Contemporary Educational Researches Journal

Volume 14, Issue 2, (2024) 120-132

www.cerj.eu

Strategic implementation of outcome-based education

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Suggested Citation:
Tjandra, E., Ferdiana, R. & Kusumawardani, S.S. (2024). Strategic implementation of outcome-based education. *Contemporary Educational Researches Journal*. *14*(2), 120-132. https://doi.org/10.18844/cerj.v14i2.9444

Received from November 02, 2023; revised from January 12, 2024; accepted from April 15, 2024.
Selection and peer review under the responsibility of Prof. Dr. Deniz Ozcan, Samsun Ondokuz Mayıs University, Turkey.

Abstract

The paradigm of higher education in Indonesia is currently changing to Outcome-Based Education, which focuses on the curriculum's accomplishment of student outcomes. Measurement of the degree of learning accomplishment in a course requires the use of a learning outcome attainment method, and providing student skills achievement reports in programming courses is crucial to improving student success in computer science study programs. This study proposes a standardized learning outcome measurement technique to provide a comprehensive course learning outcome attainment with student skills categorization, and course success level, after conducting an interview, focused group discussion, and evaluations with experts. This method includes performance indicators and acceptance criteria via Course Learning Outcome value, Course Learning Outcome level, Course Success Rate level, and student skills, which operate at the study program's course level. The researchers performed the overall attainment process using the direct attainment method. The measurement model proposed has been successfully accepted and implemented in 7 study programs in 11 universities in Indonesia.

Keywords: Attainment; course outcome; outcome-based education; student categorization; student skills.

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1. INTRODUCTION

The international accreditation instrument has determined the standard for measuring learning achievement based on Outcome Based Education (OBE). OBE, also known as the outcome-based curriculum, is a concept in education that creates a curriculum based on what students should be able to do by the end of their educational program (Spady, 1994). After students' learning outcomes are determined, the curriculum containing the material and assessment standards is determined. However, OBE is strongly suggested due to its capacity to give a more precise measurement of student accomplishment (Chen et al., 2024; Tian, 2023; Alderson & Martin, 2007; Hammami, 2020; Kennedy & Birch, 2020; Othman et al., 2020).

Currently, the paradigm of education in higher education in Indonesia is starting to use OBE. All engineering institutions must now pursue accreditation to gain acceptance and reputation in society. International accreditation institutions have also used OBE for assessing study program accreditation. One of the main provisions of OBE-based accreditation is the measurement of outcomes from the learning process. Student Outcome (SO) and Course Learning Outcome (LO) attainment must be performed to ensure that all students have acquired all required competencies set by each study program. Hence, it is necessary to measure the achievement of course learning outcomes.

Standard procedures, performance criteria, and extra support from faculty members are needed to measure student outcome achievement (Kurian et al., 2016; Upadhyaya, 2021). For this purpose, the management of the study program also needs to measure, monitor, and evaluate the LO achievement or course success rate in each course in the curriculum so that it can support the academic decision for future improvement (Neville-Norton & Cantwell, 2019; Schroll et al., 2020; Zlatkin-Troitschanskaia et al., 2017; Piriyapongpipat et al., 2024).

Meanwhile, many students in computer science departments struggle to fulfill the outcomes of programming classes, making them less interested in learning more about programming, resulting in a lower success rate in computer programming courses (We et al., 2023; Giraffa et al., 2014; Malhotra et al., 2023; Margulieux et al., 2020; Koolivand et al., 2024). Hence, earlier recognition of student skills in programming courses is essential in increasing student success in computer science study programs. In addition, it is necessary to provide a specific view of student skill achievement in each course for future personal enhancement. In general, students in computer programming courses must fulfill several skills, especially hard skills, for example, analysis, design, coding, and testing (Patacsil & Tablatin, 2017).

Prior studies of student performance, particularly in academic domains, have been conducted. Many researchers have created competency and learning outcomes measurement schemes using the OBE framework (Yang et al., 2023). They have also created competency and a learning outcomes measurement scheme by conducting curricular mapping (Arafeh, 2016; Malagi et al., 2016; Ramchandra et al., 2014; Soh et al., 2010). According to Bloom's theory, Hussain et al., (2016) added performance indicators based on three learning domains, while Lumius et al., (2020) added visual analytics to support decision-making at the study program level. According to the created curriculum matrix, Easa (2013) built a competency measurement model by segmenting the assessment process' stages into different steps. Additionally, a study was done to assess OBE-based programming classes (Bhuyan & Tamir, 2020). The performance level or level of proficiency resulting from this research is scaled into six categories. However, the generated matrix does not consider the contribution level.

To assess student proficiency, Rajak et al., (2018) created a mapping matrix that mapped Program Educational Objectives (PEO) to Program Outcomes (PO). They then downsized it to Course Outcomes (CO). This study used low, medium, and strong scales to measure the achievement contribution level. Then, in the Civil Engineering Study Program, (Khan et al., 2016) also created a successful model of educational programs assessing learning outcomes for ABET worldwide accreditation. A SO matrix was also produced for the Educational Objective Program. Five levels of contribution were used in this study, with level 5 denoting the highest level and level 1 denoting the lowest.

Nevertheless, these five levels are considered overly complex or confusing based on the lecturers' first requirements analysis findings. These studies have already used contribution levels in the matrix

but did not provide course success and student skill profiles. Kulkarni et al., (2016) and Tjandra et al., (2021) created a measurement schema using a direct method to attain students' competencies achievements at the course level with more precise measurement formulas in each course plan assessment. Kumar et al., (2021) have also performed course outcome attainment for a programming course and successfully provided the SO and CO attainment results using direct and indirect assessment. However, these studies have determined the course success rate but did not provide student skills categorization in computer programming.

1.1. Purpose of study

Therefore, this research proposes an outcome-based education course outcome attainment to provide a comprehensive course learning outcome attainment to measure the success level of LO attainment in a course. The study also provides performance indicators and acceptance criteria via Course Learning Outcome (CLO) value, CLO level, which operates at the study program's course level, based on a direct method. In addition, this study also provides the overall attainment level of course learning outcome achievement with specific student hard skills in computer programming.

2. METHOD AND MATERIALS

2.1. Data collection tool

In the present study, interviews and Focus Group Discussion (FGD) meetings were used to collect data in the second phase of the study, and a measurement scale was used to collect data at the fourth stage of the study.

2.2. Participants

The interviews were conducted with three accreditation assessors and the FGD meetings involved 18 university management representatives: the University Vice President, the Head of the Academic and Curriculum Department, 6 Deans, and 10 Heads of University Programs. Furthermore, the resulting measurement scheme was evaluated in the Evaluation stage, involving expert judgment by 4 OBE experts, model acceptance testing by 35 lecturers from 11 universities and 7 study program management representatives in Indonesia.

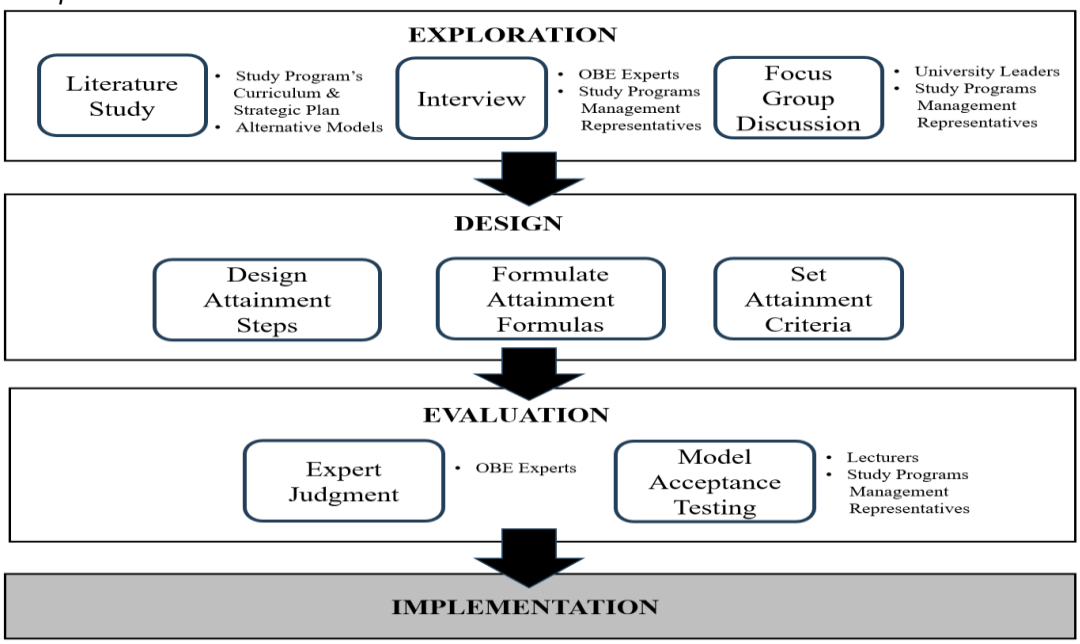
2.3. Procedure

In this research, the researchers performed five steps in the overall attainment process; using only direct attainment, the researchers performed qualitative research methods to perform all research stages in Figure 1.

- The first phase is Exploration, consisting of a literature study of study programs' curriculum and strategic plans and alternative models used by previous research and publications.
- After that, interviews with three accreditation assessors and the FGD meetings.
- After that, the Design phase is performed to develop the measurement process steps and set the required measurement criteria. An attainment model, formulas, and acceptance criteria are established in this phase.
- Furthermore, the resulting measurement scheme is evaluated in the Evaluation stage.
- The last phase is implementing the measurement model in 7 study programs: Informatics Engineering, Information Systems, Multimedia, Industrial Engineering, Manufacturing Engineering, Management, and Biology.

Figure 1

Research procedure



3. RESULTS

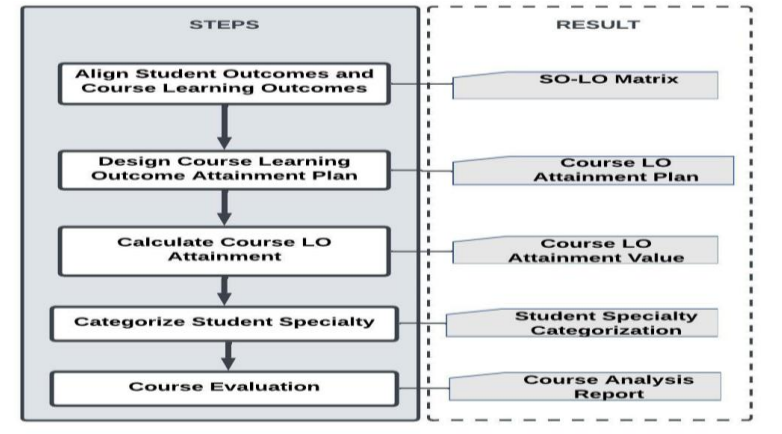
First, the study discusses the course outcome attainment steps, attainment formulas, and acceptance criteria produced in the design phase, as shown in Figure 2. The researchers selected the Object-Oriented Programming course in the Bachelor Degree of Informatics Engineering Study Program, University of Surabaya, Indonesia, for the case study. This course consists of 6 section classes, taught by four lecturers in the fall semester, 2021-2022, which has 71 students in total. All course data were collected and calculated using web-based Learning Outcome Attainment Systems and Microsoft Excel for further tabulation.

3.1. Align student outcomes and course learning outcomes

In the beginning, the lecturer must determine all Student Outcomes (SO) and course Learning outcomes (LO) set in the course. Then a matrix - containing the SO and LO mapping - is created. This matrix is called the SO-LO matrix. Each LO has a Level of Contribution (LoC) or relevance to the SO determined by the study program, consisting of three scales: 1=low, 2=medium, and 3=high. This step produces a SO-LO matrix consisting of LOs, the related SOs, and the Level of Contribution (LoC). LoC is a reference for lecturers to determine the maximum score in the course attainment plan. The higher the LoC, the higher the max score will be used in the attainment plan.

Figure 2

Course attainment steps



Before the attainment plan can be established, we align all SOs and LOs supported by the Object Oriented Programming course. Table 1 and Table 2 show all SOs and LOs correspond to this course, and the SO-LO matrix for this course can be seen in Figure 3. According to the matrix, the total LoC of LO1 is 7 (2+3+2), and LO2 is 6 (2+3+1).

3.2. Design course learning outcome attainment plan

After creating the SO-LO matrix, the next step is developing the course LO Attainment Plan. The attainment plan contains all assessments' components (assessment type, weight, max score) with corresponding LO(s) set in the matrix.

Table 1

Object-oriented programming - student outcomes

Code	Student Outcome (SO)
PP1	The student can apply fundamental mathematical concepts and principles of computer science and other relevant disciplines.
KK1	The student can analyze problems and formulate solutions through the use of information and communication technology.
KU1	The student can think logically, critically, systematically, and innovatively by applying knowledge in the field of information technology in decision-making and can document the results of scientific thinking.
KU2	The student can demonstrate quality and reliable performance both independently and in groups, including conducting supervision and evaluation, as well as being able to communicate and develop networks with various parties.

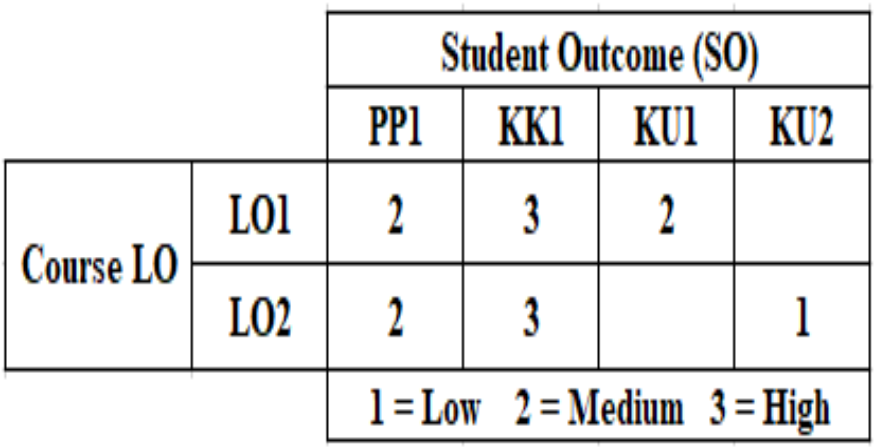
Table 2

Object-oriented programming - learning outcomes

Code	Course Learning Outcome (LO)
LO1	The student will be able to analyze and design classes using object-oriented concepts.
LO2	The student will be able to create modular programs using object-oriented concepts.

Figure 3

SO-LO matrix



The maximum score must be set appropriately based on the LoC in the SO-LO matrix. For example, if the total LoC of LO1 is higher than LO2, then we must set the higher max score for LO1. Table 3 shows an example of the Course LO Attainment Plan.

Table 3

Course LO attainment plan and calculation – example

Assessment Type	Course Term Weight (CTW)	Assessment Details	Course Assessment Weight (CAW)	Assessment Items	LO	Max Score	Student Score Example	
Term1	30.00%	Test1	20.00%	Question 1	LO1	15.00	10.00	
					LO2	15.00	10.00	
				Question 2	LO2	35.00	25.00	
					LO3	35.00	25.00	
		Test2	80.00%	All Questions	LO3	50.00	30.00	
					LO4	50.00	30.00	
Total Course Term Weight (Term1):			100.00%					
Term2	70.00%	Test3	100.00%	All Questions	LO1	100.00	90.00	
Total Course Term Weight (Term2):			100.00%					
				Total LO1:		115.00	100.00	
				Total LO2:		50.00	35.00	
				Total LO3:		85.00	55.00	
				Total LO4:		50.00	30.00	
					CLO1:	70.90	63.60	89.70%
					CLO2:	3.00	2.10	70.00%
					CLO3:	14.10	8.70	61.70%
Total Weight - All Terms:	100.00%				CLO4:	12.00	7.20	60.00%
				CLO:	Total	100.00	81.60	81.60%

In this step, the researchers create Object Oriented Programming attainment plan (Table 4). This course has two: mid-term and final terms, and the weight for each term is different (40% for mid-term, 60% for final). The total score for all terms = 40% * mid-term score + 60% * final-term score. Each term has a set of assessments consisting of items or questions with a particular weight, and each item is linked to a specific LO with a specified max score. Based on the SO-LO matrix (Figure 3), the total LoC of LO1 is higher than LO2, so the max score of CLO1 must be greater than CLO2 in the attainment plan. Table 4 shows that the total max CLO1 is 52.20, greater than LO2 (48.80).

Table 4

Object oriented programming – course LO attainment plan

Assessment Type	Course Term Weight (CTW)	Assessment Details	Assessment Weight (AW)	Assessment Items	LO	Max Score
Mid-Term	40.00%	Mid-Term Practice Work	20.00%	PW1-7	LO1	50.00
					LO2	50.00
		Mid-Term Quiz	30.00%	Question 1-6	LO1	60.00
				Question 7-10	LO2	40.00
		Mid-Term Test	50.00%	All Questions	LO1	50.00
					LO2	50.00
		Total CTW (Mid-Term):	100.00%			
Final-Term	60.00%	Final-Term Practice Work	10.00%	PW8-14	LO1	50.00
					LO2	50.00
		Final-Term Quiz	20.00%	All Questions	LO1	50.00
					LO2	50.00

		Project	30.00%	Project	LO1	50.00
					LO2	50.00
		Final-Term Test	40.00%	All Questions	LO1	50.00
					LO2	50.00
		Total CTW (Final-Term):	100.00%		Max CLO1:	51.20
Total CTW (All-Term):	100.00%				Max CLO2:	48.80

3.3. Calculate course LO attainment

All students' scores will be collected in this step, and each student's total LO attainment value for each assessment will be calculated using Eq. (E1).

$$Total\ LO = \sum_{i=1}^{l} QLO_i \qquad \text{Eq. (E1)}$$

Where:

l = number of assessment items (questions) refers to the specified LO

QLO = student's achievement score in each assessment item connected to the specified LO (question score of connected LO(s)).

After the Total LO has been obtained, the next step is formulating each student's Course LO attainment value (CLO). The CLO value of a student (in %) can be derived from Eq. (E2).

$$CLO = \sum_{k=1}^{n} (\sum_{j=1}^{m} Total\ LO * AW_j) * CTW_k \qquad \text{Eq. (E2)}$$

Where:

AW = assessment weight (in %)

m = number of assessment

n = number of terms

CTW = course term weight in each term (in %). The CTW value will be set to 100% if there is only one term in the course. For further explanation, Table 1 also provides the CLO calculation results example.

In this attainment process, all assessment scores must have a maximum value of 100. Therefore, the attainment results will only accurately reflect the student's expertise if the student submits all assessments in the course attainment plan.

Based on the attainment plan in Table 4, there are three assessments in the mid-term results: Mid-Term Practice Work (max score of LO1=LO2=50), Mid-Term Quiz (max score of LO1=60, LO2=40), and Mid-Term Test (max score of LO1=LO2=50). We calculate Course LO attainment values using (1). Because of the layout limitation, we show the attainment results in three tables. Table 5 shows the mid-term calculation results, Table 6 the final-term results, and Table 7 the all-term results.

Table 5

Object-oriented programming – attainment value (mid-term)

	Assessment Type	Mid-Term Practise Work			Mid-Term Quiz													Mid-Term Test		
	Weight	20%			30%													50%		
	Assessment Items	All Questions			1	10	2	3	4	5	6	7	8	9	All Questions					
	Course LO	Total LO1	Total LO2	Total Assessment Score	Question Score (LO1)	Question Score (LO2)	Question Score (LO1)	Question Score (LO1)	Question Score (LO1)	Question Score (LO1)	Question Score (LO1)	Question Score (LO2)	Question Score (LO2)	Question Score (LO2)	Total LO1	Total LO2	Total Assessment Score	Total LO1	Total LO2	Total Assessment Score
No.	Max Score	50	50	100	10	15	10	10	10	10	10	5	10	10	60	40	100	50	50	100
1	STUDENT 1	50	50	100	10	10	10	9	10	10	0	5	10	10	49	35	84	26.5	26.5	53
2	STUDENT 2	50	50	100	10	15	10	10	10	10	10	5	10	10	60	40	100	41.5	41.5	83
3	STUDENT 3	50	50	100	10	5	9	8	10	10	0	5	10	10	47	30	77	24.5	24.5	49
4	STUDENT 4	44	44	88	10	1	10	10	10	10	8	1	1	2	58	5	63	17	17	34
5	STUDENT 5	50	50	100	10	15	9	10	10	10	10	5	10	10	59	40	99	37.5	37.5	75
6	STUDENT 6	50	50	100	9	10	9	8	10	10	2	5	10	10	48	35	83	18	18	36
7	STUDENT 7	50	50	100	10	15	10	10	10	10	10	5	10	10	60	40	100	35	35	70
8	STUDENT 8	50	50	100	10	9	10	8	10	10	8	5	10	10	56	34	90	41.5	41.5	83
9	STUDENT 9	50	50	100	10	2	9	8	10	4	0	5	10	10	41	27	68	24	24	48
10	STUDENT 10	50	50	100	10	1	10	10	10	10	0	5	10	10	50	26	76	14	14	28
11	STUDENT 11	32.5	32.5	65	2	1	2	0	10	10	0	1	1	1	24	4	28	9	9	18
12	STUDENT 12	50	50	100	10	15	10	10	10	10	4	5	10	10	54	40	94	49	49	98
13	STUDENT 13	50	50	100	10	8	10	10	10	10	4	5	10	10	54	33	87	45	45	90
14	STUDENT 14	50	50	100	10	8	10	9	10	10	2	5	10	10	51	33	84	14.5	14.5	29
	...																			
70	STUDENT 70	49	49	98	10	15	10	10	10	9	8	5	10	10	57	40	97	48.5	48.5	97
71	STUDENT 71	50	50	100	9	15	9	8	10	9	4	5	10	10	49	40	89	37.5	37.5	75

Table 6

Object-oriented programming – attainment value (final-term)

	Assessment Type	Project			Final-Term Practise Work			Final-Term Quiz			Final-Term Test		
	Weight	30%			10%			20%			40%		
	Assessment Items												
	Course LO	Total LO1	Total LO2	Total Assessment Score	Total LO1	Total LO2	Total Assessment Score	Total LO1	Total LO2	Total Assessment Score	Total LO1	Total LO2	Total Assessment Score
No.	Max Score	50	50	100	50	50	100	50	50	100	50	50	100
1	STUDENT 1	37.5	37.5	75	50	50	100	46	46	92	37.5	37.5	75
2	STUDENT 2	42.5	42.5	85	50	50	100	50	50	100	50	50	100
3	STUDENT 3	47.5	47.5	95	50	50	100	35.5	35.5	71	49	49	98
4	STUDENT 4	10	10	20	19	19	38	50	50	100	24.5	24.5	49
5	STUDENT 5	47.5	47.5	95	50	50	100	50	50	100	46.5	46.5	93
6	STUDENT 6	37.5	37.5	75	50	50	100	30	30	60	30.5	30.5	61
7	STUDENT 7	47.5	47.5	95	50	50	100	50	50	100	50	50	100
8	STUDENT 8	47.5	47.5	95	50	50	100	50	50	100	40.5	40.5	81
9	STUDENT 9	32.5	32.5	65	47	47	94	44	44	88	42.5	42.5	85
10	STUDENT 10	45	45	90	50	50	100	30	30	60	30.5	30.5	61
11	STUDENT 11	42.5	42.5	85	48.5	48.5	97	38.5	38.5	77	40.5	40.5	81
12	STUDENT 12	42.5	42.5	85	50	50	100	50	50	100	48.5	48.5	97
13	STUDENT 13	45	45	90	50	50	100	50	50	100	49	49	98
14	STUDENT 14	37.5	37.5	75	50	50	100	42	42	84	43.5	43.5	87
	...												
70	STUDENT 70	50	50	100	50	50	100	50	50	100	47.5	47.5	95
71	STUDENT 71	42	42	84	50	50	100	50	50	100	50	50	100

Table 7

Object-oriented programming – attainment value (all terms)

	Assessment Type	CLO Attainment										
	Weight											
	Assessment Items											
	Course LO	CLO1 Attainment		CLO1 Level	CLO2 Attainment		CLO2 Level	CLO Attainment		CLO Level	Highest CLO	Student Specialty
No.	Max Score	51.20	%		48.80	%		100	%			
1	STUDENT 1	39.45	77.05%	1	37.77	77.40%	1	77.22	77.22%	1	LO2	Coding
2	STUDENT 2	48.15	94.04%	1	45.75	93.75%	1	93.90	93.90%	1	LO1	Analysis and Design
3	STUDENT 3	42.11	82.25%	1	40.07	82.11%	1	82.18	82.18%	1	LO1	Analysis and Design
4	STUDENT 4	28.70	56.05%	2	22.34	45.78%	3	51.04	51.04%	3	LO1	Analysis and Design
5	STUDENT 5	47.29	92.36%	1	45.01	92.23%	1	92.30	92.30%	1	LO1	Analysis and Design
6	STUDENT 6	34.03	66.46%	2	32.47	66.54%	2	66.50	66.50%	2	LO2	Coding
7	STUDENT 7	47.75	93.26%	1	45.35	92.93%	1	93.10	93.10%	1	LO1	Analysis and Design
8	STUDENT 8	46.29	90.41%	1	43.65	89.45%	1	89.94	89.94%	1	LO1	Analysis and Design
9	STUDENT 9	37.87	73.96%	1	36.19	74.16%	1	74.06	74.06%	1	LO2	Coding
10	STUDENT 10	34.82	68.01%	2	31.94	65.45%	2	66.76	66.76%	2	LO1	Analysis and Design
11	STUDENT 11	32.18	62.85%	2	29.78	61.02%	2	61.96	61.96%	2	LO1	Analysis and Design
12	STUDENT 12	48.57	94.86%	1	46.89	96.09%	1	95.46	95.46%	1	LO2	Coding
13	STUDENT 13	48.34	94.41%	1	45.82	93.89%	1	94.16	94.16%	1	LO1	Analysis and Design
14	STUDENT 14	38.25	74.71%	1	36.09	73.95%	1	74.34	74.34%	1	LO1	Analysis and Design
	...											
70	STUDENT 70	49.86	97.38%	1	47.82	97.99%	1	97.68	97.68%	1	LO2	Coding
71	STUDENT 71	45.94	89.73%	1	44.86	91.93%	1	90.80	90.80%	1	LO2	Coding
	Average :	**44.83**	**87.55%**		**42.39**	**86.86%**		**87.22**	**87.22%**			

See the STUDENT4 calculation result for an example. The Mid-Term Practice Work score of STUDENT4 in Table 5 is 88 (so the total LO1=LO2=44), the Mid-Term Quiz score is 63 (total LO1=68 and LO2=5), and the Mid-Term Test score is 34 (total LO1=LO2=17). Meanwhile, as seen in Table 6, the Final-Term Practice Work score is 38 (total LO1=LO2=19), the Final-Term Quiz score is 100 (total LO1=50 and LO2=50), the Project score is 20 (total LO1=LO2=10), and the Final-Term Test score is 49 (total LO1=LO2=24.50). Hence, the total LO1 of STUDENT4 for all term=222.50 of 360.00 (61.81%) and the total LO2=169.50 of 340.00 (49.84%). See Table 7 for the overall results.

3.4. Categorize student specialty

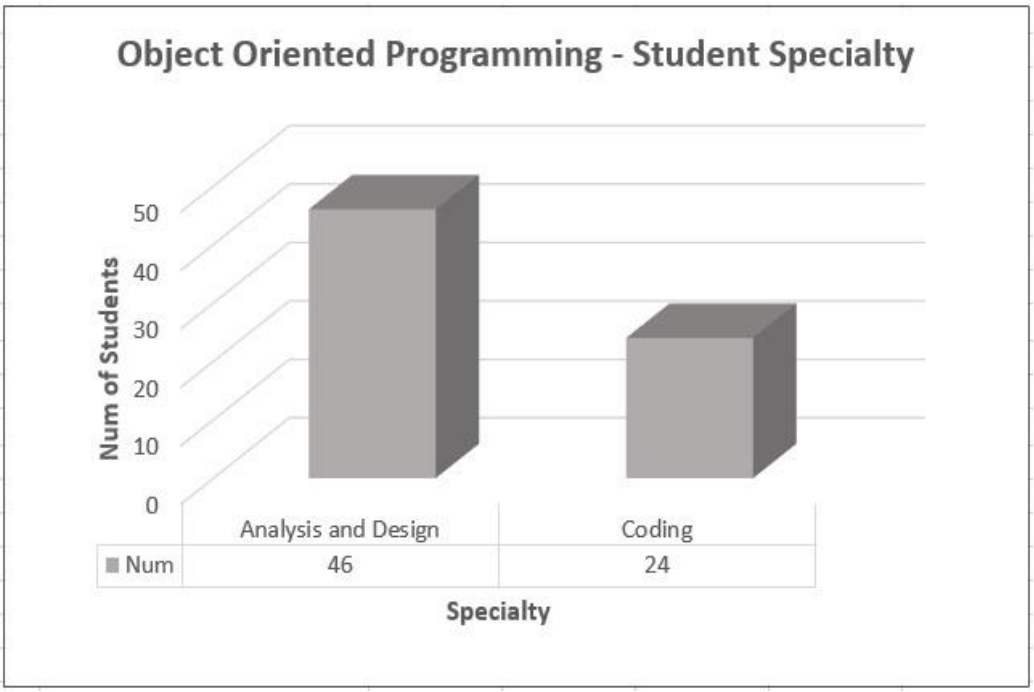
In this research, to categorize specialty, the researchers use four skills in computer programming: analysis, design, coding, and testing. Based on the course Learning Outcomes attainment value, we categorize the students based on their skills. Course LOs will be used to determine the student's skills. For example, a course has four LOs (LO1 and LO2 refer to design ability, LO3 to coding/programming ability, and LO4 testing ability). Therefore, all students in this course with higher LO4 attainment values will be considered to have a higher proficiency in testing.

In this course, LO1 (analyze and design classes using object-oriented concepts) refers to analysis and design ability, while LO2 (create modular programs using object-oriented concepts) corresponds to coding/programming ability. So students with higher LO1 values will be considered to have higher analysis and design skills, and the others refer to coding skills.

For example, in Table 5, the total LO1 of STUDENT4 is higher than the total LO2, which means that STUDENT4 has a higher capability in LO1 than LO2, so we can conclude that STUDENT4's specialty is Analysis &Design. As a result, 46 students (65.71%) have Analysis and Design skills, and 24 (34.29%) have Coding skills in this course. The summarized student specialty of this course can be seen in Figure 4.

Figure 4

Student Skills in Object-Oriented Programming



3.5.Course evaluation

At the end of the semester, a course evaluation will be conducted to provide a course analysis report. Course performance indicators and criteria are set using the CLO level of each student in the course using (3). CLO achievement level is divided into three levels: 1=high (total (CLO>=73%), 2=medium (CLO>=55% and <73%), and 3=low (CLO<55%). A low level refers to the lower fulfillment of the CLO. Students with the lowest level (level=3). Courses with low CSR levels and students with low CSO levels will need extra attention for further improvements by the study program's management.

$$CLO\ Level = \begin{cases} 1\ (high) & CLO \geq 73\% \\ 2\ (medium) & 55\% \leq CLO < 73\% \\ 3\ (low) & CLO < 55\% \end{cases} \qquad \text{Eq. (E.3)}$$

We can also determine the Course Success Rate (CSR) level using (4) based on the CLO value. There are three levels of CSR: 1=high (Average LO>=75%, 2=medium (Average LO>=35% and <75%), and 3=low (Average LO<35%). A successful course has a minimum CSR level of 2. A course with a higher CSR level is considered more successful. Course with low CSR level will need to submit corrective/improvement plan report to the study program management for the next semester.

$$CSR\ level = \begin{cases} 1\ (High) & AvCLO \geq 75\% \\ 2\ (Medium) & 35\% \leq AvCLO < 75\% \\ 3\ (Low) & AvCLO < 35\% \end{cases} \qquad \text{Eq. (E.4)}$$

Course attainment evaluation report for Object-Oriented Programming can be seen in Table 8. This report contains overall CSO achievement results and the CSR level. The CSR level for this course is Level 1 (High), meaning that this course is successful. Only one student has a low CLO level, indicating that almost all students in this course have already fulfilled all CLOs. As a result, the average CLO in this course is 87.22%, with CSR level 1 (High), and only one student has a low CLO level, which means that the lecturers must maintain this course's attainment plan and processes.

Table 8

Object-oriented programming – course evaluation report

COURSE ATTAINMENT EVALUATION REPORT

Course : **1604C021 - Object Oriented Programming (Credit: 4)**

Learning Outcomes : (LO1) The student will be able to analyze and design classes using object oriented concepts

(LO2) The student will be able to create a modular program using object oriented concepts

Assessment : Mid-Term Score = 20% Mid-Term Practise Work + 30% Mid-Term Quiz + 50% Mid-Term Test

Final-Term Score = 10% Final-Term Practise Work + 20% Final-Term Quiz + 30% Project + 40% Final-Term Test

Final Score = 40% Mid-Term Score + 60% Final-Term Score

Average CLO1 (AvCLO1) :	44.83	87.55%	**Max CLO1 :**	51.20	100%
Average CLO2 (AvCLO2) :	42.39	86.86%	**Max CLO2 :**	48.80	100%
Average CLO (AvCLO) :	87.22	87.22%	**Max CLO :**	100.00	100%
CSR Level : 1 - High					

Students with low CLO (CLO Level = 3):

No.		CLO Attainment									
		CLO1 Attainment		CLO1 Level	CLO2 Attainment		CLO2 Level	CLO Attainment	CLO Level	Highest CLO	Student Specialty
	Max Score	51.20	%		48.80	%		%			
4	STUDENT 4	28.70	56.05%	2	22.34	45.78%	3	51.04%	3	LO1	Analysis and Design

4. CONCLUSION

This research has proposed and implemented outcome-based education course outcome attainment based on a direct method using web-based Learning Outcome Attainment Systems and Microsoft Excel. The outcome attainment provides performance indicators and acceptance criteria via CLO value, determining the CLO level, CSR level, and student skills (specialties) in a course. Additionally, this study offers a comprehensive course achievement evaluation report containing CLO, CSR, and students with low CLO levels. This report can measure course success and enable study program management to monitor and evaluate the educational process and curriculum.

The report also provides student skills information, categorizing the student specialty based on skills in computer programming for each student according to the student's highest CLO value. The measurement model proposed in this study can be adapted and applied in other universities by analyzing the curriculum set at the university, of course, considering the applicable standards and the specific needs of the university. For the future development of this study, qualitative and quantitative methods can be performed to produce a model that can continuously adapt to the change in requirements and policies to support the university's strategic academic plans.

Conflict of Interest: The authors declare no conflict of interest.

Ethical Approval: The study adheres to the ethical guidelines for conducting research.

Funding: This research received no external funding.

REFERENCES

Alderson, A., & Martin, M. (2007). Outcomes-based education: where has it come from and where is it nn; lnl. *Issues in Educational Research*, *17*, 2.

Arafeh, S. (2016). Curriculum mapping in higher education: a case study and proposed content scope and sequence mapping tool. *Journal of Further and Higher Education*, *40*(5), 585-611. https://www.tandfonline.com/doi/abs/10.1080/0309877X.2014.1000278

Tjandra, E., Ferdiana, R. & Kusumawardani, S.S. (2024). Strategic implementation of outcome-based education. *Contemporary Educational Researches Journal*. *14*(2), 120-132. https://doi.org/10.18844/cerj.v14i2.9444

Bhuyan, M. H., & Tamir, A. (2020). Evaluating COs of computer programming course for OBE-based BSc in EEE program. https://dspace.aiub.edu/jspui/handle/123456789/528

Chen, G., Wang, H., Zhou, L., Yang, J., Xu, L., & Liang, Y. (2024). Development and applications of graduate outcome-based curriculum for basic medical education. *Frontiers in Medicine*, *11*, 1400811. https://www.frontiersin.org/journals/medicine/articles/10.3389/fmed.2024.1400811/full

Easa, S. M. (2013). Framework and guidelines for graduate attribute assessment in engineering education. *Canadian journal of civil engineering*, *40*(6), 547-556. https://cdnsciencepub.com/doi/abs/10.1139/cjce-2012-0485

Giraffa, L. M., Moraes, M. C., & Uden, L. (2014). Teaching object-oriented programming in first-year undergraduate courses supported by virtual classrooms. In *The 2nd international workshop on learning technology for education in cloud* (pp. 15-26). Springer Netherlands. https://link.springer.com/chapter/10.1007/978-94-007-7308-0_2

Hammami, S. (2020). Effectiveness and efficiency of course outcomes-based assessment models. In *2020 3rd International Conference on Computer Applications & Information Security (ICCAIS)* (pp. 1-6). IEEE. https://ieeexplore.ieee.org/abstract/document/9096773/

Hussain, W., Addas, M. F., & Mak, F. (2016). Quality improvement with automated engineering program evaluations using performance indicators based on Bloom's 3 domains. In *2016 IEEE Frontiers in Education Conference (FIE)*, 1-9. https://ieeexplore.ieee.org/abstract/document/7757418/

Kennedy, M., & Birch, P. (2020). Reflecting on outcome-based education for human services programs in higher education: a policing degree case study. *Journal of Criminological Research, Policy and Practice*, *6*(2), 111-122. https://www.emerald.com/insight/content/doi/10.1108/JCRPP-12-2019-0071/full/html

Khan, M. I., Mourad, S. M., & Zahid, W. M. (2016). Developing and qualifying Civil Engineering Programs for ABET accreditation. *Journal of King Saud University-Engineering Sciences*, *28*(1), 1-11. https://www.sciencedirect.com/science/article/pii/S1018363914000464

Koolivand, H., Shooreshi, M. M., Safari-Faramani, R., Borji, M., Mansoory, M. S., Moradpoor, H., & Azizi, S. M. (2024). Comparison of the effectiveness of virtual reality-based education and conventional teaching methods in dental education: a systematic review. *BMC Medical Education*, *24*(1), 8. https://link.springer.com/article/10.1186/s12909-023-04954-2

Kulkarni, V., Gaitonde, V. N., & Mench, R. G. (2016). Attainment of "Project Management and Finance" Graduate Attribute (GA) for Post Graduate Program in Engineering through Course Project. *Journal of Engineering Education Transformations*, *29*(3), 1. https://doi.org/10.16920/jeet/2016/v29i3/85187

Kumar, K. A., Worku, B., Sisay Muleta Hababa, B. R., & Prasad, A. Y. (2021). Outcome-based education: A case study on course outcomes, program outcomes, and attainment for big data analytics course. *Journal of Engineering Education Transformations*, *35*(2), 63-72. https://www.academia.edu/download/97734895/Final_20October_202021-63-72.pdf

Kurian, C. P., George, V. I., George, A. M., & Kini, S. G. (2016). Outcome Based Assessment: A Case Study on Undergraduate Course on Control Systems. *Journal of Engineering Education Transformations*, *29*(3), 1-8. https://sciresol.s3.us-east-2.amazonaws.com/srs-j/jeet/pdf/volume29/issue3/JEET273.pdf

Lumius, L. D., Hamzah, M., Yee, C. P., Pang, V., & Leng, G. S. (2020). Visual Analytics Design to Support Knowledge Generation: The Case of Outcome Based Education Assessment in Malaysia. In *2020 IEEE 10th Symposium on Computer Applications & Industrial Electronics (ISCAIE),* 135-140. https://ieeexplore.ieee.org/abstract/document/9108793/

Malagi, K. B., Swamy, V. K., & Anami, B. S. (2016). A Novel Method for Attainment Measurement of COs and POs for Tier-II Institutions. *Journal of Engineering Education Transformations*, *29*(Special Issue). https://journaleet.in/articles/a-novel-method-for-attainment-measurement-of-co-s-and-po-s-for-tier-ii-institutions

Malhotra, R., Massoudi, M., & Jindal, R. (2023). Shifting from traditional engineering education towards competency-based approach: The most recommended approach-review. *Education and Information Technologies*, *28*(7), 9081-9111. https://link.springer.com/article/10.1007/s10639-022-11568-6

Margulieux, L. E., Morrison, B. B., & Decker, A. (2020). Reducing withdrawal and failure rates in introductory programming with subgoal labeled worked examples. *International Journal of STEM Education*, *7*, 1-16. https://link.springer.com/article/10.1186/s40594-020-00222-7

Neville-Norton, M., & Cantwell, S. (2019). Curriculum mapping in nursing education: A case study for collaborative curriculum design and program quality assurance. *Teaching and Learning in Nursing*, *14*(2), 88-93. https://www.sciencedirect.com/science/article/pii/S1557308718302105

Tjandra, E., Ferdiana, R. & Kusumawardani, S.S. (2024). Strategic implementation of outcome-based education. *Contemporary Educational Researches Journal*. *14*(2), 120-132. https://doi.org/10.18844/cerj.v14i2.9444

Othman, W. N. A. W., Abdullah, A., & Romli, A. (2020). Predicting graduate employability based on program learning outcomes. In *IOP Conference Series: Materials Science and Engineering,* 769(1), 012018.. https://iopscience.iop.org/article/10.1088/1757-899X/769/1/012018/meta

Patacsil, F. F., & Tablatin, C. L. S. (2017). Exploring the importance of soft and hard skills as perceived by IT internship students and industry: A gap analysis. *Journal of Technology and Science Education*, *7*(3), 347-368. https://www.redalyc.org/pdf/3311/331152600006.pdf

Piriyapongpipat, P., Goldin, S., & Ditcharoen, N. (2024). An alternative approach to ontology-based curriculum development in higher education. *Smart Learning Environments*, *11*(1), 20. https://link.springer.com/article/10.1186/s40561-024-00307-8

Rajak, A., Shrivastava, A. K., & Shrivastava, D. P. (2018). Automating outcome-based education for the attainment of course and program outcomes. In *2018 Fifth HCT Information Technology Trends (ITT)*, 373-376. https://ieeexplore.ieee.org/abstract/document/8649532/

Ramchandra, S., Maitra, S., & MallikarjunaBabu, K. (2014). Method for estimation of attainment of program outcome through course outcome for outcome-based education. In *2014 IEEE International Conference on MOOC, Innovation and Technology in Education (MITE)*, 7-12. https://ieeexplore.ieee.org/abstract/document/7020231/

Schroll, R., Paramesh, A., Guidry, C., Zelhart, M., Killackey, M., & Levy, S. (2020). A structured quality improvement educational curriculum increases surgical resident involvement in QI processes. *Journal of Surgical Education*, *77*(6), e183-e186. https://www.sciencedirect.com/science/article/pii/S1931720420301604

Soh, C. S., Tan, K. H., Yeap, K. H., Yap, V. V., & Yong, Y. T. (2010). Measuring learning outcomes of Bachelor degree program in outcome-based education. In *2010 2nd International Congress on Engineering Education*, 176-179. https://ieeexplore.ieee.org/abstract/document/5940786/

Spady, W. G. (1994). Outcome-Based Education: Critical Issues and Answers. In *Journal of Adolescent Health Care, 7*(1).

Tian, M. (2023). Nurturing Entrepreneurial Mindsets and Talent Training for English Majors: An Outcome-Based Education Paradigm. *Journal of the Knowledge Economy*, 1-31. https://link.springer.com/article/10.1007/s13132-023-01492-6

Tjandra, E., Kusumawardani, S. S., & Ferdiana, R. (2021). Competencies Measurement Framework Using Course Scoring Sheet (CSS) and Course Competencies Score (CCS). In *2021 13th International Conference on Information Technology and Electrical Engineering (ICITEE),* 127-132. https://ieeexplore.ieee.org/abstract/document/9611961/

Upadhyaya, G. (2021). Effective Implementation of Outcome-based Education: The Role of Faculty Awareness. *Indonesian Journal Of Educational Research and Review*, *4*(3), 380-391.

Wei, H. C., Lin, Y. H., & Chang, L. H. (2023). The Effectiveness of a Blended Learning-Based Life Design Course: Implications of Instruction and Application of Technology. *SN computer science*, *4*(4), 360. https://link.springer.com/article/10.1007/s42979-023-01730-3

Yang, H., Zhu, H., Luo, W., & Peng, W. (2023). Design and practice of innovative practice workshop for new nurses based on creativity component theory and outcome-based education (OBE) concept. *BMC Medical Education*, *23*(1), 700. https://link.springer.com/article/10.1186/s12909-023-04684-5

Zlatkin-Troitschanskaia, O., Pant, H. A., Toepper, M., Lautenbach, C., & Molerov, D. (2017). Valid competency assessment in higher education: Framework, results, and further perspectives of the German Research Program KoKoHs. *AERA Open*, *3*(1), 2332858416686739. https://journals.sagepub.com/doi/abs/10.1177/2332858416686739