

Research Article

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



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ABSTRACT

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 divided 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 critica 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 teachers 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 usefull 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 (Boerwinkel, 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-saintific 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 increase 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; Ujil, 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 out 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 (Stern & 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-Ittah & 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 christiany 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 Huyssteen, 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 coreelate 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 (Salehudin 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).

Table 1. Online discussion group

Grup 1	Grup 2	Grup 3
Control, Conventional online discussion Learning method: Problems given by the instructor	Experiment 1 Problem based learning Learning method: Problems given by the instructor and teacher candidates	Experiment 2 Problem based learning Learning method: Problems given by the instructor and teacher candidates

Research samples, the teacher candidates, are divided into three large online discussion groups, namely group 1, group 2 and group 3. Each of these groups is divided into small groups totaling seven until ten people. The online discussion was carried out for four weeks on the Gen-21cs application. In large group discussions, online discussion forums are conducted by discussing themes that have been determined by educators. Group members then respond to each problem given by the instructor to the large group. Otherwise, in small group, teacher candidates who are divided into small groups discuss the review of articles on several themes on the use of GEP. They also debated about the ethical dilemmas during the online discussion period, each opinion from the group member were monitored. The trigger questions and follow-up questions are intended so that all parties involved play a role in the online discussion to sharpen the critical thinking skills of teacher candidates related to ethical issues in Genetic. The following discussion themes are given to online discussion forums in all discussion groups using the Gen-21cs application, shown in Table 2.

Table 2. Discussion themes in online discussion forum using the Gen-21cs application

No	Theme	Problems
1	Cell clone and Gene clone	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: حُرِّمَتْ عَلَيْكُمْ أُمَّهَاتُكُمْ وَأَخَوَاتُكُمْ وَأُمَّهَاتُ نِسَائِكُمْ وَأَخَوَاتُ نِسَائِكُمْ وَأُمَّهَاتُ مَا كَفَرْتُمْ وَأَخَوَاتُهُنَّ بِأَخْوَاتِنَّ وَأُمَّهَاتُهُنَّ بِأُمَّهَاتِنَّ وَأَخَوَاتُهُمْ بِأَخَوَاتِنَّ إِذْ كَفَرُوا "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" .(QS. 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
<i>Interpretation</i>	Categorize, encode data, clarify meaning	1. Understand the theme and purpose of learning 2. Express the purpose of various situations, data, assessments, rules, procedures, or criteria.	CTS 1
<i>Analysis</i>	Test ideas, identify arguments, analyze arguments	3. Linking information and concepts of the problem 4. Clarifying conclusions based on the relationship between questions and information in the problem	CTS 2
<i>Evaluation</i>	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 6. Assess a conclusion based on the relationship between information and concepts, with the questions that exist in a problem	CTS 3
<i>Inference</i>	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 8. Identify the elements needed to make rational conclusions, taking into account relevant information and its consequences based on available data	CTS 4
<i>Explanation</i>	State the results, explain the method, and forward arguments	9. Give reasoning 10. States the reasoning based on evidence, concepts, methodologies and logical criteria based on information	CTS 5

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 each 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.

Assalamualaikum, ibu izin menjawab pertanyaan mengenai etical research dalam rekayasa genetika.

Pada beberapa produk hasil rekayasa genetika diantaranya memiliki kebermanfaatan bagi kemashlatan dan kesejahteraan umat manusia serta tidak melanggar etika kemanusiaan dan keagamaan sehingga dapat diterima oleh masyarakat. Akan tetapi, tidak sedikit pula produk hasil rekayasa genetik yang masih pro dan kontra karena tidak sesuai dengan etika kemanusiaan maupun keagamaan. Produk rekayasa genetika yang masih menjadi pro dan kontra yaitu Kloning terhadap manusia. Kloning merupakan suatu bentuk intervensi hasil rekayasa manusia. Kloning menggunakan teknik dengan cara memproduksi duplikat yang identik secara genetik dari suatu organisme. Setelah keberhasilan kloning domba bernama Dolly pada tahun 1996, para ahli menerapkan pula kloning tersebut kepada manusia. Kloning manusia hanya membutuhkan pengambilan sel somatis bukan sel gonosom seperti sel telur atau sperma dari seseorang, kemudian DNA dari sel itu diambil dan ditransfer ke dalam sel telur seseorang wanita yang belum dibuahi, yang sudah dihapus semua karakteristik genetisnya dengan cara membuang inti sel atau DNA yang ada dalam sel telur itu. Kemudian, arus listrik dialirkan pada sel telur itu untuk mengelabuinya agar merasa telah dibuahi, sehingga ia mulai membelah. Sel yang sudah dibuahi ini kemudian ditanam ke dalam rahim seorang wanita yang bersedia untuk mengandung bayi tersebut, bayi yang dilahirkan secara genetik sama dengan genetika orang yang mendonorkan sel somatis tersebut. Berkaitan dengan ayat suci Al-Quran mengenai kloning terdapat pada surah Al-Hajj ayat 5: yang artinya: Hai manusia, jika kamu dalam keraguan tentang kebangkitan (dari kubur), maka (ketahuilah) sesungguhnya Kami telah menjadikan kamu dari tanah, kemudian dari setetes mani, kemudian dari segumpal darah, kemudian dari segumpal daging yang sempurna kejadiannya dan yang tidak sempurna, agar Kami jelaskan kepada kamu dan Kami tetapkan dalam rahim, apa yang Kami kehendaki sampai waktu yang sudah ditentukan, kemudian Kami keluarkan kamu sebagai bayi, kemudian (dengan berangsur-angsur) kamu sampailah kepada kedewasaan, dan di antara kamu ada yang diwafatkan dan (adapula) di antara kamu yang dipanjangkan umurnya sampai pikun, supaya dia tidak mengetahui lagi sesuatupun yang dahulunya telah diketahuinya. Dan kamu lihat bumi ini kering, kemudian apabila telah Kami turunkan air di atasnya, hiduplah bumi itu dan suburlah dan menumbuhkan berbagai macam tumbuh-tumbuhan yang indah.

Berdasarkan ayat tersebut, secara baik tersurat maupun tersirat Al-Quran menyatakan bahwa penciptaan manusia dari awal kehidupan hingga kematian telah diatur oleh Allah Sang Pencipta. Allah SWT telah menciptakan manusia melewati beberapa proses dimulai dari sanjati tanah hingga menjadi bayi yang siap dilahirkan oleh seorang ibu untuk melangsungkan kehidupannya di bumi. Al-Quran jelas menolak adanya kloning tersebut, dikarenakan kloning dapat dianggap sebagai proses peniruan manusia terhadap ciptaan-Nya sehingga hal tersebut telah melampaui batas kita sebagai makhluk yang diciptakan oleh Allah SWT. Selain itu, agama Islam menolak kloning dikarenakan Islam sangat menjunjung tinggi suatu hubungan termasuk hubungan suami istri yang berlandaskan pada perkawinan yang sah. Anak-anak hasil perkawinan otomatis akan menghasilkan keturunan dengan sifat genetik yang diwariskan dari kedua orangtuanya. Dengan adanya kloning maka akan mengacaukan hukum waris yang didasarkan pada hubungan pertalian darah. Proses kloning juga dapat membuat anak hasil rekayasa genetika tidak memiliki nasab yang jelas, misalnya anak tersebut dihasilkan dari sel somatis ibunya maka otomatis di dalam tubuh anak tersebut hanya ada DNA dari ibunya saja tanpa adanya gabungan dari DNA ayahnya sehingga anak tersebut seperti bukan anak ayahnya. Nasab tersebut berkaitan dengan hak waris dan pernikahan.

Referensi: <https://abraham4544.wordpress.com/umum/hukum-kloning-dalam-perspektif-agama-islam/>

Figure 1. Example of teacher candidate responses to cloning

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	<i>Some genetic engineering products have benefits for the wellbeing 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.</i>	CTS1	5
Analysis	Test ideas, identify arguments, analyze arguments	<i>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 feeling 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 the baby, a baby born genetically similar to the genetics of a person who donates the somatic cell.</i>	CTS2	4
Evaluation	Assess the credibility of the claim, assess the quality of the arguments that have been made with inductive and deductive reasoning.	<i>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 soil to being a baby that is ready to be born by a mother to carry on her life on earth.</i>	CTS3	6

CTS indicators	Sub indicator	Teacher candidates' response	CTS coding	CTS score
Inferencce	Questioning statements, thinking of alternatives, drawing conclusions	<i>The Koran clearly rejects the practice of cloning, because cloning can be considered as a process of imitating of humans against His creation so that it has exceeded our limits as creatures created by Allah SWT.</i>	CTS4	5
Explanation	State the results, explain the method, and forward arguments	<i>In addition, Islam rejects cloning because Islam highly upholds a relationship including marital relations which are based on legal marriages. Children from the marriage will automatically produce offspring with genetic traits inherited from both parents. With the cloning, it will disrupt the inheritance law based on blood ties. The cloning process can also make a genetically modified child not have a clear lineage, for example the child is produced from his mother's somatic cells so automatically in the child's body there is only DNA from his mother without any combination of his father's DNA so that the child is like not his father's child. The lineage is related to inheritance and marriage rights</i>	CTS5	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			
	1	2	3	4
1	24.53	24.53	25.03	27.57
2	25.54	25.66	25.68	27.78
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](#).

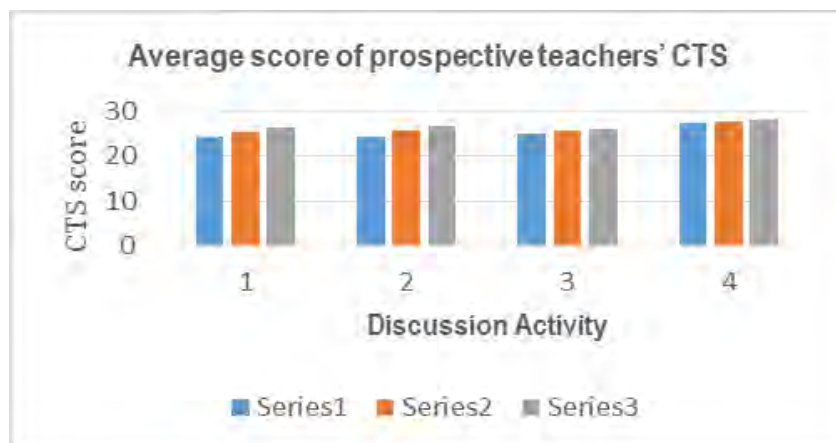


Figure 2. The increase in average CTS scores of teacher candidates in each online discussion group

[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 Kampourakis, 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 the genetics field (Cebesoy and Oztekin, 2018; Cebesoy and Tekkaya, 2012).

Perception of Teacher candidates also shows their understanding, belief and competency as a provision for their teaching activities later (Mangahas, 2017). This perception needs to be built by synchronizing laws in science education that have a basis from epistemology and science ontology on several topics of social-science issues regarding 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 journals or books 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-Shwartz, 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 were presented from their responses, perceptions and ethical norms by using religious perspectives related to the 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 Islamic 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).

(Scheitle 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 (Gericke 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 Muslim majority, the study of Islamic perspectives in addressing the ethical issue (Grine, Bensaid, Nor, and Ladjal, 2013), especially health risks, perceptions of modern food like GEP (Haukenes, 2004). This study describes 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 described that not only critical thinking skills possessed by teacher candidates, but also other skills such as communication skills, group collaboration and creative thinking by religiously approaching that appear in the online discussion forum.

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