Development of OBE-Based Learning Evaluation Model in Mechanical Engineering Education Program

Ika Nurjannah[1,*] Mochamad Cholik[1] Muhaji[1] Theodorus Wiyanto[1]

Diastian Vinaya Wijanarko[1] I Made Arsana[1]

[1]*Department of Mechanical Engineering Universitas Negeri Surabaya, Indonesia*
**Corresponding author. Email: ikajannah@unesa.ac.id*

ABSTRACT
This study aims to determine the appropriate OBE-based learning evaluation model to be applied to Mechanical Engineering Education undergraduate at State University of Surabaya (S1 PTM Unesa). The research was carried out qualitatively using a development model based on a 4D model consisting of Define, Design, Development, and Dissemination developed by Thiagarajan, with a limit of 3 stages, namely the Define, Design, and Development stages. This experiment makes the FGD data collection method. the results of this study were obtained from learning evaluation document sheets that have been made by researchers, these results are based on the analysis of the learning outcomes of the Program Learning Outcome (PLO) for the subject. OBE-based learning evaluation research is known to be able to improve the quality of learning, improve the curriculum, which leads to improving the quality of graduates who are qualified and competent in the field of mechanical engineering.

Keywords: *Learning evaluation model, OBE, 4D Model, FGD.*

1. INTRODUCTION

The existence of competition in the era of globalization to get decent job results in the need for qualified and competent human resources in their fields. So those activities are needed as early as possible starting from the lecture bench by applying the Outcome-Based Education (OBE) learning method [1,2,3].

Results-based methods (OBE) have been adopted in education systems around the world, at various levels. Australia and South Africa adopted OBE policies from the 1990s to the mid-2000s, [4,5]. The United States has had an OBE program since 1994 which has been adapted over the years [6], whereas Malaysia implemented OBE in all their public school systems in 2008 [7].

Shamsul Mohamad, et al [8] in his research related to evaluating the assessment of OBE at the Faculty of Electrical and Electronic Engineering (FKEE) UTHM Malaysia, using two assessment tools for program learning outcomes (PLO) and course learning outcomes (CLO) to manually measure and analyze both PLO and CLO achievements. The results obtained indicate that the evaluation process requires a better system and is expected to be carried out online.

Devasis Pradhan [9] in his research related to the effectiveness of OBE on student performance in Engineering courses, In the analysis, direct and indirect assessments related to student performance are carried out and it is known that the most effective use of OBE can be done with the joint efforts of all stakeholders, including students, instructors, employers, and the authorities - because each assumes that one of them will receive an award. benefit from it.

Haris Wahyudi [16] in his research related to Innovation and Implementation of Outcome Oriented Learning Models (OBE) and Washington Accord at the Mechanical Engineering Study Program, Mercu Buana University by using the Continuous Quality Improvement (CQI) approach evaluation method. good results were obtained where graduation in the Product Design course showed a score above 80%.

The focus group discussion (FGD) method carried out by the Physics Department, Faculty of Mathematics and Natural Sciences (FMIPA) Andalas University (UNAND) was carried out in the context of a "need assessment" of graduate users so that a "gap" was obtained between the needs and the reality of the current

curriculum. The curriculum being developed is the Outcome-based education (OBE) curriculum [16].

Based on the research data above, to improve the quality of graduates, the Unesa Mechanical Engineering Education (PTM) study program periodically conducts evaluations related to curriculum improvements, Currently, the curriculum applied by the PTM Unesa undergraduate study program is an OBE-based independent learning curriculum. The expected output of OBE is in the form of knowledge and skills that must be measured.

To be able to measure learning outcomes based on OBE, it is necessary to have assessment criteria for learning achievement. Therefore, there is a need for a study in order to obtain good measurement results in determining the appropriate OBE-based learning evaluation model in the PTM S1 Study Program.

2. METHOD

This research was carried out in the Mechanical Engineering Education program at State University of Surabaya. The research uses a qualitative approach that is based on efforts to obtain a more in-depth description and information on the data with a thematic approach. Qualitative data were obtained through focus group discussions by policymakers in the Mechanical Engineering department and the Mechanical Engineering Education undergraduate study program (S1 PTM) and evaluation experts.

This study uses development based on the 4D model which has 4 stages, namely the stages of defining, designing, developing, and disseminating. In this study, it is limited to using only 3 stages, namely the stage of define, design, and the stage of development.

The research design uses a 4D research and development model consisting of:

1. Define

Making PEO and PLO matrices, Program learning outcomes (PLO) must be able to meet the objectives of the Program Education Objectives (PEO) To find out the fulfillment, a relationship matrix was made between PEO and PLO (Quality Assurance team and Officials in the Unesa S1 Study Program have been working on it).

Making PLO matrices and courses, Making PLO road maps with courses that have been carried out by the quality assurance team and department officials.

2. Design

The research team will make an assessment classification, the assessment includes knowledge and skills. Each course has different learning outcomes, therefore it is necessary to classify which courses contain knowledge achievements and which contain skill achievements. Next, make a learning evaluation document sheet and validate the evaluation draft.

Table 1. Interpretation of the score validation

Category	Weighting Value	Percentage Rating (%)
Very Valid	4	82-100
Valid	3	63-81
Valid enough	2	44-62
Invalid	1	25-43

3. Development

At this stage, after validating the evaluation draft, then the FGD was carried out with policymakers in majors and study programs, the UPM TEAM, the Research Team, and experts in the evaluation field to avoid misunderstanding the meaning of the researcher. Next, analyze and process the results of the learning evaluation.

After conducting focused discussions (FGD) by policymakers in majors and study programs, the UPM TEAM, the Research Team, and experts in the evaluation field, the results of the evaluation method will be obtained that can be used to assess the learning achievement of the subjects in the Mechanical Engineering education at Unesa which is expected to improve the quality of graduates.

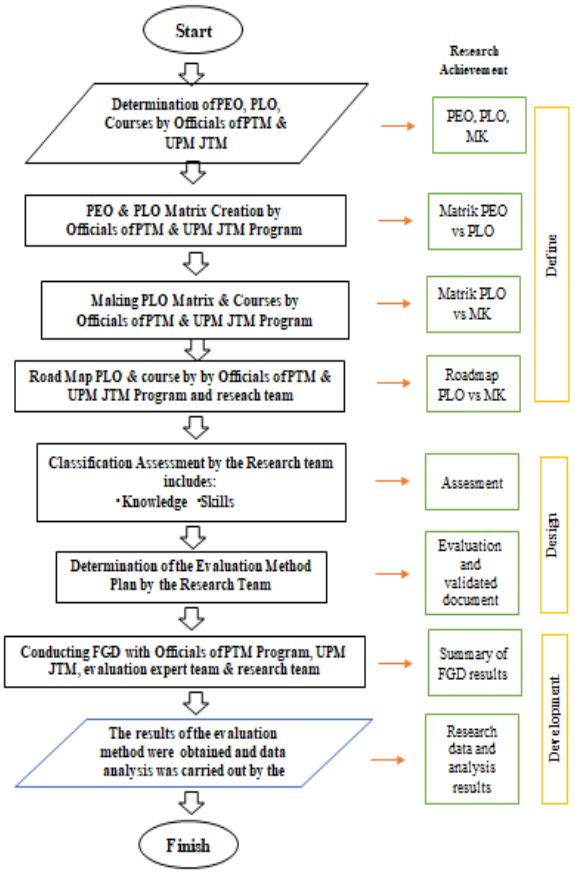


Figure 1 Research flow chart

3. RESULT AND DISCUSSION

This chapter will explain the stages of the process in developing an OBE-based learning evaluation model. The implementation process is carried out from the stage of determining PEO, PLO, Course until the evaluation results are obtained.

3.1 Program Education Objectives (PEO) in Mechanical Engineering Education undergraduate (S1 PTM)

Program education objectives (PEO) are competencies that are expected to be achieved by students 5 years after students graduate, the following is the PEO in the mechanical engineering education undergraduate (S1 PTM):

1. Have pedagogic competence, personality competence, social competence, professional competence in mechanical engineering education.
2. Have competence in maintenance, repair, and technopreneurship in automotive engineering (automotive concentration) or have competence in operating various production equipment and machines in manufacturing (production concentration).

The suitability of PEO points in the Mechanical Engineering Education S1 Study Program based on the results of the Tracer study on the acceptance of the world of work for S1 Mechanical Engineering Education graduates in Figure 2.

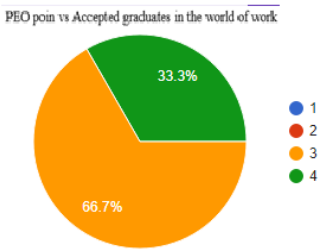


Figure 2 The suitability of PEO points based on the results of the tracer study acceptance of graduates in the world of work

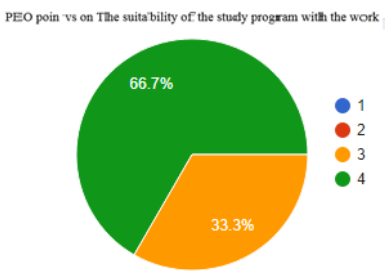


Figure 3 The related PEO point for suitability of the study program with the work of graduated S1 PTM Unesa

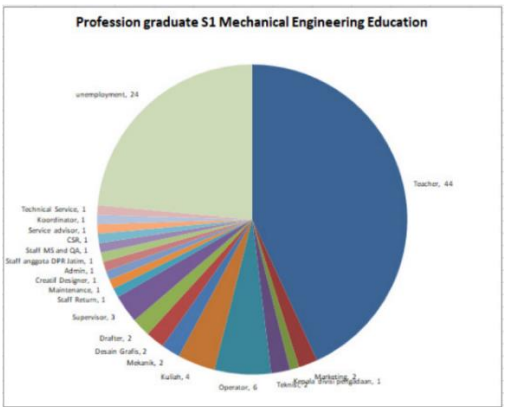


Figure 4 Profession graduated S1 PTM Unesa

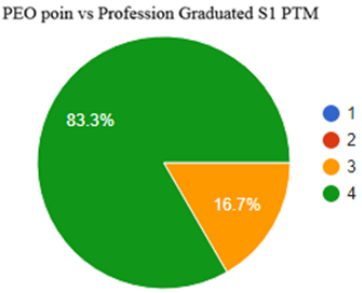


Figure 5 Related PEO point with profession graduated S1 PTM

The Related of PEO points in the Mechanical Engineering Education S1 Study Program based on the results of the Tracer study on the suitability of the study program with the work of graduates of S1 Mechanical Engineering Education.

Based on Tracer's study data related to the Profession of graduated S1 PTM in Figure 4, we know that The profession as a teacher is the most common profession from other professions.

Based on the results of the PEO Points validation obtained from the tracer study, it can be said that the PEO S1 Mechanical Engineering Education is appropriate and competencies that are expected to be achieved by students 5 years after students graduate.

3.2 Program Learning Outcomes (PLO) in Mechanical Engineering Education undergraduate (S1 PTM)

PLO can be measured after students graduate from the study program, one of the important measures that can be seen from the PLO results are cognitive, psychomotor, and effectiveness. the following is the PLO in the mechanical engineering education undergraduate (S1 PTM):

1. Able to apply and analyze pedagogic competence in mechanical engineering education in a lifelong sustainable manner.
2. Having social competence and personality competence in mechanical engineering education.
3. Have an understanding of mathematics and basic mechanical engineering
4. Able to perform maintenance and repairs in the field of automotive engineering (automotive concentration) or able to operate various production equipment and machines in manufacturing (production concentration).
5. Able to research mechanical engineering
6. Have an understanding of technopreneurship in the field of automotive technology or production technology.

3.3 Course Learning Outcomes (CLO)

CLO is structured based on PLO and is more specific for each course. The measure of PLO achievement is determined from the student's graduation in the course.

3.4 Roadmap PLO and Course

Table 2. Roadmap PLO and Course

No.	Code	Courses	SKS	Smt	PLO					
					1	2	3	4	5	6
					Pedagogik	Sosial, Pribadi	Dasar	Skill	Riset	Entre
1		Bahasa Indonesia	2	I		1				
2	8320302209	Fisika Teknik	2	I			1			
3	8320302210	Ilmu Bahan	2	I			1			
4	8320302050	Kimia Teknik	2	I			1			
5	8320302208	Landasan Pendidikan	2	I	1					
6	8320302063	Matematika Teknik	2	I			1			
7	8320302202	Pendidikan Jasmani dan Kebugaran	2	I		1				
8		Pendidikan Pancasila	2	I		1				
9	8320302111	Pengetahuan Alat Ukur	2	I			1			
10	8320302186	Teknologi Mekanik	2	I			1			
11	8320302213	Mekanika Fluida	2	II			1			
12	8320302118	Perencanaan Pembelajaran Teknik Mesin	2	II	1					
13	8320302216	Strategi Pembelajaran	2	II	1					
14	8320302188	Teknologi Motor Bensin	2	II				1		
15	8320302048	Kelistrikan Otomotif	2	II				1		
16	8320302189	Teknologi Motor Diesel	2	II				1		
17	8320302190	Teknologi pembakaran dan bahan bakar	2	II			1			
18	8320302077	Menggambar Teknik Otomotif	3	II			1			
19	1000002026	Pendidikan Agama Islam	2	II		1				
	1000002024	Pend. Agama Budha								
	1000002025	Pend. Agama Hindu								
	1000002027	Pend. Agama Katolik								
	1000002029	Pend. Agama Kristen								
20	8320302046	Literasi Digital	2	II	1	1				
21	1000002033	Pendidikan Kewarganegaraa	2	II		1				
22	8320302230	Teori Belajar	2	III		1				
23	8320302150	Praktik Kelistrikan Otomotif	2	III				1		
24	8320302001	Teknologi AC Mobil	2	III				1		
25	8320302223	Termodinamika	2	III			1			
26	8320302024	Elemen Mesin Otomotif	2	III			1			
27	8320303145	Praktik Sepeda Motor dan M	3	III				1		
28	8320302192	Teknologi Pengecatan dan P	2	III				1		
31	8320303147	Praktik Motor Bensin	3	III				1		
32	8320302005	Analisis Perfoma Mesin	2	IV				1		
33	8320302015	CAD	2	IV			1			
34	8320302032	Evaluasi Pembelajaran	2	IV	1				1	
35	8320302203	Microteaching	2	IV	1					
36	8320302227	Praktik Motor Diesel	2	IV				1		
37	8320302228	Praktik Pengecatan dan Pert	2	IV				1		
38	8320302229	Praktik Chasis	2	IV				1		
39	8320302136	Praktik AC Mobil	2	IV				1		
40	8320302123	Perpindahan Panas	2	IV			1			
41	8320302231	Pneumatik dan Hidrolik	2	IV			1			
42		Mata Kuliah Pilihan	2	IV				1		
43	8320302011	Bahasa Inggris	2	V		1				
44	832030227	Manajemen Pendidikan Vok	2	V	1					
45	8320302044	Kajian Kurikulum SMK	2	V	1					
46	8320302080	Metodologi Penelitian	2	V					1	
47	8320302072	Mekatronika	2	V				1		
48	8320302165	Statistik	2	V			1		1	
49	8320302232	Pengembangan Bahan Ajar	2	V	1					
50	8320302200	Kewirausahaan	2	V						1
51	8320302233	Konstruksi dan Stabilitas Ker	2	V					1	
52	8320304132	PLP	20	VI	1	1				
53	8320303201	KKN / PI	20	VII				1	1	1
54	8320306163	Skripsi	6	VIII	1				1	
Total			**151**		**11**	**9**	**16**	**17**	**6**	**2**

Based on table 2, the roadmap PLO and course in Mechanical Engineering Education undergraduate (S1 PTM) have 54 courses in 7 semesters (151 credits point). Each course can have 1 or more PLOs. Each semester has an average of 20-22 credits. We have data relations between course and PLO in Figure 6. PLO 1 Pedagogic consists of 11 courses, PLO 2 Social and personal consists of 9 courses, PLO 3 Basic engineering consists of 16 courses, PLO 4 Skill consists 17 courses, PLO 5 Riset consists 6 courses, and PLO 6 Entrepreneurship consists 2 courses.

Among the courses that have more than 1 PLO are Digital Literation (PLO 1 and 2), Learning evaluation (PLO 1 and 5), Statistic (PLO 3 and PLO 5), Internship program or PLP (PLO 1 and PLO 2), Practice field experience at Senior High School (PLP) have PLO 4, 5 and 6.

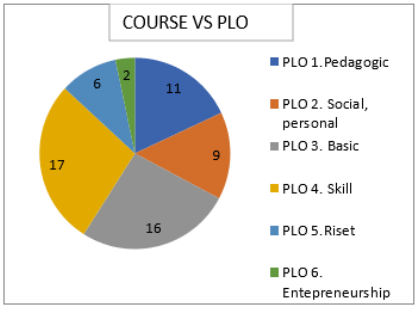
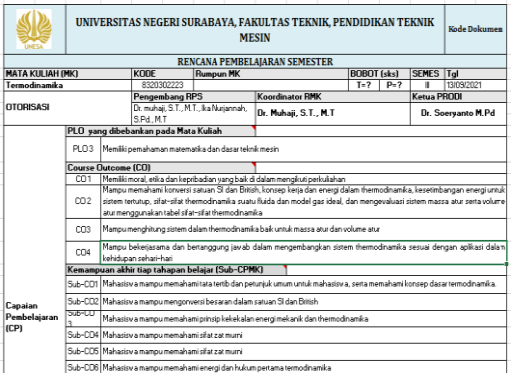


Figure 6 Relations between Course and PLO

To ensure that the implementation of OBE in courses is in line with the course outcomes (CO), at the study program level, the document that must be prepared is the semester lesson plan (RPS). RPS contains course descriptions, course outcomes (CO), learning materials, and plans for implementing lessons for one semester.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RENCANA PEMBELAJARAN SEMESTER

MATA KULIAH (MK)	KODE	Rumpun MK	BOBOT (sks)		SEMES	Tgl
Termodinamika	8320302223		T=?	P=?	II	13/09/2021
OTORISASI	Pengembang RPS	Koordinator RMK	Ketua PRODI			
	Dr. muhaji, S.T., M.T., Ika Nurjannah, S.Pd., M.T	Dr. Muhaji, S.T., M.T	Dr. Soeryanto M.Pd			

Capaian Pembelajaran (CP)	PLO yang dibebankan pada Mata Kuliah	
	PLO 3	Memiliki pemahaman matematika dan dasar teknik mesin
	Course Outcome (CO)	
	CO1	Memiliki moral, etika dan kepribadian yang baik di dalam mengikuti perkuliahan
	CO2	Mampu memahami konversi satuan SI dan British, konsep kerja dan energi dalam thermodinamika, kesetimbangan energi untuk sistem tertutup, sifat-sifat thermodinamika zuatu fluida dan model gas ideal, dan mengevaluasi sistem massa atur serta volume atur menggunakan tabel sifat-sifat thermodinamika
	CO3	Mampu menghitung sistem dalam thermodinamika baik untuk massa atur dan volume atur
	CO4	Mampu bekerjasama dan bertanggung jawab dalam mengembangkan sistem thermodinamika sesuai dengan aplikasi dalam kehidupan sehari-hari
	Kemampuan akhir tiap tahapan belajar (Sub-CPMK)	
	Sub-CO1	Mahasiswa mampu memahami tata tertib dan petunjuk umum untuk mahasiswa, serta memahami konsep dasar termodinamika
	Sub-CO2	Mahasiswa mampu mengonversi besaran dalam satuan SI dan British
	Sub-CO3	Mahasiswa mampu memahami prinsip kekekalan energi mekanik dan thermodinamika
	Sub-CO4	Mahasiswa mampu memahami sifat zat murni
	Sub-CO5	Mahasiswa mampu memahami sifat zat murni
	Sub-CO6	Mahasiswa mampu memahami energi dan hukum pertama termodinamika

Figure 7 Template of the semester lesson plan (RPS)

KORELASI PLO Vs Course Outcomes (CO)

8320302223	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6
CO 1			x			
CO 2			x			
CO 3			x			
CO 4			x			

Figure 8 Template correlation PLO vs CO

The selection of the type of assessment (assignments, presentations, exams, and quizzes) and learning methods (online lectures, discussions, practicum, case studies, or research) is adjusted to the course and is the responsibility of the supporting lecturer as long as all course outcomes (CO) are met.

Table 3. thermodynamics course value

No	NIM	Part	Tugas	UTS	UAS	NA	Huruf	Pakai
1	17050524062	50	0	0	0	10	E	1
2	19050524001	75	85	30	70	67.5	B-	1
3	19050524002	75	82	55	50	65.6	B-	1
4	19050524003	75	85	50	67	70.6	B	1
5	19050524005	95	85	50	85	80	A-	1
6	19050524006	75	85	60	67	72.6	B	1
7	19050524007	75	68	50	58	62.8	C+	1
8	19050524010	75	76	65	50	65.8	B-	1
9	19050524011	85	87	60	50	70.1	B	1
10	19050524012	75	82	50	50	64.6	C+	1
11	19050524013	75	63	55	58	62.3	C+	1
12	19050524014	85	85	100	75	85	A	1
13	19050524015	90	90	90	76	85.8	A	1
14	19050524016	88	90	50	88	81	A-	1
15	19050524017	75	82	55	68	71	B	1
16	19050524018	75	75	65	60	68.5	B-	1
17	19050524019	80	85	70	66	75.3	B+	1
18	19050524020	80	84	55	68	72.6	B	1
19	19050524021	75	87	50	50	66.1	B-	1
20	19050524022	80	87	50	75	74.6	B	1
21	19050524024	95	86	70	82	83.4	A-	1
22	19050524025	80	86	55	75	75.3	B+	1
23	19050524026	80	83	55	66	71.7	B	1
24	19050524027	95	92	70	87	86.7	A	1
25	19050524028	80	65	55	57	63.6	C+	1
26	19050524029	85	84	50	55	68.7	B-	1
27	19050524031	75	74	55	60	66.2	B-	1
28	19050524032	75	83	50	55	66.4	B-	1
29	19050524033	70	83	50	58	66.3	B-	1
30	19050524034	75	75	55	55	65	B-	1
31	19050524035	80	87	60	58	71.5	B	1

From the Course value from table 3, research makes a template for understanding the relation between PLO and course.

From table 4, the diagram about Relation PLO and Value of Course in Thermodynamics can show in Figure 9.

From the Roadmap of PLO and Course, we know that thermodynamics has PLO3, so, it can be measured with Template PLO vs Course to find out the achievement of the course.

Table 4. Template PLO Vs Course Value

No	KRITERIA	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6
1	EXCELLENT	0.00%	0.00%	9.68%	0.00%	0.00%	0.00%
2	VERY GOOD	0.00%	0.00%	9.68%	0.00%	0.00%	0.00%
3	GOOD	0.00%	0.00%	6.45%	0.00%	0.00%	0.00%
4	VERY SATISFY	0.00%	0.00%	25.81%	0.00%	0.00%	0.00%
5	SATISFY	0.00%	0.00%	32.26%	0.00%	0.00%	0.00%
6	FAIR	0.00%	0.00%	12.90%	0.00%	0.00%	0.00%
7	POOR	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
8	VERY POOR	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
9	FAIL	0.00%	0.00%	3.23%	0.00%	0.00%	0.00%
	TOTAL	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%

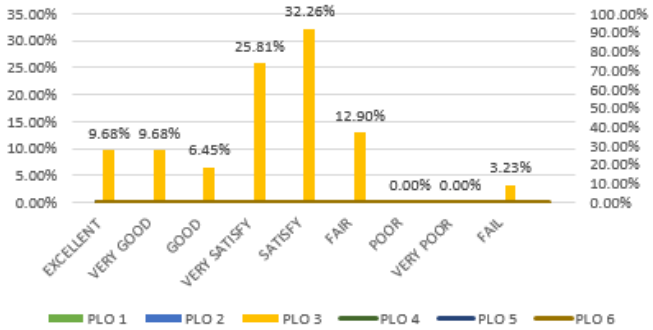

Figure 9 Relation PLO and Value of Course

Table 5. Description of Value

Value	Descriptions	Huruf
≥85	EXCELLENT	A
≥80	VERY GOOD	A-
≥75	GOOD	B+
≥70	VERY SATISFY	B
≥65	SATISFY	B-
≥60	FAIR	C+
≥55	POOR	C
≥40	VERY POOR	D
<40	FAIL	E

Based on Figure 9, relations PLO and Value, when referring to the OBE-based assessment, from this point on PLO 3, 96,73% of students passed the thermodynamics course, and only 3,25% failed. Where, the value range the average value obtained in the thermodynamics course is from excellent to fail.

4. CONCLUSION

The implementation of the OBE-based learning method has been implemented in the Mechanical engineering department. The OBE-based learning system is focused on course outcomes (CO) for each subject. The positive results of the OBE-based learning approach are indicated by the fulfillment of the learning outcomes specified in the courses.

OBE-based learning evaluation research is known to be able to improve the quality of learning, improve the curriculum, which leads to improving the quality of

graduates who are qualified and competent in the field of mechanical engineering.

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