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The Effectiveness of Bioinformatic Module Based on Problem-Based Learning Toward Technology Literation Skills of Biology Master Program Students

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Abstract- **Bioinformatics is one of the elective courses in the master degree of Biology study program, Universitas Negeri Malang, which prepares student technology literacy skills related to the field of biology through the use of available technology and information. This is in accordance with the learning outcomes (LO) that must be possessed by students and contained in the lecture plan for the semester course. Bioinformatics modules have been developed and the purpose of this study is to test the effectiveness of using bioinformatics modules with problem-based learning (PBL) models of technology literacy skills. The research method was pre-experimental with a one group pretest-posttest study design and using the observation sheet of technology literacy skills as an instrument of data collection. The test results of the effectiveness of bioinformatics modules obtained N-gain value of 0.71 with the category of module effectiveness classified as high. Descriptive analysis results also showed that bioinformatics modules were able to improve student technology literacy skills based on four aspects, namely aspects of computer-based technology, design aspects, aspects of selection and use, and product aspects.**

I. INTRODUCTION

Universities as providers of higher education have an obligation to guarantee the competence and qualifications of human resources, so that they are more productive and able to build national civilization through education in accordance with what has been determined in the Indonesian Qualifications Framework (IQF) based on the Republic of Indonesia Presidential Regulation Number 8 of 2012. Learning outcome at level 8 or equivalent to Applied Masters and non-Applied Masters must have the qualifications to develop science and technology through inter/multi-disciplinary research, innovation, and testing (Curriculum Development Higher Education Team, 2014). Universities also need to continue to develop and improve learning so that they can guarantee the quality of human resources who have the skills and competencies to face the

challenges of the 21st century. Seven skills and competencies are (1) critical thinking and problem solving skills, (2) collaboration and leadership, (3) agility and adaptability, (4) initiative and entrepreneurial spirit, (5) being able to communicate effectively both orally and in writing, (6) being able to access information technology and analyze it, and (7) having curiosity and imagination (Wagner, 2009).

Based on qualifications at level 8 IQF, namely developing science and technology through research, and skills in accessing information technology and analyzing it is one of the skills that students must possess in facing the challenges of the 21st century called technology literacy skills (Greenstein, 2012). Technology literacy is the ability of individuals to be able to work independently or with other people, responsively, appropriately and effectively using technology tools to access, manage, integrate, evaluate, create and convey information (Judson, 2010). Technology is an integral part of life that cannot be separated, so technology literacy skills are very important as part of the life skills that must be owned (Jones, Windsor, & Visinescu, 2011). Technology literacy skills are one example of the action skills that must be possessed in facing the challenges of the 21st century. Technological literacy skills involve several aspects, such as basic knowledge of computational technology, designing by utilizing technological tools, selecting and using the right technology and produce technology-based products (Greenstein, 2012). Technology literacy skills can be trained through learning, one of which is in bioinformatics learning.

Bioinformatics is one of the elective courses in the magister level of Biology study program, Universitas Negeri Malang. This course is prepared to be able to practice student technology literacy skills related to the field of biology through the use of available technology and information. This is in accordance with the learning outcomes (LO) that students must have contained in the semester lecture plan of bioinformatics courses. The LO contains the understanding the nature and principles of molecular biology, basic principles and procedures of molecular engineering in the field of biology, principles of molecular data analysis based on characteristics and uses of data analysis by using information technology both online and offline for technology development in order to improve human welfare.

Bioinformatics is interdisciplinary in that it involves various studies of science such as molecular biology, mathematics and information engineering (IT). Bioinformatics is also interpreted as the use of computational tools to analyze and interpret data on molecular biology (Bayat, 2002). Bioinformatics studies consist of 3 elements of activity, namely data center or database, data analysis, and prediction (Witarto & Sajidan, 2010). Bioinformatics is a study that continues to evolve and has an impact on the advancement of biotechnology (Kumar & Chordia, 2017; Tripathi, 2000). Bioinformatics has been applied to solve problems through various studies carried out such as finding compounds for antiviral therapy (Speck-Planche & Natalia DS Cordeiro, 2011), identifying pathways that cause an illness (Barrenäs, 2012), and applications from bioinformatics in searching, designing, and develop drugs based on *in silico* approach (Shah, Rathod, Basuri, Modi, & Parmar, 2015). *In silico* studies and docking for the discovery of candidate drugs is one of the material presented in bioinformatics learning that can train students' technology literacy skills. However, from observations during teaching and learning that conducted in January 2019, it was found that 92% of students had difficulty in attending lectures. Difficulties faced by students are related to learning material (25%), learning methods (16%) and learning resources (67%), thus impacting the low literacy skills of students. Based on this information, efforts are needed to find solutions to existing problems. One effort that can be conducted to overcome these problems is by developing a teaching material that can help students in learning which contains material, methods, boundaries and ways of evaluating learning that are arranged in an interesting and systematic manner (Widodo & Jasmadi, 2008) Based on observations, 92% of students want teaching materials in the form of print modules that contain clear and complete information related to bioinformatics analysis for drug discovery.

Modules are defined as one form of teaching material in which there is a set of planned learning experiences, arranged in a complete and systematic manner and designed to help achieve learning goals effectively and efficiently (Daryanto, 2013). The use of modules in the learning process has several advantages, including being flexible, increasing students' sense of responsibility for learning, assessment can be done throughout learning, providing feedback from learning, and providing opportunities to relearn material in modules (Vidal Rodeiro & Nádas, 2012; Mulyasa , 2005).

The developed module in this study is a bioinformatics module entitled "Analysis of the Potential of Natural Compounds in Silico as Drug Candidates with the Problem Based Learning (PBL) Model". PBL syntax is used to facilitate students in compiling knowledge, developing expected abilities and skills, and developing self-reliance and self-confidence (Arend, 2012), obtaining concepts and essence of the material studied based on problems that exist in real life (Abdullah, Tarmizi, & Abu, 2010; Akcay, 2009). The contents of the module developed are the results of bioinformatics research related to *in silico* drug discovery.

Developed modules based on research results have advantages, including being able to improve the ability of students to answer the challenges of the 21st century (Juliana et al., 2016), providing real experience because it contains information based on research results so that it can expand and deepen the material implicatively (Primiani, 2014), as well as helping students to achieve the expected competencies in learning (Wenno, 2017) specifically technology literacy skills. Modules that are developed based on research are an important way to develop knowledge-based education (Amin, 2015).

II.   METHODS

The research conducted was a pre-expertmental study with a one group pretest-posttest research design (Leedy & Omrod, 2005). The bioinformatics module titled "Analysis of the Potential of Natural Compounds in Silico as Drug Candidates with Problem Based Learning (PBL) Model" which has been developed and meets the requirements of validity and practicality is then tested for its effectiveness on technology literacy skills in Bioinformatics course in magister level of Biology students at Universitas Negeri Malang. The instrument for data collection uses observation sheets of technology literacy skills by observers consisting of observations 1 and 2.

Data from the observation of student technology literacy skills using the next observation sheet were analyzed using the N-gain value to measure the effectiveness of the module using the following formula:

$$\text{N-gain (g)} = \frac{skor\ obs\ 1 - skor\ obs\ 2}{100 - skor\ obs\ 1}$$

The data obtained are then interpreted using the effectiveness criteria adapted from Hake (1999), showed in Table 1.

Table 1. Criteria for Module Effectiveness Based on N-Gain Value.

Percentage Range (%)	Criteria
$0,70 < g \leq 1,00$	High level
$0,30 < g \leq 0,70$	Middle level
$0,00 < g \leq 0,30$	Low level

Data from observations on student technology literacy skills were also analyzed descriptively in each aspect and then interpreted with the level criteria of technology literacy skills adapted from Greenstein (2012) in Table 2.

Table 2. Criteria for Score in Technology Literacy Skills

Score	Criteria
1	*Novice*
2	*Basic*
3	*Proficient*
4	*Exemplary*

III.   RESULTS

The results of testing the effectiveness of bioinformatics modules entitled "Analysis of the Potential of Natural Compounds in Silico as Drug Candidates with Problem Based Learning Model (PBL)" on student technology literacy skills analyzed using the N-Gain formula obtained as follows (Table 3).

Table 3. Test of Module Effectiveness Based on N-Gain Value

Observation 1 (average)	Observation 2 (average)	*N-gain*	criteria
53.13	86.46	0.71	high

Observation data 1 and 2 conducted by observers on student technology literacy skills in bioinformatics learning using teaching materials in the form of bioinformatics modules were analyzed descriptively on four aspects in technology literacy skills: (1) computer-based technology, (2) design, (3) selection and use, and (4) products. The following is the observation of technology literacy skills based on computer-based technology aspects in Figure 1.

From this picture it is shown that in the second observation, all students (100%) had exemplary abilities from observation 1 which was still at the level of 32%. Thus all students who at observation 1 were at the proficient level, on observation 2 increased to exemplary.
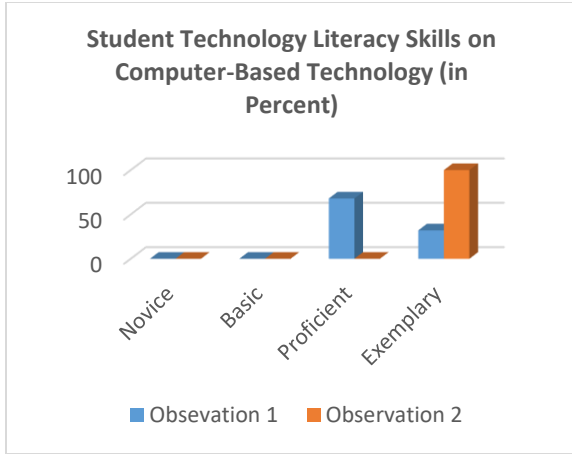
Figure 1. Student Technology Literacy Skills on Computer-Based Technology Aspects

Descriptive analysis of data from observations of technology literacy skills based on the second aspect, namely design, is presented in Figure 2. From the data, it can be explained that there is a change in level, namely on observation 1, amounting to 84% (notice) and 16% (basic) to 68% (proficient) and 32% (exemplary). There is a significant level change from notice and basic to become proficient and exemplary.
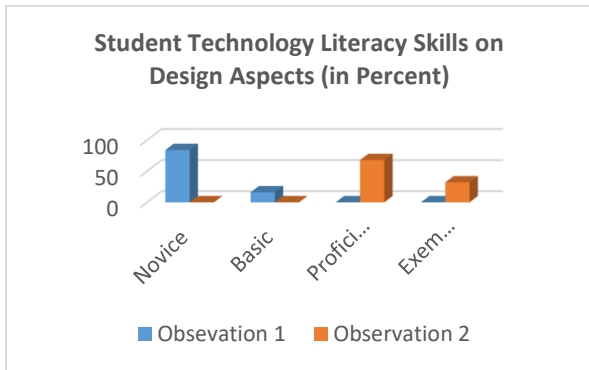

Figure 2. Student Technology Literacy Skills on Design Aspects

Descriptive analysis of data from observations of technology literacy skills based on the third aspect, namely selection and using, is presented in Figure 3. Data from figure 3 shows that there is a change in level, namely in observation 1 68% of the basic level becomes proficient with the same percentage and 32% proficient increases to exemplary with the same percentage as well.
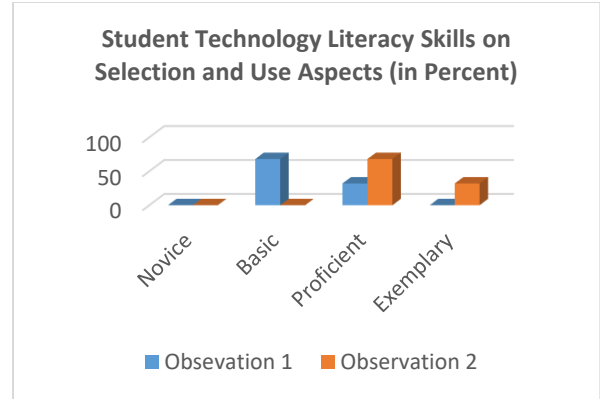

Figure 3. Student Technology Literacy Skills on Selection and Use Aspects

Descriptive analysis of data from observations of technology literacy skills based on the last aspect, namely products, is presented in Figure 4. The observation of the highest level is basic (84%) and the remainder is proficient (16%), but only at the basic level is only 16 %, while proficient increased to 50% and exemplary by 34%. The product level shows a significant level increase.
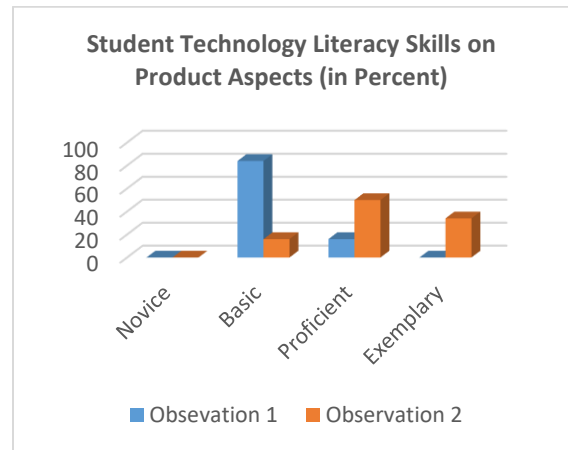

Figure 4. Student Technology Literacy Skills on Product Aspects

Overall the results of observations indicate that there is an increase in levels for all aspects that are determined, namely student technology literacy on (1) computer-based technology, (2) design, (3) selection and use, and (4) products.

IV. DISCUSSION

In modern society, information and communication technology has developed as a tool to change the education system, support economic development through the creation

of new products and services, provide access to information and expertise to support improvements in all fields of education (Kaeophanuek et al., 2018). This is relevant to Galbreath's (1999) explanation that at this time we have entered an era of knowledge which is marked by all activities based on telecommunications and computers that have developed in the previous era. ICTs provide facilities and resources for collecting and analyzing data, making multimedia presentations, and gaining deeper knowledge for teachers and students (Smith, 2015). In the digital era, it is well known that digital technology plays an important role. Therefore, the gap in the accessibility of digital devices is reduced and the opportunity to access technology to create equality needs to be expanded. However, there is a new impact, namely the emergence of problems in the form of students' failure to understand how to use these technologies in the learning process. Although students are able to access technology, they cannot use it efficiently, especially in the learning process (Kaeophanuek et al., 2018).

Bioinformatics is the application of information technology in biology and learning. The bioinformatics module entitled "Analysis of the Potential of Natural Compounds in Silico as Drug Candidates with Problem Based Learning (PBL) Model" as a product produced and compiled based on the results of research related to in silico drug discovery aims to train student technology literacy skills during the learning process facilitated by the module. Technology literacy skills are one of the action skills students must possess to face the challenges of the 21st century that have made technology a part of everyday life (Greenstein, 2012).

Students' technology literacy skills are trained through learning activities and training activities arranged in bioinformatics modules. The effectiveness of the use of modules on student literacy skills can be determined through the effectiveness test carried out by implementing modules in learning. The effectiveness of the module is a module quality criteria seen from the presence or absence of influence on the quality of its use, namely the results desired by the researcher on the use of modules that have been produced (Plomp & Nieveen, 2013). Related to this research result through observation during teaching and learning process, Kaeophanuek (2018) suggest that to develop digital literacy must be developed three skills, namely: information management skills, the use of digital tools and the creation of new content and information consolidation. Three skills are based on the process of developing cognitive skills, which must be integrated into each step of the development process.

The module effectiveness test is related to technology literacy skills carried out on four aspects, namely computer-based technology (basic knowledge of computational technology), design (making designs using technology tools), selection and use (selection and use of appropriate technology), and products (produce with the use of technology). Based on observations 1 and 2 conducted on the module implementation activities in bioinformatics learning, descriptively showed that there was an increase in technology literacy skills in all four aspects.

Based on the results of descriptive analysis of observational data shows that aspects of computer-based technology on observation 1, 68% of students are at the level of proficient and 32% exemplary who are the top two levels of technology literacy skills. Observation data 2 shows an increase in this aspect to 100% of students able to reach the exemplary level. This aspect is the most basic aspect of technology literacy skills. This aspect also assesses student technology literacy skills based on the ability of students related to the basic operation of computing devices in supporting learning.

The results of observations on technology literacy skills in the design aspects showed that in observation 1, the majority of students were at the lowest two levels, namely novices (beginners) as much as 84% and basic (basic) 16%. Observation data 2 shows a change in this aspect. Students who were previously at the lowest two levels experienced an increase by being on the top two levels, as many as 68% of students were at the proficient level and the other 32% were at the exemplary level. The design aspect is an aspect of technological literacy related to the ability of students to compile research designs using computing devices.

In the third aspect, namely selection and use, the majority of students from observation 1 were at a basic level of 84%, proficient as much as 16% and there were no students who reached the exemplary level. However, the results of observation 2 showed an increase in student technology literacy skills in the aspects of selection and use with the reduction of students at the basic level to 16%, the increase in the proficient level to 50% and there were students who were able to reach the exemplary level of 34%. The aspects of selection and use in technology literacy skills assess the ability of students to choose, access and run related software in conducting research using computing devices.

The final aspect of technology literacy skills is the product. Descriptive observations showed that there was an increase in students' technology literacy skills in this aspect from those at the basic level as much as 68% and 32% proficient from observation 1 to become proficient at 68% and

exemplary 32% from observations 2. This product aspect assessed student technology literacy skills based on the ability of students to analyze and interpret the output obtained from the use of computing devices and the ability to compile the results of research that has been done.

Observation data were tested quantitatively using N-gain analysis to obtain the effectiveness of the module on student technology literacy skills. The results of the analysis obtained that the average value of N-gain from the observation of student literacy skills is equal to 0.71. This value is interpreted using module effectiveness criteria based on N-gain so that the module tested has high effectiveness criteria for improving student technology literacy skills.

Through guided reading, teachers are better able to make instant pedagogical decisions in response to students' reading and thinking skills. In guided literacy allows the teacher to guide students in taking strategic actions as they read, analyze, synthesize, and evaluate the texts prepared (Greenstein, 2012; Plomp & Nieveen, 2013). However, to achieve this goal, the teacher must be critically aware of his decision because he integrates reading and digital literacy skills into guided reading lessons (Van Allen, 2016). In learning, teachers integrate digital tools and technology by exploring content and problems from various perspectives (in this case is four aspects: aspects of computer-based technology, design aspects, aspects of selection and use, and product aspects), while teaching students to critically analyze and evaluate the texts prepared (developed module).

V. CONCLUSION

Effectiveness test of the bioinformatics module entitled "Analysis of the Potential of Natural Compounds in Silico as Drug Candidates with Problem Based Learning (PBL) Model" obtained an N-gain value of 0.71 indicating that the use of these modules in bioinformatics learning has a high level of effectiveness. The use of the module also shows the improvement of student technology literacy skills both in the aspects of computer-based technology, design, selection and use, and products.

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