Education for industry revolution 4.0: using flipped classroom in mathematics learning as alternative

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Abstract. The industrial revolution 4.0 that we have faced nowadays has triggered the development of digital and cyber technology which will affect all aspects of human life, including educational aspect teaching of mathematics. Therefore, a new learning model that can be a reference for teachers in facing the industrial revolution 4.0 is needed. This article would review the flipped learning model as a form of Blended Learning (BL) in the teaching of mathematics. The flipped learning model was a learning model that conveys learning information remotely through video or text in an online context, and then the learning material would be further learnt through face-to-face learning. The implementation of this model was supported by a variety of technologies so that it was suitable to be used in the current 4.0 industrial era. In addition, this article would explain the example of implementing flipped learning in teaching mathematics that could be used as a reference for teachers. The overall description was expected to be an inspiration for researchers, teachers, or prospective mathematics teachers in conducting further research and in the process of learning mathematics.

1. Introduction
The potential of technology usage in education has brought a new perspective by providing convenience in the process of teaching and learning in the classroom. This shifts the way teachers and students access information and bring new learning innovations in classroom. Technology provided resources to obtain up-to-date information and improve learning by introducing a collaboration that made distance no longer a problem in hindering the education process [1]. This is in line with the challenges that must be faced in the field of education, including mathematics in the era of industrial revolution 4.0. Industry was a part of the economy that automatically produced highly mechanical material [2] and it was able to influence all aspects of life in a country [3,4]. Industrial revolution was a case related to daily life and it was able to provide significant improvements [5]. Throughout history, there had been four basic industrial revolutions [6, 7] namely: (1) industry 1.0 which was caused by mechanization; (2) industrial revolution 2.0 which led to the use of electricity; (3) industrial revolution 3.0 which was related to electronics and automation; and (4) industrial 4.0 revolution which was related to the development of digitalization and robotics that we were currently facing [8]. The whole revolution not only influences mechanical production, but also labor to the world of education system. The term industrial revolution 4.0 was first introduced by the German government in 2011 at an exhibition called Hannover Fair [5]. Industry 4.0's main vision was to create "smart factories" that
would connect all production into the cyber system by utilizing internet services as part of technological advancement [9]. The main objective of industry 4.0 was to achieve a higher and more efficient level of operational productivity [10]. Thus, technology will affect all aspects of human life, especially the aspect of education which is a means to prepare humans to face challenges in the future.

The revolutionary shift towards digital and cyber technology indirectly affects the education system in Indonesia, including in mathematics teaching. However, the rising problem was that the industrial revolution 4.0 which had a high correlation with the internet-based technology system and advanced algorithms [11] had not been in line with the mathematics learning model which was generally used in Indonesia. Mathematics learning in Indonesia still uses conventional scientific learning without the balance use of technology. If this is continuously happening, Indonesia will be left behind compared to other countries, especially in the field of mathematics teaching.

The solution offered related to these problems is implementing Blended Learning (BL) in mathematics teaching and learning process in classroom. Blended Learning (BL) was a combination of traditional face-to-face learning with online technology-based learning (e-learning) in order to improve the quality of education [12]. Experts even argued that BL would be a learning model that would later dominate the world of learning system [13]. This was in line with the variety of research results shown that BL was very effective in improving student learning in schools [14].

BL has various forms of implementation, one of which is the Flipped Learning Classroom or flipped learning model. Flipped learning was a learning model that referred to the BL strategy [15] and it was becoming increasingly popular in math classes throughout the world [16]. Flipped learning is the delivery of lesson remotely through video or text. Flipped learning is called "flipping" because it comes from traditional structures where class time is used to provide direct instruction, while applications from lesson content are made into homework. Experts argued that the inversion of this activity further supported technological novelty and led to more efficient use of resources [17]. The fact that many studies proved the advantages of flipped learning is not yet fully utilized by educators [11] especially in Indonesia. The implementation of flipped learning is still very uncommon in Indonesia even though this learning model is very much in accordance with the demands of the industrial revolution 4.0 that is currently happening in the world. The possible cause is that educators do not yet fully know the flipped learning model and how to implement it.

Based on the explanation, this article will explain the flipped learning model as one form of blended learning in mathematics teaching to prepare Indonesian education in confronting the industrial revolution 4.0. The explanation includes the concept of flipped learning as one of Blended Learning, the principles of flipped learning, the role of flipped learning in effective mathematics teaching, and ideas related to the implementation of flipped learning models in mathematics learning. In this article, the technology used in implementing flipped learning is Google Classroom, learning videos from Khan Academy, Quizizz, and also Google Form. These technology are used because they are easily accessible to anyone and can be installed for free.

2. Methods
This research was a literature review that aimed to evaluate deeply and critically about previous research related to the topic of industrial revolution 4.0 in relation to flipped learning as one of blended learning.

3. Result and Discussion
3.1. The flipped learning concept as one of blended learning
Flipped learning referred to Blended Learning (BL) strategy in which before the material in class was taught, students had to study the material at home as homework beforehand [15]. This learning was originally used in 2007 at a university, but at that time it was only referred to as “flipping” [16]. The cause of the emergence of flipped learning model was due to dissatisfaction with the achievement of conceptual understanding through traditional learning method. In addition, the time of class learning was also limited despite of the loaded material which made educators are only able to convey each
concept of the material once at a time without a follow-up of the concept. This was what started the popularity of this learning model and over time had attracted the attention of educators around the world, especially in the field of STEM (Science, Technology, Engineering, and Mathematics) [15].

According to the Flipped Learning Network (FLN) in [18], flipped learning was a pedagogical approach where learning instruction moves directly from group learning space to individual learning space, and the learning community it followed was transformed into a dynamic and interactive learning environment. Flipped learning was called "flipping" because it came from traditional structures where class time was used to provide direct instruction, while applications from the lesson were used as homework by utilizing technology as an implementation of online learning. Experts argued that the inversion of this activity which increasingly supported technological novelty led to more efficient use of resources [16]. In this learning model, the role of educators was to guide students as they apply concepts and engage creatively in the learning process. Thus, it could be concluded that flipped learning was the delivery of learning material remotely through video or text in an online context, then the learning material would be further explored through face-to-face learning in class.

Most studies related to flipped learning had described variations in models used in various contexts with different features. Several studies had provided analytical tools to assess the quality of videos used in mathematics learning [19]. There were also studies that focus on the systematic application, such as the role of textbooks in videos made by teachers [19], learning opportunities provided for students during their time in class [20], ways the teacher used information gathered through outside-class activities [21], or the role of other elements in supporting flipped learning [22]. The overall study showed that flipped learning had a positive impact on classroom learning.

3.2. Principles of flipped learning

Flipped learning believed that lectures, demonstrations, and explanations could be delivered remotely at the right time for students and could be replayed repeatedly [23]. Based on that view, Flipped Learning Network (FLN) in [18] described four principles or pillars of flipped learning as follows:

a) Flexible Environment. Classrooms could be used for a series of learning activities, including group work, performance assignments, evaluations, etc.

b) Learning Culture. Classroom learning should be student-centered by making them active in gaining the knowledge.

c) Intentional Content. The teacher maximized time in class using strategies such as group instruction, problem-based learning, etc.

d) Professional Educator. Although online learning used video assistance, the teacher's role could not be replaced by video. The teacher should be a facilitator in encouraging students' knowledge development during face-to-face class and this required substantial expertise and skills.

Based on these principles, it could be concluded that the main purpose of flipped learning was to be able to make students evaluate their own progress for a particular material. The researchers even emphasized that student learning performance in the flipping class might not be as good as expected without the support of the students themselves [23]. This study also showed that flipped learning places more responsibility on students (and parents) to monitor learning, because the teacher was not present to assess students' understanding during the presentation of video content (online learning), but when in class (face-to face learning -face), the teacher should play a full role as a facilitator in overcoming students' misunderstanding.

3.3. The role of flipped learning in an effective mathematics teaching

In a review by Hiebert and Grouws [24] on effective mathematics teaching, it was concluded that there were two features of instruction that consistently directed students to develop and strengthen understanding of mathematical concepts: (1) explicit attention of the concepts which would be studied, and (2) student involvement in trying to be accompanied by mathematical ideas. Explicit attention to the concepts needed leads students to consider not only "how" the mathematical strategy, but also "why" and "when" the strategy was used. This meant that in flipped learning, the relationship between
ideas, strategies, and representations needed to be done explicitly in learning videos or during in class. The purpose of trying to be accompanied by mathematical ideas was that students make every effort to understand mathematical problems and to find out how to solve something abstract. Another feature reflected in the NCTM Principles [25] was the support for productive attempt/effort in learning mathematics as one of eight teaching practices that should be applied in student mathematics learning. This could be achieved through flipped learning by not only presenting the right and efficient solution strategy, but the possibility of students experiencing misconceptions could also be considered. In accordance to the research conducted by Webel, Sheffel and Conner [23], teachers could use videos to provoke students' ideas and arranged so that students could further hone their productive efforts during the learning learning.

de Araujo, Otten and Birisci [19] also described the elements of effective instruction in learning mathematics by emphasizing social and relational aspects. Students needed a lot of time to explore various mathematical ideas for a particular concept. This was done so that they were able to develop ideas in problem solving. Empirical evidence to support the discussion of mathematics among students was also reflected in the formation of "meaningful mathematical discourse facilities" as one of the eight main practices in the Principles to Actions [25]. Flipped learning might support this by providing more time in class to discuss with students because other aspects of teaching could be completed outside the classroom. This was in line with the four pillars of flipped learning [18] which emphasized the use of class time for student-centered activities, including less time spent in teaching and more time for students to conduct discussion so that they were actively involved in developing their knowledge.

3.4. Ideas related to the implementation of the flipped learning model in mathematics learning

This section would examine examples of ideas related to the implementation of flipped learning models in mathematics teaching. The following examples of ideas had been examined using the perspective of the concept of flipped learning, the pillar of flipped learning, and the role of flipped learning in effective mathematics teaching as described in the previous section. The following was a detailed description of the implementation of idea:

In order to focus more on the problem, the topic of probability material was chosen which was one of the mathematical material in the grade 11. In conventional learning, teachers generally spent more time in face-to-face interactions and the learning process was less focused on student-centered. This was because the classroom interaction time was used by the teacher to explain the basic theory, so that the teacher could not give enough time for students to solve the problem given. As a result, the learning process was more teacher-centered. Another problem was that there were six skills (starting from the low level: knowledge, understanding, application, analysis, synthesis, and evaluation) that are expected to be developed by the students in the learning process [26]. In flipped learning, instructions and explanations were given first so that the understanding process (low level thinking skills in the Bloom taxonomy) occurred before the face-to-face session in class. The students watched audio-visual videos that contained explanations regarding concepts and examples of probability material. In addition, notes were also prepared as further explanations to students.

In order to support flipped learning, Google Classroom was used. Google classroom was an educational platform provided by Google and could be accessed for free if a user already had a Google private account. Google classroom was very useful because it allowed the teacher to create a virtual classroom, where in the virtual classroom we could upload material, creating quizzes, and assigning homework for students. The use of Google Classroom also allowed students to access material anywhere and anytime they needed. Features of the Google Classroom including learning videos, additional notes, material, schedules / announcements, messages, and various links provided by the teacher could be accessed freely by students. In order for students to join the Google Classroom that had been created, students would be given a class code. This code could be obtained on the virtual classroom page that was created.
In this study, videos from Khan Academy were used. Khan Academy was a learning resource that can be accessed for free by anyone, both students or teachers, and covered a variety of subjects, one of which was mathematics. Khan Academy was a very complete learning media, all materials were explained in detail so that the various videos contained on the website could be used by the teacher to support their teaching in the classroom.

In virtual classes that had been created, students should access mandatory material and additional material so that they could understand the probability material well. For compulsory material, a link to the introduction video of probability material by Khan Academy was included. The video contained theoretical explanations and practical examples related to probability material for 11th grade students. This video used animation with audio explanations that could attract students' attention. For additional material, students could access teacher’s notes that contained more complex questions and also simple examples. More complex questions were aimed at students who have high capability, while simple examples were used to accommodate students with lower capability.

In order to ensure that all students had watched the assigned video, students were instructed to prepare at least one question related to the topic of probability, then they were randomly asked to express their opinions in front of the class. This could build students' sense of responsibility to be involved in preparing material before learning. Moreover, the design of pre-face learning that focused on the use of technology would create a special attraction for students and a comfortable learning environment. By using this kind of learning procedures, students were expected to be able to understand the material presented in the video so that students' creative thinking skills could be further developed in face-to-face learning.

In face-to-face learning in classroom, students were expected to be able to directly solve the problems given by applying the knowledge previously obtained from the learning video. The time available in class meetings could be allocated to working on more examples and solving more problems. To simplify the problem solving process, students would be divided into several groups so that they could discuss with their friends. This showed that learning was really student-centered, while teachers could act as facilitators during the learning process in classroom. The development of students' creative thinking skills would be assessed through the projects they made. Thus, in addition to solving problems in class, students also had to design a project related to probability material as a final assessment of the lesson. Therefore, flipped learning could facilitate the students to explore their way of thinking creatively. Flipped learning had shown a great contribution to improving students' creative thinking skills as in the study of K. Lee and Lai [27].

The mechanism of learning in class in detail was as follows: Each student would solve the problem of the probability to use one of the online learning media, namely Quizizz. Quizizz was an online-based learning game that could be accessed using any device. The benefit of using this application was to allow teachers to make games related to a particular topic. This application also adapted system game components that could attract students' interest. Quizzes that would be created through the Quizizz application had difficulty levels according to Bloom's taxonomy. Each student would answer all questions individually with a predetermined time limit. Every student competed to get the highest score. By using Quizizz, the level of academic competition could also be developed so that students were motivated to study harder. Furthermore, using Quizizz, the teacher could get detailed data about student knowledge based on their answers regarding the questions that had been made. From this application, it could also be concluded that the dominant questions were answered correctly by students, as well as questions that were mostly difficult to solve. This could help teachers in making judgments and planning exercises and online materials that were suitable for students' abilities. In addition, because the results could be displayed immediately after completing the game, teachers could begin evaluating the problem by discussing difficult questions in the class. Students would be given time to discuss together that positively encouraged students to improve their achievement [28]. During this stage, the teacher would control the discussion by visiting each group one by one, and directing them if they were wrong.
In order to further hone students’ creative thinking skills, they would be asked to make a project. Students would be given dice to test and compare the concepts of probability with real experiments. Each group should make its own problems, and then test whether the results of mathematical calculations and experiments were done the same. If there were differences, students should find out why theories and experiments could be different. If both were the same, students were then asked to design a project using the concept of probability in a practical and effective way in real life. After that, each group should present their findings in front of the class. Students were given the freedom to explain their findings, either by using direct experiments, videos, animations, or other creative methods.

As feedback from the learning that had been done, a simple survey would be designed using Google Form to ask students' opinions about classroom learning. Google Form was a simple way to conduct surveys because it could be accessed by anyone using e-mail. In surveys, students not only assessed the effectiveness of the class, but they could also provide comments or suggestions such as math games or educational applications that they considered very useful and could be applied in the learning process.

The above explanation was the description of ideas related to the implementation of flipped learning models in mathematics learning for probability material. The overall description of the implementation of flipped learning was expected to provide new references for the process of teaching mathematics in Indonesia.

4. Conclusion
From the description in the previous section, the following conclusions could be drawn. First, flipped learning was one form of blended learning by delivering learning information remotely through video or text in an online context, then the learning material would be further followed-up through face-to-face learning in class. Second, the four principles/pillars of flipped learning could be used as a theoretical foundation in implementing flipped learning in teaching mathematics. Third, the implementation of flipped learning could take advantage of various technological applications including: Google Classroom, Learning Videos from Khan Academy, Quizizz, and also Google Form. All the technologies were used because they were easily accessed by anyone and could be installed for free. Fourth, through the ideas described in the example of implementing flipped learning, it could be concluded that the concept of flipped learning was actually very effective and easy to conduct. The teacher as an educator should have special expertise especially related to the use of technology. Fifth, the various benefits of flipped learning based on the results of previous studies showed that flipped learning models were effective in improving students' mathematics achievements and this could be used as a reference for teachers as the latest learning model that could be applied to face the industrial revolution 4.0.

In conclusion, the writer hoped that the simple description in this article could be used as an inspiration or reference for researchers, teachers, or prospective mathematics teachers in further research and in the process of teaching mathematics. Further study and research related to the implementation of flipped learning mainly in Indonesia was a research area that needed to be explored.

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