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The Implementation of Outcome Based Education to Support Student Understanding and Performance in the Internet of Things Course

Undayani Cita Sari[1*], Bagus Hario Setiadji[2], Amelia Kusuma Indriastuti[3], Banu Ardi Hidayat[4], Danang Dwi Admojo[5]
[1,2,3,4] Department of Civil Engineering, Faculty of Engineering, Universitas Diponegoro, Semarang, Indonesia
[5]Tokyo Electric Power Services Co. Ltd (TEPSCO), Tokyo, Japan

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ABSTRAK

Outcome Based Education (OBE) merupakan suatu metode pembelajaran yang menitikberatkan pada hasil suatu proses pembelajaran. Dalam bidang keinsinyuran, penyampaian materi perkuliahan yang disertai dengan pencapaian target outcome menjadi sebuah tantangan, khususnya dalam penerapan teknologi. Hal ini dikarenakan penerapan teknologi memerlukan contoh nyata, sehingga peserta didik (mahasiswa) dapat mempunyai gambaran dan pemahaman yang menyeluruh. Penelitian ini dilaksanakan pada mata kuliah Internet of Things (IoT) pada Program Studi Sarjana Teknik Sipil Fakultas Teknik Universitas Diponegoro. Mata kuliah ini merupakan mata kuliah mengenai dasar-dasar penerapan perangkat IPTEKS (Ilmu Pengetahuan, Teknologi, dan Seni) yang dapat dimanfaatkan dalam bidang ke-teknik-sipil-an, terutama pada Revolusi Industri 4.0 saat ini. Penelitian ini dimaksudkan untuk mengevaluasi pelaksanaan OBE, ditinjau dari partisipasi dan tingkat pemahaman mahasiswa. Observasi dilakukan selama satu semester dengan mengamati hasil evaluasi mahasiswa dan masukan yang diterima dosen. Evaluasi dilakukan secara kualitatif dan kuantitatif berdasarkan Capaian Pembelajaran Mata Kuliah (CPMK). Hasil penelitian menunjukkan bahwa seluruh mahasiswa berpartisipasi aktif dalam proses pembelajaran menggunakan metode OBE ini. Tingginya pemahaman materi ditunjukkan dengan tercapainya tingkat kelulusan sebesar 100%. Namun demikian masih terdapat dua mahasiswa yang belum memenuhi dua CPMK. Oleh karena itu, masih diperlukan upaya perbaikan yang berkesinambungan dalam penerapan OBE pada mahasiswa, sehingga seluruh mahasiswa dapat memenuhi seluruh CPMK pada mata kuliah kuliah Internet of Things.

ABSTRACT

Outcome Based Education (OBE) is a learning method that focuses on outcomes in a learning process. In the field of engineering, the delivery of lecture materials coupled with the achievement of targets for outcomes is a challenge, especially when it comes to technology applications. This is because the application of technology requires real examples, so that the students can have a comprehensive picture and understanding. This study was carried out on the Internet of Things (IoT) course at Undergraduate Program in Civil Engineering, Faculty of Engineering. This course discusses the basics of applying IPTEKS (Science, Technology and Arts) tools that can be utilized in the field of Civil Engineering, especially in the current Industrial Revolution 4.0. This research was intended to evaluate the OBE implementation, in terms of student participation and level of understanding of students. Observations were made during one semester by observing the results of student evaluations and the feedback received by the lecturers. The evaluation was carried out qualitatively and quantitatively based on the course learning outcomes (CLO). The results showed that all students actively participate in the learning process using this OBE method. The high level of material understanding was indicated by the achievement of a 100% passing rate, but there were still two students who have not fulfilled two CLOs. Therefore, continuous improvement efforts are still needed in implementing OBE for students, so that all students can fulfill all CLOs in Internet of Things courses.

1. INTRODUCTION

Outcome Based Education (OBE) is one of the de-facto standards for modern educational system. Specifically, Outcome Based Education is a learning system centered on the outcomes of the learning process, and not only the completion of the materials delivered by the lecturer (Damit et al., 2021; Kaliannan & Chandran, 2012; Muzakir, 2023). This system emphasizes the learning process implemented to ensure that the students can learn do well and measure the achievement of the goals of the process at the end of their learning experience. Outcomes themselves are clear learning results that we want students to demonstrate at the end of a significant learning experience. The key principle of OBE states that all activities (teaching, assessment, etc.) are geared

** Corresponding Author: Undayani Cita Sari: undayanicita@gmail.com*

towards, not what the teacher is going to teach, but what the outcome of that teaching should be, what the learner is supposed to do, and what standard is used (Kusstianti et al., 2022; Macayan, 2017). Using OBE, it aims at equipping learners with the knowledge, competence, and orientation needed for success after they leave the institution.Moreover, The Higher Education curriculum which has been developed based on SN-Dikti actually also uses theOutcome Based Education (OBE) approach (Aminuddin et al., 2021; Muhammad Noor Sehabudin et al., 2020). Therefore, the application of OBE is needed inthe teaching and learning process in lectures.

Implementing OBE means focusing and organizing everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences This system is started with a clear picture of what is important for students to be able to do, then organizing curriculum, instruction, and assessment to make sure this learning ultimately happens (Faridin & Syakib, 2020; Yusuf, 2022). Thus, before that, a Course Learning Plan(CLP) should be set up. CLP is guidance for lecturers and students in carrying out lecture activities for one semesterto meet predetermined learning outcomes. For the Outcome-Based Education system, first and the foremost significant task is to develop ProgramLearning Outcomes (PLOs) and Course Learning Outcomes (CLOs) (Kicklighter, 2021; Kumar, 2016). Therefore, the CLP shouldcontain the Program Learning Outcomes (PLO) that should be achieved. PLO is a written statement of what thesuccessful student is expected to be able to do at the end of the module/course unit, or qualification. The key aspecteach of the definitions has in common is the desire for more precision and consideration as to what exactly alearner acquires in terms of knowledge and/or skills when they complete a period of learning. Then, PLO shouldbe detailed into Course Learning Outcome (CLO). CLO describes the complex performances a student should be capable of as a result of learning experiences within a course (Ibáñez et al., 2020; Pahlevi et al., 2018). The mostimportant, both PLO and CLO should be clear, observable, measurable, and achievable during the learning process. The effectiveness of OBE in the education discipline is influenced by various factors. The findings suggest five important factors from the literature that influence student learning outcomes, including assessment strategies, learning objectives based on complexity levels, preferred learning styles of students, English language proficiency, and industry requirements (Park et al., 2011; Yuliana et al., 2022). Thus, to achieve outcomes that are following the learning objectives prepared, various learning methods can be selected in the material delivery stageof OBE. This selection depends on various factors. These factors include the ability of lecturers to deliver the materials, the characteristics of the students, the level of understanding of the students, as well as the complexity of the lecture materials (Kaliannan & Chandran, 2012; Shanks et al., 2017).

There is no single teaching or assessment method specified in OBE. Any methods are suitable and effective as long as they can help the students achieve the specified results. On the other side, lecturersare expected to be able to adapt themselves to become instructors, trainers, facilitators, and/or mentors based on the delivered materials and the targeted results and measure the effectiveness of the roles performed based on theevaluation of the level of achievement of the outcomes. In other words, the use of OBE creates a paradigm shift from Teacher Centered to Student Centered Learning (SCL) or students as the center of the education system. It makes a change from conventional learning which is the transition from 3'R's (Reading,Writing,Arithmetic) to 4'C' (Creativity, Critical thinking, Communication & Collaboration) and makes significant change in the course attainment of the students (Priyastuti, M. T., 2020; Yaacob & Lubis, 2022).

In delivering material to students, each teacher has challenges. As the example in Indian, some of the common challenges faced by Indian teachers in the classroom include large class sizes, lack of infrastructure and resources, limited teacher training and professional development (Azizah et al., 2018; Birhan et al., 2021). Likewise in delivering material to students, each field of science has its peculiarities and challenges. The delivery of lecture material in the field of Civil Engineering. This is because the lecturer needs ability in describing the actual conditions that occur in the field, starting from the stage of planning, procurement of materials and equipment, construction, maintenance, and rehabilitation during operation, for both buildings and civil infrastructures. At the industrial revolution 4.0 today, the application of technology in the field of Civil Engineering requires real illustrations, so that students can obtain a more comprehensive picture, understanding, and use of knowledge. Theprovision of this technology content in the field of Civil Engineering is realized in the Internet of Things (IoT) course (Hanzelik et al., 2022; Kipper et al., 2020; Noura et al., 2019). However, it is hoped that implementing OBE can help in the learning process.

IoT is a compulsory subject at Universitas Diponegoro. The purpose of this course is to provide provisions for anticipating academic demands in the 4.0 era in accordance with the scientific fields of each study program. However, the main characteristics of education in the industrial revolution 4.0 are use of digital technology in theeducational process (cyber system) (Hanzelik et al., 2022; Indrayana & Sadikin, 2020). In the Undergraduate in Civil Engineering Study Program at Universitas Diponegoro, this course provides an understanding and application of IoT technology to support theworks in Civil Engineering, from the stage of planning to construction until the operation and maintenance period,in accordance with the demands of the industrial revolution 4.0.

The occurred problem is the students cannot understand the IoT course materials which are only theoretically delivered by the lecturer in the class. Moreover, the application of IoT is sometimes beyond

expectation because it involves technology that is currently developingrapidly and widely. The implementation of OBE in the IoT learning process is expected to increase student participation and understanding of IoT lecture materials. Based on this reason, this study is intended to evaluate the implementation of OBE in the IoT learning process, in terms of participation and level of understanding of thestudents, by conducting the following activities. The novelty of this study not only focuses on improving students' theoretical understanding, but also their performance in practical implementation of IoT. This aspect of results-based performance assessment combined with technology can be a significant contribution to the field of engineering and engineering education.

2. METHOD

This research was carried out in Semester 1 Academic Year 2021/2022 from February until May 2022 (4 months). The object of the research was 34 students of Class B (regular class) of the IoT course in the Undergraduate Program in Civil Engineering, Universitas Diponegoro. OBE incorporates innovative teaching methods such as problem-based learning, capstone projects, oral presentations, professional talks, site visits, and so forth. Lecturers must design learning processes that foster students' critical thinking and creativity (Adiyawati & Nuroh, 2023; Oberer & Erkollar, 2018). Based on this, the analysis of students was carried out based on a combinationof teaching methods carried out by lecturers in class and assignments that must be carried out by students in groups. The research was conducted in several stages as follows. CLP is a projection of activities to be done by lecturers and students in the learning process. Further, CLP usually takes the form of a document containing a guide for lecturers and students in carrying out lecture activities for one semester to meet predetermined learning outcomes, both Program Learning Outcomes (PLO) and Course Learning Outcomes (CLO) (Imaduddin & Hidayah, 2019; Welerubun et al., 2022). CLP is used as a reference for lecturers in preparing lecture materials and assignments per Course Learning Outcome (CLO). Lecture materials and assignments for the IoT course can be seen in Table 1.

Table 1. Summary of Lecture Materials and Assignments in the IoT Course

Week	Activities	Remarks
1-2	Theory related to CLO-1.1 (Students are able to explain aspects of artificial intelligence used in understanding patterns of the market and patterns of using tools in the IoT)	
3	Presentation of assignment 1 (related to CLO-1.1)	The use of social media as a data and survey platform.
4-5	Theory related to CLO-1.2 (Students are able to explain and implement the IoT in various science and technology objects/devices related to data collection and social, economic, and political platforms.)	
6	Presentation of assignment 2 (related to CLO-1.2)	Create a video as an IoT marketing tool
7	The general concept of artificial intelligence in the use of IoT (related to CLO-1.1 and CLO-1.2)	
8	Mid-term examination	
9-11	Theory related to CLO-2.3 (Students are able to explain the basic concepts of cyber, architecture, & organization of the IoT	
12	Presentation of assignment 3 (related to CLO-2.3)	Create a store with a storefront of IoT products
13–14	Theory related to CLO-2.4 (Students are able to apply the IoT for e- commerce-based entrepreneurship and in multi-disciplinary projects)	
15	Presentation of assignment 4 (related to CLO-2.4)	Create an IoT project
16	Final examination	

This evaluation was based on the results of the lecturer's assessment and peer review for each assignment given. This evaluation was carried out using two methods: questionnaires distributed via a Google Form and writtenexamination (mid-term and final examinations). The assessment components of this course can be seen in Table 2.

Table 2. Assessment Components of IoT Course

Course Learning Outcome(CLO)	Proportion of the Assessment Component		
	Group assignment	Mid-term exam	Final exam
CLO-1.1	6.50 %	17.50 %	
CLO-1.2	9.00 %	7.50 %	
CLO-2.3	7.00 %		35.00 %
CLO-2.4	27.50 %		15.00 %
Total	**50.00 %**	**25.00 %**	**25.00 %**

Recommendations were made based on the results of the evaluation and discussions. This stage is important as feedback to improve student performance and understanding of IoT in the field of Civil Engineering in the following years.

3. RESULT AND DISCUSSION

Result

The fourth assignment, which was the last assignment and was a final project made by students at the end of the course. At the beginning of the course, students were asked to express their opinion aboutthe Internet of Things (IoT) on the Jamboard (online), as shown in Figure 1.

Figure 1. Students' First Opinion about the Internet of Things (IoT) on Jamboard

In the second week, the first assignment was given and the students were asked to deliver a presentation of the results in the third week. This assignment was used as one of the assessment indicators for CLO-1.1. In this assignment, students were asked to survey some Civil Engineering problems. The survey resultswere compiled using various survey applications that can be used freely on the internet. The number of respondents was from 100 to 500 (according to the number of group members). This is a learning innovation in this course because assignments, in the form of paper reports, are generally rarely read by students even though the substance is important, therefore, the information from the assignment results is not conveyed. Examples of the survey results in PowerPoint format are shown in Figure 2.

Figure 2. Examples of Survey Results of Assignment 1 (Related to CLO-1.1) in Powerpoint Format

In Figure 2, it can be seen that the students are able to interpret well the assignments given by the lecturer. The topic of the field of Civil Engineering that was raised as a survey topic is quite interesting, full of creativity, and fulfills the criteria given. A large number of respondents indicated that the community was interested in contributing to the survey conducted by the students. The use of Jamboard was also quite interesting for students

to study the work of other students so that it becomes a comprehensive learning to improve students' understanding of the material. The second assignment was making videos for marketing tools. This assignment contributed to the assessment of CLO-1.2. Students creatively createdvideos that explain IoT applications that can help works in the field of Civil Engineering, during planning, procurement of materials and tools, construction, and after construction was completed. By using Video Project Assignments (VPAs) provides many benefits for students. Making videos was performedsimply with examples found around the neighborhood where each student lives. This assignment was expected tofoster students' sensitivity to the materials and construction of buildings found in their environment. Theparticipation of each student can be seen from the contribution of each student to the group related to the content of the video. Next, the third assignment contributed to the CLO-2.3 assessment. This assignment was carried out after the mid-term examination. In this assignment, the students created a storefront for IoT-based products in the field of Civil Engineering using websites, Instagram or WhatsApp as a direct simulation in marketplaces such as Shopee or Tokopedia. Examples of an IoT product showcased on the website are shown in Figure 3.

Figure 3. Examples of Video as a Marketing Tool in Assignment 2 (Related to CLO-1.2)

The last assignment was a combination of the application of all IoT products in various multidisciplinary sciences,as encountered in the practice. This assignment contributed to the CLO-2.4. In this assignment, the students were asked not only to discuss IoT products in the Civil Engineering field, as the third assignment but in all fields that are harmonized with each other to help human life. The presentation was made inthe form of a poster accompanied by an explanation of the relationship between the field of Civil Engineering andother fields of science. Examples of student work in assignment 4 are shown in Figure 4.

Figure 4. Poster For the Application of IoT Products in Various Multidisciplinary Sciences in Assignment 4 (Related to CLO-2.4)

Evaluation of the second assignment was conducted by assigning a score with the lowest scale (1) to the highest (5). In this evaluation, students were asked to rate their group and others. The results of the assessment were returned to students. The assessment components of this second assignment include delivery of marketing, the creativity of ideas in making videos, completeness of information delivery in marketing, and the application of IoT in marketing. The results of the evaluation are shown in Figure 5.

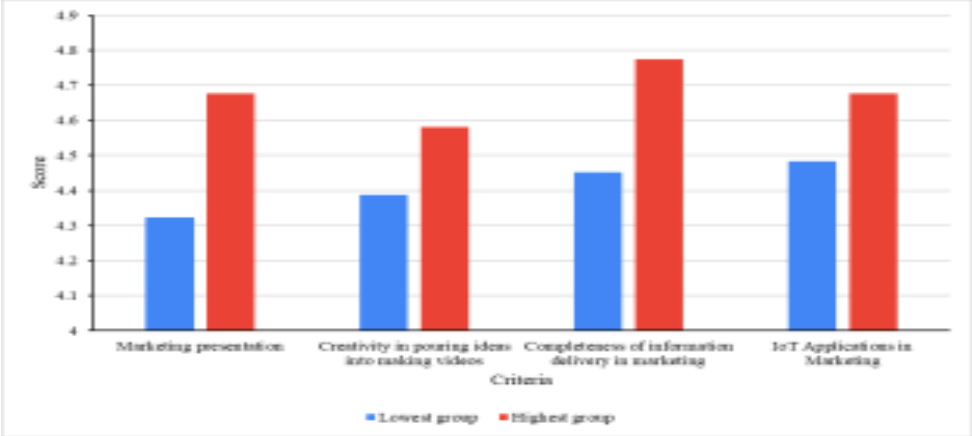

Figure 5. Assessment Results of Assignment 2 for the Lowest and Highest Grades Criteria in Class

In general, students considered that the presentation of each group was quite good and inspiring. The students also provided feedback for each group suchas better sound during the presentation, marketing that can be improved, and so forth. This result indicated that when a group delivered a presentation, other student groups still paid attention and focused on what was conveyedby their friends. The combined evaluations for the third and fourth assignments had a similar format and questions as the second assignment. This evaluation was conducted by the assigned student to give a score of scale 1-5 to his/her group and also to other groups. The assessment components include the delivery of presentations, the creativity of ideas, rationality and application possibilities, and completeness of information delivery. The results of the evaluation for the third and fourth assignments are shown in Figure 6.

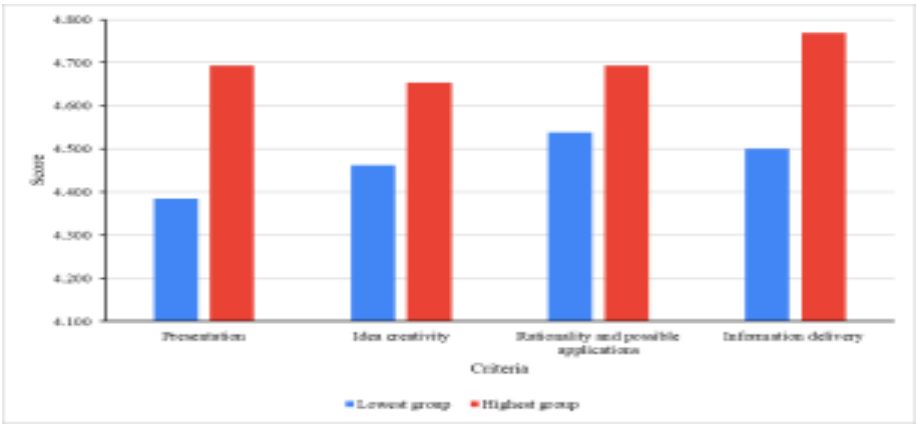

Figure 6. Assessment Results of Assignment 3 for the Lowest and Highest Grades Criteria in Class

The last assessment was conducted by the lecturers to evaluate the fulfillment of Course Learning Outcomes (CLO), Program Learning Outcomes (PLO), and course passing grades. The assessment was based on the gradesof the four assignments, and also the grades from written exams (mid-term and final examinations). The grade ofeach component (assignments and written exams) was multiplied by the proportion of the assessment componentsin Table 2. Based on this calculation, all students get a final score above the course passing grade (equal to 60), soall of them passed this course. However, two students did not pass all CLOs. The first student did not pass CLO-1.1 with a score of 16.5 due to this student did not take the mid-term exam. The second student did not pass CLO-with a score of 53.3 because this student only got 52 for the final exam result. Even though they did not meetall CLOs, they still passed the course because their total grades were above the course passing grade, that is, a minimum of 60. The indicator that this course met CLO and PLO was based on the average achievement of CLO and PLOscores that should be greater than the minimum value, which is 2.5. The average achievement of CLO and PLO scores is shown in Figure 11. Based on Figure 7, it can be seen that all students have met the required CLO and PLO-achievement levels (i.e., more than 2.5).

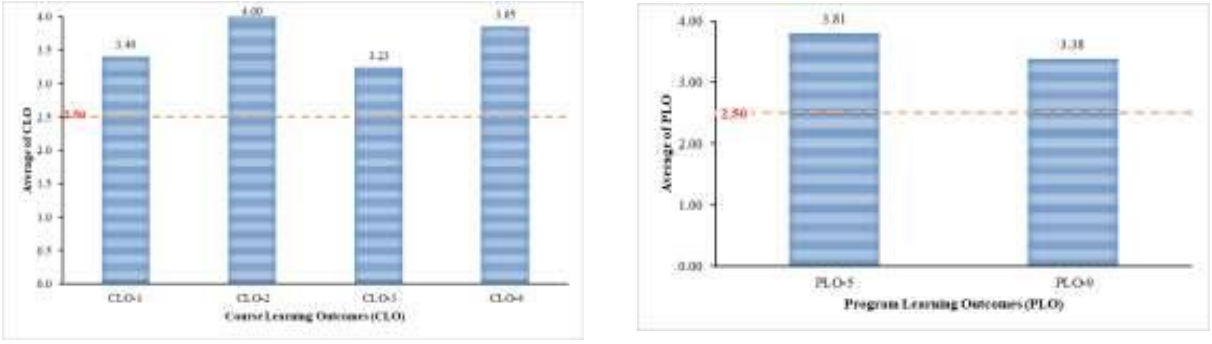

Figure 7. Average Achievement Score for Course Learning Outcomes (CLO) and Program Learning Outcomes (PLO)

Therefore, by using evaluation and improvement plans as well as institutional support, it is hoped that the implementation of OBE in Internet of Things 'course will be better in the coming years. The recommendations for improvement based on the evaluation of this course is show in Table 3.

Table 3. Recommendations for Improvement Based on The Evaluation of this Course

CLO (Min Target)	Average (>2.50)	%> Threshold (>50%)	Acceptance?	Analysis of Learning Implementation	Next Semester Improvement Plan
1.1	3.4	94%	YES	The introduction of IoT technology has been known to students, but the application of ethics in the use of technology and the internet has not been done well	It is necessary to relate the ethics of what users can and cannot do, especially when carrying out assignments so that students can apply them and understand directly
2.3	3.2	98%	YES	Students understand the theoretical basis for IoT compilers	Need to do direct practice by connecting the theoretical basis with the real thing
2.4	3.9	95%	YES	Merging IoT projects in various multidisciplinary fields is a real example in engineering life	Need to add examples and ideas about IoT projects so that students can specifically solve problems given in class well

Discussion

The summary of the survey results was presented in PowerPoint format, while the presentation was delivered in the form of a poster on the Jamboard. Theuse of the Jamboard was intended to train the students in displaying data briefly and concisely, while still being clear and interesting. By using Jamboard which can be accessed online, it makes it easier for students to discuss and make interactive class (Christiana, 2021; Melvina Chung Hui Ching, 2021). This is in line with research which stated that many students agreed that the online platform was useful and simple to use. In addition, the presentation in the form of Jamboard was also to attract the students and encourage them in learning the works ofother groups (Christiana, 2021; Gideon & Rahmansyah, 2021). Evaluation is the action to determine the value of something. The evaluation of student participation in the four assignments used questions in the google form. In the first assignment, there were questions regarding the names of group members who did not participate (Bosica et al., 2021; Qodr et al., 2021). The data showed that

all students participate actively, as proved by the answers that there are no students who do not participate in doing assignments.

In the second assignment, no specific questions were given as in the first assignment. The question is more directed to the assessment of four aspects of the second assignment: the delivery of marketing, the creativity of ideas in making videos, the completeness of information delivery in marketing, and the application of IoT in marketing. Based on the answers or feedback from students, it can be indicated that when a group delivered a presentation, other students still paid attention and focused on what was conveyed by their friends. The feedback and attention of the students showed that all students participated in the second assignment. The feedback is important for student and teacher. Previous study stated that it has shown that effective feedback enables students identify gaps in their learning and provides suggestions to improve their learning; creates responsive learners; sharpens teaching strategies; provides constructive information for both students and teachers; motives students to learn; and many more (Andarwulan et al., 2021).

Furthermore, participation evaluation for the third and fourth assignments was carried out simultaneously. The results showed that all students were interested in these assignments, as shown by the active participation of students in providing feedback and suggestions to their colleagues. Based on the results of the feedback given by students, it can be said that the form of project learning, which is one form of OBE learning, is quite interesting for the students, and encourages them to play an active role in every activity carried out. Evaluation of material understanding was carried out using a questionnaire distributed through google forms and written examinations (mid-term and final exams). The purpose of assessment is to obtain data to improve the quality of learning. Research shows that without assessment the learning process will be pointless (Jensen et al., 2014; Wibowo & Veronica, 2022). The analysis is carried out based on the achievement of Course Learning Outcomes (CLO), the achievementof Program Learning Outcomes (PLO), and the assessment component in the Course Learning Plan (CLP) relatedto student passing grades in this course.

In the first and second assignments, the evaluation of the student's level of understanding was carried out by the lecturer using a questionnaire via Google Forms. Using Google Forms is an effective way because of the ease of using the form and getting quick answers and responses instantly anywhere (Namoun & Alshanqiti, 2021; Zamora-Antuñano et al., 2022). This questionnaire was also intended to get feedback from students about the lectures. Meanwhile, in the third and fourth assignments, the evaluation of material understanding was given only once at the end of the fourth assignment. This is because these two assignments have a continuous topic, the application of IoT. The applicationof IoT in the third assignment was in the field of Civil Engineering, while the fourth assignment was in various fields of science (Daryono & Rochmadi, 2020; Welsen et al., 2023).

The evaluation of the first assignment was presented in questions regarding (1) the difficulty in doing the task; (2) the presence of group members who do not participate in doing the task; (3) the experience or information obtained from all presentation of the assignments conducted by all groups; and (4) the matters to be conveyed regarding the material of the assignment. The results of the evaluation on the first assignment showed that, in general, students did not experience difficulties in doing the assignments. The most difficult in doing the assignment was finding respondents and coordinating with group members. This problem greatly improved student's soft skills. Using group discussion as a creative learning strategy is beneficial because it encourages interaction and learning, develops respect for other people's ideas, and improve the students' self-confidence (Kapile et al., 2023; Ray et al., 2021). In addition, students felt that they gained knowledge regarding the materials, and the learning process in class is quite fun even though the lectures were conducted online.

Implementing Outcome-Based Education (OBE) in IoT courses can make a significant contribution to increasing student understanding. By focusing on clear learning outcomes, students are more motivated to achieve the expected competencies. This research shows that the OBE approach allows for a deeper integration of IoT theory and practice, thereby preparing students with the skills needed in the technology-based industries of the future. This research focuses specifically on IoT courses, so the relevance and relevance of these findings may be limited to similar courses that require advanced technological understanding. Courses in non-technical fields may not benefit as much from an OBE approach, due to differences in the types of learning outcomes expected.

4. CONCLUSION

In the implementation of the OBE in the Internet of Things (IoT) course at the Undergraduate Program in Civil Engineering, Faculty of Engineering, Universitas Diponegoro, various active learning methods haves been applied that involve student participation. Moreover, supporting tasks were also given which were carried out in groups. This active student involvement was expected to increase student understanding. This study has evaluated student participation, and the results showed that students can accept and like the learning method proposed and were willing to play an active role in it. The results of the evaluation of student understanding also showed a good level of understanding, as shown by the passing rate of the courses of 100%, the fulfillment of the Course Learning Outcomes (CLO) on average of 90.5%, and the fulfillment of the average Program Learning Outcomes (PLO) of

89.9%. However, there were two students who cannot fulfill all the specified CLOs. Therefore, improvements were still required in the future so that a better learning process can be realized.

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