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LOCAL MATERIAL BASED (LMBE) RESEARCH EXPERIENCE ON DNA EXTRACTION TO DEVELOP STUDENT'S CRITICAL AND CREATIVE THINKING SKILLS DURING COVID-19 SHUTDOWN

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Abstract

The novel Coronavirus (Sars-CoV-2) infection has caused global pandemic which resulted in school moving from classroom learning to online teaching and learning process. During pandemic, the local material-based biochemistry experiment (LMBE) was designed to boost students' critical and creative thinking skill through laboratory practice at home. The experiments asked students to design and conducting DNA extraction experiment by utilizing materials that could be easily obtained, safe to use, and affordable. The research method employed is a quasi-experimental with one-group pretest and posttest design. The participants involved in this research were 53 students who enrolled in the biochemistry laboratory class. Data of students' critical and creative thinking skills were collected through written test instrument in the form of essay and reflective LMBE-worksheet that have been through expert validation. Students found successful to design simple DNA experiment procedure to be carried out at home by utilizing easy, safe, and affordable materials. The improvement of students' high order thinking skills was indicated by the increase of the average of total scores of critical thinking from 36.95 to 67.31 with n-gain 48.14% and for creative thinking skill from 36.03 to 60.30 with n-gain 37.94%. These current results imply that LMBE-worksheet format can develop critical and skills in creative thinking of the students.

Keywords: Creative, Critical thinking, DNA extraction, Education, Student Worksheet.

1. Introduction

Biochemistry is one of the subjects that is focused on the study of chemical substances and their processes within and related to living organisms. Biochemistry teaching and learning was not only given in classroom but also in the laboratory. Biochemistry laboratory is one of the compulsory courses that must be taken by all undergraduate students at chemistry department of Universitas Pendidikan Indonesia Laboratory learning activities will help students to get in-depth comprehension of a concept that should be understood [1, 2]. Through laboratory works, students will be facilitated to make relation between the world of objects and events, as well as the world of abstract thoughts and ideas [2, 3]. Laboratory course also facilitates students to understand how science is done professionally and appreciate how scientists work to find concepts for the phenomena they are observed. These activities are also likely to set the best approach for improving concepts and students' high order thinking skills (HOTS). Hence, the laboratory exercise should be designed to promotes students to be able to think critical and creative in finding the proper solution for the problem their met through scientific method [4].

Unexpectedly, the long covid-19 pandemic has caused the routine classroom teaching could not be implemented yet including for Biochemistry laboratory course due to a long period of closure. Many alternatives have been carried out to encounter the situations, ranging from cancelling the laboratory activities, holding virtual experiments, guiding students to design experimental procedures, and encourage students to critically analyse available data [5]. Toward this purpose, we encouraged students to design an at home experiments for conducting DNA extraction utilizing easy, safe, and affordable materials. These activities were guided by local material based (LMBE) student worksheet and were designed not only to facilitate students' practical biochemistry skills, but also to develop their critical and creative thinking skills. Many studies have been reported that one of the proper instruments for improving critical and creative thinking skills of students is through and experiment activity [2, 6, 7]. Linking laboratory learning to real-world application will effectively facilitate students to construct the knowledge by themselves.

In this current article was described the profile of students critical and creative thinking skills that were encouraged by asking students to design their own mini research project about DNA extraction by utilizing local materials. Students' learning activities was guided through the LMBE-student worksheet format which linked laboratory learning to real-world applications. Students' curiosity was explored through the context of "varieties of tomatoes". The context provides students with opportunity to study the characteristic of DNA from different species of fruits or vegetables through the experiment. The LMBE format also was asked students to analyse the function of each reagent used for DNA extraction and was challenged to find out local materials with simply procedure as the way to develop critical and creative thinking skills.

2. Theoretical Framework

According to the 21st Century Partnership Learning Framework, both critical and creative thinking skills must be possessed to face the globalization era and disruption innovation. Critical thinking is described as an intellectually disciplined process of actively and skilfully conceptualizing, applying, analysing, synthesizing, and evaluating information collected as a guide to belief and action [8]. Critical

thinking is connected to both problem solving and decision making. LMBE-project facilitated students to complete each task even from distance learning. They encouraged to work out the best way to approach their group project. Through the experience given students learnt the skills to think through problem and make wise decisions. There are 12 indicators according to Ennis [9]: (i) focus on question, (ii) analysing arguments, (iii) asking and answering questions of clarification and challenge, (iv) Judging the credibility of a source, (v) observing and judging observation report, (vi) deducing and judging deductions, (vii) inducing and judging inductions, (viii) making and judging definitions, (ix) defining term and judging definitions, (x) identifying assumptions, (xi) giving decision on an action, and (xii) making interaction with others.

Creative thinking skill is explained as the whole set of cognitive activities used by people based on specific object, problem and condition, or a type of effort to use the imagination, insight, or ideas to face the situations [10]. There are four key elements of creative thinking: (i) ability to raise many ideas (fluency), (ii) ability to observe at a question or topic from different angle (flexibility), (iii) ability to raise new ideas to previous way of thinking (originality), and (iv) ability to develop or add ideas to produce more detail ideas (elaboration) [11]. Creative thinking skill provide individuals with the capacity to deal with the opportunities and challenges that must be possessed in the twenty-first century [12].

During the early 1900, all living organisms are composed of cells arising from the growth and division of other cells. The invention and improvement of microscope than led to the observation of cells and found dark staining threads in the nucleus called chromosome which carried out the information for cell heredity information in the form of genes. Chromosomes are about half DNA and half of protein. The proposed model for the structure of the double stranded DNA by James Watson and Francis Crick has made the revolutionary discovery of DNA. From this model, DNA molecules could provide the information for their own replication.

DNA is the language of life consisted of four bases: (i) adenine (A), (ii) thymine (T), (iii) guanine (G), and (iv) cytosine (C). DNA stores genetic information that and defines the phenotype of living things. Therefore, DNA has known as blueprint of living things. DNA is polymer of nucleotides. The order of long-chain monomer of nucleotide causes the similarity of organisms of their species, but different as an individual. Chromosomal DNA of eukaryotic cells is in the nucleus, while in prokaryotic cells is organized in rings of circular plasmid. DNA can be interpreted into molecules of RNAs and proteins, called flow of genetics information.

To study DNA, we must extract DNA from the cells and then isolates it from other unwanted molecules. There are three basic steps involved in DNA extraction: (i) lysis, (ii) precipitation, and (iii) purification. In the lysis, the nucleus and the cells are broken open, thus releasing DNA. Lysis cells involves mechanical and enzymatic disruption. The mechanical treatments can be carried out by grinding, vortexing, or even by put the samples into a solution containing salt. In addition, the chemical compounds that particularly used for dissolving lipid membrane, cellular protein, DNA-associated protein and free of DNA are detergents and protease. All the steps were carried out by using simple and low-cost material from daily life. The next step is conducting precipitation of DNA with an alcohol. DNA is soluble in water but insoluble in the presence of salt and alcohol. If there is a lot of DNA contained in the samples, white stringy precipitate of DNA will be visible

and can be spooled out. Once the DNA successful to be extracted, the next step is separation and characterization. Electrophoresis is one of the alternative methods that can be used to show the presence of extracted/isolated DNA in the sample and give an indication of the quality of DNA.

3. Research Method

The method was employed in this current study was quasi experimental research with pretest and posttests design [13]. The participants involved in this study are 53 chemistry undergraduate students from two classes who enrolled the Biochemistry laboratory course, which are similar in academic background. They had learned structure and functional biomolecule (previously designated as Biochemistry 1) but had not had experiences yet for conducting DNA experiments. In this lecture, students learned DNA as genetic materials. Participants' critical and creative thinking skills were assessed at two points: prior to the implementation and after the implementation of the treatment. The data were collected by an instruments test consisting of 20 essay questions which were design to measure students' understanding related the DNA concepts, critical and creative thinking skills. The test was conducting in online platform using learning management system (LMS). The data obtained was then used to identify the n-gain value [14] from the average of pretest and posttest. Critical and creative thinking skills of students were also obtained from students' laboratory report and student worksheet.

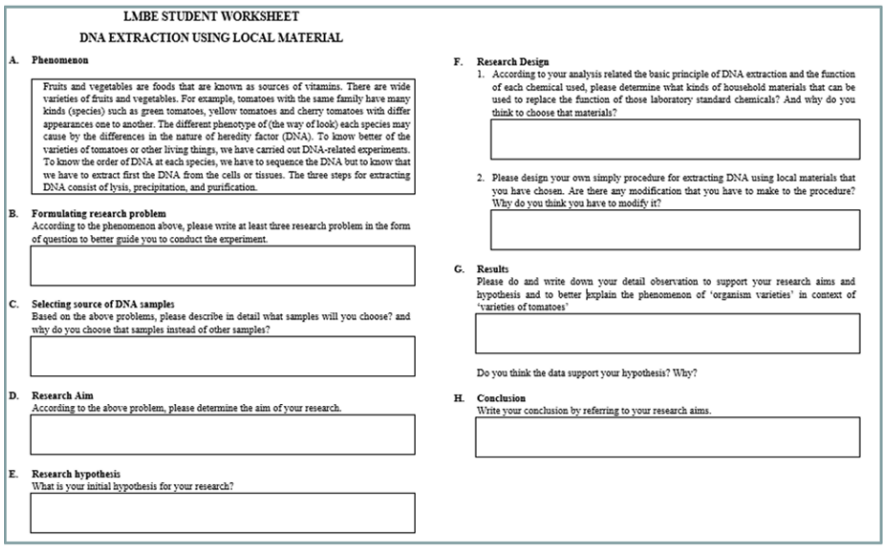
4. Results and Discussion

4.1. LMBE-worksheet: Effort to develop critical and creative thinking skills of students

The online Biochemistry work for DNA extraction and characterization was designed to facilitate student to develop their critical and creative thinking through experiment. Since the pandemic Covid-19 requested the teaching process to be held in online platform, the laboratory work should be modified to better experience the students with biochemistry laboratory skills and as well as their thinking skills. Particularly, the DNA technology was conducted in laboratory through DNA extraction and characterization experiments. The standard procedure to conduct this experiment in laboratory involved in standard chemicals such as proteinase K, sodium dodecyl sulphate (SDS), TE buffer, Tris HCl, and supporting equipment such as bench centrifuge, micropipette, glassware, etc. However, those of materials and equipment are not available at home. Therefore, students encouraged to critically think the fundamental concept of the DNA extraction in term of process and the function of each chemical. The creative thinking skill was encouraged through the inquiry how to design simple procedure by utilizing the affordable household materials. The ability of students to set experiment for scientifically explain the phenomenon may lead the multiple solutions or products [15].

The entire set of teaching and learning process was implemented a guided inquiry-based valued by science writing heuristic which supplemented by LMBE student worksheet. The worksheet requested students to propose the questions according to the phenomenon given, to analyse the basic principle of DNA extraction, the function of each chemical used for extract DNA and searching alternative household with the same function. These activities have trained students' ability to think critical in reading context and solve the problem Fig. 1.

Instead of formulating questions, students also encouraged to design the easy DNA extraction with household materials. This strategy was designed to experience students to solve problems using scientific method and to systematically generate new ideas through "at-home" laboratory experience. These steps may lead students to gain creative thinking skills [16]. The experience to use local materials can promote students' creative thinking skills in selecting laboratory materials [17]. The environmental or local wisdom-approach in learning can improve student awareness on the environmental' issues [18], build creative thinking skills and student creative attitudes [19]. Laboratory-based learning experienced students to have basic skills and performance ranging from laboratory techniques, research designing, conducting experiments, and scientific academic writing.



LMBE STUDENT WORKSHEET

DNA EXTRACTION USING LOCAL MATERIAL

A. Phenomenon

Fruits and vegetables are foods that are known as sources of vitamins. There are wide varieties of fruits and vegetables. For example, tomatoes with the same family have many kinds (species) such as green tomatoes, yellow tomatoes and cherry tomatoes with differ appearances one to another. The different phenotype of (the way of look) each species may cause by the differences in the nature of heredity factor (DNA). To know better of the varieties of tomatoes or other living things, we have carried out DNA-related experiments. To know the order of DNA at each species, we have to sequence the DNA but to know that we have to extract first the DNA from the cells or tissues. The three steps for extracting DNA consist of lysis, precipitation, and purification.

B. Formulating research problem

According to the phenomenon above, please write at least three research problem in the form of question to better guide you to conduct the experiment.

C. Selecting source of DNA samples

Based on the above problems, please describe in detail what samples will you choose? and why do you choose that samples instead of other samples?

D. Research Aim

According to the above problem, please determine the aim of your research.

E. Research hypothesis

What is your initial hypothesis for your research?

F. Research Design

1. According to your analysis related the basic principle of DNA extraction and the function of each chemical used, please determine what kinds of household materials that can be used to replace the function of those laboratory standard chemicals? And why do you think to choose that materials?
2. Please design your own simply procedure for extracting DNA using local materials that you have chosen. Are there any modification that you have to make to the procedure? Why do you think you have to modify it?

G. Results

Please do and write down your detail observation to support your research aims and hypothesis and to better explain the phenomenon of 'organism varieties' in context of 'varieties of tomatoes'

Do you think the data support your hypothesis? Why?

H. Conclusion

Write your conclusion by referring to your research aims.

Fig. 1. LMBE-format of DNA extraction experiment from fruits and vegetables.

The LMBE-format completed by several guiding questions for facilitating student discussion within group and with others. The discussion determined the research variables such as what kind of samples, how many samples, what alternatives SDS that would be chosen, and why they made selection to those materials. The alternative SDS which chosen are liquid detergent, liquid soap, dishes soap. Instead of kind of sources of detergent and soap, students also conducted experiment by varying the concentration of detergent or soap. The mixture of sterile water, baking soda (sodium bicarbonate), and table salt (sodium chloride) was prepared by student to substitute the function of buffer to maintain the native structure of DNA.

The precipitation process was carried out by students by adding certain concentration of cold alcohol. The white stringy precipitate in the alcohol layer. The question "how do you visualized the extract DNA from your samples, and do you think you get the pure DNA" were promoted students to link between the concept of DNA properties and the fact of the observations. The detail of local materials that students reported shown in Table 1.

Table 1. The list of alternatives materials used for conducting DNA extraction experiment.

Step of the extraction	Standardized chemicals	Local materials	Function
Lysis	Lisozyme / Proteinase K	Bromelain / papain* (*in this experiment no students reported the utilization of this local materials).	Degrade the protein integral membrane and other DNA-attached protein (histone protein)
	ethylenediaminetetraacetic acid (EDTA)	Warm water	Inhibitor of DNA activity (prevent the DNA degradation)
	NP-40, Sodium dodecyl sulphate (SDS), Triton-X, Tween-20, etc.	Detergent, dishes soap, liquid soap	Dissolve cell membrane and release the content of the cells
	Tris-HCl, HEPES	Kitchen salt, water, and baking soda	Stabilizing the pH to maintain the native structure of extracted DNA
Precipitation	Phenol: Chloroform =1:1 ethanol 70-99%	Ethanol 70-99%	Precipitates DNA from the solution.

4.2. Students' critical thinking in conducting local material-based DNA experiment

The profile of students' critical and creative thinking skills after the implementation of guided-inquiry valued by science writing heuristic (SWH) that supplemented by LMBE-format were obtained from the instrument test and student report. The instrument test measured the development of students' critical and creative thinking skills at each indicator.

Student critical thinking was observed by eight indicators: focus on question, analysing arguments, asking and answering questions of clarification and challenge, judging the credibility of a source, observing and judging observation report, inducing and judging inductions, identifying assumptions, and deciding on an action. Meanwhile for the creative thinking skills was evaluated by four indicators: fluency, flexibility, originality, and elaboration.

To understand the students' comprehension, pretest and posttest was done [20]. Here, student' critical thinking development was measured by comparing students' score achievement on pretest and posttest. Posttest was given after the implementation of the teaching and learning strategy. The improvement of students'

critical thinking skills as an impact of the treatment were evaluated by the average score of n-gain as shown in the Fig. 2.

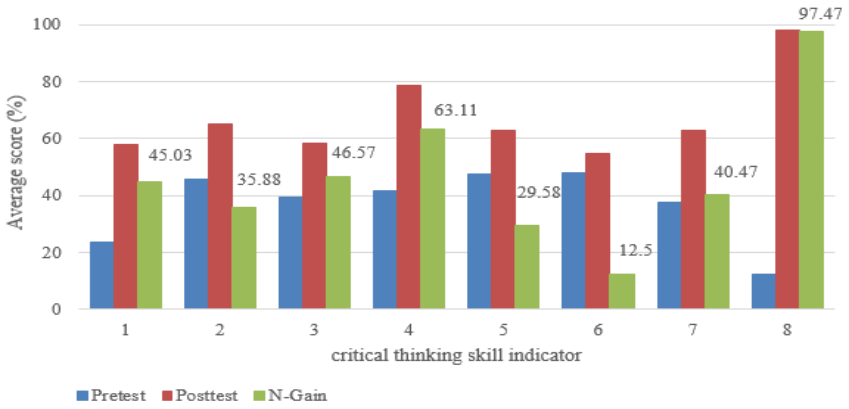


Fig. 2. Students' critical thinking at each indicator: (1) Focus on question, (2) Analysing arguments, (3) Asking and answering questions of clarification and challenge, (4) Judging the credibility of a source, (5) Observing and judging observation report, (6) Inducing and judging inductions, (7) Identifying assumptions, and (8) Deciding on an action.

As can be seen in Fig. 2, that highest average score of N-gain at each indicator of critical thinking skills was of 97.47 for indicator of determine action, while the lowest average score of n-gain was 12.50 for inducing and judging inductions indicator. However, from the data, it was observed that there is an alternation of students' critical thinking before and after the implementation of LMBE experiments, suggesting the treatment gave positive impact on students' critical thinking. The moderate improvement designated by category of N-gain, suggesting the habituation of student-centred approach and inquiry based that integrated daily life experience can train the development of critical thinking skill. This current finding supports the previous research that laboratory activities and active learning enhanced student critical thinking skill [21]. On the other hand, the expository laboratory (cooked book experiment) was obtained to be failure to improve and enhanced student critical thinking skill [22, 23].

The students' report analysis showed that students can find the local materials which have the same function with the standard chemicals used in the regularly laboratory work for DNA experiment. The picture of DNA extracts was also figure out in the students' report. The results from all students' report showed that almost all group students succeed to obtain the extract DNA, indicating the local material-based procedure that they designed enable to use for conducting DNA extraction experiment at home or to learn DNA technology simply utilizes procedure and easy, safe and affordable materials.

The most selected samples as source of DNA are strawberry. Other chosen samples are variants of banana, apple, spinach, eggplant, tomato, cucumber, and orange. The most reasons why they selected the samples are the easiness to get the samples, the easily to be disrupted, and the water content of the samples. Only few of students included the reason of sample selection according to genomic copy per cells of the samples. The presentation session was also carried out to give students opportunity to

share their experiment and to elaborate the way of their thinking in solving the problem and completed the task. Students' report also strengthen that the LMBE can facilitate the students' critical thinking skill development.

4.3. Creative thinking skills of students in designing local material-based DNA experiments

Creative thinking skill shown the capacity of individual to deal with the opportunities and challenges that must be possessed in the twenty-first century [13]. Here, the development of creative thinking skill was evaluated by four key elements of creative thinking: ability to raise many ideas (fluency), ability to observe at a question or topic from different angle (flexibility), ability to raise new ideas to previous way of thinking (originality), and ability to improve or add ideas to produce more detail ideas (elaboration). The design of LMBE format encouraged students to develop their own experiment starting from selecting samples, determine the materials, designing the procedure, and conducting the experiment. The improvement of students' creative thinking skills is presented in the Fig. 3.

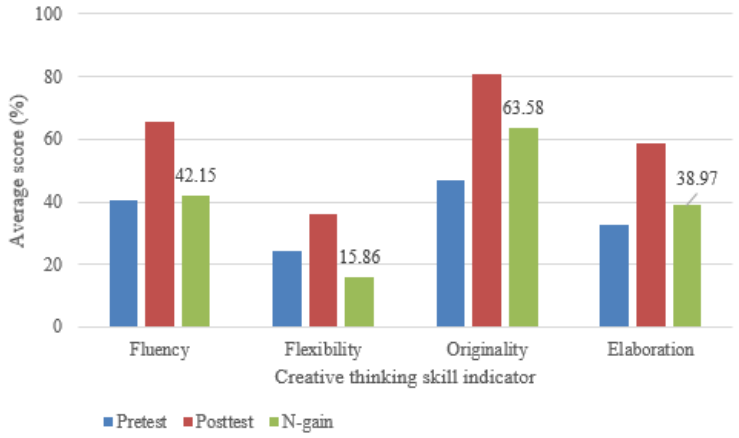


Fig. 3. Students' creative thinking at each indicator: Fluency, Flexibility, Originality, and Elaboration.

As can be seen in Fig. 3, that there is an improvement of all students' creative thinking skill indicator. The highest average score of N-gain was of 63.58 for indicator ability to raise new ideas to previous way of thinking (originality). The ability of all students to design the simple procedure for extraction DNA indicated by the successful of students to get the "white stringy of DNA" reflecting their ability for originality aspect. In contrast, the ability of students to look at a question or topic from different angle (flexibility) reached the lowest average score of n-gain (15.86 %), suggesting the habituation of creative-based approach required to be carried out in the teaching and learning process.

Student report analysis performed that LMBE-format facilitated the development of students' critical and creative thinking skills. Students' ability to give an argument why they selected sample A / B / C / D / etc. as DNA sources and what kinds of household materials that can be chosen, and how they would carry out the experiment

using local materials meet fluency indicator of creativity. Deciding the household materials for replacing standardized chemicals or even modified the standardized chemicals concentration reflect flexibility indicator of creativity. Originality indicator of creativity was evidently shown by the ability of students to discover the alternatives chemicals from household materials. The ability of students to elaborate on the discussion in the laboratory report, instead of constructing experiments were clearly demonstrated the elaboration element of creativity.

From the current results, it shown that LMBE experience can foster students' critical and creative thinking skills as well Fig. 4. The n-gain of the critical thinking skill was 67.31%, while the n-gain of the creative thinking skill was 60.30%. This result implies that both of critical and creative thinking skills were enhanced with the implementation of local based material experiment. The LMBE also served as an alternative to develop the high order thinking for students during at home.

In addition, the limitations of this study need to be considered because this research was conducted when the COVID-19 outbreak occurred online or from home studies that need additional strategies for enhancing students' comprehension [24-33].

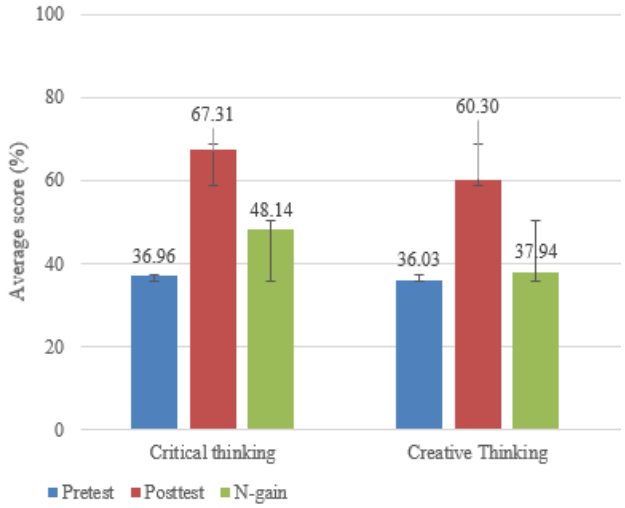


Fig. 4. Students' critical and creative thinking skills.

5. Conclusion

The twenty first century generation should be possessed the critical and creative thinking skill to thrive in our fast-changing world. Therefore, the teaching and learning process that oriented in fostering both critical and creative thinking skill should be developed in all learners. Teaching strategy should be moved to focus on stimulating both of those skills. The current findings demonstrate that critical and creative approach in local material-based DNA extraction laboratory work potentially enhances students' critical and creative thinking skills domain in applied university students. The current findings suggest that by spending some time to think the proper and best strategy on critical and creative thinking skills development, we can contribute to preparing students to equip the competencies that required for struggling in the globalization era and innovation disruption after graduation.

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