can be used to ensure the other thinking skills.

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INTRODUCTION

The role of teacher as educators is very important in guiding students as future generation to be aware of problems in life related to genetics such as gene therapy, cloning, and stem cell research which are currently becoming a social issue. Freidenreich, Duncan, and Shea (2011) stated that genetic literacy is to understand three integrated models: genetic models (genetic inheritance patterns), meiosis models, and molecular models (the mechanisms of connecting genotypes with phenotypes). Teaching genetics to teachers candidate is very important so they will have genetic literacy, it would be useful to solve the future life problems (Gottheiner & Siegel, 2012). Genetic literacy requires not only a good understanding of genetic concepts such as the genetic material, patterns of inheritance, gene expression and regulation, genetic variation, and evolution but also an
ability to overcome various problems related to genetics (Boenwinkel, Yarden, & Waarlo, 2017). Moreover, a teacher’s pedagogical ability is influenced by his knowledge and attitude in genetic literacy on various issues related to genetics. Taking a solution as an answer to the problems of life is a critical thinking skill, especially when dealing to genetic problem related to the ethical issues such as the use of Genetically Engineered Products (GEPs) in human life, which is interesting to be discussed and debated in the alternative learning process in science classes.

Improving the critical thinking on students by creating a learning model is a challenging task for teachers (Wang, 2013). One of biology teaching materials that has difficulty in increasing students’ critical thinking is genetic course. Genetic material is developing rapidly with a number of socio-scientific issues globally (Freidenreich et al., 2011). Conventional learning is not considered sufficient to improve students’ critical thinking skills, because there are many sub-discussions in genetics to understand. This fact shows that teacher candidates must be equipped with steps to improve the student critical thinking skills on various ethical issues of genetic with a religious approach characterized by the ability to question controversial issues (Wang, 2013). In the end of day, the teacher candidates is expected to have the critical thinking skills based on the knowledge and religion approach, so they can also implement this way in the future to increase the student critical thinking skill.

One of alternative learning activities to improve the critical thinking skills in accordance with 21st-century learning is online discussion (Luterbach & Brown, 2011; Sun, Lin, Wu, Zhou, & Luo, 2018; Swart, 2017; Uijl, Filius, & Ten Cate, 2017). This activities covered discussion about the risk factors, advantages and disadvantages of the use of GEP, and allows discussion members to improve their assessment and critical thinking skills about genetic problems. It can be done through responses in the online discussion by interpreting problems, analyzing several possible solutions, evaluating various references as a basis for making decisions, referring to the decision to be taken, and providing an explanation by describing the alternative solutions as the best answer to the problems in the online discussions (Kendal, Kirk, Elvey, Catchpole, & Pryjmachuk, 2017). Preliminary studies have been carried on learning through online discussion forums in social media groups to discuss the basics of inheritance chromosomes, and the results show that the use of online discussion forum can increase the profile of critical thinking skills (CTS) in prospective biology teachers (Maryuningsih, Hidayat, Riandi, & Rustaman, 2019).

Learning through online discussion forums by discussing ethics in the use of GEP is one example of bioethics education and one of the genetically literacy in the post-genomic era (Stem & Kampourakis, 2017). Bioethics education through argumentative processes that focus on critical thinking skills needs to be trained through discussion forums on ethical issues in the use of GEP (Chowning, Griswold, Kovarik, & Collins, 2012). The debate over ethical issues related of the use of GEP is interesting activity in a learning process, to find out the critical thinking skills possessed by members of the discussion. The study of ethical issues in the use of genetic engineering products is an effective way to provide experiences for teacher candidates, about genetic consultation (Cantor, Hippman, Hercher, & Austin, 2019) compared to genetic learning in a classical way which is only focused on providing material about the concept of genes (Burian, 2013). Exploring students’ understanding of the three conceptual models in genetics can enhancing the teacher candidate conception of genetic phenomena (Haskel-Itthä & Yarden, 2018) and also can enhance students’ conceptions of research about stem cells, and cloning (Concannon, Siegel, Halverson, & Freyermuth, 2010). Moreover, by genetic literacy would develop the knowledge, attitudes, and perceptions of science teacher candidate in a learning process, as well as critical the thinking skills of teacher candidate (Cebesoy & Oztekin, 2018; Cebesoy & Tekkaya, 2012).

Firstly, the teacher candidates need to understand about the religious values related to genetic issues, due to the most of the Indonesia citizens are moeslem. They must gather the information and evidence on various social issues and religion related to ethical issues on genetic (Freidenreich et al., 2011). They assess the truth and suitability of information and evidence for possible solutions to answer the problem by religious approach (Chattopadhyay, 2005). There are some research that linked between the truth or religion with a science, like the christianty teachers’ belief related to evolution science, the result showed that teachers’ beliefs regarding evolution and their Christian faith were mixed and complex (Barnes, Elser, & Brownell, 2017; Mangahas, 2017; Van Huytssteen, 2017). Moreover, there are not so many study about religion linked to the genetic, like the research conducted by Anderson et al(2017) and Scully, Banks, Song, and Haq (2017) that find the correlation between faith and genetic course, but there is no study corelate between faith and especially in GPE, stem cell, cloning and inbreeding. In the other hand, Islam as one of the majority religion in Indonesia, have a rules related to the genetic product (Salsehudin and Iksan, 2017), so this research is really important to conduct due to the fact that there is no study before about critical thinking skills of teacher candidate toward the ethical issues related to the genetic field. In addition, the result of this study can also provide comprehensive information about the response and perspective of the teacher candidate about ethical issues related to the genetic field through online discussion. The information obtained can be used as a basis for policy and a basis for improving the quality of
learning, as well as input for further research. Therefore, the purpose of this research was to describe how the critical thinking of teacher candidates related to the ethical issues related to genetic field.

**METHOD**

This research was conducted with an experimental method by implementing an online discussion forum on Genetics. The population in this study was students who took the Genetics course in the 2017/2018 academic year at one of the teacher training with total one hundred and four teacher candidates. The sample in this study was the total population divided into three discussion groups (Table 1) conducted online in android-based learning application called Gen-21cs on smartphones developed by Maryuningsih et al (2019).

| No | Theme | Problems |
|----|-------|----------|
| 1  | Cell clone and Gene clone application | Animal clones have succeeded. What do you think if clones are also applied to humans? |
| 2  | GEP (Genetically engineered Product) | With the development of molecular genetics and considering ethical norms, please describe and give some examples of genetically modified products that are ethically good and very beneficial for the well-being of human life. And what about halal law and the illegitimacy of these products by including the proposition of the Koran and authentic hadith to support your opinion |
| 3  | STEM Cell | What is your opinion based on Islamic law considering that the tissue taken originates from an embryo. What is your opinion if the stem cells are mass produced to replace damaged human organs and the stem cells used are derived from animal embryonic tissue? |
| 4  | Inbreeding | In Islam there are known three groups of women who are forbidden to be married who are called “mahram”, among them are women with the same lineage as mentioned in the Qur'an An Nisa verse 23 which reads: “Forbidden to you are your mothers and your daughters and your sisters and your paternal aunts and your maternal aunts and brothers’ daughters and sisters’ daughters and your mothers that have suckled you and your foster-sisters and mothers of your wives and your step-daughters who are in your guardianship, (born) of your wives to whom you have gone in, but if you have not gone in to them, there is no blame on you (in marrying them), and the wives of your sons who are of your own loins and that you should have two sisters together, except what has already passed; surely Allah is Forgiving, Merciful” *(Q.S. an-Nisa: 23)* |

From the explanation of the above verse, it is clear that in Islam there are some forbidden marriages. What do you think about it based on genetic studies?
Data collection and analysis

Data collection techniques in this study were done by observing the critical thinking skills of teacher candidates on their responses to the online discussion forums using the application Gen-21cs. The aspects of critical thinking skills according to (Facione, 1990, 2011) are as follows: Interpretation, Analysis, Evaluation, Inference, Explanation, and Self-regulation. In this study, limit the critical thinking skills to five indicators only namely: Interpretation, Analysis, Evaluation, Inference, and Explanation. These indicators are in accordance with the topic of genetics (Maryuningsih et al., 2019). Critical thinking skills of teacher candidates are measured according to the CTS with Facione Frame work as seen in the Table 3.

Online discussion forum members' responses on ethical issues related to the genetic were observed then analyzed for their critical thinking skills using observation sheets with discussion and rubric assessments as seen in Table 3. Then the total scores were calculated in each online discussion forum activity with 1-3 scales for each CTS sub-indicator, so the total score is 30.

Table 3. Critical thinking skills assessment rubric with Facione Framework

| Framework    | Sub skill                              | Assessment                                                                                     | Coding |
|--------------|----------------------------------------|-------------------------------------------------------------------------------------------------|--------|
| Interpretation| Categorize, encode data, clarify meaning| 1. Understand the theme and purpose of learning                                                 | CTS 1  |
|              |                                        | 2. Express the purpose of various situations, data, assessments, rules, procedures, or criteria. |        |
| Analysis     | Test ideas, identify arguments, analyze arguments | 3. Linking information and concepts of the problem                                                | CTS 2  |
|              |                                        | 4. Clarifying conclusions based on the relationship between questions and information in the problem |        |
| Evaluation   | Assess the credibility of the claim, assess the quality of the arguments that have been made with deductive and inductive reasoning. | 5. Assess the credibility of a statement or other representation of someone's opinion            | CTS 3  |
|              |                                        | 6. Assess a conclusion based on the relationship between information and concepts, with the questions that exist in a problem |        |
| Inference    | Questioning statements, thinking of alternatives, drawing conclusions | 7. Identify the elements needed to make rational conclusions, taking into account information that is relevant to an existing problem | CTS 4  |
|              |                                        | 8. Identify the elements needed to make rational conclusions, taking into account relevant information and its consequences based on available data |        |
| Explanation  | State the results, explain the method, and forward arguments | 9. Give reasoning                                                                              | CTS 5  |
|              |                                        | 10. States the reasoning based on evidence, concepts, methodologies and logical criteria based on information |        |

RESULTS AND DISCUSSION

In large groups, there were three group that divided into control group, experiment group 1 and experiment group 2, the discussions include major themes relating to ethical laws and theoretical studies of GEP and genetic as general. The small group discussions were consist of seven until ten people per groups, in the small group teacher candidates discuss the review of articles on several themes on the use of GEP. The teacher candidate in each group discussion feel free to response the issues anytime without waiting for their turn like in conventional group discussion. Moreover, due to the using of online discucssion forum they also could expand their knowledge to find any source in the internet related to the specific issues of the genetic. The result show that every teacher candidates responses the issues based on reading source from the internet, Figure 1 describe how the eacher candidates’ responses to ethical issue in genetic. The instructor role as the observer to monitor the interactions between students and educators discussing several examples of specific ethical issues in genetic field. The topics selection was appropriate to build the critical thinking of teacher candidates, in line with the (Cooling et al., 2010) stated that the most appropriate topic to discuss was the controversial issues related to the religion.
The responses were then analyzed for their critical thinking skills based on the CTS framework of Facione described in Table 4.

**Table 4.** The technique for coding prospective teacher responses is based on the CTS indicators

| CTS indicators | Sub indicator | Teacher candidates’ response | CTS coding | CTS score |
|----------------|---------------|------------------------------|------------|----------|
| Interpretation | Categorize, encode data, clarify meaning | Some genetic engineering products have benefits for the well-being and welfare of humanity and do not violate humanitarian and religious ethics so that they can be accepted by society. However, many products of genetic engineering still draw pros and cons because they are not in accordance with humanitarian and religious ethics. Genetically modified product that still draws pros and cons is Cloning of humans. Cloning is a form of human engineering intervention. Cloning uses techniques by producing genetically identical duplicates of an organism. After the successful cloning of a sheep named Dolly in 1996, experts also applied the cloning to humans. | CTS1 | 5 |
| Analysis | Test ideas, identify arguments, analyze arguments | Human cloning requires only somatic cell retrieval, not gonosomal cells such as eggs or sperm from a person, then the DNA from that cell is taken and transferred into the egg of a woman who has not been fertilized, which has all the genetic characteristics removed by removing the cell nucleus or DNA is in that egg. Then, an electric current is passed to the egg cell to trick it into thinking it has been fertilized, so it begins to divide. The fertilized cell is then implanted into the womb of a woman who is willing to conceive a baby, a baby born genetically similar to the genetics of a person who donates the somatic cell. | CTS2 | 4 |
| Evaluation | Assess the credibility of the claim, assess the quality of the arguments that have been made with inductive and deductive reasoning. | With regard to the human cloning the Koran says in surah Al-Hajj verse 5: which means: O mankind! If you are in doubt about the Raising up (the Resurrection), then surely We created you (at first) from dust then from a Nutfah (a drop, small seed), then from an "Alaqah" (an embryo hung on to the wall of the womb at one point) then from a lump of flesh, shaped and unshaped, that We may make clear to you. And We cause (you) to stay in the wombs till an appointed term that We wish, then take you out as a baby to reach your puberty. And of you is he who is caused to die, and of you is he who is brought back to old age so that after having knowledge he does not know anything. And you see the earth dry, but when We send down on it the water, it moves and it rises and grows vegetables of every charming pair. Based on this verse, both explicitly and implicitly the Koran states that human creation from the beginning of life to death has been arranged by God, the Creator. Allah SWT has created humans through several processes starting from the essence of the soul to being a baby that is ready to be born by a mother to carry on her life on earth. | CTS3 | 6 |
The responses of teacher candidates was measured, so the average CTS scores could be obtained as seen in Table 5.

Table 5. The average score of teacher candidates’ CTS in each group’s discussion activity

| Group | Discussion activity | CTS score |
|-------|---------------------|-----------|
| 1     | 1                   | 24.53     | 24.53 | 25.03 | 27.57 |
| 2     | 2                   | 25.54     | 25.66 | 25.68 | 27.78 |
| 3     | 3                   | 26.55     | 26.78 | 26.17 | 27.99 |

The increase in the critical thinking skills of teacher candidates in each group for all discussion activities carried out online through the Gen 21 cs application was illustrated in Figure 2.

Figure 2. The increase in average CTS scores of teacher candidates in each online discussion group

Table 5 and Figure 2 explain the average score of critical thinking skills of teacher candidates in each online discussion group. Online discussions related to the ethical issues of genetics are an appropriate way to describe the critical thinking skills of teacher candidates compared to offline discussion in class. The offline discussion in class have a limited time and the student alternately to deliver their opinions, while in online discussions people are free to express their opinions without waiting for their turn and without any limited time. This proves that online discussion forums provide wider space for discussion participants. The highest CTS score lies in Groups two and three which apply online discussions with Problem Based Learning compared to Group one. The online discussion forums in Groups two and three, that the problems come from instructors and teacher candidates, can increase the active participation of the group members in responding to the issues raised by other group members.

The study of genetic concepts, especially the use of genetic engineering products as a topic of discussion in the learning process is an effective way to provide experience to teacher candidates about genetic literacy (Cantor et al., 2019). This can be seen from the responses of teacher candidates, they were more active to provide any critical answer in each session on online discussion forum when compared to classical learning in class. The study conducted by (Burian, 2013) who states that classical learning is only focused on providing material about the concept of genes. The understanding of teacher candidates on genetic field is really important
because it will have an impact on their social life (Chattopadhyay, 2005). Teaching techniques as a framework to improve genetic literacy in the post-genomic era need to be improved (Stern and Kampilras, 2017), so the teacher candidates can understand about the three conceptual models in genetics (Freidenreich et al., 2011) and enhance the teacher candidates conception of genetic issues (Haskel-Iltah and Yarden, 2018). This activity also can increase the student specific conceptions about stem cells and cloning (Concannon et al., 2010). The understanding of teacher candidates about genetic literacy was measured from their responses in online discussion forums, it could describe the knowledge, attitudes and perceptions of teacher candidates to the various issues especially in genetics field (Cebeosoy and Oztekin, 2018; Cebeosoy and Tekkaya, 2012).

Perception of Teacher candidates also show their understanding, belief and competency as a provision for their teaching activities later (Mangahas, 2017). This perception need to be built by synchronize laws in science education that have a basis from epistemology and science ontology on several topics of social-science issues regarding the genetic issues (Mansour, 2010). The molecular genetic through online discussion was a learning progress for better understanding of genetic concepts (Todd and Kenyon, 2013) because by using electronic journal or book as references the biology teacher candidates can be a fast learner in this 4.0 revolution industry era (Todd and Romine, 2017). The most recommended learning is by learning that supplies the future needs, that known as online learning through online discussion (Shalev-Schwartz, 2011). The online discussion is a model for authenticating knowledge transfer by understanding cognitive skills in a constructive learning environment (Akyol and Garrison, 2011; Brown, 2014; Tucker, Gonzaga, and Krause, 2014).

The result showed that critical thinking skills of teacher candidates was presented from their responses, perceptions and ethical norms by using religious perspective related to genetic field. This was indicated by their responses in several cases related to the genetic field such as cloning, stem cell, GPE and inbreeding by quoting several verses of the Koran and hadith. Teacher candidates cite a number of Qur’anic verses and hadiths related to the themes discussed according to the islam norms. Discussing issues related to religious studies is something that needs to be done (Cush and Robinson, 2014). Moreover, this activity is an important part as an effort to increase religious beliefs for adherents (Cooling, 2012). Controversial themes such as cloning, stem cells were much debatable in the world, especially about ethical use, so the teacher candidates can explore the right information about Islamic laws in presenting their opinions (Fink, 2002).

(Scheell and Ecklund, 2017) explained that the role of religion is needed in developing thought patterns in addressing various social problems related to genetic knowledge, genetic determination and applications in daily life. All these ethical issues are linked to religion (Genicke et al., 2017), so the religious knowledge possessed by teacher candidates greatly influences his thinking patterns and is reflected in his opinion exposure. As a Moeslem majority, the study of Islamic perspectives in addressing the ethical issue (Grine, Ben, said, Nor, and Ladjal, 2013), especially health risks, perceptions of modern food like GEP (Haukenes, 2004). This study describe the dogmatic in moral education and religious studies that both of them should be present in the learning process especially Genetic learning in teacher candidates (Muchnik, 2018; Nie, 2019; Podoprigora, 2018).

CONCLUSION

Critical thinking skills on ethical issues in the genetic field can be trained and improved through online discussion forums. The result of this study was describe that not only critical thinking skills possessed by teacher candidates, but also other skills such as communication skills, group collaboration and creative thinking by religious approaching that appear in the online discussion forum.

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