SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS BASED ON BLENDED LEARNING FOR IMPROVING CRITICAL THINKING ABILITY OF STUDENTS

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Abstract This study aims to develop STEM (learning model *Science, Technology, Engineering and Mathematics* Based *Blended Learning* a practical). The problem posed is to produce a practical STEMBL model in terms of the implementation of learning, learning activities, lecturer responses and student responses. The STEMBL model was developed by adapting the *Plomp* development flow, namely (1) initial investigation; (2) design; (3) realization/construction; (4) tests, evaluations, and revisions and (5) implementation. The model components developed refer to Arend and the model criteria refer to Nieveen. The subjects of this study were PGSD students at the University of Bosowa. The practicality of the model data was obtained through the instrument implementation of the model, the implementation of learning, as well as learning activities *offline* and *online.* The results of this study indicate that the STEMBL model is declared practical based on the observations of the observer on the implementation of the model, learning management and student learning activities based on the results of the practitioner's assessment of the learning model. Based on the findings, it can be concluded that the STEMBL model is practical in improving students' critical thinking skills.

Keywords: STEM, *blended learning*, critical thinking skills

INTRODUCTION

The rapid development of technology as it is today, makes it easier for humans to do things that were previously very difficult to reach. The great development of technology itself also has an impact on human life from various aspects so that humans need to make the best use of the existing technology at this time. Seeing this situation, reform in the field of education, especially the learning process to improve HR (Human Resources) in the era of technology and information**.**

Improving the quality of education in Indonesia can be done through the implementation of education reform. Changes that occur in traditional learning towards learning that further enhances critical thinking are called educational reform (Redhana, 2010). One form of education reform is to use a learning approach that can assist educators in creating experts by applying the STEM (approach *Science, Technology, Engineering, and Mathematics*)in learning.

Mastery of exact sciences, especially in the fields of science (*Science*), technology (*Technology*), engineering (*Engineering*), and mathematics (*Mathematics*), has an important role in education. The interdisciplinary integration of these disciplines is expected to be the key to success for changing a country, especially in the context of competition for 21st Century job career development/skills at the global level (Hanover Research, 2011). The STEM approach of course involves other sciences as support, such as Social Sciences, Languages, Arts, etc. (Bybee, 2013; Sanders, 2009).

The application of the STEM approach that has been implemented in educational institutions can make students know that the education they are taking is very important and useful in solving problems and situations in the real world today (Banks, 2011). Through a design-based problem solving process, it is expected to be able to overcome real-world situations (Williams, 2011). The integration of STEM subjects will be more effective if using a strategic approach in its

implementation so that it can make learning more relevant, stimulate the emergence of meaningful experiences, encourage students to think at higher levels and solve problems and increase retention (Stohlmann et al., 2012). Building a strategic approach to integrating STEM concepts requires a strong conceptual understanding of how students learn and implement STEM (Kelley & Knowles, 2016).

Based on this, lecturers must be able to design learning systems that are able to improve critical thinking, especially in the world of education. Referring to the teaching and learning process in the classroom, sometimes the material presented cannot be received optimally due to limited face-to-face time. To deal with these shortcomings, we can take advantage of the system *online* in terms of interacting in the learning process. There are several social media that are used as interactive learning media, now known as *Learning Management System* (LMS). LMS allows educators to create virtual classrooms as a means to interact and access subject matter anytime and anywhere as long as there is an internet network (Rosy, 2018).

The process of implementing *blended learning* certainly contains STEM approach learning. The STEM approach in question is teaching and learning content as well as interdisciplinary knowledge practices that include science and mathematics through the integration of engineering and design practices using relevant engineering technologies. The form of STEM integration in the classroom generally consists of three, including: integrated content, integrated content supporters or integrated context (Johnson *et al*., 2016).

Therefore, the boundaries between humans, machines and resources, information and communication technology are increasingly convergent, which has an impact on various sectors of life. One of them is having an impact on the education system in Indonesia, which has entered the era of the industrial revolution 4.0. To answer the challenges of the industrial revolution era 4.0 generation, it is necessary to create a learning model that integrates abased STEM approach *blended learning* -assisted by a *Learning Management System* (LMS) to improve critical thinking skills in creating an active and applicable problem-solving-based learning.

Based on the description above, a learning model was developed by applying a-based STEM approach *blended learning* that could improve students' critical thinking skills. The learning model developed is expected to meet the validity criteria to be used in learning. This refers to Nieven (2007), namely *"the wide array of educational products play important roles in education"*, the quality of learning model development products must meet the criteria of validity (*validity*), practicality (*practicality*), and effectiveness (*effectiveness*). Validity refers to 2 things, namely: (1) the developed model is based on a strong theoretical rationale or "*state-of-the-art knowledge*" or content validity/relevance, and (2) all components relate to each other consistently. or construct validity. If the intervention meets these requirements, it is considered valid or valid.

The problem posed is whether the learning model developed is practical in terms of model implementation, learning management and student learning activities. Based on the above, the purpose of this research is to develop a STEMBL (learning model*Science, Technology, Engineering and Mathematics* based *Blended Learning*) to improve critical thinking skills.

RESEARCH METHODS

This research is research and development or *Research and Development* (R&D) which refers to the development model *Plomp*. This model consists of five development phases, namely (1) initial investigation phase, (2) design phase, (3) realization phase, (4) test, evaluation, and revision phase, and (5) implementation phase. This development aims to produce a product in the form of a STEMBL Model that is practical in improving students' critical thinking skills. The research product is STEMBL. The components of the developed model refer to *Joyce, et al.* (1992). The characteristics of the developed model refer to Arend (2012), and product quality criteria refer to Nieven (2007). The data collection technique was carried out using the STEMBL model of practicality assessment instrument.

The practicality of the STEMBL model is seen based on the observer's observations on the implementation of the model, learning management and student learning activities. Learning models and supporting devices in learning are said to be practical in terms of the implementation of the learning model. Referring to the Hobri interval formula (2009), namely: 1 TK < 2 = not implemented,

2 TK < 3 = less implemented, 3 TK < 4 = quite implemented, 4 TK < 5 = well implemented, and TK = 5 = very well done. TK is the value of determining the level of practicality.

Data analysis of student learning activities while *offline is considered* active if they carry out at least 25% of activities during learning and students are considered active when the average percentage of students who are active *online* is above 50%. Students are considered to study effectively if the effective time taken is above 75%.

Based on the results of the practitioner's assessment If the results of the practitioner's assessment, the responses of lecturers and students indicate that the STEMBL model is not practical, then a revision of the model is carried out based on the suggestions of practitioners. The implementation of data analysis (TK) refers to Nurdin (2007) and Hobri (2009). The learning model developed is declared good, if it is at the level of practicality in the minimum category of "well implemented". If the level of achievement of implementation is below the minimum category, it is necessary to make revisions based on input or corrections from practitioners and responses from lecturers and students. After that, the practitioner will re-examine. And so on until the indicators of the ideal STEMBL model are obtained at the practical level.

RESULTS AND DISCUSSION

Results

The design of the STEMBL learning model activity is based on constructivism learning theory in which lecturers stimulate students' critical thinking skills so that they can build their own knowledge and provide opportunities to find and apply their own ideas in order to be able to solve problems in everyday life through design. learning with an interdisciplinary approach, namely the STEM approach based on *blended learning*.

A. Trial I

1) Implementation of the Learning Model The

results of the observation of the implementation of the learning model with the STEMBL model in trial I on PGSD students at the University of Bosowa are shown in Table 1.

Table 1. Implementation of the STEMBL Model in Trial I

Uji Coba I Pertemuan ke-	Keterlaksanaan Komponen Model STEMBL				
	Sintaks	**Sistem Sosial**	**Prinsip Reaksi**	**Sistem Pendukung**	**Rata-rata**
1	4,69	4,34	4,44	4,60	4,56
2	4,61	4,44	4,30	4,20	4,30
3	4,59	4,60	4,39	4,54	4,46
Rata-rata	4,63	4,46	4,37	4,44	4,44

Table 1. shows that the average value of implementation the STEMBL model in the first trial was 3.93. When referring to the implementation criteria, namely 4 Va < 5 = well implemented, then the STEMBL model is included in the category of well implemented or already practical.

2) Implementation of Learning with STEMBL

The results of observations of implementation of learning with the STEMBL model in trial I on PGSD students at the University of Bosowa are shown in Table 2.

Table 2. Implementation of STEMBL Learning Model in Trial I

Pertemuan ke-	Keterlaksanaan fase-fase pembelajaran						Rata-rata
	Fase 1	**Fase 2**	**Fase 3**	**Fase 4**	**Fase 5**	**Fase 6**	
1	4,69	4,34	4,44	4,60	4,56	4,25	4,48
2	4,61	4,44	4,30	4,20	4,30	4,50	4,39
3	4,59	4,60	4,39	4,54	4,46	4,61	4,53
Rata-rata	4,63	4,46	4,37	4,44	4,44	4,45	4,46

Table 2. shows that the average value of implementation of learning with the STEMBL model of 4.46. When referring to the implementation criteria, namely 4 $Va < 5$ = well implemented, then learning with the STEMBL model is in the category of well implemented or practical.

B. Trial II

1) Implementation of the Learning Model The

results of observations of the implementation of the STEMBL learning model in the second trial of PGSD students at the University of Bosowa are shown in Table 3.

Table 3. Implementation of the STEMBL Model in Trial II

Uji Coba II Pertemuan ke-	Keterlaksanaan Komponen Model STEMBL				
	Sintaks	**Sistem Sosial**	**Prinsip Reaksi**	**Sistem Pendukung**	**Rata-rata**
1	4,85	4,79	4,84	4,80	4,82
2	4,89	4,84	4,88	4,84	4,86
3	4,94	4,90	4,92	4,90	4,91
Rata-rata	4,89	4,84	4,88	4,85	4,86

Table 3. shows that the average value of the implementation of the STEMBL model in the second trial of 4.86. When referring to the implementation criteria, namely 4 $Va < 5$ = well implemented, where the STEMBL model in the second trial is in the category of well implemented or practical.

2) Implementation of Learning with STEMBL

The results of observations of implementation of learning with the STEMBL model in trial II for PGSD students at the University of Bosowa are shown in Table 4.

Table 4. Implementation of STEMBL learning in Trial II

Pertemuan ke-	Fase 1	Fase 2	Fase 3	Fase 4	Fase 5	Fase 6	Rata-rata
1	4,87	4,80	4,84	4,86	4,96	4,86	4,86
2	4,76	4,86	4,95	4,90	4,84	4,94	4,87
3	4,82	4,90	4,90	4,84	4,98	4,89	4,88
Rata-rata	4,82	4,84	4,89	4,89	4,92	4,89	4,87

Table 4. shows that the average value of implementing learning with the STEMBL model of 4.46. When referring to the learning implementation criteria, namely 4 $Va < 5$ = well implemented, then learning with the STEMBL model in the second trial is in the category of well implemented or practical.

The results of trial I and trial II of the implementation of the STEMBL model when analyzed using the normalized average Gain index (g), it was found that in the second trial there was an increase in Table 4.31. When referring to the gain index (Hake, 1999), the implementation of the STEMBL model has increased in the moderate category ($0.70 \geq g > 0.30$) for the syntax indicators and the support system for the STEMBL model. Meanwhile, there was an increase in the high category ($g > 0.70$) for the reaction principle indicators and the STEMBL model support system.

Table 5. Analysis of Normalized Gain Implementation of the STEMBL model

No	Komponen Model STEMBL	Uji Coba		Selisih Uji Coba	SM-I	Indeks Gain
		I	II			
1	Sintaks	4,63	4,89	0,26	0,37	0,70
2	Sistem Sosial	4,46	4,84	0,38	0,54	0,70
3	Prinsip Reaksi	4,37	4,88	0,51	0,63	0,81
4	Sistem Pendukung	4,44	4,85	0,41	0,56	0,73

SM = Skor Maksimal

The results of trials I and II of the implementation of learning with the STEMBL model were analyzed using the normalized average gain index (g), it was found that the second trial still showed an increase in Table 4.32. When referring to the gain index (Hake, 1999), the implementation of learning with the STEMBL model in the second trial was also included in the high category ($g > 0.70$) in phase 1 to phase 5, while the implementation of learning in phase 1 showed an increase in medium category.

Table 6. Normalized Gain Analysis of STEMBL Model Learning Implementation

No	Deskripsi Pembelajaran dengan Model STEMBL	Uji Coba		Selisih Uji Coba	SM-I	Indeks Gain
		I	II			
1	Fase 1	4,63	4,82	0,19	0,37	0,51
2	Fase 2	4,46	4,84	0,38	0,54	0,70
3	Fase 3	4,37	4,89	0,52	0,63	0,82
4	Fase 4	4,44	4,89	0,45	0,56	0,80
5	Fase 5	4,44	4,92	0,48	0,56	0,86
6	Fase 6	4,45	4,89	0,44	0,55	0,80

SM = Skor Maksimal

DISCUSSION

The practicality of the model can be seen through the implementation of the STEMBL model in learning. The implementation of the STEMBL model was stated to be well implemented. The discussion of the implementation of the STEMBL model in face-to-face activities is carried out qualitatively as a form of implementing supporting theories with an emphasis on the learning syntax that has been implemented.

The implementation of the STEMBL model and learning management was stated to be "very good" and practical. These results were obtained through a series of improvements/revisions carried out in stages starting from trial I and trial II.

Based on the first trial, there are a number of improvements to technical problems from observers that need to be considered for improvement in the implementation of learning with the STEMBL model, namely (1) lecturers should pay close attention to each phase of learning according to syntax and time used in class, (2) optimizing STEM (content *Science, Technology, Engineering and Mathematics*)in learning, (3) optimizing the use of learning media, especially during face-to-face activities in class, (4) providing the right stimulus during the reconstruction of knowledge to students, and (5) observe optimally the use of textbooks before the face-to-face meeting is carried out.

The syntax of the STEMBL model is stated practically by showing the syntax of the STEMBL model which consists of 6 phases "*reflection, research, discovery, acquisition, application, synthesizing.*

The results of the improvements in the first trial were then re-implemented in the second trial. The results of the observations showed that in the second trial, all components of the model and learning management were stated to be very well implemented with a gain index of 0.73 (high). This means that there is an increase in model implementation and learning management from trial I to trial II. The consequences of improvements made gradually have an impact on student learning activities in general.

The STEMBL model was implemented in terms of syntax, social systems, reaction principles and support systems. Based on the test results, all the STEMBL components were carried out well and very well. The normalized gain analysis showed an increase in the implementation of the STEMBL model from trial I and trial II with an average gain index of 0.37 or an increase in the implementation of "high".

CONCLUSIONS

Based on the results of data analysis and discussion of the practicality of the STEMBL learning model, it can be concluded that the STEMBL learning model is practical because it is based on the results of observer assessments, practitioners and student responses to the learning model, both in terms of the theoretical basis and the components supporting the learning model. everything is practical. It is suggested that the STEMBL learning model can be used as a learning model that can be applied by lecturers in the learning process at universities, which can improve students' critical thinking skills in responding to the challenges of the 21st century.

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