International Joint Conference on STEM Education (IJCSE) 2020

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Preface

2020 had brought challenges for everyone and every aspect of life due to the COVID-19 pandemic. People must adapt to social distancing, wearing masks, learning, working from home, and meeting virtually. This situation also impacts our event, International Joint Conference on STEM Education (IJCSE) 2020, which must be held online.

The IJCSE 2020 is a forum for Mathematics and Science educators from various countries to share their research results and best practices related to current issues regarding Science, Technology, Engineering, and Mathematics (STEM) Education. The IJCSE 2020 was held using the blended method: face to face and online. IJCSE 2020 is a collaboration of three international conferences held by three Southeast Asian educational institutions as follows:

- International Symposium on Mathematics Education and innovation (ISMEI) - a biennial symposium held by SEAMEO QITEP in Mathematics (SEAQIM) based in Yogyakarta, Indonesia.
- International Conference on Science Education (ICONS) - a biennial international conference conducted by SEAMEO QITEP in Science (SEAQIS) based in Bandung, Indonesia.
- The International Science, Mathematics and Technology Education Conference (ISMTEC) - initiated in 2013 by the Institute for the Promotion of Teaching Science and Technology (IPST) based in Bangkok, Thailand.

The aims of this conference remain to (1) provide an international platform for educators to share ideas and experiences, learn new knowledge and best practices, and disseminate recent research results in the field of Mathematics Education, Science Education and STEM Education; (2) strengthen STEM education especially in Southeast Asian Region; (3) establish and expand networks of academic cooperation at the international level; promote the organization of online conference platform that corresponds with the time of crisis.

In this conference, the plenary speakers and keynote speakers were given 30 minutes for presentations and Q&A session. It was followed by a parallel session separated into three different rooms based on the main subject: Mathematics Education, Science Education and STEM Education. Each presenter had 15 minutes to present their papers, after which the audience has a chance to ask questions and provide comments or suggestions. The conference ran well, although some technical challenges also happened during the conference.

Finally, we would like to extend our gratitude to everyone who has contributed and supported this conference. Without the hard work of committees, invited speakers, keynote speakers, parallel presenters, reviewers, etc., there would be no conference at all. Thank you very much for all the supports and helps.

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Plenary Speakers

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Dr. Iwan Syahril	Directorate General, Teachers and Education Personnal Ministry of Education and Culture of The Republic of Indonesia

Invited and Keynote Speakers

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Prof. Lew Hee Chan	Korean National University of Education, South Korea
Prof. Minoru Itoh	Tokyo University of Science, Japan
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Prof. Lyn D English	Queensland University of Technology, Australia
Dr. Edward Reeve	Utah State University and SEAMEO Regional Centre for STEM Education
Dr. Farida Nurhasanah	SEAMEO QITEP in Mathematics (SEAQiM), Indonesia.

Peer review declaration

All papers published in this volume of Journal of Physics: Conference Series have been peer reviewed through processes administered by the Editors. Reviews were conducted by expert referees to the professional and scientific standards expected of a proceedings journal published by IOP Publishing.

- **Type of peer review: Double-blind**
- **Conference submission management system:**

  The submission process was proceeded in the Open Conference System (OCS). Authors, who has problem with the OCS were allowed to send their papers through conference email.

- **Number of submissions received: 194**
- **Number of submissions sent for review: 108**
- **Number of submissions accepted: 79 (48 papers are accepted to be submitted in Journal of Physics - IOP Conference Series)**
- **Acceptance Rate (Number of Submissions Accepted / Number of Submissions Received X 100): 40,72%**
- **Average number of reviews per paper: 2 reviewers**
- **Total number of reviewers involved: 31 reviewers**
- **Any additional info on review process:**
- **Contact person for queries:**

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Students' higher-order thinking skills in discrete mathematics during covid-19 pandemic

Students' higher-order thinking skills in discrete mathematics during covid-19 pandemic

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Abstract. Mathematics learning in the era of 4.0 must be oriented to the aspects of higher-order thinking skills that important for any mathematics subject including discrete mathematics. The online learning caused Covid-19 pandemic influence many aspects of mathematics learning and skills. The purpose of this study was to analyse students' higher-order thinking skills in the discrete mathematics subject during COVID-19 Pandemic using Two-Tier Multiple Choice (TTMC) instrument. This research was conducted from March to May 2020. Subjects in this study were 11 students of class IIB of Mathematics Education Study Program Universitas Mahasaraswati Denpasar. This study used descriptive analysis techniques. Data collected through tests, interviews, observations, and documentation. The results of the data analysis showed that the higher-order thinking skills percentage of students with very low categories of 18.18%, low 36.36% and moderate 45.45%. Online learning due to COVID-19 Pandemic also causes the difficulties for students to do group discussion as well as the decrease in student motivation. In contrast, students are more familiar with discrete mathematics concepts in their environment such as graph concepts and can use internet facilities in learning more effectively. Some solutions for the problems occurred are: 1) Using interactive learning, 2) Using Project-Based learning (PBL), 3) Discussing current trends in learning, 4) Demonstrating assertiveness, and establishing learning rules, and 5) Supporting students to get better internet facilities.

Keywords: Higher-order thinking skills, Two-tier Multiple Choice, Qualitative Analysis, COVID-19 Pandemic

1. Introduction

Mathematics learning in the era of 4.0 must be emphasized by the aspects of students' higher-order thinking skills [1]. Higher-order thinking skills are a thinking process of students at a higher cognitive level developed from various cognitive concepts and methods and learning taxonomies such as problem-solving methods, bloom taxonomy, and learning, teaching, and assessment taxonomies [2].

Higher-order thinking skills are very important for students to learn mathematical concepts. One of the mathematical concepts or material that really requires higher order thinking skills is Discrete Mathematics.

Discrete mathematics has many uses in various fields. Discrete mathematics is very important because the concept is contained in various fields of application; one of the most important is the field of computers. The concept of Discrete Mathematics is the basis for compiling computer algorithms that require good logic and reasoning. Discrete mathematics is a part of mathematics that studies

different and separated objects. Generally, discrete mathematics is used to count many objects, study the relationship between finite sets and analyze process that engages infinite steps [3]. Therefore, in order to understand the concept of Discrete Mathematics well, students must have a high level of thinking ability [3].

The emergence of the 2019 Corona Virus Disease (COVID-19) Pandemic in early 2020 has had a profound impact on people's lives. The sudden wave of online learning caused by the Covid-19 Pandemic has changed the face of education in Indonesia and is causing unpreparedness from both teachers and students. [4] state that online learning causes students to be difficult to cause a decrease in student understanding because of the difficulties faced by students to adapt to accessing learning content properly. Learning Discrete Mathematics that are usually done face-to-face must be affected by this change, causing a major change in the thinking ability of students who are accustomed to follow learning directly and take advantage of direct social interaction with teachers and other students.

There are some research conducted to describe relation between higher-order thinking skills and discrete mathematics. One of that reserach is from [3] that found that the student with middle level of HOTS is able to identify the main idea, analyze an argument, and show the usage of the thing known to answer some questions, so she has quiet good analysis skill while study discrete mathematics. Students are also able to give assessment to the solution and methods used and recheck the questions, it means that the student has quite good evaluation skill. The student also can design how to answer and show well to the questions. While on their logic and reasoning skill, the student can write the answer content, evidence and language style clarity logically, well and effectively. It is also found that students who are classified as having higher-order thinking skills with low levels are less able to identify main ideas, analyze arguments, and show the usefulness of things that are known to answer several questions, so they have poor analytical skills [3]. These students are also less able to evaluate the solutions and methods used and carry out re-examination of the questions, so they have poor evaluation skills.

From some of these studies, there has been no research that specifically analyzes the effect of higher-order thinking skills on discrete mathematics material during the pandemic. This is very important considering that there are many changes in student learning systems which will certainly affect the level of ability and knowledge of students. For these reasons, researchers are interested in examining how students' higher-order thinking skills in Discrete Mathematics in the middle of COVID-19 Pandemic. The Two-Tier Multiple-Choice question (TTMC) form was developed by [5]. [6] states that two tier tests can determine the level of understanding of an individual sign using a lot of wasted time and a lot of paper, and it takes great effort to analyze the data. Treagust uses multilevel multiple-choice questions to diagnose students' ability to understand science concepts [7]. He used the TTMC assessment instrument to measure students' higher order thinking skills. The form of the question consists of two levels of questions, the first level is the content of the question which has two alternative answers, and the second level is the reason for the answer chosen on the basis of the first choice. [8] used Two-Tier Multiple Choices Diagnostic instrument to analyze the misconceptions of junior high school students on bull number material The development of the TTMC assessment instrument can be applied to measure students' science process skills by changing the pattern of questions and there are parts that need to be developed or adjusted.

The purpose of this study is to investigate how students' higher-order thinking skills in the subject of Discrete Mathematics using Two-Tier Multiple Choice (TTMC) instrument in the online learning period due to the COVID-19 Pandemic. The results of this study will be used as a reference for educators in the future to be able to arrange appropriate online learning during the COVID-19 Pandemic period to improve students' higher-order thinking skills.

2. Method

The research design in this study is a qualitative descriptive study, which seeks to describe a symptom of an event or incident systematically according to the circumstances in a population [9].

This research was conducted at the Mathematics Education Study Program, Mahasaraswati University, Denpasar. The subjects in this study were 11 students of Class IIB Mathematics Education

Study Program Mahasaraswati University Denpasar. The study period is from April to May, even semester 2019/2020.

Data collection techniques used are test based on Two-Tier Multiple Choice (TTMC) Instrument, interview, observation, and documentation. The test is used to see the extent to which students 'metaphorical thinking skills and the impact caused by online learning due to the COVID-19 Pandemic on students' higher-order thinking skills. The interview used in this study was an unstructured interview to find out more about the obstacles faced by students in online learning in the middle of the COVID-19 Pandemic. The observation and documentation are used to strengthen and describe the results obtained.

Data in the form of test results were analyzed in-depth to obtain results in the form of portrayals of students' high order thinking abilities. Two-Tier Multiple Choice (TTMC) instrument are not only used as a basis for the preparation of test descriptions, but they are also used as a reference to describe the extent of the higher-order thinking skills students have. Besides, various obstacles and learning difficulties faced by students, especially in showing their higher-order thinking skills during the learning period of discrete mathematics online due to the COVID-19 Pandemic will also be described in depth.

3. Result and Discussion

The achievement of higher-order thinking skills of Class IIB Mathematics Education Study Program Mahasaraswati University Denpasar students can be seen from the two tier multiple choice test scores obtained. The categories of high-lorder thinking skills of students in the discrete mathematics subject are presented in table 1 below.

Table 1. Summary of results of student answers

Categories	Number of Students	Percentage
Very High	0	0%
High	0	0%
Moderate	5	45,45%
Low	4	36,36%
Very Low	2	18,18%

The data shows that the students' higher-order thinking skills are very low, even if there are no students who reach the high or very high categories. Several causes are the lack of student motivation and interaction in participating in online learning.

The results of the analysis of the answers of students who are at a low level also show a lack of analytical power, understanding, and higher-order thinking skills possessed by students. This can be seen from the students' lack of ability in choosing answers to questions and in determining the reasons for choosing these answers. The following is an example of student answers to the Two Tier Multiple Choice questions given.

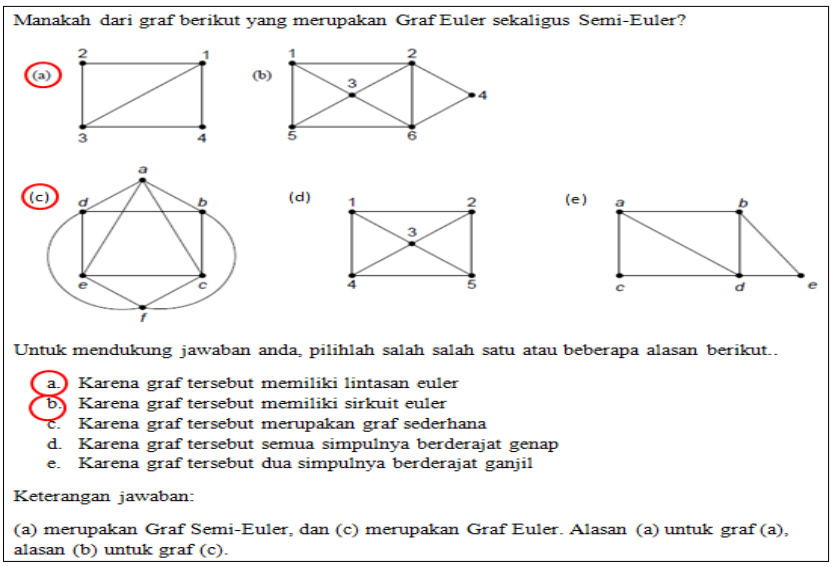

Figure 1. Student's answer

Based on these answers, it can be seen that students do not understand the questions given. Students choose two answers that are considered correct where Graph (a) is a Semi-Eulerian Graph and Graph (c) is a Eulerian Graph. This shows that students do not understand the questions given where students should only choose one graph that meets these two criteria, namely graph (c). Students are also unable to analyze in depth the characteristics of an Eulerian graph which is a graph containing an Eulerian circuit. According to the Theorem, a graph which has two vertices of odd degree or no vertices of odd degree is a Semi-Eulerian graph (containing Euler trajectory), while a graph with all vertices with even degree is an Eulerian graph. The conclusion of these two theorms means that an Eulerian Graph which only has even-degree vertices is also a Semi-Eulerian Graph, or a graph that has Eulerian Circuits must also have Eulerian Paths. So, the correct answer is graph (c) in the answer choices, as well as (a) and (d) on the reason. The answer chosen by the student shows that the student does not understand the question given and cannot understand the concept of the theorem well. The inability of students to conclude the relationship between the two theorems shows a lack of analytical power and higher-order thinking power of students. This is in line with [3] who also found that students who are classified as having higher-order thinking skills with low levels are less able to identify main ideas, analyze arguments, and show the usefulness of things that are known to answer several questions, so they have poor analytical skills.

According to the interview, students stated that the absence of group formation and discussion made it difficult for them to exchange ideas with colleagues in working on problems. They said online learning that was carried out in the middle of the COVID-19 Pandemic limited cooperative discussion that they could do with other students to avoid the process of sharing and exchanging opinions in solving problems. The rest also claimed to have decreased learning motivation during the online learning period. In contrast, students are more familiar with discrete mathematics concepts in their environment such as graph concepts and can use internet facilities in learning more effectively. These findings are in line with [10] added that online lectures conducted by lecturers were accompanied by assignments that were numerous in the outbreak of COVID-19 Pandemic, making it difficult for students to move in completing their assignments through interactions between students as usual.

According to observation, students look less enthusiastic during online lessons. Students also lack focus in paying attention to the explanation regarding the discrete mathematics material obtained so that students do not understand the material well. Uncomfortable conditions, difficulties in obtaining a good internet signal, as well as student limitations in financial matters also lead to less effective online learning. This causes students not to have the opportunity to practice their thinking skills in understanding the material and solving problems in discrete mathematics courses.

In contrast to the negative impacts, students are more familiar with discrete mathematics concepts in their environment such as graph concepts. Students also state the positive effects that were felt during the online statistics lecture. Students are more flexible in accessing the internet so that when viewed from the duration of the test, the average student answers questions more quickly than face-to-face learning.

The low higher-order thinking skills of students in online learning during the COVID-19 Pandemic period should be a concern in mathematics education. This causes teachers and lecturers to be smart in preparing effective and interactive online-based learning. Some solutions that can be taken by mathematics educators to this conditions are:

- Using interactive learning. Interactive included here is learning that can attract interest and increase student motivation. As is well known, online learning due to the COVID-19 Pandemic gives many temptations to students. Learning that is not directly supervised by the teacher will make students free and can do other activities so they are less interested in participating in learning. This causes the teacher to design learning that is not monotonous, teachers should not only do the learning by lecture method only. The provision of learning videos, animations, and the use of interactive e-learning are solutions that can be used.
- Using Project-Based learning (PBL). PBL can direct students to be active in learning not just to listen to the teacher's explanation. The project provided can stimulate students' thinking abilities and provide fun activities for students, coupled with internet facilities that are freely accessed by students, PBL can direct students to utilize their internet facilities efficiently and positively.
- Discussing current trends in learning. By creating contemporary learning, students will be able to be more interested and serious in learning. Students who are on average young are certainly very updated with current issues such as the Pandemic COVID-19. Linking learning with current issues will increase students' motivation and mathematical thinking skills that are very dependent on the contextual domain. One example is making questions related to the COVID-19 Pandemic.
- Demonstrates assertiveness and sets learning rules. Lack of student motivation in online learning due to the COVID-19 pandemic which has caused a lack of students' higher-order thinking skills, one of which is caused by the difficulty in providing supervision to students when learning online. This situation can be improved by giving strict rules to students in participating in online learning so that the rest do not underestimate online learning and can feel if the teacher is always watching and paying attention to learning that takes place.
- Supporting students to get better internet facilities. The big cause of the ineffectiveness of online learning is the limited internet facilities that students have due to the financial limitations of students. This problem requires institutional and government policies to help students, for example, with the free internet quota that has been given by the government and universities recently which can be used by underprivileged students to continue to be able to participate in online learning properly.

4. Conclusion

From the tests, interviews, and observations made, several conclusions were obtained which showed the lack of students' higher-order thinking skills in the subject of Discrete Mathematics during the COVID-19 Pandemic where the higher-order thinking skills percentage of students with incredibly low categories of 18.18%, low 36.36% and moderate 45.45%. Students that are mostly have low level highe-order thinking skills shows less ablility to understanding the problems, identify main ideas, and poor analytical skills.

Online learning due to COVID-19 Pandemic also causes the difficulties for students to do group discussion as well as the decrease in student motivation. In contrast, students are more familiar with discrete mathematics concepts in their environment such as graph concepts and can use internet facilities in learning more effectively. Some solutions for the problems occured are: 1) Using interactive

learning, 2) Using Project-Based learning (PBL), 3) Discussing current trends in learning, 4) Demonstrating assertiveness, and establishing learning rules, and 5) Supporting students to get better internet facilities.

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