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Model of a Collaborative Blended Learning Environment in Internet of Things Courses

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ABSTRACT— *Mastering the Industry 4.0 competencies such as Internet of Things (IOT) effectively due to its nature require enhancement and update to the current instructional design (ID) model. Our research has been conducted in 3 cities involving almost 500 active participants to examine which IT-based learning methods were best for this particular competency. We provided face to face and online intervention through collaborative strategies with half of the group. Several instruments were observed such as assessment through rubrics, questioners, self-assessments, peer-reviews, social and collaborative aspects as well as the role of facilitators. This research was meant to develop instructional design model that suits the requirements and demands for IoT competencies.*

Keywords*—Collaborative Blended Learning, Instructional design model, IOT-Assessment, IOT competencies*

I. INTRODUCTION

Internet of Things (IOT) has the potential of success even bigger as the Internet. IOT is the next generation network movement which gathers input from sensors and sends the data in huge amount to the central monitoring system. IOT enables the full automation of devices. IOT triggered the industrial revolution 4.0 [1].

But it has created new problems, on how to cope with the new technology. These problems include on how to prepare human resources such as IOT workers and professional to create, execute and maintain IOT applications and devices.

There is a tendency to find a learning model, which can fulfill the gap and catch up with the modern technology. The purpose of this paper is to demonstrate a model, which uses blended learning platform that can effectively build IOT competencies. We have chosen the collaborative strategies to be able to reach the expected learning outcomes.

An instructional design model is developed to support IOT courses with intervention of collaborative learning strategies. The result is assessed with several instruments such as questioners, rubrics, interviews, peer-reviews, and others.

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II. LITERATURE REVIEW

A. Instructional Design Model

In the 5th Edition of Instructional Developments Models Branch and Dousay (2015) demonstrated a bunch of instructional models which have its own characteristics and uses. Although it depends strongly on the project situation, there are 2 Models of interest, namely ADDIE (Analyze Design Develop Implement Evaluation) and SAM (Successive Approximation Model) [2], [3], [4]. We have chosen ADDIE with Bloom's Learning Taxonomy, but still keeping the opportunity in mind to implement the SAM Model in the next project.

B. Collaborative Learning

Many research have been made in collaborative learning, and most of them stated that there are more positive results in using collaborative strategies, which led into the positive interdependence, individual and group accountability, interpersonal and small group skills, face-to-face interaction, and group processing [5], [6],[7].

Enforcing collaboration between students and introducing self-assessment was discussed in [24] as an act to extend the traditional learning. According to them collaboration will generate learning, build knowledge and again enhance collaboration. In the evaluation they used questionnaire to measure various aspects of learning. The result was in general increasing student's satisfaction with the course and consequently to gain greater motivation to learn. These studies although not completely elaborate the full aspects of collaborative learning like peer-review, collaborative strategy, we find it useful to strengthen our goals in collaborative learning.

C. Blended Learning

There is no doubt that blended learning nowadays has created new opportunities for students and educators to interact more with each other, to improve performances and to engage more in learning [8],[17]. Jordan K. (2015) stated in his paper, that blended learning has more flexible advantages compared to face-to-face, but also better completion rate than MOOC. The high drop out rate of MOOC was discussed by Ventista (2018) in [9], it was as high as 52%.

In case of IOT Courses there will be some problems while doing the Hardware Lab, which demands psychomotor [18]. The only way to go around it, is using a simulation program something like *node-red* [10] and some others, but it needs more time and skill to install and to get familiar with the simulation software by the participants, and at this time it was not an appropriate choice. We stayed with blended learning as the delivery platform with face-to-face Lab.

In our previous paper [11] we have shown that facilitators have a significant role to the success of blended collaborative learning. It is also cost-effective [19].

D. Competency based assessment

Competency refers to knowledge, skill and attitude towards IOT Technology, and to mastering sets of specific challenges to connect IOT devices, troubleshoot and create useful IOT applications. It has become common practice to participate in some sort of self-assessment to observe, analyze, and judge its own performances on the basis of criteria. This assessment should clarify also the information about previous competency of participants, which is very useful for the facilitators to choose a learning delivery's strategy [13], [14].

III. METHODOLOGY

E. Research Methodology

We followed Borg & Gall Educational Research [20] using the R&D Cycle to develop IOT Courses. After literature-review we defined the competency as learning outcome after cognitive and knowledge dimensions according to Anderson and Krathwohl [15].

The cognitive domain will be used for building learning material, quizzes, and others, while the outcome should be in tact with dimension of competencies, that is in agreement with Surono's statement [16], namely *task skill* , which is in carrying out the individual skill, *task management skill* which is the capability of doing several tasks at the same time and the ability to work in a group, and lastly the *contingency management skill*, which is the ability to search and find a solution if something goes wrong (troubleshooting skill).

The participants are targeted for following skills:

- Able to describe the fundamental concept of Internet of Things
- Able to identify problem and give a solution for a given problem (troubleshooting)
- Able to use the appropriate protocols to connect the IOT devices to the Internet
- Able to process the messages of sensors in a Dashboard and display the results in graphical form

After defining skills, we produced preliminary form of products such as instructional materials (including slides and video), student's book, facilitator's guide, quizzes and evaluation form.

F. Instructional Model

We used the popular ADDIE instructional model and 4 implementation platforms, namely MOOC, virtual classroom, blended learning and face-to-face. For this research we chose a blended learning method that has both face-to-face part and eLearning part.

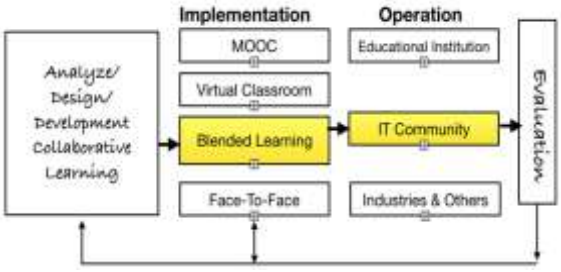

Figure 1: Collaborative Learning Model with ADDIE [21]

One big note here is that IOT training uses micro-controller lab which needs facilitator's companion, especially for the beginners that do not have much experiences with electronics, cabling and connections. Even in a virtual classroom environment we still need assistance of a facilitator. In case of full eLearning, this will be difficult to accomplish, unless you use simulation program, but that will give the participants extra efforts.

In the operation site we can actually use any institution, but for this research purpose we have opened the course to the public to have more variation in results.

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The preliminary product was conducted in one-to-one learners, small group of 8 and 16, and adopted the 4 subject matters expert's judgement in *instructional design*, *learning materials*, *multimedia*, and *language.* The formative evaluation was then completed before the operational field testing. We also conducted the Train-the-Trainer program, especially with the deeper knowledge of collaborative strategies for the facilitators.

G. Participants

Academic

Students lower semester (1-4)	122	21.0%
Students higher semester (5-8)	173	29.8%
Lecturers	20	3.4%
Teachers	12	2.6%

Non Academic

Professional IT	197	33.9%
Professional non IT	35	6.0%
Others	21	3.6%

Table 1: Number of participants

From more than 1000 applicants we have selected 580 students and IT professional by using social media in Jakarta, Bandung and Surabaya. Most of them are IT professionals, technical engineers, lecturers and IT teachers. Of the sample, 86 % of them were male. All of the participants were randomly divided into 2 groups of 2 persons. One group will be taken with collaborative session. IT Professional is a person who is working for IT on daily basis.

H. Facilitators

Before the research began, we conducted a train-the-trainer program for the facilitators with the target to be conversant during the collaborative sessions. All facilitators were recruited from IT training center with good knowledge in teaching and IOT. Facilitators should always check if the objectives are completed and monitor the process where participants using the collaborative learning have improved relationships in the group and the participants show the capability of working together. Facilitators do not give instruction like in a classroom session, instead they assist and give the students ideas on how to solve the problems.

I. Collaborative Learning Tasks

We chose the think-pair-share as the collaborative learning technique [5]. Each participant will receive a certain topic about IOT, and after reading it for about 20 minutes, she will present the content to her partner. After explaining the material, the partner will be questioned. If the partner gave a wrong answer, then she will try to explain and clarify it further. If this session is finished, then the partner will in return represent a different topic. Before the end the participants with the same topic will be invited to the front class. The facilitator will give each of them a question. In case of a wrong answer, the question will be discussed until the right answer is found.

J. Procedures

The purpose of collaborative learning was to strengthen what the participants have learned earlier as well as to generate new ideas. The initial knowledge map was drawn based on the collaborative learning tasks, such as programming language knowledge, about sensors, multi-controller, and the protocols to connect the devices to the internet .

We wrote the items of pre-test and self-assessment form, and the post-test or the expected results of the learning tasks, including rubrics and final exam depicted by Taylor [13]. There are 5 modules which consist of short video, quizzes, and lab assignment. The major part of pre-test is actually identic with the post-test.

For a 4 weeks period, we conducted 5 times face-to-face meeting, and 12 hours online learning with video and quizzes. The participants were assigned in group of four. We preferred that the member of the group doesn't belong to the same institution.

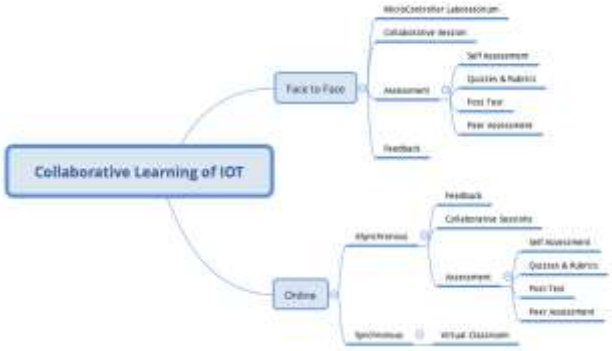

Figure 2: Collaborative Learning Platform

In the online collaborative part, each individual has to write an essay about her ideas to build something with IOT, and this will be evaluated by other participants randomly. In the case of face-to-face, it will be evaluated by peers.

K. Instrument and Data Analysis

In the face-to-face session a variant of TPS (Think- Pair- Share) was conducted. At the end of the session, every 'expert' of the group with the same topic or category will be invited to present together what they have learnt so far. The facilitator asked questions and documented the results. After the lab is finished, the last activity was to do the quizzes.

In the collaborative online session, the participant should write a short plan to create an interesting IOT application based on what they have learned so far. This essay will be evaluated by facilitators and one peer student.

We deployed a leaderboard after quizzes have been done. Leaderboard should give students motivation to reach better performance than before [14].

IV. IMPLEMENTATION

In the first meetup we collected self-assessment data from each participant. We also recorded the previous knowledge of participants to be compared with later result of competency.

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We used LMS (Learning Management System) hosted in a Cloud to manage the collaborative learning application. The participants will be given 5 sessions of eLearning and at the end of every session there will be always quizzes to solve. The participants will have a second change if the failed on the first try. The number of tries will be notified.

After every session the participants will have the face-to-face meetup. For the collaborative group there will be a collaborative task as the first activity before the microcontroller lab.

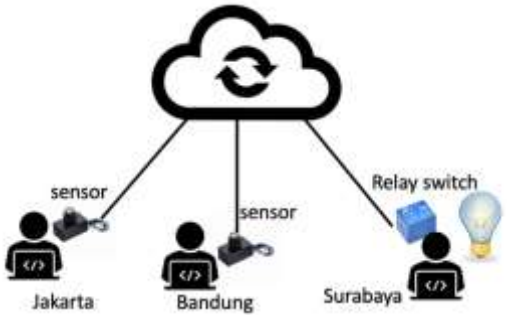

Figure 3: Interconnected IOT Devices

To make it more interesting we built an online collaboration between participants in different cities. For example, one group in Jakarta worked with IOT and light sensor and connected through Cloud to Surabaya. The group in Surabaya prepared the IOT with relay and a real lamp. If there is no light in Jakarta, then the lamp in Surabaya will be automatically turned on. We created many groups mixed with different tasks. To be able to solve the problem the groups have to work together. This session triggered excitement and enthusiasm, we believed that this can construct willingness to achieve a better learning outcome.

The result was a graphic of visualized collected data with node-red software.

V. RESULTS AND DISCUSSIONS

The first result is the completion rate of participants, which points that collaborative learning has a higher completion rate than the traditional one. From total 580 participants we divided into 2 groups with 345 belong to the collaborative learning and the other 235 to the traditional learning.

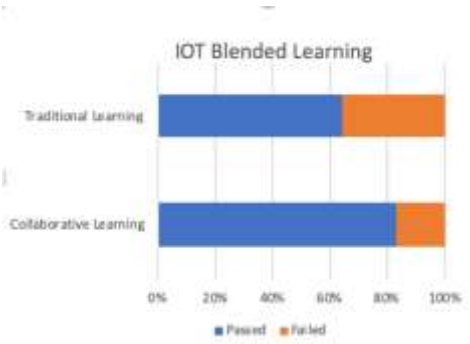

Figure 4: End Result of completed courses

Members of the group were selected randomly. Some of uncompleted result (failed) was caused by the lack of motivation and accountability. It could happen, because the training for the respondent was free and there were no consequences whatsoever, if someone stopped in the middle of the course, with no reason at all. To improve the result, we prepared additional reward. At the end of the course, the top participants received complete micro-controller package to take home.

Because Facilitators play a significant role, we depicted the feedback of facilitators' performance.

Figure 5: Student's feedback of Facilitators

Participants expressed their experience working with collaborative strategy.

Figure 6: Collaborative Learning Feedback

The overall result of the training:

PreTest vs PostTest

			Poor	Satisf	Good	Excel.
Abitility to describe the fundamental concept of IOT	Collaborative	Pre Test				
		Post Test				
	Non Collaborative	Pre Test				
		Post Test				
Able to identify problem and give a solution for a given problem (troubleshooting	Collaborative	Pre Test				
		Post Test				
	Non Collaborative	Pre Test.				
		Post Test				
Able to use the approriate protocols to connect the IOT Devices to the Internet	Collaborative	Pre Test				
		Post Test				
	Non Collaborative	Pre Test				
		Post Test				
Able to process the messages of sensors in a Dashboard and display the results in graphical form	Collaborative	Pre Test				
		Post Test				
	Non Collaborative	Pre Test				
		Post Test				

Figure 7: Pre-Test vs Post-Test

The findings of this result demonstrated that the activation of collaborating technique can significantly increase level of knowledge building. The result shows collaborative learning as sharing information which

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helped learners to acquire domain knowledge, skill and following competencies. It provided insights into how group members co-constructed knowledge. Thus, the level of knowledge building could be measured by the performances in pre- and post-testing

VI. CONCLUSION

In general, the model was designed to deliver learning materials for any IT training, but in case of IOT training it involves facilitators to assist the participants. The training was divided into 2 classes, a collaborative class and a traditional class. Collaborative learning is certainly a more effective approach to promoting learning in blended learning context.

The problem with collaborative is that it has to cope more with the *preparation of the facilitators*. They have to master the face-to-face collaborative session in a way that the participants will have good understanding on what to do and what to accomplish. Carefully training of facilitators should be considered as an important point of a successful project. More about the significant role of facilitators in our previous paper [11].

Compared in agreement with research from Slavin, Hurley and Chamberlin, Cooperative Learning and Achievement [22] and based on *Peer interaction* through questionnaires collected by facilitators, we summarized some of the important facts that collaboration encourages following action:

- learning by teaching
- motivating one another
- working together for a solution
- participating in argumentation
- creative thinking

Contrasting this study's results with similar studies in [23] which use online collaborative learning, proved to be different in perspectives and process model which used initial vision, context analysis, revised vision and planning for improved practice. Especially they had strong influences from stakeholder's expectation, SWOT analysis, constraints and resource inventory.

Because this research was open to public participation, there were some problems with lack of motivation and ambition, which led to uncompleted result. We think that this model can have better implementation results in a non- public class where the participants have the same motivation and ambition to reach a certain accomplishment. This will be open for another research topic.

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