Conceptual Understanding of Complex Analysis Number using Flipped Learning

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ABSTRACT

Flipped Learning is one of the alternatives of teaching and learning approach in mathematics classroom. The objective of this study is exploring students’ conceptual understanding about complex number using flipped learning with handout. The subject of the study are the students in 5th semester students of mathematics education department in 2019/2020. The study used qualitative approach to describe the implementation of flipped learning. There are 31.6% of 19 respondents give score very satisfied. This result then observed by using the test with all the students understand with the definition of complex numbers. Besides they can adapt their learning activity using flipped learning with complex analysis handout. As legibility aspect of the handout, there are 52.6% of the respondents gives score satisfied and 26.3% of the respondents are very satisfied. The score indicates that the flipped learning with handout helps students to understand about the complex number concepts.

Keywords: Flipped Learning, Handout, Complex Number

INTRODUCTION

Flipped Learning is one of the alternatives of teaching and learning approach in mathematics classroom for twentieth century (Flipped Learning Network (FLN), 2014; Nouri, 2016; van Alten et al., 2019). During the learning process, students are expected to be able and active in finding relevant learning resources by utilizing information technology. This is in accordance with the efforts to make students independent in learning. Adequate information technology facilities and infrastructure allow...
students to easily access various kinds of learning resources. The number of learning resources is not necessarily proportional to student learning outcomes. However, the development of learning media have a significant contribution in the development of learning resources (Widodo & Wahyudin, 2018). In 2020, the demand of using technology as the learning media is rising significantly. As the effect of using technology, lecturer have a free access to choose their style in teaching process as relevant as their efforts in developing learning media and approach. For example, since pandemic, lecturers used to give students’ task, as synchronous or unsyncronous learning activity, in teaching the concepts. The media used are android, social media (facebook, youtube, twitter, etc) and interactive quiz. The lecturer can gives feedback, reinforcement, and the follow up effectively, if the students have already learn or read the concept before. This activity is one of the characteristics of flipped learning implementation in learning process.

The implementation of flipped learning in analysis course is not the first time that researchers did in 2019/2020. In 2018, the researcher has already developed flipped learning as the alternatives of learning. However, the result of the study mentions that students are motivated to attend the lectures (Setyawan & Istiandaru, 2019). This is reflected when students are asked to explain material related to problems given in class. In the evaluation stage, the researcher asks about the process and results written by students while in class. From this previous study, it was found that the motivation and a positive attitude of students had occured while the teacher were implementing self regulated flipped classroom approach. Since it was implemented in Calculus, the researched have a plan to implements flipped learning in complex analysis course.

This action is carried out to ensure that every step that has been conveyed by the lecturer can actually be followed by students, so that student learning outcomes are in accordance with learning objectives. The implementation of flipped learning is given in calculus course. The researchers think that the students can evaluate and assessing their study as their expected target as their process by using flipped learning (Michalsky & Schechter, 2013; Siadaty et al., 2012). This process related with the students’ self regulation in learning process. The process when students were looking for the material, doing the tasks, take the evaluation is a part of a good self-regulation (Lai & Hwang, 2016; Rahman & Ahmar, 2016). From this previous study, it was found that the motivation and a positive attitude of students had occured while the teacher were implementing self regulated flipped classroom approach. Since it was implemented in Calculus, the researched have a plan to implements flipped learning in complex analysis course.

In 2020, the development of learning media is targeted in complex analysis course. Complex analysis course is related with the complex numbers, complex function and its properties, derivatives, and integral of complex numbers. The learning media used is the handout of complex analysis course. The development of the learning media is using 4D design that consist of defining, designing, developing, and desseminating. The development of the handout are tested as the final stage of the study. Thus, the objective of this study is limited in exploring college students’ conceptual understanding about complex number and its properties (Setyawan, Prasetyo, & Nurnugroho, 2020).

The students’ conceptual understanding is about recognizing functional relationship between known and unknown, dependent and independents variables, and interpret the representation of the
concepts (Panasuk, 2011). The concept of known and unknown variables in complex number. It is related with the definition of the complex number itself that consist of real and imaginary numbers. The competencies of the students who understand the concept is measured based on the competency in writing, reading, and manipulating the symbols in complex number. The students’ conceptual understanding described based on the previous studies (Panasuk, 2010, 2011; Pratama & Ali, 2018; Setyawan, 2015) that consist of: 1) defining the concept by using students’ own word, 2) giving example and non-example of the concepts, 3) determine the representation of the concepts using symbolic or diagrams, 4) make a mathematical modelling, 5) make a connection with the previous concepts. The indicators of conceptual understanding is related to the way of the concepts delivered during teaching and learning process. The students who garsp conceptual understanding about a concept can dicern, interpret, compare, and relate the concept in various situations. The students are fluent and flexible using mathematics properties and convections in operating mathematical modelling and its intepretation.

Based on the description before, the study recommend the implementation of flipped learning with handout to observe students’ understanding. Thus, this research describes the students’ satisfaction using flipped learning with complex analysis handout, determine the readability of the handout, and evaluating the conceptual understanding of the students in complex numbers.

**METHOD**

This study is a research and developments study as the final stage of the 4D model. 4D model (that consist of defining, designing, developing and disseminating stages) are derived based on the previous result of the study (Setyawan et al., 2020). The previous study described the 3 stages (defining, designing, and developing) of the learning media using complex analysis handout. As the final stage (disseminating process), the researchers used flipped learning approach as the learning activity using handout that developed in 2019-2020. In previous study, the researchers have already identified the need analysis of the learning media in teaching and learning process, designed the handout as relevant as the characteristics of the students, and validated the handout (its content and layout) to the experts. This study highlighted the implementation of flipped learning using Complex Analysis handout to the 5th semester college students in mathematics education department. The subjects are 19 students who take complex analysis course in mathematics education department in even semester 2019/2020.

The researchers chose the subject purposively to provide the insight into the research questions (Davers & Frankel, 2000; Miles, M.B. & Huberman, 1994). The criteria used are the subjects have a good communication, understand the concept of real function in calculus, and have a moderate or a good score in calculus. The researchers collect the data by using a questionnaire, conceptual understanding test, and interview as the aids instrument. The interview is limited to one student who can communicate well while the researchers were interviewing only use whatsapp massanger. The chosen subject is selected randomly based on the response that he/she gave in interview. Besides, the researchers as the main instrument of the study. The validation of the data
using subject and time triangulation. The data then reduced, interpreted, and presented as a narrative explanation.

RESULT AND DISCUSSION

Handout of Complex Analysis Course

![Diagram of student satisfaction](image)

Figure 1. Diagram of the of students’ satisfaction in taking Complex Analysis course through the flipped learning approach with Complex Analysis handout.

This study developed a Complex Analysis handout that has been carried out previously using 4D-model. The result of the study interpret the data about the implementation of flipped learning using complex analysis handout as the final stage of the development study. Students gave score of the readability of the handout by filling out the questionnaire that given during the teaching and learning process. However, as the characteristics of flipped learning, the students find the concepts independently through the Complex Analysis handout. Based on the questionnaire given on April 6, 2020, it was found that 31.6% of the 19 respondents gave score of 5 of 5 (very satisfied) in the course using the flipped learning approach with complex analysis handout. In addition, there are 42.1% and 26.3% of the 19 respondents, respectively, filled out the questionnaire on a scale of 4 of 5 (satisfied) and 3 of 5 (moderate). This results shows that students understand the concepts delivered in handout using the flipped learning approach. In detail, the of students’ satisfaction in taking Complex Analysis course through the flipped learning approach with Complex Analysis handout is described in Figure 1.

![Questionnaire results](image)

Figure 2. The results of evaluating student understanding in using handouts.
In understanding competencies (C2), it was obtained that 100% of the total 19 respondents stated that the given handout was easy to understand. This is because the concepts, written in the handout, linked the previous concepts that have been studied. The diagram of the results of evaluating student understanding in using handouts is presented in Figure 2.

In the handout readability aspect, 52.6% of respondents (out of 19 respondents) obtained a scale of 4 of 5 (satisfied), 26.3% of respondents (out of 19 respondents) gave a scale of 5 of 5 (very satisfied) and 21.1% gave a scale of 3 of 5 (moderate). This indicates that the handout developed can be followed well by students by considering aspects of the language and layout of the handouts used. The explanation of the readability aspect of the handout is presented in Figure 3.

Based Figure 1, 2 and 3, it can be concluded that the Complex Analysis Handout can be used to enhance students’ understanding. Furthermore, the researchers dug students’ understanding data by using conceptual understanding test that consist of the questions which is exploring students’ conceptual understanding based on their representation.

This finding is relevant with the previous study related with the beneficial of using learning media. By using learning media, the students were interact with the surrounding environments (Adi Widodo, Turmudi, & Afgani Dahlan, 2019). In this study, the learning media used is Complex analysis handout. However, most of learning approach in pandemic were using learning management system (LMS). The LMS was poses with many challenges such as how the students engaged with the material used. Most studies have already mention about this challenges (Donnelly & McSweeney, 2008; Irfan, Kusumaningrum, Yulia, & Widodo, 2020; Kabilan & Khan, 2012). Thus, form the finding of this study, it gives a good framework that not only using LMS that can highlight students understanding about a concept, but also gives a new perspective that a handout as a learning media can also gives a good access for the students. They can download it easily using email, WhatsApp, or LMS itself. Online learning in a pandemic is an alternative learning since the students not always on air or ready to receive the learning material (Basilaia & Kvavadze, 2020; Laprairie & Hinson, 2006; Taha, Abdalla, Wadi, & Khalafalla, 2020).

Students’ Conceptual Understanding of Complex Numbers
The students’ conceptual understanding is about recognizing functional relationship between known and unknown, dependent and independents variables, and interpret the representation of the concepts (Panasuk, 2011). The concept of known and unknown variables in complex number. It is related with the definition of the complex number itself that consist of real and imaginary numbers. The competencies of the students who understand the concept is measured based on the competency in writing, reading, and manipulating the symbols in complex number. First, the students define the complex number by using their own word. Second, they mention the example and non-example of the complex number. Third, they can interpret the complex number in symbol or a diagram based on the given problems.

Firstly, students define the complex number by writing and describing that complex number is the number that consist of real and imaginary numbers. The definition of the complex number than observed based on the literature given in the Complex Analysis Handout that the representation of the complex number is written by $z = x + iy$, where $x, y \in \mathbb{R}$ and $i = \sqrt{-1}$. $x$ and $y$ interprets the real numbers and $i$ interprets imaginary unit. The interviews showed the students can define the complex number by its properties that consist of real and imaginary numbers. Thus, for the first indicator support previous research that students can improve their conceptual understanding if they are given a proper learning approach and learning media that can accommodate their understanding about a concept. The student's interview is described in Figure 4.

![Figure 4. Students’ definition of complex number](image)

Furthermore, the students mention about the example and non-example of the complex number. It can be obtained that some of the students cannot find the non-example of complex number. They are confused since the complex number is one of the widest scope of numbers that they ever know. However, the hypercomplex number is not introduced since the curriculum of the course limited to the complex number. It is different with the real number, especially in calculus, has the non-example number, called imaginary number. The discussion about the example and non-example of complex number is shown in Figure 5.

![Figure 5. Students’ interview about example and non-example of complex number](image)
The researchers found that even the students can define complex number, nor they cannot distinguish complex and real number if it was written as a symbol representation. As the students’ activity to mention the example of complex number, they are given a test related to the interpretation of complex number. The question is about making a representation of a given complex number: a) $z = 1 + 5i$; b) $z = 2$; c) $z = 3i$. The chosen subject (who has a good communication skill) classified $z = 2$ as non-example of the complex number. Thus, for the second indicator the conceptual understanding of the students using flipped learning with handout cannot justified that all of them understand about the concept. This result contradicts with the discussion mention in Figure 2. Thus, this result also gives a contradict evidence that if the students only fluents but not flexible in interpreting a concept, they just know but the understanding is still low. As the students’ fluent and flexible using mathematics properties and its interpretation, they have a good conceptual understanding (Panasuk, 2011). The students’ work is shown in Figure 6.

![Figure 6. Students’ representation of complex number](image)

When the researchers ask the students about the representation of complex number, they wrote in both symbol and diagram representation. The discussion about the symbol representation is shown in Figure 6.

![Figure 6. Students’ interview about the representation](image)
Last, for the preferences that obtained as the chosen subject. She prefers to write a complex number using symbol $z = 1 + 5i$. The subject chose the representation mentioned because she can distinguish the real and imaginary unit in a number. However, to get more reasoning, there are still need more study related with gender, mathematics ability, learning style, or the other variables that affect students’ preferences in representing a concept, particularly in complex number.

This study examines students’ conceptual understanding in complex analysis course using flipped learning and complex analysis handout. The finding gives a new perspective that even the students can define a concept well, the researchers need to carry more critical questions about the example and non-example of a concept. For the next study, the researchers recommend to the reader in observing students’ understanding by his/her representation about the concept. However, the lecturer gets a challenge in transferring the concept by using handout. First, the handout is an independent learning media, so the lecturer needs to give more scaffolding when the students used it. Second, the support media used such as synchronous platform such as zoom, google meet, skype are recommended to help the lecturer facilitate a discussion while the students are using the handout. However this research find a contrast result with the study that there are many obstacles in the application of LMS during a pandemic (Ali & Magalhaes, 2008; Assareh & Hosseini Bidokht, 2011; Childs, Blenkinsopp, Hall, & Walton, 2005). For the further study, it is interesting to examine students’ conceptual understanding by using their representation about a concept.

CONCLUSION

Based on the data obtained, students feel comfortable in participating in learning using the flipped learning approach. It was found that all students understood the material given either using the flipped learning approach assisted by the given handout. In the legibility aspect of complex analysis handout, it was found that the developed handout could be followed properly by students by considering the language aspects and the layout of the handouts used. There are three indicators used to know students’ conceptual understanding about the complex number. First, the students define the complex number by using their own word. Second, they mention the example and non-example of the complex number. Third, they can interpret the complex number in symbols or a diagram based on the given problems. For the first indicator, subject mention that complex number is a number that consist of real and imaginary numbers. Second, the researchers need sure that even students fluent in defining a concept, they still need to be explored especially in how fluent the interprets the concept, particularly non-example of complex number. Last, there are still need more study related with gender, mathematics ability, learning style, or the other variables that affect students’ preferences in representing a concept, particularly in complex number.

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