

The Effect of e-Bioinformatics Module (e-BIMO) in Forensic Science Theme on High School Students' Conceptual Understanding in Genetics Concept

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Abstract

The study tried to find out the effect of e-Bioinformatics Module (e-BIMO) by using SMS tools for forensic science theme towards high school students' conceptual understanding of genetics. Quasi-experimental method was applied with pretest-posttest control group design in this study. The class XII MIPA A was used as experimental class, while XII MIPA B was control class at one of the senior high schools in Tangerang, Indonesia. Technique in collecting data were tests which were carried out to measure students' conceptual understanding. The result of the research showed that the average score of conceptual understanding in control class was 65.2 which belonged to sufficient category, meanwhile, in experimental class was 77.9 which belonged to good category. Analysis of hypothesis test was done through Mann Whitney Test for conceptual understanding and obtained p-value of 0.027 (<0.05). It could be concluded that the use of e-BIMO with SMS tools for forensic science theme had significant effect on high school students' conceptual understanding in genetics.

Keywords: Bioinformatics Education, Conceptual Understanding, e-BIMO, e-Module, Genetics Concepts

INTRODUCTION

Etobro and Banjoko (2017), Hera (2017), and Waskito et al. (2020) assert that genetics is among the biology instructional materials that is difficult to comprehend, abstract, and not applicable to everyday life. The assertion is in agreement with the findings of Fitriana et al. (2022) in which they reveal that Banten students have problems comprehending foreign phrases and concepts regarding cell division and inheritance of traits, chromosomes, genes, DNA, and RNA.

Based on the results of the interviews conducted in a senior high school in Tangerang, Indonesia. Both teachers and students who are already accustomed to using smartphones will gain benefit from this school. The interviews that were conducted with biology teachers at one of the senior high schools in Tangerang, Banten showed that the students' understanding of the genetic lessons was poor up until now; therefore, it is important to improve their conceptual understanding before they continue studying further. This is in line with the research conducted by Hartono et al. (2023) and Nainggolan et al. (2023) that students' conceptual understanding is still weak in genetics material, there is a need to increase understanding. The developing concept of biology, especially molecular genetics, has great potential for students to understand genetics material holistically (Sari et al., 2022). Molecular genetics is fundamental to the advancement of many applied sciences, including forensics, agriculture and medicine (Wulandari et al., 2021).

The concept of molecular genetics that can be raised in learning is forensic science. This is an applicative and contextualised form of genetics learning. The concept is also related to the substance of genetics in the inheritance of traits (Sandwinata, 2019). However, the concept of science forensics in learning has not been widely studied. This can be an attraction of learning so that students feel the applicative form of genetics material in everyday life. As molecular genetics research increases, computational technology is needed in genomic data analysis, so a new branch of science called bioinformatics emerged (Paul, 2015).

Bioinformatics is an emerging interdisciplinary field encompassing the biological sciences, computer science, and information technology (Sari et al., 2022). The application of bioinformatics in genetics aims to analyze and manage biological data, such as: DNA, RNA, and proteins (Nurfadillah et al., 2023; Pradana et al., 2019). There are three main objectives of bioinformatics: organizing data, developing tools to analyze biological data, and interpreting the results to obtain information (Edi, 2017; Sari et al., 2022).

The process of learning biological concepts in genetics requires bioinformatics learning resources equipped with various tools so as to provide weighty and interesting genetics learning outcomes. In addition, these tools are useful for reducing the impact of factors that inhibit students' conceptual understanding (Pradana et al., 2019). It is supported by the result of the study conducted by El Islami & Sari (2023), which discovered that bioinformatics learning was generated by the digital learning medium named e-BIMO, which stands for electronic Bioinformatics Module, including bioinformatics-related learning activities. In doing the research for forensic science using Sequence Manipulation Suite (SMS) bioinformatics tools.

The concept of genetic substance in the genetic material being studied is combined with SMS technology using the concept of bioinformatics. The set of JavaScript applications used for creation, formatting, and evaluation of DNA sequences constitute SMS (Stothard, 2000). It is important that students understand the concept of DNA sequencing to effectively use the SMS tool. To carry out DNA sequencing and identification of DNA using Ident and Sim menu, students must understand the concept (Mukhlisa, 2021).

Learning activities e-Bioinformatics Module (e-BIMO) using Sequence Manipulation Suite (SMS) tools can be done through Computational Inquiry based Teaching (CIbT) which is needed as a bioinformatics learning strategy in high school. Research results Fortmann et al. (2020) stated that through the development of CIbT learning aims to increase confidence in analyzing data and learning experiences for students through the CIbT learning model.

Learning activities in CIbT steps can be carried out at several stages including: orientation, conceptualization, investigation, conclusion, and discussion (Sari et al., 2022).

There were studies conducted regarding the combination of forensic science and bioinformatics learning as the means of exploring the DNA information and its applications in real-world settings (Al Hakim et al., 2022; Zulkifli et al., 2021). The bioinformatics-based learning can be promoted with the help of the Bioinformatics Module combined with the Computational Inquiry-based Teaching (CIbT) approach (El Islami & Sari, 2023; Sari et al., 2022). In view of the increasing importance of bioinformatics in molecular genetics education, there should be further research conducted to determine the effects of utilizing the Sequence Manipulation Suite (SMS) software tools in the forensic science settings on students' conceptual understanding of genetics.

METHOD

This research used a quasi-experimental design. This involved the use of pretest-posttest control group design where both experimental and control groups were subjected to pre-tests and post-tests to evaluate their changes in learning achievement after instruction. Experimental group received instructions that incorporated the use of the software known as Sequence Manipulation Suite (SMS), while the control group received the same instructions but without SMS.

The subjects were selected using the purposive sampling technique depending on the established characteristics of the research subjects at one of the senior high schools in Tangerang, Indonesia. The number of minimum participants was calculated based on the requirements of multivariate analysis in line with the three variables used in this research that is one independent variable and two dependent variables. As per the suggested minimum ratio of 10 participants per variable, a total of 30 participants was needed. This research had 60 subjects consisting of 30 students from Grade XII MIPA A as experimental group and 30 students from Grade XII MIPA B as the control group.

The data collection was carried out using both test and non-test instruments. The test instrument was a constructed-response test designed to measure students' conceptual understanding, while the non-test instrument was given in the form of a questionnaire. The conceptual understanding test included items measuring three indicators of conceptual understanding. Before conducting the study, the instrument was validated by experts in Biology Education and Science Education.

Validity and reliability test instruments are included in the concept understanding questionnaire measurement test instrument analysis method. The validity test used the Product

Moment formula with the assistance of SPSS 25.0 application (Pramesti, 2014). In making decisions in the validity test, if the result is $> r_{table}$, then the item is valid. When the result is < 0.05 then the item is valid. But if the p-value is > 0.05 , then the item is invalid. The reliability test uses the Cronbach Alpha method with the assistance of SPSS 25.0 application. In making decisions in the reliability test, if the r_{Alpha} value is $> r_{table}$ then the question is reliable. And when $r_{Alpha} < r_{table}$ then the question is not reliable. It can be said that the instrument is reliable if the r_{count} value is $> r_{table}$ with a significance level of 5%.

The methods of data analysis applied include parametric statistics in the concept understanding test. Parametric statistics carry out pre-requisite tests and hypothesis tests. The normality test is a pre-requisite test, which is used to find out whether the tests of the two sample groups are normal or not. The test used in the normality test includes Kolmogorov-Smirnov test. In conducting the normality test using SPSS version 25.0 software. The criteria for the test apply significance level of 0.05. When the significance level ≥ 0.05 , then the data is said to be normally distributed. Data which is normally distributed is then subjected to the homogeneity test. The test applied in homogeneity test includes Levene test. The test criteria adopted a significance value of 0.05. If the significance value is greater than or equal to 0.05, the data set will be considered homogeneous. Hypothesis testing is conducted once the data is determined to be normally and homogeneously distributed. The test used in this case is the t test (paired sample t test) that uses SPSS 25.0 software. The test criteria adopted a significance value of 0.05. If the data is not normally and homogeneously distributed, a non-parametric statistical test will be used and will adopt the Mann Whitney Test formula with the hypothesis $Sig < 0.05$, the hypothesis will be accepted, while if $Sig > 0.05$, the hypothesis will be rejected. The test criteria adopted a significance value of 0.05. If the significance value is smaller or equal to 0.05 then:

H_0 : The e-Bioinformatics Module (e-BIMO) using Sequence Manipulation Suite (SMS) tools has no effect on students' conceptual understanding in genetics concept.

H_a : The e-Bioinformatics Module (e-BIMO) using Sequence Manipulation Suite (SMS) tools affects students' conceptual understanding in genetics concept.

RESULTS AND DISCUSSION

The control group students showed a mean concept understanding value of 15.7 (pre-test) and 65.2 (post-test) (fair), whereas the experimental group students gave a mean value of 18.3 (pre-test) and 77.9 (post-test) (good). This is because the conceptual comprehension test has a question on how the problem was solved by utilizing bioinformatics knowledge. Figure

1 is a graph of the average value of the conceptual knowledge of students in genetics learning, categorized into control and experimental groups.

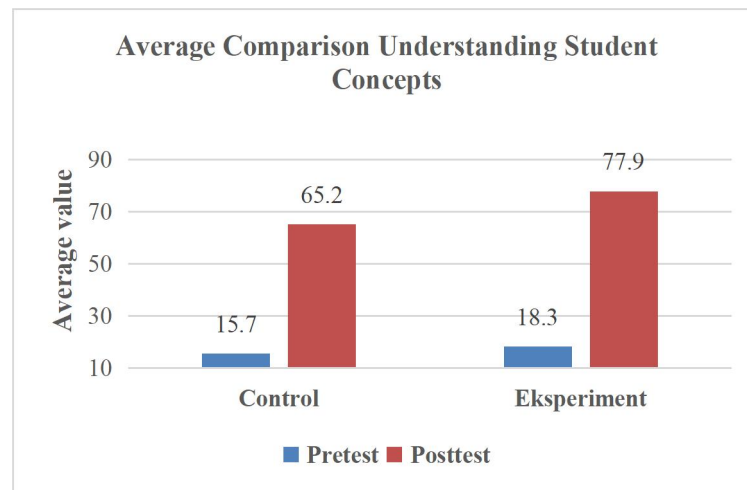


Figure 1. Average Comparison of Students' Concept Understanding

The data was then subjected to a test prerequisite, which is the normality test by using the SPSS version 25.0 software. Results from the Kolmogorov-Smirnov normality test were obtained a value of p-value from pretest of control class of 0.200. Posttest of control class data is 0.005. Pretest of the experimental class data is 0.000 and posttest of experimental class is 0.200. This means that in the normality test of posttest control class ($0.005 < 0.05$) and pretest of experimental class ($0.000 < 0.005$) data is not normally distributed. When a data is not normally distributed, then non-parametric statistical test is performed, which is the Mann Whithney test and the Mann Whithney hypothesis test was obtained a value of p-value of 0.027 ($0.027 < 0.05$), it means that the hypothesis is accepted, thus there is an effect of using SMS tools for science forensics on students' conceptual understanding on genetics material. Table 1 indicates the outcome of the analysis of the impact of SMS applications on students' conceptual knowledge.

Table 1. Results of Data Analysis of Students' Concept Understanding

	Control Class		Experiment Class		
	Pretest	Posttest	Pretest	Posttest	
N	30		30		
Test normality	<i>p-value</i> = 0.200	<i>p-value</i> = 0.005	<i>p-value</i> = 0.000	<i>p-value</i> = 0.200	The <i>p-value</i> < 0.05 , meaning that the scores are not normally distributed in the control and experimental groups.
Test homogeneity		0.015			The <i>p-value</i> > 0.05 means that the control and experimental group data are homogeneous.
Non-parametric statistical test (Mann Whitney test)		0.027			The <i>p-value</i> of $0.000 < 0.05$ means that H_0 is rejected and H_a is accepted.

Bioinformatics-related forensic science learning by way of use of SMS tool in genetics will enable students to appreciate the process of analyzing and manipulating genetic information in understanding forensic cases requiring DNA analysis. The use of bioinformatics tools like SMS in learning will not only enable students to learn from a technology point of view, but they will also learn through hands-on manipulation of genetic information. This will help solve the challenges that are posed by conventional forms of learning which are mostly theoretical and hard to apply practically (Iqbal & Kumar, 2023; Bianci & Lio, 2007). Past literature shows that the incorporation of technology in bioinformatics learning results in improved learning outcomes of students, particularly analytical and practical learning. It is therefore important to focus on learning techniques that not only teach basic genetics concepts but also enable students to understand and apply the concepts in context of forensic science (Brown, 2019).

The level of a component of concept understanding for control and experimental class students consists of very good, good, fair, low and very low. Control class students, namely 27% (very good category), 10% (good category), 27% (fair category). Meanwhile, experimental class students had levels of understanding of concepts in various categories, namely 40% (very good category), 30% (good category), 10% (fair category). According to Tahir et al. (2022), the experimental group is dominant in very high and high levels, whereas the control group's average percentage values for conceptual understanding are predominant in low and sufficient levels. Figure 2 depicts the percentage of conceptual understanding among the students.

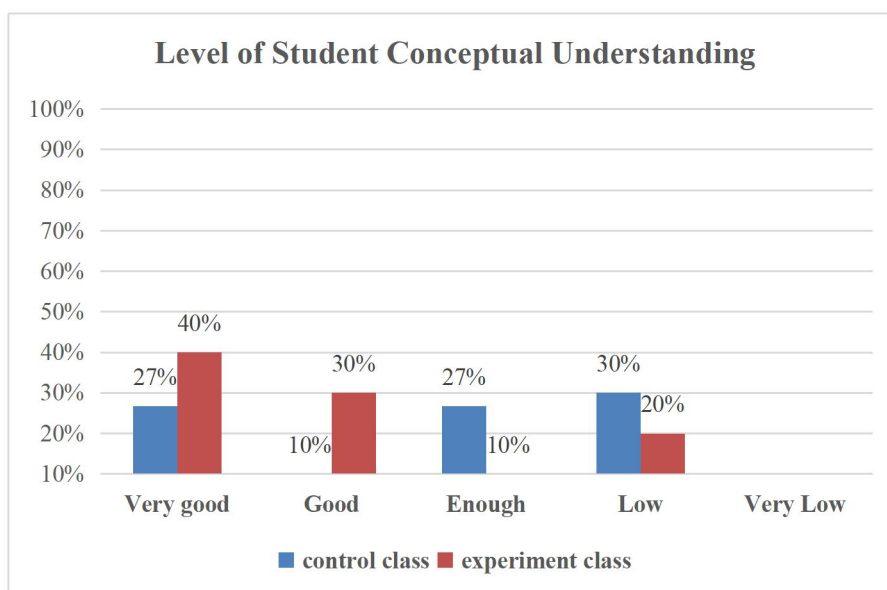


Figure 2. Level of Student Concept Understanding

The level of students' understanding of concepts depends on the factors that influence them, including; attitudes, needs, stimuli, competence, and reinforcement (Akrim, 2021; Utami et al., 2020). The average understanding of concepts also shows differences that are influenced by various factors, one of which is internal factors, namely the inability of students to develop understanding of concepts that have a higher level of difficulty than before. Apart from that, students also have difficulty connecting basic concepts with more complex concepts. External components can also contribute to the process of learning besides the internal ones through the provision of learning materials and facilities. The use of SMS tools for learning purposes by the experimental group, which scores better than the control group, shows the gap in the level of conceptual understanding between the two groups (Putri & Hindrasti, 2020; Rosawati & Dwiningsih, 2016).

The high conceptual understanding of experimental class students is due to factors other than students' conceptual understanding. However, the treatment given to students in the experimental class using SMS tools had an impact on increasing understanding of concepts that was superior and significant compared to students in the control class, resulting in differences in the average level of understanding between the two classes (Sugiyono, 2017).

Experimental class students having high average levels of understanding of concepts via the use of SMS tools in learning (Radiusman, 2020) show that through the application of SMS tools in learning, students can solve forensic science problems through bioinformatics learning assistance that is equipped with SMS tools as the learning medium. The application of SMS tools has a positive effect on the students' understanding of concepts in solving forensic problems in relation to DNA data identification through a certain case, so that they are able to solve problems using the Ident and Sim menu in SMS tools properly. DNA data determination in relation to forensic science cases gives the students knowledge and understanding of problem solving since they know the steps of applying SMS tools (Chatterjee, 2018; Xu & Lu, 2021).

Average scores of the experimental class in the three parts of the conceptual understanding test were higher compared to those of the control group. The main difference between the experimental class and the control class is that there are tools for SMS available to the experimental class (Sugiyono, 2019).

The translation element had an average score of 83.47 for the experimental group and 67.53 for the control group. According to this element, students are understood to have understanding if they are able to answer questions given by the teacher based on their language development and the answers are expected (Sudjana, 2016). The average score

comparison of the control group falls under the sufficient category while the average score of the experimental group is in the good category (Raharja et al., 2018). The truth is that understanding of concepts in this category is about the ability of the students to explain questions based on the expected answers (Handayani, 2018). Acquisition of the initial knowledge regarding the genetic material learned is one of the main aims of learning at school. This is due to the reason that this initial knowledge enables the students to have understanding of the subject matter and hence be able to answer the questions given (Fitriana et al., 2022; Wulandari et al., 2021).

Interpretation component got the value of 72.31 on average for the experimental class and 63.61 for the control class. This component has the lowest score compared to other components. It indicates that in this component, students from both the control class and the experimental class should be able to provide a detailed explanation about the meaning, concept, process, or principle. Also, they can compare, contrast or relate with others (Sudjana, 2016). The comparison of the average value of the control class is categorized as sufficient while that of the experimental class is good (Raharja et al., 2018). Research conducted by Farida et al. (2019) found out that in order to understand how much students have understood of the material taught, they are able to explain in detail. Some of the questions asked, this can be seen if the student is able to answer and understand the questions asked. Difficulty in understanding concepts occurs when students are unable to demonstrate adequate understanding of material. This is characterized by the student's inability to provide a more in-depth explanation or description of the material they have studied. The explanation should be conveyed using the student's own language appropriately and appropriately. Apart from that, students also experience difficulty in providing concrete examples that are relevant to the material or connecting it to real problems in the surrounding environment. This situation reflects that students have not fully mastered the concept being studied (Nurhayati, 2019).

The extrapolation section is the highest average score both in the control group and the experimental group. The average score in the extrapolation section of the experimental group obtained 83.51%. In other words, students are able to make estimates or predictions about certain things using their existing knowledge in situations that they have not gone through before (Sudjana, 2016). Similarly in the control group, the average score obtained is 73.31%, which falls under the good category (Raharja et al., 2018). The fact that in previous research conducted by Astuti et al. (2015) it is said that students play an important role in giving information on data, stating it in another form and implementing concepts according to the

cognitive structure of the student, not just memorizing some concepts. Average scores of the concept understanding component can be seen in Figure 3 below.

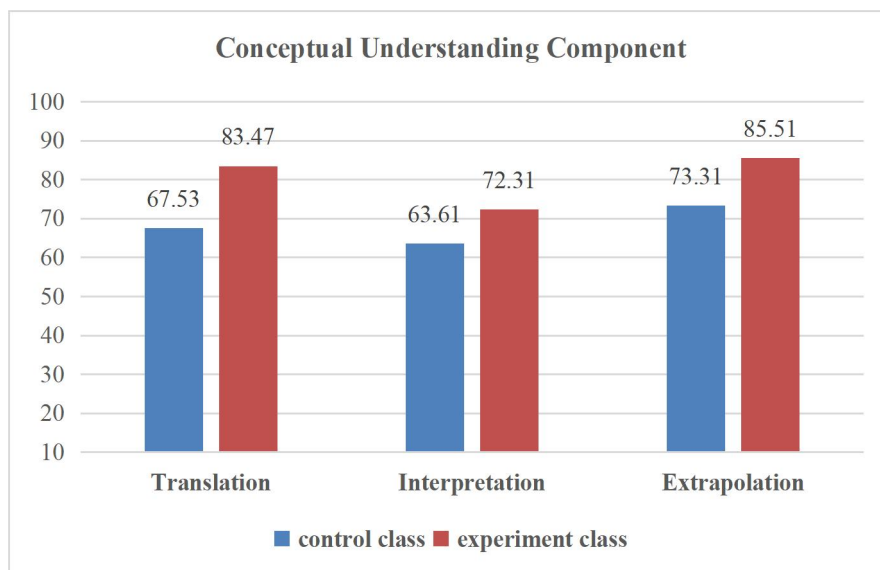


Figure 3. Components of Concept Understanding

Learning activities that utilize SMS bioinformatics tools can influence students' understanding of concepts. By providing a forensic science case, it can become a learning attraction so that students experience the applicability of genetic material in everyday life. This can show that students can participate in learning actively, fun and not boring. Bioinformatics learning that is integrated with digitalization can be realized well, rapid learning through the use of technology is currently an important aspect in the field of education. The development of digital technology has become a learning innovation that can provide effectiveness to students, help students understand, access and use this technology in learning. Through the use of digitalization in learning, student learning outcomes can also be improved (Ervianti et al., 2023; Rahayu et al., 2022)

CONCLUSION

From the results of the hypothesis test on conceptual understanding, the p-value from conducting the t-test is 0.000 ($0.000 < 0.05$), and for conceptual understanding, after conducting the test using non-parametric statistics, there is a p-value of 0.27 ($0.27 < 0.05$). The difference in the p-value between the control class and experimental class in terms of conceptual understanding by using learning media in the form of Sequence Manipulation Suite (SMS) tools makes students confident about solving computational problems in relation to digital technology and the ability of students to solve forensic science problems. From the above results, it can be concluded that Sequence Manipulation Suite (SMS) tools in science forensics have an influence on conceptual understanding of high school students of genetics concept.

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