Problem-based learning flipped classroom design for developing higher-order thinking skills during the COVID-19 pandemic in geometry domain

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Abstract. Higher-order thinking skills are skills demanded by society for the 21st century and ability that is required to succeed academically and in the work environment. As one of the learning objectives in the 21st century, higher-order thinking skills developed since in primary education until higher education. A variety of learning methods and learning media developed to develop this thinking ability. The purpose of this study is to design a learning model to improve the Higher Order Thinking Skills in geometry. It is the literature review study based on related articles and books. The sources were analyzed to formulate a useful learning model. The results show that Problem Based Learning Flipped Classroom improve students’ Higher Order Thinking Skills, and appropriate to be used during The Covid-19 Pandemic. Also, Problem Based Learning Flipped Classroom provides students the opportunity to increase self-directed learning and collaboration.

1. Introduction

The new knowledge and skills demanded by society for the 21st century are known as 21st-century competencies or abilities [1]. It refers to experience and skills that can be applied or used to perform academic assignments and can be transferred to the world of work [2]. These 21st-century skills can be grouped into two main groups: the first group contains ICT competencies, while the second group consists of high-level skills [3]. ICT competence or digital competence is understood as a set of students’ knowledge and skills. It allows them to master several technological resources for use in various academic assignments and training activities [2]. High-level skills, including those related to cognitive skills, such as critical thinking, creative thinking, self-managed learning, problem-solving, communication skills, are all called high-level thinking skills [2].

Most high skill competencies are not new because they are triggered by technological advances [4]. The development of technology has brought changes in the teaching and learning process. Technology becomes a powerful tool for the operation of transforming learning, facilitating the acquisition of high-skilled competencies [1]. One of learning model that utilizes technology facilities is the Flipped Classroom. Flipped Classroom is a learning approach that is the opposite of the learning that is usually before face to face in class students learn material outside the classroom through lecture materials that have been organized online, such as in the form of videos, ebooks, e-notes, PPT, etc. In face to face session, students do active learning activities to apply knowledge that has been learned before outside the classroom.
Some research on the application of Flipped classrooms in universities has been carried out in several countries. Danker [5] examines the application of Flipped Classroom in large classes. The research sample was 33 Art students at Sunway University, Malaysia. Students learn online videos at home and then proceed with the application of concepts in class. Class activities include inquiry-based learning and peer-learning. Research findings show that grouping students into small groups make large classes effective. Active learning in small groups produces productive interactions between students.

Foldnes [6] examines the comparison of the effectiveness of Flipped Classroom with conventional learning. There are one control class and two experimental classes. Both experimental classes received Flipped Classroom learning but differed in terms of the frequency of group activities when face to face. The findings of the study are that there is no significant difference in learning outcomes between conventional classes and Flipped Classroom classes with little group activity face to face. Flipped Classroom classes that always involve students in group activities face to face have a significant increase in learning outcomes.

DeRuisseau [7] stated about experiments on the Anatomy and Psychology course at Le Moyne College. The University provides videos, PPT, YouTube animations, note outlines. Besides that, it is equipped with Lecture Tools that contain questions that students must answer online. Activities in class are evaluating student answers, discussing difficult material, and solving problems in the form of cases. The research findings are that the Flipped Classroom gives more time for active learning and exercises critical thinking. Nevertheless, this research only develops critical thinking skills. In contrast, high-level thinking includes critical and creative thinking that enables a person to solve problem-solving [8].

González-Gómez [9] examined the effect of Flipped Classroom on Self efficacy and scientific attitudes towards pre-service teachers in Spain. Experiments were carried out on Science courses, outside the face-to-face hours of participants studying online with a website platform containing videos and questions. During the meeting, they discussed complex problems using rules and case-based reasoning. The study concludes that Flipped Classroom can contribute to improving the science of self-efficacy and positive attitudes that are important for teacher professional development.

Hwang [10] conducted a quasi-experiment about the effect of flipped classroom-based collective problem solving on student learning abilities and interactive patterns on students in Taiwan. The experimental class gets converted classroom combination of collaborative problem solving, and the control class flipped classroom combination of group discussion. They found that Flipped Classroom supports self-efficacy, learning independence, and high-level communication in student discussions such as negotiation and comparison.

Following the current coronavirus pandemic situation, this paper will present the design of a problem-based flipped classroom that aims to improve students’ high thinking skills in the geometry domain. Geometry is a branch of mathematics that deals with the study of different shapes or figures and their properties. Geometry plays a significant role in primary schools’ mathematics, and it provides a rich source of visualization for arithmetical, algebraic, and statistical concepts.

2. Methods
This method of the study is a literature review. The literature review was conducted by analyzing some literature, arrange them to interrelated ideas to develop the central issue [11]. To obtain the purpose of the study, we collected journals and books related to HOTS, Flipped Classroom, and Problem Based Learning. Then we analyze and synthesize to design Problem Based Learning Flipped Classroom learning model.

3. Result and discussion

3.1. Higher-order thinking (HOT)
HOTS always attracts the attention of educators and researchers. Resnick first conceived HOTS in 1987. Until now, HOTS remains the focus of research. HOTS is even included in the 21st-century educational goals, problem-solving, and critical thinking [12]. HOTS is believed to influence the ability of students
to access information to use new contexts and easily transfer knowledge into different situations [13]. Features of HOTS are: (a) not routine/differ from previous problem, (b) complicated, (c) sometime more than one solution, (d) uncertainty and, (f) persistent [14]. HOTS impacts students’ ability to solve a problem, decision making [15], asking questions, making comparisons [16].

On the other hand, Lower Order Thinking Skills (LOTS) restate facts or apply rules and algorithms through routine problems according to [17]. As recipients of information, students are given knowledge from simple concepts to complex. Students, in this case, repeat the experience that has been received to answer memory questions. LOTS occurs because, in the learning process, students don’t get the opportunity to develop thinking skills and actively acquire knowledge. Besides, students are also not challenged with open questions and non-routine problems.

3.2. Flipped classroom

The Flipped Classroom model was first introduced in the mid-2000s by chemistry teachers Jon Bergman and Aaron Sams [18]. Usually, learning is carried out by gaining knowledge in the classroom and doing assignments individually or in groups outside the classroom. Here are many definitions regarding flipped classrooms in literature. While in Flipped Classroom, students prepare themselves by studying outside the classroom through books or the internet and then developing their knowledge through active learning activities in the classroom [19].

A similar opinion was raised that students are tasked with learning from digital media such as eBooks, e-notes, presentations, mind maps, videos, animations [20]. In the learning process in class, it can be in the form of blended learning, collaborative learning, problem-based learning, computer-supported collaborative learning, or peer teaching [21].

Computer-aided learning is an advantage of the Flipped Classroom. Computer-aided learning allows students to learn according to their learning styles and learning speeds [22]. They can choose the facilities provided in the form of audio-visual, visual, or notes. If they don't understand something, they can playback the video again, and the information is always identical. They can arrange their own time and place of study.

Another advantage of the Flipped Classroom is that it involves students actively during lectures. Involvement in learning has a positive effect on student learning outcomes with low ability and increased critical thinking skills [23]. Furthermore, they conducted a meta-analysis study concluded that Flipped Classroom could be applied to all disciplines and at all levels of education. In addition, Flipped Classroom forms lifelong learning habits and 21st Century Skills at all levels of education [24].

The Flipped Classroom model is very appropriate to be implemented because students now belong to the millennial generation or "digital natives" who have been familiar with information technology from an early age [25]. Millennials access technology, information, and digital media more often and more than previous generations. Millennials have characteristics: 1) always access to hint at the "fingertips"; 2) multitasking environment; 3) prefers learning in an active and collaborative environment [25].

3.3. Developing HOTS using problem-based learning flipped classroom during the Covid-19 pandemic

Since the pandemic corona swept the world, many sectors are adversely affected, including the education sector. The implementation of education is no longer done face-to-face in the classroom, but education will be carried out remotely. The performance of distance education can be done by using the facilities of technology and communication from elementary school to college. Therefore, the ability of teachers and students in the use of IT positively influences the process of distance learning.

Flipped Classroom is implemented in 3 stages, namely the stage before learning, during learning, and after class learning [26]. In the scene before learning in class, students gain basic knowledge through material that has been given in various formats such as online video and text formats. At the learning stage in the classroom, students are active in learning, such as problem-solving, experimentation, role-playing, etc. In the third stage, after learning in class, students review their knowledge and skills through
questions or exercises. The implementation of the Flipped Classroom and outside the classroom are outlined in figure 1.

![Figure 1. Problem-based learning flipped classroom design.](image)

Figure 1 shows that Problem Bases Learning Flipped Classroom begins before the students learn in the classroom. Students learn the material geometry independently outside of class from a variety of sources such as an ebook, video, and animation. Ebooks can be uploaded in the format of the word, pdf, to a website or blog created by the teacher. Video and animation can also be upload on your Blog or YouTube. In addition, the student exploration of geometry by software GeoGebra. The learning process is guided by the Learning Management System or platform that is readily available and easy to use, like Google Classroom. Communication facilities contained in the smartphone can also be used as WhatsApp Messenger. While to facilitate the students to discuss in group, Trello can be used. Trello has a feature list that serves to work facilities of students in groups such as chat, upload the results of the work in writing, pictures, or video.

During-class or face-to-face students learn through Problem Based Learning to develop the ability of students to do the questions the orientation of the HOTS in the graph and the function. Student collaboration in small group applying new ideas/concepts and skills. After the class session, the teacher gives a matter of stuffing in the form of a short, multiple-choice, or essay through Google Form, Quizzes, and similar applications available on the internet.

Flipped Classroom is integrated with problem-based learning can be used as an alternative implementation of the distance learning process because the learning process is assisted by the learning facilities available on the internet and not paid. The application used belongs to the category of easy application that can be used by teachers and students. The application used can be accessed through a computer or smartphone, so learning programs like this can be implemented with better.

By using animation video in this Flipped Classroom can correct misconceptions of students towards mathematical concepts [27]. Besides, students' low ability can use the video repeatedly according to the needs of the study. In addition, students use GeoGebra before and during the class stage. GeoGebra improves students' conceptual understanding of geometry concepts [28]. In line with [29], GeoGebra also improved HOTS of the prospective teachers as well as enhance their collaboration and motivation. Exploration with GeoGebra developing the ability of understanding, reasoning, which is an essential aspect in HOTS.

Further on, at the moment in the classroom through PBL, students discuss the relationship between concepts and principles, integrating a variety of literature resources, applying concepts and guides to the problems discussed in the group, and integrate knowledge and skills. Therefore, PBL is assumed to help
students understand the idea of a predictable time is studied before learning in the classroom. PBL also allows students to apply the knowledge and skills to new problems as a result, and students are challenged to analyze problems and devise a network of concepts to make strategies looking for a solution to the problem. Activities to solve new problems or solve problems in everyday life, including to HOTS.

4. Conclusion
Some of the things that can be concluded is a problem based learning flipped classroom gives students opportunities to develop the ability to think high level. It can be shown with the student activities independently outside of the classroom acquire the knowledge from the source readings and video. Also, when the students using the software GeoGebra to understand the concept of graphs and functions through reasoning and communication presented in visual form. The development of HOTS to be more optimal when students work in a group through the PBL to solve the problem of non-routine.

Model problem based learning flipped classroom can be implemented well if the teachers make good planning such as teaching materials; the task is done students before learning. Besides, students engage the PBL following the range of ability of students. Model problem based learning flipped classroom can also be developed to be applied in other subjects.

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