



Received: 12/02/2019
Revision: 24/08/2019
Accepted: 30/08/2019
OnlineFirst:14/11/2019

Trend of Critical Thinking Skill Researches in Biology Education Journals across Indonesia: from Research Design to Data Analysis

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Empowerment of critical thinking skill is one of numerous goals the 21st century education intends to acquire. This study employed content analysis on a number of articles that had been published in Biology education journals across Indonesia since 2010 to 2017, with critical thinking skill as the main focus of the study. This current study has revealed that in the past three years, the number of publications that focused on critical thinking skill had improved. Among those publications, the most dominant research designed was quantitative. In addition, the tenth graders of senior high school and ‘Ecosystem’ were consecutively the subject and material targeted the most. Test and t-test were serially the most commonly-used instrument and data analysis method. In respect to the findings of this study, some recommendations have been proposed for upcoming researches underpinning critical thinking skill as the main focus. Some of these recommendations include increasing the diversity of research type and choosing more precise data analysis techniques.

Keywords: biology educational journals, critical thinking skills, data analysis, biology educational, critical thinking

INTRODUCTION

Presently, education has been considered very crucial as a means of creating competent societies in the 21st century (Kivunja, 2014). It is said that not only is conceptual mastery needed by students to survive within the century (Glaze, 2018), in addition to memorizing every single concept that is served (Lindsey, Shroyer, Pashler, & Mozer, 2014), but also a competence that leads them to critical thinking and life skills. A collaborative with communicative skill is another competence that is supposed to be sharpened (Kivunja, 2014). In addition, scientific process skills is also considered

Citation: Susetyarini, E., & Fauzi, A. (2020). Trend of Critical Thinking Skill Researches in Biology Education Journals across Indonesia: from Research Design to Data Analysis. *International Journal of Instruction*, 13(1), 535-550. <https://doi.org/10.29333/iji.2020.13135a>

strongly essential for scientific and technological eras nowadays (Gultepe, 2016). Besides, some patterns of thinking skills, such as metacognitive (Perry, Lundie, & Golder, 2018), creative (Mumford & McIntosh, 2017), and critical thinking skills (Strauss, 2016) have also been said to be the most essential capital for graduates to deal with tight competition in the 21st century.

Among all mentioned competences, critical thinking is frequently included in the list of must-acquired competence for the 21st century education (Binkley et al., 2012). Critical thinking collaborated with creative, collaborative, and communicative thinking skills, closely interlinked to 4Cs, constitutes a central aspect in almost all programs of education (Moser, 2017). Correspondingly, critical thinking skill belongs to 10 key competences that have been formulated into Assessment and Teaching of 21st Century Skills (ACT21S) (Binkley et al., 2012). In addition, LMTF also inserts critical thinking skill as a sub-domain of Global Framework of Learning Domains - 21st century skills framework designed by UNESCO (Learning Metrics Task Force, 2013). In essence, the aforementioned happens closely due to positive characteristics that are going to unify with the graduates that are prepared to be critical thinkers.

In contrary to the urgency of critical thinking skill, some studies reported that students' critical thinking in some countries were still less empowered. Studies from Gedik reported that Turkish students' critical thinking skill was still categorized low or, in other words, less optimum (Gedik, 2013). In line with those studies, Aktas & Unlu also reported that the critical thinking of Turkish prospective teachers was not high (Aktas & Ünlü, 2013). The low level of students' critical thinking skill was also found in the Philippines (Salas, 2016) and Malaysia (Fadhlullah & Ahmad, 2017). Further, similar case was also reported by some studies conducted in some locations in Indonesia, such as Subang (Santika, Purwianingsih, & Nuraeni, 2018) and Malang (As'ari, Mahmudi, & Nuerlaelah, 2017). The less intensive attention to the empowerment of critical thinking skill in some countries might be caused by educational system applied of which designs and practices restrict students to get actively involved in discussion, debate, and evaluation on their thinking process (Sellars et al., 2018). Whereas, those sorts of activities are completely essential to create critical thinkers.

Educational development should be able to accommodate the optimization of students' critical thinking skill empowerment (Strauss, 2016). The development itself cannot be separated from a number of studies that have contributed to providing plentiful discussions about sustaining quality improvement on instructional process (Fauzi & Pradipta, 2018; Spencer-rodgers & Cortijo-ocaña, 2015). Some studies, also, have strayed to uncover the level of students' critical thinking skill in search of potential attempt for optimization of critical thinking empowerment during instructional activities (Huber & Kuncel, 2016; Tiruneh, Verburgh, & Elen, 2014). Mass of information gained from those several studies is frequently utilized as a fundamental basis for governmental policy as well as instructional planning designed by teachers and lecturers.

In Indonesia, numerous studies on critical thinking skill are also found, especially in Biology education context. Some studies focus on the distribution of students' critical thinking level (As'ari et al., 2017; Santika et al., 2018), and the other discuss the effect

of specific instructional design on students' critical thinking skill (Wulandari, Amin, Zubaidah, & Henie, 2017). There has also been a study that discusses the relationship between critical thinking skill and other parameters of learning accomplishment (Naimnule & Corebima, 2018). Notwithstanding, among all those studies, none of which attempts to review information that has been reported in all of the studies.

Using content analysis on several scientific Biology education journals published in Indonesia, from 2010 to 2017, this current study aimed at collecting information about variety of studies discussing critical thinking skill in Indonesia. In detailed, this study was intended to answer the following questions: (1) How was the trend of the number of studies on critical thinking skill from year to year? (2) How was the variety of research designs employed to investigate critical thinking skill in Indonesia? (3) What was the most frequent topic used to investigate students' critical thinking skill? (4) What kinds of treatments did the researchers implement to improve students' critical thinking skill? (5) What were the instruments used by the researchers to measure critical thinking skill? (6) What were the techniques of data analysis used by the researchers to analyze critical thinking skill? (7) How was the portrayal of the series of studies that had been conducted by the researchers in investigating critical thinking skill?

In some aspects, this current study differs from previous ones that concerned on critical thinking skill. Firstly, this study was focused on the whole articles that had been published from 2010 to 2017; all of which were accredited by Science and Technology Index (SINTA). Secondly, this study was devoted to investigate a number of articles with critical thinking skill as their main focus. Thirdly, various parameters were used as foundations for content analysis.

METHOD

Research Design

This study adhered to the principle of content analysis, which was focused on findings from numerous studies that had been published in scientific journals in Indonesia. The research method used was similar to those used by Fauzi & Pradipta (2018).

Data Source

The data were collected from the results of content analysis on Biology education articles. The whole articles were taken from Biology education journals registered at Science and Technology Index (SINTA) on July 2018. SINTA (<http://sinta2.ristekdikti.go.id/>) is a platform to measure science and technology development which was designed and developed by Ministry of Research, Technology, and Higher Education of Indonesia. In total, there were 13 biology education journals in the SINTA database. Henceforth, all of the articles that reviewed critical thinking skill were collected from each of those journals. The articles under analysis in this study had been published on-line before July 2018. Of the hundreds of articles collected, there are 42 articles that examine critical thinking. All of the articles were analyzed in this study.

Research Instrument

The instrument used for this current study was a guideline of content analysis that contained related aspects under observation (Table 1.). There were as many as seven main aspects to review for content analysis in this study. Those aspects included (1) the number of publications per year; (2) types of research; (3) research subjects; (4) Biology topics chosen for the studies; (5) treatments; (6) data collection instruments; and (7) data analysis methods. Exceptionally, categories on aspect (1), (4), and (5) were not decided in the beginning due to the absence of previous studies that might be referred to determine what should be included in the categories and the possibility of overgeneralized categories that might appear when content analysis on some articles was performed. Besides, categories on aspect (2), (3), (6), and (7) were defined before data collection. The categories are shown in Table 2, which were adapted from (Fauzi & Pradipta, 2018). In addition, aspect (2) was divided into two sub-aspects, including (2a) general types of research and (2b) quantitative research design.

Table 1
The Aspects and Categories used for Content Analysis in the Study

Aspects	Categories	
Types of research (2a)	A.1-R and D A.2-CAR	A.3-Qualitative Research A4-Quantitative Research
Types of quantitative research (2b)	B.1-Observation Studies (OS) B.2-Correlational Research (CR) B.3-Survey Research (SR) B.4-Pre-Experimental Designs (PED)	B.5-True Experimental Designs (TED) B.6-Quasi-Experimental Designs (QED) B.7-Ex Post Facto Designs (EPFD)
Research subject	C.1-VII Grade JHS students C.2- VIII Grade JHS students C.3-IX Grade JHS students C.4-X Grade SHS students C.5-XI Grade SHS students C.6-XII Grade SHS students	C.7-Undergraduate students C.8-Postgraduadate students C.9-JHS teacher C.10-SHS teacher C.11-lecturer
Data collection instruments	D.1-questionnaire sheet D.2-observation sheet D.3-test sheet	D.4-interview sheet D.5-unidentified
Data analysis methods	E.1-mean E.2-percentage E.3-N-gain E.4-t-test E.5-ANOVA	E.6-ANCOVA E.7- Correlation E.8-Unidentified E.9-Others

Data Analysis

Each of articles was classified into specific category based on certain aspect that met the defined category. The decision was based on information that was shared by the authors in abstract, method, and discussion parts. Further, the data that had been collected were presented in a form of bar chart.

FINDINGS

Number of Publications

The number of article publications indicated how frequent the research was conducted in certain period. Alluding to the graph shown in Figure 1, the articles that reviewed critical thinking skill could be found since 2010. No specific pattern of shift occurred to the number of publications from year to year. Nonetheless, referring to Figure 1, the number of publications since 2015 had increased higher than those in the previous years. The improvement trend on the number of publications about critical thinking skill indicated that there was a significant increase in the number of researchers who were fervent to investigate high-level critical thinking skill.

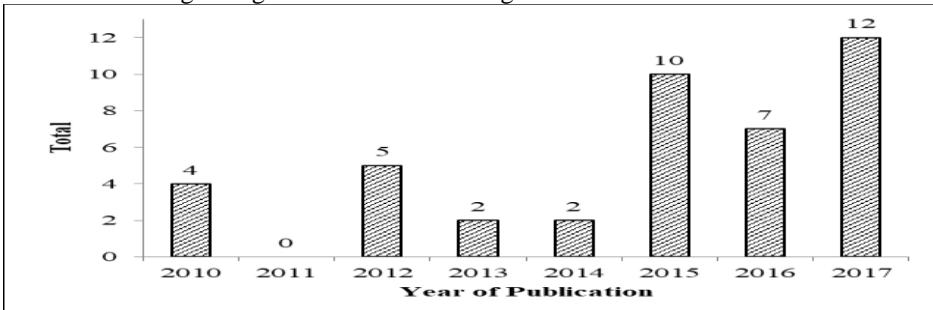


Figure 1

The Improvement Trend of the Number of Educational Researches with Critical Thinking Skill as the Main Concern in Indonesia in 8 Years

Most researches were generated from the researchers' sensitivity on common issues that frequently occurred around them. One of the most commonly found issues nowadays was in regards to Indonesian students' critical thinking skill level that was still considered low. For that reason, conducting research was believed as the most effective way for the purpose of dealing with and overcoming the issue. By research, the researchers could identify the most effective instructional design or media that might be able to optimally accommodate students' critical thinking skill.

The higher the number of researches investigating critical thinking skill, the more positive influence on Indonesian educational development will be. The premise is based on an idea proclaiming that the most ultimate goal of a research is to improve educational practices (Coburn & Penuel, 2016). Further, a research will influence educational practices because of various reasons, namely that: (1) its findings can be referred as credible information that can be implemented by teachers; (2) it can be a fundamental basis for educational decision making, in national, local, or specific institutions; and (3) its findings can affect teachers' ways of thinking.

Types of Research

Types and designs of research determine the focus of a study. Based on Figure 2, quantitative research constituted the most dominant design the researchers employed to

investigate critical thinking skill. The higher number of quantitative researches than other types of research is in line with some previous studies reporting that the researchers preferred quantitative research design to conduct research in education, instead of qualitative one (Goktas et al., 2012; Uzunboylu & Asiksoy, 2014). In addition, qualitative approach is considered relatively new for educational researches (Sharma, 2013). However, the trend of qualitative design has been shown to start increasing (Shakouri, 2014) and have targeted social researches, including some issues of education (Mohajan, 2018). Such a condition was closely interlinked to the advantage of qualitative approach to define a phenomenon in detailed and comprehensively. For that reason, the lack of qualitative research existence has been a good chance for further researchers to make use of qualitative design and focus their researches on critical thinking skill.

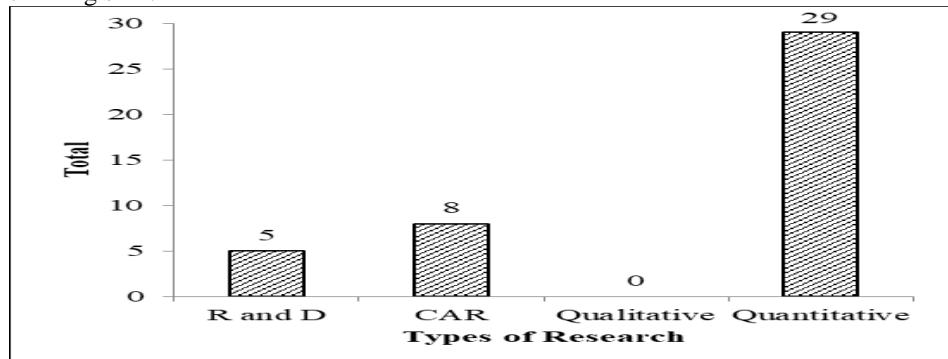


Figure 2

The Distribution of Researches with Critical Thinking Skill as the Main Concern based on Types of Research

Nevertheless, the finding revealing the rarity of R and D research about critical thinking skill was contested by a study of Fauzi & Pradipta. Their research claimed that R and D research was the most chosen type of research published in 2017 (Fauzi & Pradipta, 2018). R and D research constituted one of up-to-the-minute trends in Indonesian educational researches. In this sort of research, the researchers often resulted in educational products based on the results and processes of purely Biology researches they had conducted previously. The products, further, could be in the forms of books, modules (Suciati & Adian, 2018), or instructional materials (Kamaludin, Surtikanti, & Surakusumah, 2018). In regards to those researches, it was revealed that, among R and D researches by Indonesian researchers, critical thinking skill was still not equipped as a fundamental basis to develop their researches.

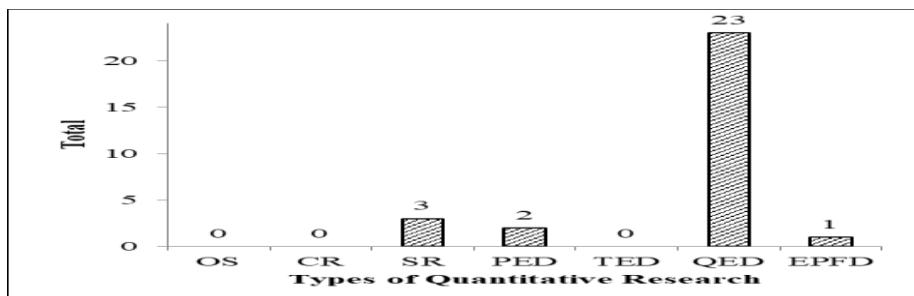


Figure 3
The Distribution of Quantitative Researches with Critical Thinking Skill as the Main Concern in Indonesia

In addition to the types of research, this study also aimed at revealing the distribution of quantitative researches that had been chosen by most researchers. Based on Figure 3, quasi experimental design signified the most common experimental research about critical thinking skill. The high frequency of quasi-experimental use than other designs of experimental research explicated that the researchers had to choose the one that best fitted their educational concern (Randler & Bogner, 2008). Compared to other experimental designs, pre-experimental design was the rarest (Knapp, 2016) and only found in two publications. On the other hands, true experimental design, which was said as the most difficult design to apply for educational issues, was not found, at all, in publications that highlighted critical thinking skill.

In quasi-experimental research, the researchers attempt to compare which one is the most effective treatment for critical thinking skill empowerment. The most remarkable characteristic of this type of research is that the researchers are allowed to involve the whole students in classroom as control group, while appointing another group of students in another classroom (or more) as experiment group. By applying different treatment and formulating hypotheses, the researchers are allowed to sum up which of the treatments worked more significantly for empowering students' critical thinking skill. In this sort of research, the researchers do not need to take into account true-experimental design for it demands them to complete certain requirement, for instance, the participants are randomly selected and randomly assigned (Martella, Nelson, Morgan, & Marchand-Martella, 2013). In fact, true-experimental design cannot be implemented in researches since most educational institutions must have set their students into several classes; and therefore, the researchers are only allowed to choose which classes to be involved. In addition, the researchers cannot reselect the students and re-divide them into some classes randomly, too.

Beside experimental design, survey was also frequently chosen by the researchers. In survey, there are some advantages offered to the researchers, such as low budget, time efficiency, and abundance of information about attitudes, beliefs, thoughts, and capabilities of population they are about to observe (Brewer, 2009). Besides, observational study and correlation research were two less frequent quantitative

researches. Whereas, there was a study in Indonesia highlighting critical thinking skill that had employed correlation research in spite of its being unpublished in Indonesian journals (Naimnule & Corebima, 2018). Accordingly, any information generated and shared in this current study is supposed to contribute to enriching forthcoming researches dealing with critical thinking skill in Indonesia.

Research Subjects

The empowerment of critical thinking skill was aimed for students. Based on the information regarding the types of research, quasi-experimental design constituted the most commonly used design the researchers preferred. It indicated that, in general, the researches attempted to compare some finest instructional designs in empowering students' critical thinking skill. In conducting research, the researchers needed research subjects to examine their hypotheses. Based on Figure 4, the most selected research subjects were students of senior high school, consecutively followed by students of higher education and junior high school. This finding is in line with a study conducted by Fauzi & Pradipta analyzing the content of all Biology education studies published within 2017 in Indonesia (Fauzi & Pradipta, 2018).

The dominance of students of senior high school level was also shown in a study of T. Lin, Lin, & Tsai (2014). Based on their study, students' learning process and conceptual understanding constituted two out of three topics that were frequently selected as the focus of study in 15 recent years. The finding is similar to that in Choi, Seo, & Kim (2016) revealing that "students" was the third most-searched keyword used for educational researches. Withal, this current study is different from a study of Goktas et al. (2012). In Goktas', the most frequently taken research sample in Turkey's educational articles was students of higher education and teachers.

Beside showing information about the comparison of senior high school, higher education, and junior high school levels, Figure 4 shows that the higher the level of a class in certain educational level, the less frequent the class would be selected as research subject. The first graders of junior high school were also frequently selected; while the third graders were rarely taken into consideration. Similarly, the first graders of senior high school reached the highest frequency of being involved in researches; while the third graders were shown to be the lowest. This phenomenon is in line with the trend that most of schools are selective to give permission to the researchers to conduct researches in the third grade of junior high school or senior high school level due to the tightly-scheduled preparation for national examination.

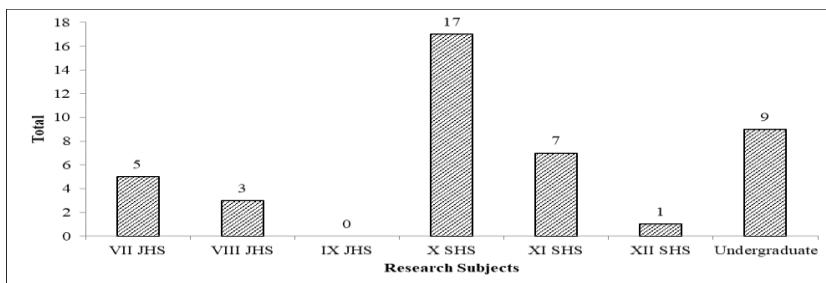


Figure 4

The Distribution of Research Subjects in Some Educational Researches with Critical Thinking Skill as the Main Concern in Indonesia

Biology Topics Selected when Conducting Studies

Biology is one of scientific courses with numerous topics. There are some topics considered easy and some remained difficult for students (Fauzi & Fariantika, 2018; Fauzi & Mitalistiani, 2018). Departing from the analysis, there were some publications that only underpinned one specific topic; while others highlighted several topics. Based on Table 2, some topics were chosen by the researchers to pilot their researches in senior and junior high school levels. Specifically, ecosystem was the most commonly selected topic for conducting the researches. As many as five publications reviewed students' critical thinking skill level under the theme of ecosystem. Unfortunately, none of them elaborated the background of the study in respect to factual condition between students' critical thinking skill and ecological topic.

Referring to other studies, ecosystem has not only been said to be one of Biology topics that is closely related to today's human activities but also becoming a challenging topic for students (Agboghoroma & Oyovwi, 2015). On the other hands, there was a review that showed the significance of instructional activities empowering critical thinking skill when students learned about the topic of environment (Burrow, 2018). As a consequence, it is of importance to impart specific reason why ecological topic was chosen to pilot an investigation about critical thinking skill, especially for the purpose of transparency to the readers.

Table 2

Three Biology Topics Mostly Selected in Educational Researches with Critical Thinking Skill as the Main Concern in Indonesia

Topics	Number of articles
Ecosystem	5
Biodiversity	3
Pollution and environmental changes	3

Further, there were two other topics commonly adopted as the main concern for researches, namely biodiversity as well as pollution and environmental change (Table 2). Each of the two was highlighted in three publications that were concerned on critical thinking skill. Similar to ecological topic, the three publications under the topic of

biodiversity did not completely explain any background related to factual condition of students' critical thinking skill. Only a study of Shopia & Mulyaningrum (2017) defined the reason behind the selection of biodiversity topic despite its disconnection to critical thinking skill. The researchers argued that the topic contained complex materials and theories, thus it needed an analysis on numerous issues of biodiversity. However, based on in-depth analysis, biodiversity as well as pollution and environmental change were said similar to the topic of ecosystem. The similarity lied on a reason that all of those three topics discussed relationships, roles, and effects of human's existence in specific environment. This portrayal indicated that Indonesian researchers were more potential to find out a solution to help students become critical thinkers and good problem solvers for their environment.

Treatments

Giving treatment aims at testing the researchers' hypotheses or at identifying the significance of specific condition upon any parameter under investigation. Based on Table 3, Inquiry Based Learning (IBL) and Problem Based Learning (PBL) constituted the most commonly used treatments in the researches about critical thinking skill. There were eight publications using IBL, and seven using PBL. Following the aforementioned treatments, scientific approach positioned the third most-used treatment. To some extents, PBL, in fact, is similar to IBL. The latter is said to be the main framework of the former. On top of that, both are categorized into scientific approach. By nature, PBL, IBL, and scientific approach stand over the similarly fundamental principle, in which students are facilitated to perform a series of scientific activities (Oguz-Unver & Arabacioglu, 2014). Critical thinker constitutes the ultimate characteristic of science (Schmaltz, Jansen, & Wenckowski, 2017). As a matter of fact, any instructional activities that lead students to scientific activities are very potential to optimally empower students' critical thinking skill.

Table 3

Three Types of Treatments or Independent Variables Frequently Selected in Educational Researches with Critical Thinking Skill as the Main Concern in Indonesia

Treatments/independent variables	Number of articles
Problem-based learning	8
Inquiry-based learning	7
Scientific approach	2

The finding of this current study also informed that most researchers preferred to implement specific instructional design as treatment or independent variable of their researches. On the other hands, researches that were focused on the influence of demographical factor were rarely found on articles published in Indonesia, despite the fact that demography is one of determining factors closely interlinked to students' learning achievement. A number of studies showed different results about the influence of demography on students' critical thinking skill. There were some studies pinpointing that demographical aspect did not significantly influence students' critical thinking skill (Demirbag, Unisen, & Yesilyurt, 2016). In addition, other study revealed that demography had significantly influenced students' critical thinking skill (Harish, 2013).

For that reason, studies on demographical influence on students' critical thinking skill need considerable improvement.

Data Collection Instruments

In conducting research, researchers need an instrument to help them collect data. Students' critical thinking skill could be measured by means of numerous instruments developed by previous researchers. Based on the graph shown in Figure 5, test has been the most commonly used instrument to collect the data about critical thinking skill. In essence, critical thinking skill constitutes a way of thinking that could be accessed or assessed based on students' answers to high-level questions. Additionally, data collection by means of test is deemed more objective than questionnaire and observation.

There were some tests that could be administered to measure students' critical thinking skill. The most common one found in Indonesian publication was Cornell Critical Thinking Tests (CCTT), together with critical thinking skill assessment in the form of essay developed by Zubaidah, Corebima, & Mistianah (2015). Unfortunately, some researchers did not inform what instruments were used to collect the data about critical thinking skill in their papers. Some who made use of test as the main technique of data collection did not inform whether the instrument had been tested in terms of validity and reliability. It is key point that validity and reliability of instruments are to be tested before being used to collect any data (Bajpai & Bajpai, 2014). In other words, the information about validity and reliability is considered crucial to convince target readers.

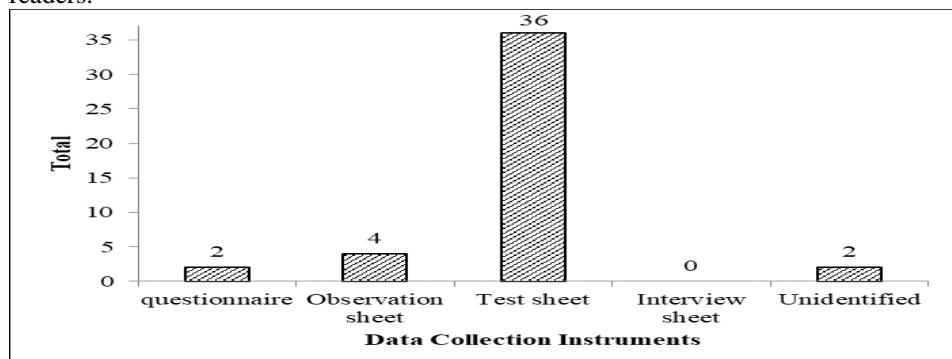


Figure 5
The Distribution of Instrument Selection for Data Collection in Some Educational Researches with Critical Thinking Skill as the Main Concern in Indonesia

Data Analysis Methods

The accuracy of method selection for data analysis would determine the level of validity of a research. Referring to the graph shown in Figure 6, there were 24 researches using quasi-experimental design (Figure 3), but only eight researches used ANCOVA as data analysis method (Figure 6). Further, Figure 6 shows that t-test was data analysis method

the researchers used the most. This finding has clarified that the researchers often used t-test to compare the achievements of two groups or classes. There were two common trends shown by the researchers in using t-test for hypothesis test. Firstly, the researchers only took the post-test data from each class, then testified them by means of t-test. Secondly, the researchers referred to pre-test and post-test data before calculating N-gain from both of the data. Afterwards, N-gain from both classes were examined by means of t-test. These sorts of trends would decrease the validity level of the researches. This inaccurate use of data analysis method is in line with the finding shown in a study of Fauzi & Pradipta (2018).

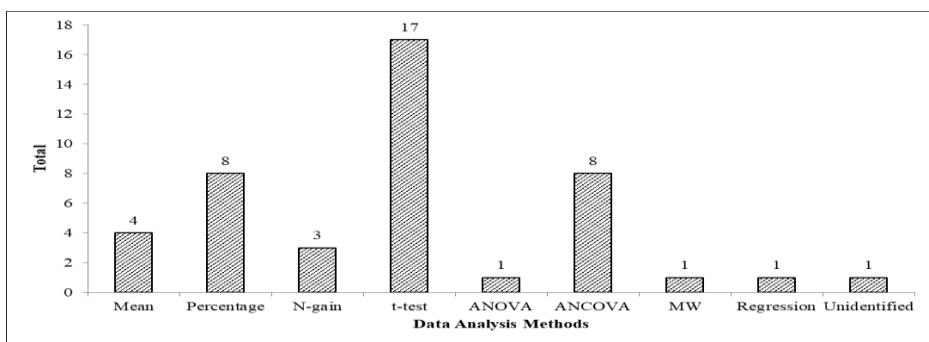


Figure 6

The Distribution of Data Analysis Method Selection in Some Educational Researches with Critical Thinking Skill as the Main Concern in Indonesia

The use of ANCOVA is highly recommended particularly when the researchers attempt to choose quasi-experimental design, where they could not select students one by one as their research subjects (only students in the determined class were possible to be chosen). By using ANCOVA in such a condition, the researchers could control external variable that might influence the relationship between independent and dependent variables. Further, by using ANCOVA, it could identify the differences that occur between groups with respect to the corrected average based on the characteristics of the research subjects shown in pre-test data (Warner, 2012). To sum up, the use of ANCOVA is recommended for quasi-experimental research with pre-test and post-test data.

CONCLUSION

In this current study, articles that highlighted critical thinking skill and were published in Biology education journals across Indonesia from 2010 to 2017 have been reviewed. The trend has been found that there was an increase in the number of publications with critical thinking skill as the main concern in the past three years. Among hundreds of publications, quantitative researches were mostly found. In addition, the tenth graders of senior high school were mostly chosen as the research subjects; while ecosystem material constituted the most chosen topic. PBL signified the most implemented treatment; while test and t-test were the most commonly used instruments for data collection and analysis. Alluding to the findings of this study, some recommendations

have been set up for further researches. Firstly, it is of necessity to raise the frequency of conducting qualitative research to investigate critical thinking skill development. Secondly, R and D that aims at developing instructional product should be targeted to increase students' low level of critical thinking skills. Thirdly, the researchers are to inform clearly about their research instruments, along with instrument validity and reliability. Finally, it is suggested that the researchers select the best-fitted test for hypothesis and research design in conducting any research.

ACKNOWLEDGEMENT

The authors would like to say thank you to Universitas Muhammadiyah Malang for support in this research.

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