CB-BL model (challenge based on blended learning) for mathematical creativity

A S Ardiansyah*, Mulyono, Mashuri, R A Fiyanti and F S Hamidah

Department of Mathematics, Faculty of Mathematics and Natural Science, Universitas Negeri Semarang

*Corresponding author: adisatrio@mail.unnes.ac.id

Abstract. To improve students’ mathematical creativity, which is the competency in the industrial revolution 4.0 and is in 4-C and 5-C, it is necessary to have learning innovation for it. Challenge-based on blended learning (CB-BL) is a framework that integrates challenge-based learning and blended learning so that the need for face-to-face learning and learning using IT is satisfied. This research is a literature study research with the research aims to describe the CB-BL model steps that consist of The Big Idea, Essential Question, The Challenges, Solution – Action, and Assessment. The Big Idea and Essential Question are carried out face-to-face such that students know the learning objectives through solving challenges. The Challenges and Solution – Action are carried out online by providing the instructional video, textbook, and discussion forum integrated with the learning management system to solve the challenges. The last step is Assessment, which consists of Publishing Student Sample and Reflection, carried out face-to-face. In this stage, students publish the results of solving challenges and through self-reflection based on learning experiences they have carried out. By integrating challenge-based learning and blended learning, mathematics creativity can be developed. It is also a learning model that can be applied during New Normal.

1. Introduction
Creativity is a challenge for learning mathematics in the industrial era 4.0. It not only plays a vital role in math learning but is also an influential qualification or competency in the industrial age 4.0 and is one of the essences of 21st-century learning [1-5]. It is one of the four skills (4C) that consist of critical thinking and problem solving, creativity and innovation, collaboration, and communication [6]. It is also one of the five skills (5C) that consist of collaboration, communication, creativity, critical thinking, and celebration, which are the essential skills for superior human resources in the 21st century, especially for technological and vocational education [7]. The Ministry of Education and Culture added that creativity is one of the competencies that would be most useful for any change were besides collaboration, compassion, computational logic, critical thinking, and communication. Also, the development of mathematical creativity, which is the highest level in Bloom's taxonomy, along with several other abilities and skills such as critical thinking skills, problem-solving, communication, connections, and mathematical reasoning, as well as metacognitive can develop into higher-order thinking skills [8-10]. Mathematics learning without involving creativity and overriding students' ability, extraordinarily gifted students, because developing talent requires creativity in exploring mathematical problem solving [11].

Mathematical creativity is characterized as the context of problem formation, discovery, independence, and originality, as well as the process of formulating hypotheses about cause and effect.
in mathematical situations, testing and re-testing these hypotheses and making modifications, and finally communicating the results [12]. The creativity that can be viewed as a combination of logical and divergent thinking can be assessed by identifying fluency, flexibility, and novelty [4,13-15]. Problem-solving is one way that can be used to develop students’ mathematical creativity. Students can not only become fluent in building many problems from a situation, but they can also develop flexibility by generating many solutions to a problem [16]. In this way, students can also develop themselves in producing new solutions.

The development and development of learning models are so fast that in line with the times and future needs. Learning models can develop student potential and develop the next advances in information technology [17-18]. Challenge-based learning is collaborative learning that requires students to solve urgent problems, propose solutions to real problems, and take action, and be able to publish their solutions to audiences around the world, built on problem-based learning practices that require students to solve real problems in groups [19-20]. Furthermore, blended learning, which is closely related to technological innovation, institutional practices, the interaction between institutions, and the impact of technology policies, is defined as learning by combining face-to-face and online learning activities [21-23].

CB-BL as the combination of challenge-based learning and blended learning is a learning innovation that accommodates the need for the potential development of students and developments in information technology. This learning model is expected to improve mathematical creative thinking abilities. Therefore the aim of this research is to describe the CB-BL model step that can improve mathematical creativity.

2. Research Methods

Literature study is used in this research as a series of research related to library data collection methods, or research whose research object is explored through a variety of library information included books, scientific journals, and documents that are included in secondary data. Literature studies are conducted to critically examine or review the steps of the CB-BL model through academic-oriented literature activities and formulate theoretical contributions to the influence of the CB-BL model on mathematical creativity. The stages in this research are (1) Organize, organize the literature to be reviewed through the activity of looking for ideas, general goals, and conclusions from the literature by reading the abstract, introductory paragraphs and conclusions, and classifying literature based on certain categories; (2) Synthesize, unifying the results of the literature organization into a summary so that they become a unified whole, by looking for linkages between literature; (3) Identify, identify controversial issues in the literature; and (4) Formulate, namely formulating questions that require further research. Data were analyzed using bibliographic annotation techniques which are defined as the collection of research data through a list of sources where each of these sources provides conclusions related to the steps of the CB-BL model and the effect of the CB-BL model on mathematical creativity.

3. Results And Discussion

The development of the Challenge Based on Blended Learning takes into account the qualification needs of graduates in the Industrial 4.0 era and the development of information technology. CB-BL is designed as an innovative learning model that can develop mathematical creativity. The stages in CB-BL adopt the stages in CBL which consist of The Big Idea, Essential Question, The Challenges, Solution – Action, and Assessment [24] which are carried out face-to-face and online. The integration of face-to-face and online learning is carried out comprehensively through a learning management system such as Google Classrooms or any other application such as Whatsapp.

The Big Idea is the first step in this learning model. The students are given a Big Idea as a trigger in learning. At this stage, students are asked to listen to an idea presented by the teacher. Ideas are conveyed at the beginning of the lesson to attract students’ attention so that students are motivated during learning and the concept construction process through solving challenges can be carried out by the learning
objectives. Learning objectives and subject matter topics are also presented at this stage. It can be said, this stage is the first stage in learning which is carried out face-to-face.

A good Big Idea is Meaningful Big Ideas. Teachers need to develop a Big Idea that fits the current situation and considers the fulfillment of learning objectives. With Big Idea that is interesting, authentic, and following the student experience, students will make personal connections with the content and be able to complete Challenges well [19-20]. Also, student interest can increase.

Essential Questions are a set of questions submitted by teachers related to the Big Idea. Essential Questioning allows the Learners to contextualize and personalize the Big Idea. Through direct questioning, students are asked to answer several questions related to the Big Idea. Essential Question is an important stage in this learning. Teachers must have the ability to develop good questions [25] so that students will be well directed to meet learning objectives. This activity is carried out face to face.

The Challenge is a time when students are asked to complete a given challenge. The Challenge consist of several activities such as Guiding Questions, Guiding Activities, and Guiding Resources. In this stage, students in groups carry out self-exploration and indirectly receive direction through several questions, directed activities, and learning resources as their guide in solving challenges. These activities are carried out online through the provision of instructional videos and teaching materials that are integrated into the learning management system and search for other references through search engines.

Challenges turn the Essential Questions into a call to action by charging students to learn about the subject and develop a Solution [20]. Thus, Challenges are immediate and actionable. Students plan and participate in activities that build the foundation of the Solution and achieve learning objectives. Guiding Questions point towards the knowledge students will need to develop a solution to the Challenge. Teachers must pay attention to develop excellent Guiding Questions that will create an organized learning experience. Guiding Activities and Resources are used to answer Guiding Questions. This activity is developed to include any methods and tools available to students. The process of constructing materials is picked through the Activity Guide and provides a basis for identifying solutions to solving challenges.

Solution - Action is a stage where students ask students to complete challenges by getting the right solution. The process of solving challenges is carried out by students individually or in groups, but it is recommended that they be carried out in groups. Each solution given must be clearly articulated and then published in class. Group discussions are carried out through discussion forums provided in the learning management system. The group discussion process is directly monitored by the teacher, so that students focus on completing the Challenge well and preparations for publication of the Solution are well executed. In developing solutions, students can also be encouraged to think creatively in designing solutions [19-20].

Proof-based solutions are created, actualized with an authentic audience, and after that assessed based on the results. Solution concepts rise from the discoveries made during the investigation phase. Utilizing the plan cycle, students will prototype, test, and refine their Solution concepts [20]. Usage of the Solution takes put inside a real setting with an authentic audience.

Assessment is the last stage in this learning model which is carried out face-to-face. Assessment stage consists of two activities, namely Publishing Student Samples and Reflection. In the Publishing Student Samples activity, students are asked to publish Solutions from Challenges. After students submit solutions, other students are asked to provide feedback and the teacher corrects or provides feedback on solutions developed by students. The next activity at Assessment stage is Reflection. Reflection is a self-reflection activity carried out by students based on the learning experiences they have carried out. Students assess their learning success through a self-assessment questionnaire that the teacher has developed. Assessment gives the opportunity to assess the effectiveness of the Solution, make adjustments and develop subject area of knowledge [20].
The combination of CBL and blended learning is a learning innovation that is effective to increase mathematical creativity. The process of constructing a concept by students begins with the giving of a Big Idea which is followed by Good Questions that explore and guide students towards the concepts they must understand. With this process, students must be able to solve the given problems well and provide new and unusual ideas as a form of developing mathematical creativity. Several studies stated that the challenge-based learning activity was effective to increasing mathematical creativity. CBL is not only effective for students' creative thinking skills but also effective in increasing mathematical creativity in solving MST (multiple solution tasks) and student creative problem solving [11,16,26-29].

The integration of CBL with STEM also has a positive influence on students' creative thinking skills [30]. Johnson & Adams [22] included that nearly 88% of students concur that CBL experiences make them creative individuals.

In its implementation, several challenges will be presented that are contextual and characterized by ill-structured and open-ended which are oriented towards the context of the field in which they are engaged, so that the development of mathematical creativity can be carried out properly. Challenge Based Learning can be created in circumstances that are as flexible and creative as possible and give a safe space for all students to think creatively, try new ideas, experiment, fail, get criticism, and attempt once more [20]. The challenges can trigger students to think creatively by attempting to create new ideas, experiences, failures, and feedback on spatial learning [31].

Blended learning integration gives its color to the CB-BL model. Blended learning as learning that is needed during the development of technology and information has a positive impact on students' mathematical creativity. Wahyudi, et al. [32-34] stated that 3CM (Cool-Critical-Creative-Meaningful) model with a blended learning approach can increase mathematics instruction understudies’ creative thinking ability in solving mathematics problems. Another integration of blended learning with project-based learning was also noted to be very good, with 67% of students being categorized as very good in achieving creative thinking skills [35]. Furthermore, flipped classroom-blended learning is effective against students' creative thinking skills [36]. The creativity of mathematics instruction understudies in Figure 1. The Stages CB-BL Model
creating learning media based on Macromedia flash through blended learning was also develop where 71% of them were within the exceptionally great category and the rest of them were classified as great, insufficient, and destitute [37].

The application of CB-BL to learning management systems such as Google Classrooms or other applications such as Whatsapp is expected to have an impact on students' mathematical creativity. The implementation of Mix Apps that consist of Web applications, Google classroom applications, and hang out applications is effective to develop students' creativity [38]. The application of google classroom in the RADEC learning model with the STEM approach can develop student creativity [39]. The implementation of other learning management systems such as Gnomio can develop students' mathematical creativity [40-41]. Whatsapp application also takes effect on students’ creative thinking skills [42].

4. Conclusion
The CB-BL model gives its color to the implementation of learning nowadays, which demands the development of graduate qualifications and potential student skills such as creativity. This model's development is also caused by the development of information technology, which demands that the learning process be more effective and efficient. CB-BL model activities consisting of The Big Idea, Essential Questions, The Challenges, Solution - Action, and Assessment can be carried out face-to-face and online. Online implementation can be done by utilizing Google Classroom. This model's uniqueness is that the student's concept construction process can be done anywhere and anytime so that students can provide innovative and creative solutions to the challenges given. The development of Meaningful Big Ideas, right Essential Questions, current issues or Challenges, and paying attention to learning objectives are homework for teachers. Implementing the CB-BL model can be carried out well and give the effort to develop students' mathematical creativity. What is no less important than this learning model is that CB-BL can be used as an alternative in implementing distance learning during the pandemic or New Normal.

References
[1] Malik A 2019 Int. Res. J. Adv. Eng. Sci. 4 (1) 209
[2] Prifti L, Knige M, Kienegger H and Kremar H 2017 Proc. 13. Int. Tag. Wirtsch. 46
[3] Benešová A and Tupa J 2017 Procedia Manuf. 11 2195
[4] Levenson E 2013 J. Math. Teach. Educ. 16 269
[5] Fatah A, Suryadi D, Sabandar J and Turmudi 2016 J. Math. Educ. 7(1) 9
[6] Partnershiop for 21st Century Skills 2011 21st Century Skills Map: Math. Washington: P21.org
[7] Sudira P 2015 Cakrawala Pendidik. 34(1) 1
[8] Thompson T 2008 Int. Electron. J. Math. Educ. 3(2) 96
[9] Dewi N R and Kusumah Y S 2014 Int. J. Educ. Res. 2(12) 101
[10] Rajendra 2008 Teaching and Acquiring Higher Order Thinking Skills Theory and Practice (Tanjong Malim: Universiti Pendidikan Sultan Idris)
[11] Ardiansyah A S and Asikin M 2020 J. Phys.: Conf. Ser. 1567(2020) 022088
[12] Akgul S and Kahveci N G 2016 Eurasian J. Educ. Res. 52 57
[13] Yazgan-Sag G & Emre-Akdogan E 2016 Aust. J. Teach. Educ. 41(12) 25
[14] Lekin R and Lev M 2013 ZDM Math. Educ. 45 183
[15] Silver E 1997 ZDM Math Edu 29(3) 75
[16] Ardiansyah A S, Junaeda I and Asikin M 2018 Unnes J. Math. Educ. Res. 7(1) 61
[17] Iswan & Herwina 2018 Prosiding Seminar Nasional Pendidikan Era Revolusi. 21
[18] Subekti H, Taufiq M, Susilo H, Ibrohim & Suwono H 2018 Educ. Hum. Dev. J. 3(1) 81
[19] Johnson L and Adams S 2011 Challenge Based Learning: The Report from Implementation Project (Texas: The New Media Consortium)
[20] Nichols M, Cator K, and Torres M 2016 Challenge Based Learner User Guide (Redwood City, CA: Digital Promise)
[21] Castro R. 2019. *Educ. Inf. Technol.* **24** 2523
[22] Garrison D R & Kanuka H. 2004. *Internet High. Educ.* **7** 95
[23] Manwaring K C, Larsen R, Graham C, Brigham C H, & Halverson L R. 2017. *Internet High. Educ.* **35** 21
[24] Yoosomboon S and Wannapiroon P 2015 *Procedia Soc. Behav. Sci.* **174** 2102
[25] Rochmad and Masrukan 2016 *J. Kreano* **7**(1) 47
[26] Nufus H, Duskri M & Bahrun 2018 *J Res Adv Math Educ* **3**(2) 57
[27] Naim S S, Ibnu S & Santos A 2020 *J Pendidik: Teori Penelit dan Pengemb* **5**(4) 478
[28] Ardiansyah A S & Junaedi I 2020 *PRISMA* **3**(2020) 258
[29] Junita S 2016 *J. Pengajaran MIPA* **21** (1) 19
[30] Putri N, Rusdiana D & Suwarma I R 2019 *J. Sci. Learn.* **3**(1) 7
[31] Johnson L F, Smith R S, Smythe J T and Varon R K 2009 *Challenge Based Learning: An Approach for Our Time* (Texas; The New Media Consortium)
[32] Wahyudi, Waluya B, Suyitino H & Isnarto 2020 *J Technol Sci Educ* **10**(1) 32
[33] Wahyudi, Waluya B, Suyitino H & Isnarto 2019 *J Educ Sci Technol* **5**(1) 26
[34] Wahyudi, Waluya B, Suyitino H & Isnarto 2018 *Adv. Soc. Sci. Educ. Humanit. Res.* **247** 577
[35] Candra R A, Prasetya A T & Hartati R 2019 *J Inov Pendidik Kim* **3**(2) 2437
[36] Sya'roni A R, Inawati P A, Guswanti E, Susanto & Hobri *J. Phys.: Conf. Ser.* **1563**(2020) 012046
[37] Fitriasari P, Octaria D & Sari N 2020 *J. Phys.: Conf. Ser.* **1521**(2020) 032085
[38] Andriani A & Sagala O B 2020 *J. Phys.: Conf. Ser.* **1462**(2020) 012027
[39] Ma’ruf A S, Wahyu W & Sopandi W 2020 *J Educ Sci* **4**(4) 758
[40] Ulinnuha R, Waluya B, & Rochmad 2021 *Unnes J Math Educ Res* **10**(1) 20
[41] Ulinnuha R & Rochmad 2020 *PRISMA* **3**(2020) 476
[42] Nida N K, Usodo B & Saputro D R S 2020 *J Educ Learn* **14**(2) 307