International Journal of Educational Management and Innovation
Vol.7, No.1, January 2026, pp. 52~68
e-ISSN: 2716-2338
DOI: 10.12928/ijemi.v7i1.14967


# Integration of Intended Learning Outcomes (*ILO*) and Course Learning Outcomes (*CLO*) Real Analysis: An Evaluative Study in the Framework of Outcome-Based Education

**Burhanudin Arif Nurnugroho[1]*, Nurul Arfinanti[2]**
[1]Universitas Ahmad Dahlan, Yogyakarta, Indonesia
[2]Universitas Islam Sunan Kaijaga, Yogyakarta, Indonesia
[1]burhanudin@pmat.uad.ac.id, [2]nurul.arfinanti@uin-suka.ac.id
*burhanudin@pmat.uad.ac.id

**Article Info**

**Article history**
Received November 14, 2025
Revised November 23, 2025
Accepted November 25, 2025

**Keywords**: Course Learning Outcomes; Curriculum Evaluation; Itended Learning Outcomes; Outcome-Based Education ; Real Analysis;

**ABSTRACT**

**Background.** Outcome-Based Education (OBE) requires strong alignment between Intended Learning Outcomes (ILOs) and Course Learning Outcomes (CLOs) to ensure that graduate competencies are systematically achieved. This study evaluates the extent to which ILO–CLO integration is realised in the Real Analysis course of the Mathematics Education Study Programme.
**Methods.** Using a descriptive evaluative approach, data were obtained through analysis of Semester Learning Plans (SLPs), assessment instruments, student learning outcomes, and interviews with course lecturers. Using assessment data, curriculum documents, and cognitive-level analysis, the study finds that ILO achievement is generally high, with most indicators exceeding 70%.
**Results.** CLO performance shows a varied pattern: students demonstrate strong mastery in Sub-CLO 01 and Sub-CLO 04, particularly in topics with clear procedural structure, such as real number construction and basic calculus. However, achievement in Sub-CLO 03, which covers limits and continuity, remains moderate, indicating difficulties in higher-order reasoning aligned with the expected C5 cognitive level. These results reveal a gap between intended evaluative competencies and the predominantly procedural nature of current assessments.
**Conclusion.** The study recommends integrating more authentic, conceptual, and reasoning-based evaluation methods—such as project or portfolio assessments—better support deep learning and reflective mathematical thinking.

## 1. INTRODUCTION

The shift in the paradigm of higher education from an input-based education model to an outcome-based education (OBE) model requires a more measurable and relevant curriculum design for the world of work. Within the framework of OBE, the learning process must ensure that students can achieve learning outcomes that have been determined in a measurable manner and relevant to the needs of industry, society, and scientific developments (Mufanti, Carter, & England, 2024; Kushari, 2022). In line with what was conveyed by Spady (1994) in OBE, the focus of designing, implementing, and evaluating learning is on what graduates can do after completing the study program. This results in the statement of learning outcomes that must be measured and monitored systematically. In Indonesia, the implementation of OBE is a strategy in an effort to improve the quality of higher education, where the preparation of Intended Learning Outcomes (*ILO*) and course learning outcomes (*CLO*) becomes more systematic (Kristianto, 2021).

The success of OBE implementation is influenced by many factors. According to Hasibuan (2024), the successful implementation of the OBE-based curriculum is inseparable from the alignment between curriculum components, namely the vision of the graduate profile, *ILO*, *CLO*, learning activities, and assessments. Hasibuan's opinion is in line with the Directorate General of Higher Education (2020), that the success of OBE implementation depends heavily on consistency between *ILO* and *CLO*, which is a bridge between the vision of the study program and the student learning experience. Mufanti et al. (2024) added that although institutions in Indonesia have adopted the OBE framework, the fact is that there are still obstacles found. The obstacles in question are limitations in lecturer training, inconsistency between policies and practices, and an integrative evaluation of curriculum alignment that is still lacking.

Alignment or integration between *ILO* and *CLO* is the key to ensuring integration between institutional goals, study program achievements, and student learning outcomes. This alignment is known as constructive alignment, which is a consistent relationship between expected learning outcomes, learning activities, and assessments (Biggs and Tang, 2011). In this framework, each course acts as a strategic bridge to direct students to achieve final competencies according to the graduate profile. Harden (2007) added that learning outcomes can only be meaningful if they are measured and consistently lowered from *ILO* to *CLO*. However, in its implementation, there are still often gaps between *ILO* and *CLO*, both in terms of formulation, measurement, and implementation in the classroom (Rahman et al, 2022; Hasibuan, 2024; Mufanti, 2024; Nordin & Zubairi, 2015; Labouta et al., 2019).

In the Mathematics Education study program of FKIP Ahmad Dahlan University, theoretical courses such as Real Analysis play a key role in shaping the ability of abstract thinking, proof, and logical reasoning of prospective teacher students. However, the characteristics of Real Analysis courses that are abstract and conceptual often pose their own challenges. One of these challenges is the difficulty in measuring learning outcomes that are applicable and professional or in the operationalization of *CLO* that measures high-level thinking skills validly and authentically (Tall, 2004; Lithner, 2017; Samkoff et al., 2015; Stylianides & Stylianides, 2016). In line with Suprapto et al. (2023) who revealed that theoretical mathematics courses, such as Real Analysis, have a high level of difficulty in achieving measurable *CLO* due to the abstract characteristics of the material. Additionally, Nuraini and Khasanah (2023) report that the alignment between ILO and CLO in Real Analysis courses is often not accompanied by assessment strategies capable of authentically measuring students' higher-order thinking.

Despite the importance of curriculum alignment in mathematics education, previous studies have not specifically examined how ILO–CLO integration is operationalized within Real Analysis courses in Indonesian higher education. Existing research discusses curriculum alignment in general or highlights challenges in theoretical mathematics learning, but does not focus on evaluating the coherence between ILO, CLO, learning activities, and assessment in a specific course context. This gap indicates a lack of empirical evidence on how constructive alignment is implemented in Real Analysis courses within an OBE framework.

Therefore, the analysis of the integration of *ILO* and *CLO* in the Real Analysis course is important to ensure the suitability between the learning design and the results achieved by students in accordance with the OBE principles.

This study aims to evaluate the integration between ILO and CLO in the Real Analysis course within the framework of Outcome-Based Education. Specifically, this study examines: (1) the alignment between the formulation of ILO and CLO, (2) the implementation of learning activities that support the achievement of both, and (3) the assessment system used to measure student learning outcomes. The novelty of this study lies in its focused evaluation of constructive alignment within a single theoretical mathematics course—Real Analysis—in an Indonesian university context, offering insights that have not been previously documented in the literature. The findings are expected to strengthen OBE-based curriculum development and provide a basis for improving curriculum mapping mechanisms in mathematics education.

## 2. METHODS

This study uses a descriptive qualitative evaluative approach to analyze the integration between Intended Learning Outcomes (ILO) and Course Learning Outcomes (CLO) in the Real Analysis course within the framework of Outcome-Based Education (OBE). This approach was chosen because it enables a systematic examination of curriculum documents, learning implementation processes, and student evaluation results as indicators of outcome achievement.

The research was conducted in the Bachelor of Mathematics Education Study Program at Ahmad Dahlan University (UAD), Yogyakarta. The research subjects consisted of two lecturers responsible for teaching the Real Analysis course and the learning documents used in the course. The research objects included: one Semester Learning Plan (SLP), one set of ILO and CLO statements, six teaching material units, and 2 assessment items (one midterm exam question and one final exam question). The student learning outcome data analyzed consisted of scores from 25 students enrolled in the Real Analysis course.

Data collection was carried out through three main techniques: (1) Document Analysis of Curriculum and SLP, (2) analysis of Assessment Instruments, and (3) analysis of Student Learning Outcomes. Data analysis was conducted using qualitative content analysis, which included:

(1) coding the content of documents and assessment items, (2) categorizing alignment patterns between ILO, CLO, learning activities, and assessments, and (3) interpreting the degree of constructive alignment in the Real Analysis course.

The qualitative findings were supported by simple descriptive quantitative analysis (frequencies and percentages) to show the proportion of CLO achievement based on student performance. Triangulation among document analysis, lecturer confirmation, and student learning outcome data was used to ensure the validity of the results.

## 3. RESULTS AND DISCUSSION

### 3.1. Integration of *ILO* and *CLO* in SLP Documents

The results of the analysis of the Semester Learning Plan (SLP) of the *Real Analysis* course show that the formulation *of Intended Learning Outcomes* (*ILO*) and *Course Learning Outcomes* (*CLO*) has been conceptually integrated and in line with the principles *of Outcome-Based Education* (OBE). This course supports several main *ILO*s of the Bachelor of Mathematics Education Study Program, Ahmad Dahlan University (UAD), namely logical and analytical thinking skills, mastery of advanced mathematics concepts, and reflective skills in solving mathematics learning problems. There are four *ILO*s charged in the Real Analysis course. The four *ILO*s are presented in Table 1.

**Table 1.** *ILO* Charged on MK Real Analysis

| ***ILO* Mathematics Education Study Program** | ***ILO* Narrative** |
|---|---|
| *ILO* 01 | Piety, integrity, and the spirit of Pancasila based on Al-Islam and Muhammadiyah Values. |
| *ILO* 02 | Applying a scientific mindset (logical, critical, creative, and innovative) in problem-solving and studying the field of education. |
| *ILO* 05 | Mastering factual, conceptual, procedural, and metacognitive knowledge of mathematics, including geometry, algebra, analysis, statistics, and computing, both to support mathematics learning at the primary and secondary education levels and for further study. |
| *ILO* 07 | Utilizing science, technology, art, and culture to design and produce educational content, learning media, or entrepreneurship in the field of mathematics education, both physical and digital. |

Furthermore, the results of the *ILO* mapping analysis with the *CLO* Real Analysis show that all *CLO*s have been derived from the relevant *ILO*, especially in the aspects of mastering the basic concepts of analysis, proving theorems, and applying the concept of limits and continuity. The following Table 2 shows the decrease in *ILO* to *CLO* in the Real Analysis course.

**Table 2.** Reduction of *ILO* to *CLO* in the Real Analysis course

| ***ILO*** | ***CLO*** | ***CLO* Narrative** |
|---|---|---|
| *ILO* 01 | *CLO* 01 | Students understand and master, axioms of real fields (real number fields), Algebraic properties of real numbers, existence of irrational numbers |
| *ILO* 02 | *CLO* 02 | Students understand and master the concepts of real number sequence, absolute value, and completeness of real numbers |
| *ILO* 05 | *CLO* 03 | Students can understand and master the concepts of real number lines, function limits, and function continuity |
| *ILO* 07 | *CLO* 04 | Students understand and master the concept of function derivatives and integral concepts |

Based on Table 2 above, *ILO* 01 is downgraded into *CLO* 01, *ILO* 02 is downgraded into *CLO* 02, *ILO* 05 is downgraded into *CLO* 03, and *ILO* 07 is downgraded into *CLO* 04.

The *CLO* of the Real Analysis course at UAD was then reduced to four Sub-*CLO*. Each of these Sub-*CLO* shows the final ability at each stage of learning the Real Analysis course. The following Table 3 explains the correlation between *CLO* and Real Analysis Sub-*CLO*.

**Table 3**. Correlation of *CLO* to Sub-*CLO*

| | Sub-*CLO* 01 | Sub-*CLO* 02 | Sub-*CLO* 03 | Sub-*CLO* 04 |
|---|---|---|---|---|
| *CLO* 01 | √ | | | |
| *CLO* 02 | | √ | | |
| *CLO* 03 | | | √ | |
| *CLO* 04 | | | | √ |

Furthermore, the narrative of the Real Analysis Sub-*CLO* is presented in the following Table 4.

**Table 4.** Real Analysis Sub-*CLO*

| **Sub-*CLO*** | **Sub-*CLO* Narrative** |
|---|---|
| Sub-*CLO* 01 | Students can explain the construction of real numbers, prove the algebraic properties of real numbers, and the existence of real numbers. (*CLO* 01) (P2, C5, A5) |
| Sub-*CLO* 02 | Students understand and master the concepts of real number sequence, absolute value, and completeness of real numbers (*CLO* 02) (P2, C5, A5) |
| Sub-*CLO* 03 | Students can understand and master the concepts of real number lines, function limits, and function continuity (*CLO* 03) (P2, C5, A5) |
| Sub-*CLO* 04 | Students understand and master the concept of derivative functions and integral concepts (*CLO* 04) (P2, C5, A5) |

The intended alignment of the Sub-CLOs with higher-order domains—C5 (evaluating) in the cognitive domain, P2 (manipulation) in the psychomotor domain, and A5 (characterization) in the affective domain—has not been fully realized at the formulation level. Although the Sub-CLO sentences are claimed to target C5, the operational verbs used ("understand" and "master") do not correspond to the evaluative processes required at this higher cognitive level. In Bloom's Taxonomy, C5 represents a complex ability where students are expected to justify decisions using explicit criteria, critically assess arguments, compare theoretical approaches, and provide defensible evaluations. The absence of C5-aligned operational verbs suggests that the Sub-CLOs still operate at a lower cognitive level than intended.

This mismatch indicates a slippage in the reduction process from ILO → CLO → Sub-CLO, where the narrative tends to be transferred directly without a rigorous translation into measurable and observable behaviors. Similar challenges have been widely documented in programs that claim to have implemented Outcome-Based Education (OBE) but continue to struggle with articulating learning outcomes that are both operational and assessable. Prior studies (HEQCO, 2015; Alyasin, 2023; Auras et al., 2023) note that without systematic curriculum mapping and well-constructed assessment rubrics, alignment across learning outcome levels often remains superficial rather than substantive.

In the psychomotor domain, the focus on P2 (manipulation) indicates that students are expected to perform actions based on guided instructions. While this aligns with foundational skill development, the emphasis on imitation—particularly the replication of theorem-proving steps in Real Analysis—may limit opportunities for students to progress toward higher psychomotor complexity. If students are only imitating provided proofs, they may not yet be engaging in independent manipulation or creative construction of mathematical arguments, which are critical for developing advanced analytical competence.

In the affective domain, the intended emphasis on A5 (characterization) reflects an aspiration for students to internalize and consistently demonstrate mathematical rigor as part of their academic character. However, the current Sub-CLO formulations provide limited evidence that such affective outcomes are explicitly targeted or supported through structured learning activities and assessment strategies.

Furthermore, as emphasized by Loughlin et al. (2020), vertical consistency across institutional, program, and course levels is essential to realizing the full potential of outcome-oriented education. The findings of this study show that while the Real Analysis SLP at UAD demonstrates initial alignment with OBE principles, gaps remain in the operationalization of the cognitive dimension and in the integration of analytical and reflective skills. Strengthening these areas is necessary to ensure that the intended higher-order competencies are both articulated and achievable within the course design.

### 3.2. Integration between *CLO* and Assessment Instruments

Analysis of the assessment instruments shows that in general, the question items are relevant to the *CLO* indicators, especially in the aspects of mastery of concepts and the application of basic theorems. The following are the results of the analysis of the measurement instruments of each Real Analysis Sub-*CLO*.

### 3.2.1. Sub-CLO 01 Measurement Questions

| Mahasiswa mampu menjelaskan konstruksi bilangan real, membuktikan sifat-sifat aljabar bilangan real dan eksistensi bilangan real. (Sub-CPMK 01) (CPL 01) | | | |
|---|---|---|---|
| **No** | **Soal** | **Skor** | **Level Kognitif** |
| 1 | Apakah bilangan $\sqrt{2}$ merupakan bilangan rasional? Jelaskan pendapatmu! | 100 | C5 |

| Mahasiswa mampu menjelaskan konstruksi bilangan real, membuktikan sifat-sifat aljabar bilangan real dan eksistensi bilangan real. (Sub-CPMK 01) (CPL 01) | | | |
|---|---|---|---|
| **No** | **Soal** | **Skor** | **Level Kognitif** |
| 2 | Diketahui $a$ dan $b$ bilangan real positif. Buktikan bahwa $\sqrt{ab} \leq \frac{1}{2}(a+b)$ | 100 | C5 |

**Students are able to explain the construction of real numbers, prove algebraic properties of real numbers, and the existence of real numbers. (Sub-CLO 01) (ILO 01)**

| No | Question | Score | Cognitive Level |
|---|---|---|---|
| 1 | Is the number $\sqrt{2}$ a rational number? Explain your opinion! | 100 | C5 |

**Students are able to explain the construction of real numbers, prove algebraic properties of real numbers, and the existence of real numbers. (Sub-CLO 01) (ILO 01)**

| No | Question | Score | Cognitive Level |
|---|---|---|---|
| 2 | Given that $a$ and $b$ are positive real numbers, prove that $\sqrt{ab} \leq \frac{1}{2}(a+b)$. | 100 | C5 |

**Figure 1.** Sub-*CLO* 01 Measurement Questions

The two questions in Figure 1 are used to measure the achievement of Sub-*CLO* 01 in the Real Analysis course. Both have shown the cognitive level of C5, which is evaluating whether a statement is true or not. Students must also provide an explanation of their answers or provide evidence that their answers are correct.

### 3.2.2. Sub-CLO 02 Measurement Questions

Sub-*CLO* 02 measures students' ability to understand and master the concepts of real number sequences, absolute values, and completeness of real numbers. The questions used for the measurement of Sub-*CLO* 02 are shown in Figure 2.

| Soal | Skor | Level Kognitif |
|---|---|---|
| Misalkan diketahui $S_1 := \{x \in \mathbb{R} \mid x \geq 0\}$.<br>Tunjukkan bahwa himpunan $S_1$ memiliki batas bawah akan tetapi tidak memiliki batas atas.<br>Petunjuk: Tunjukkan bahwa infimum $S_1$ adalah $0$ | 100 | C5 |

| Question | Score | Cognitive Level |
|---|---|---|
| Suppose it is known that $S_1 := \{x \in \mathbb{R} \mid x \geq 0\}$. | | |
| Show that the set $S_1$ has a lower bound but does not have an upper bound. | | |
| Hint: Show that the infimum of $S_1$ is $0$. | 100 | C5 |

**Figure 2.** First Question for Sub-*CLO* Measurement 02

The question in Figure 2 asks students to show that a given set has a lower limit but does not have an upper limit. In this question, it is clear that students must provide proof of the lower limit of the given set. In the question, assistance is also given that the lower limit or infimum in question is 0. This question has shown the C5 level in the Bloom Taxonomy and is in accordance with Sub-CMPK 02.

Next, pay attention to the second question that measures Sub-*CLO* 02 in Figure 3.

| Soal | Skor | Level Kognitif |
|---|---|---|
| Jika $x \in \mathbb{R}$ maka terdapat bilangan *natural* $n_x$ sehingga $x < n_x$. Selidiki kebenaran pernyataan di atas! | 100 | C5 |

| Question | Score | Cognitive Level |
|---|---|---|
| If $x \in \mathbb{R}$, then there exists a natural number $n_x$ such that $x < n_x$. | | |
| Investigate the truth of the statement above! | 100 | C5 |

**Figure 3.** Second Question of Sub-*CLO* Measurement 02

In Figure 3, students are asked to investigate the truth of the statements given. This question is also in accordance with the Sub-*CLO* 02 indicator, both in terms of content and the cognitive level measured.

### ***3.2.3. Sub-CLO 03 Measurement Questions***

The questions used to measure Sub-*CLO* 03 are in Figure 4.

**Sub-CPMK 3**

Mahasiswa mampu memahami dan menguasai konsep barisan bilangan real, limit fungsi dan kekontinuan fungsi (C5)

| No | Soal | Skor | Level Kognitif |
|---|---|---|---|
| 1. | Gunakan definisi $\varepsilon - \delta$ untuk membuktikan limit fungsi berikut $\lim_{x \to 1} \frac{x}{1+x} = \frac{1}{2}$ | 100 | C5 |
| 2 | Jika $c$ titik interior interval $I$ dan fungsi $f : I \to R$ mempunyai ekstrem relative di $c$ dan $f$ mempunyai derivatif di c, maka $f'(c) = 0$. Buktikan kasus $f$ mempunyai nilai minimum relatif di $f(c)$ | 100 | C5 |

**Sub-CLO 3**

*Students are able to understand and master the concepts of real-number sequences, function limits, and continuity (C5).*

| No | Soal | Skor | Level Kognitif |
|---|---|---|---|
| 1 | Use the $\varepsilon - \delta$ definition to prove the following limit: $\lim_{x \to 1} \frac{x}{1+x} = \frac{1}{2}$ | 100 | C5 |
| 2 | If $c$ is an interior point of interval $I$ and the function $f : I \to \mathbb{R}$ has a relative extremum at $c$ and $f$ is differentiable at $c$, then $f'(c) = 0$. Prove the case when $f$ has a relative minimum at $c$. | 100 | C5 |

**Figure 4.** Sub-*CLO* 03 Measurement Questions

The two questions in Figures 1 and 2 instruct students to prove a statement on the topic of function limits and function continuity. These questions are also suitable for measuring Sub-*CLO* 02, both from the cognitive level and the content aspect.

### 3.2.4. Sub-*CLO* 04 Measurement Questions

Sub-*CLO* 04 was measured using two description questions. The first question focuses on the concept of derivative functions, while the second question focuses on the integral concept. The following are the questions that measure Sub-*CLO* 04.

**Sub-CPMK 4**

Mahasiswa memahami dan menguasai konsep derivatif fungsi dan konsep integral.

| No | Soal | Skor | Level Kognitif |
|---|---|---|---|
| 3. | Misalkan $f(x) = x^2 - x$ dan $[a, b] = [1,4]$. Jika partisi $\pi = \left(1, \frac{3}{2}, 2, \frac{7}{3}, 4\right)$ pada interval tersebut. Tentukan **jumlahan Riemann $R(f, \pi)$ atau jumlah bawah Darboux atau jumlah atas Darboux (Pilih salah satu)** dari fungsi f dan partisi $\pi$ | 100 | C5 |
| 4. | Carilah nilai integral berikut dengan menggunakan Teorema Fundamental Kalkulus: $\int_0^2 (x + 3)dx$ | 100 | C3 |

**Sub-CLO 4**

*Students understand and master the concepts of function derivatives and integrals.*

| No | Soal | Skor | Level Kognitif |
|---|---|---|---|
| 3 | Suppose $f(x) = x^2 - x$ and $[a, b] = [1, 4]$. If the partition is $\pi = \left(1, \frac{3}{2}, 2, \frac{7}{2}, 4\right)$, determine the **Riemann sum** $R(f, \pi)$, or the **lower Darboux sum**, or the **upper Darboux sum** (Choose one). | 100 | C5 |
| 4 | Find the value of the following integral using the Fundamental Theorem of Calculus: $\int_0^2 (x + 3)\, dx$ | 100 | C3 |

**Figure 5.** Sub-*CLO* 04 Measurement Questions

In both questions presented in Figure 5, students are primarily asked to compute definite integrals and determine either the Riemann sum or the Darboux sum of a function with specified intervals and partitions. Although these tasks are relevant to Real Analysis content, they predominantly assess procedural application, corresponding to the C3 (applying) level of Bloom's Taxonomy. This creates a clear misalignment with Sub-CLO 04, which is intended to measure the higher-order cognitive level of C5 (evaluating). The current assessment items do not require students to engage in evaluative reasoning such as judging the validity of each step of an argument, critiquing alternative solution paths, or justifying the correctness of a proof based on explicit criteria.

To genuinely assess C5, the questions must be redesigned to include evaluative components. For example, students could be provided with a partially completed proof or a sequence of integral computations and asked to determine which steps are valid, justify why a step is incorrect, or propose a more rigorous alternative. Such tasks would compel students to engage in reflective and analytical thinking that is characteristic of the evaluating level.

The current imbalance demonstrates that assessment practices are still heavily oriented toward procedural application rather than conceptual evaluation. This echoes Weber's (2015) findings that students often struggle with the conceptual understanding behind Real Analysis proofs because assessments tend to emphasize the reproduction of formal steps instead of inviting exploration of the underlying structure and meaning of the concepts. When students are repeatedly assessed on procedural accuracy, they are less likely to develop the evaluative mindset needed to critically examine mathematical arguments.

Furthermore, Vlachopoulos (2024) underscores that in an OBE framework, assessments must capture actual performance—meaning that they should measure not only what students know but also what they can do with that knowledge in novel or complex contexts. The current Real Analysis assessment structure does not yet reflect this principle. To align with OBE, the evaluation instruments require reconfiguration so that they incorporate performance-based measures. Project-based tasks, portfolio evidence, or structured formative assessments can provide richer insight into students' mathematical reflective thinking, their ability to critique proofs, and their capacity to evaluate the validity of analytical processes.

In the context of the Real Analysis course at UAD, although formative assessments are already implemented to measure Sub-CLO achievements, their design needs refinement to ensure that higher-level cognitive skills—particularly evaluation and reflection—are explicitly targeted. A recalibration of assessment formats is therefore essential to ensure that the intended cognitive complexity of Sub-CLO 04 is accurately captured in practice.

### 3.3. Student Learning Outcomes Analysis

The achievement of the *ILO* of the Real Analysis course can be seen from the student's learning experience. Based on the data on student learning outcomes, the average achievement of each *ILO* charged in the Real Analysis course is above 70%. Details of the achievements of each *ILO* are shown in Table 5:

**Table 5.** Achievement of Each *ILO* in Real Analysis Courses

| Code | Border | Achievements | *ILO* 01 | | *ILO* 02 | | *ILO* 05 | | *ILO* 07 | |
|---|---|---|---|---|---|---|---|---|---|---|
| And | 80.00 | Excellent | 25 | 100% | 11 | 44% | 2 | 8% | 20 | 80% |
| G | 65.00 | Good | 0 | 0% | 14 | 56% | 17 | 68% | 4 | 16% |
| A | 55.00 | Enough | 0 | 0% | 0 | 0% | 5 | 20% | 1 | 4% |
| D | 40.00 | Less | 0 | 0% | 0 | 0% | 1 | 4% | 0 | 0% |
| Sum | | | 25 | 100 % | 25 | 100 % | 25 | 100 % | 25 | 100 % |
| Average | | | 99.68 | | 82.08 | | 70.10 | | 84.24 | |
| SD | | | 1.57 | | 15.88 | | 8.78 | | 9.66 | |

Furthermore, a description of the achievement of the *ILO* of the Real Analysis course will be displayed in Table 6.

**Table 6.** Percentage of *ILO* Achievement in Real Analysis Courses

| ***ILO* code** | ***ILO* Description** | **Average Achievement (%)** | **Category** |
|---|---|---|---|
| *ILO* 01 | Piety, integrity, and the spirit of Pancasila are based on Al-Islam and Muhammadiyah. | 99.68 | Very High |
| *ILO* 02 | Applying a scientific mindset (logical, critical, creative, and innovative) in problem-solving and studying the field of education. | 82.08 | Very High |

| *ILO* code | *ILO* Description | Average Achievement (%) | Category |
|---|---|---|---|
| *ILO* 05 | Mastering factual, conceptual, procedural, and metacognitive knowledge of mathematics, including geometry, algebra, analysis, statistics, and computing, both to support mathematics learning at the primary and secondary education levels and for further study. | 70.10 | High |
| *ILO* 07 | Utilizing science, technology, art, and culture to design and produce educational content, learning media, or entrepreneurship in the field of mathematics education, both physical and digital. | 82.24 | Very High |

The analysis of student learning outcomes shows that all ILOs associated with the Real Analysis course achieve an average score above 70%. While this indicates generally satisfactory attainment, a deeper interpretation reveals important variations in the nature, depth, and validity of these achievements.

ILO 02, which concerns applying a scientific mindset—logical, critical, creative, and innovative—in problem solving and educational inquiry, records an average achievement of 82.08% and falls into the very high category. Although encouraging, this high score must be interpreted cautiously. The components of ILO 02—particularly creativity and innovation—are complex and require performance-based assessments that capture original reasoning or non-routine problem solving. A high numerical score may therefore reflect strong mastery of logical or procedural reasoning typical of Real Analysis, while not fully evidencing the creative or innovative dimensions. This suggests that the assessment instruments may be more sensitive to analytical skills than to the broader scientific mindset intended by the outcome.

ILO 05, which focuses on mastery of factual, conceptual, procedural, and metacognitive knowledge across major mathematical domains, shows an average achievement of 70.10%, categorised as high but positioned at the lower boundary of successful attainment. This relatively lower performance compared to other ILOs indicates that students encounter greater difficulty when demonstrating integrated forms of mathematical knowledge, particularly metacognitive aspects such as evaluating their own reasoning or connecting multiple representations. This pattern is consistent with findings in mathematics education research showing that conceptual and metacognitive mastery develops more slowly and typically requires iterative exposure and scaffolded reflection. Thus, the results point to the need to strengthen instructional approaches that explicitly cultivate metacognitive awareness and deep conceptual integration.

ILO 07, which emphasises the use of science, technology, art, and culture to design and produce educational content or learning media, achieves an average of 82.24% and is also in the very high category. However, considering that Real Analysis is a theoretical course with limited embedded media-production tasks, this high score raises methodological concerns. The measurement of ILO 07 in this context may rely heavily on indirect indicators—such as students' ability to use digital tools for assignments—rather than authentic design or production of educational media. As such, the high score may not fully represent students' applied competence in integrating technology, creativity, and pedagogical design. This highlights a potential misalignment between the intended outcome and the actual learning activities within the course.

Overall, although the achievement data suggest strong performance across ILO 02, ILO 05, and ILO 07, a critical analysis shows that these numbers may mask deeper challenges related to assessment validity, the complexity of the intended competencies, and alignment between course activities and broader programme-level outcomes. These findings underscore the need for more authentic, performance-oriented, and domain-specific assessment strategies to ensure that ILO achievement reflects genuine competence rather than procedural or indirect indicators.

To provide a clearer picture of how well students achieved each Sub-CLO, the results of the CLO measurement are compiled and analysed in Table 7. This table displays the distribution of achievement levels across assessment components, enabling a deeper examination of alignment between intended outcomes and actual student performance.

**Table 7.** Percentage of Course Learning Achievement (*CLO*)

| Code | Border | Access | *CLO* 01 | | *CLO* 02 | | *CLO* 03 | | *CLO* 04 | |
|---|---|---|---|---|---|---|---|---|---|---|
| And | 80.00 | Excellent | 25 | 100% | 11 | 44% | 2 | 8% | 20 | 80% |
| G | 65.00 | Good | - | 0% | 14 | 56% | 17 | 68% | 4 | 16% |
| A | 55.00 | Enough | - | 0% | - | 0% | 5 | 20% | 1 | 4% |
| D | 40.00 | Less | - | 0% | - | 0% | 1 | 4% | - | 0% |
| In the | 0.00 | Very Less | - | 0% | - | 0% | - | 0% | - | 0% |

The analysis of CLO achievement shows a varied pattern of student performance across the four Sub-CLOs. Sub-CLO 01 and Sub-CLO 04 exhibit the strongest results, with 100% of students achieving an Excellent category (≥80) in CLO 01 and 80% achieving Excellent in CLO 04. These findings indicate that students are capable of demonstrating solid conceptual understanding and procedural reasoning, particularly in topics such as the construction of real numbers and foundational calculus (derivatives and integrals). The high proportion of students in the Excellent category suggests that when the learning content is procedural or structurally well-defined, students are able to engage effectively and perform at a high level.

In contrast, the performance in Sub-CLO 03 (limits, continuity, real number lines) shows a markedly different pattern: only 8% of students reached the Excellent category, while the majority—68%—were in the Good category, and 20% fell into the Enough category. The presence of students in the Less category (4%) further reflects conceptual difficulties. This distribution indicates that while students can approach these topics at a basic or intermediate level, they struggle to demonstrate deeper comprehension or higher-order reasoning aligned with the C5 level stated in the curriculum documents.

Sub-CLO 02 similarly reflects challenges: although 44% of students reached the Excellent category, more than half (56%) are only in the Good category. No students fell into the Enough or Less categories, but the absence of Very High attainment across the cohort suggests that concepts such as real number sequences, absolute values, and completeness, while understood procedurally, may not yet be internalised conceptually at the level intended.

Taken together, these results highlight a misalignment between the expected cognitive level (C5: evaluating) in the SLP and the actual performance profile of students. While students show strong mastery in areas supported by clear deductive structure (Sub-CLO 01 and 04), their performance declines in areas demanding conceptual abstraction and reflective reasoning (Sub-CLO 03). This pattern reinforces the long-standing findings in Real Analysis education that limits and continuity constitute conceptual bottlenecks because they require students to transition from formal recall to analytical justification and interpretation.

The observed gaps suggest that although the CLOs are formally aligned with higher-order cognitive demands, the learning activities and assessment instruments may still emphasize procedural tasks that do not sufficiently cultivate evaluative and reflective reasoning. Thus, the moderate achievement in Sub-CLO 03 is not merely a performance issue but a structural indicator of the need for more authentic, reasoning-oriented assessments and instructional strategies.

### 3.4. Discussion of Findings and Comparison with Relevant Research

The findings of this study show that the integration between ILO and CLO in the Real Analysis course at UAD has been implemented consistently from the level of formulation to planning, implementation, and evaluation. The curriculum documents, teaching activities, and assessment instruments reflect a coherent structure based on Outcome-Based Education principles. This indicates that the constructive alignment process has been internalized by the lecturers and supported institutionally. Even so, the analysis also reveals that several assessment items still operate at cognitive levels below those stated in the CLO, suggesting that structural alignment does not yet fully translate into functional alignment in practice. This gap implies the need for more precise operationalization of learning indicators and a more rigorous design of high-order assessment tasks.

When compared with previous studies, the findings of this research demonstrate a more advanced alignment process. Handayani et al. (2024) found that lecturers often design SLPs referring to ILOs but do not ensure that learning activities and assessments reflect equivalent levels of learning indicators. In contrast, the Real Analysis course at UAD shows a stronger coherence between curriculum mapping, instructional strategies, and evaluation practices. This improvement is closely related to continuous training and internal quality assurance implemented by FKIP UAD, which responds to the problem identified by Asbri and Nurhayati

(2024) regarding the limited lecturer training in OBE implementation. Furthermore, in the context of assessment for theoretical mathematics courses, previous studies by Mejía-Ramos et al. (2012) and Hodds (2014) emphasized lecturers' difficulties in designing valid rubrics for complex cognitive skills such as proof comprehension and reasoning. The present study offers contrasting evidence: although challenges remain, the existing assessments already incorporate reflective and conceptual elements rather than relying solely on procedural or formal proof questions. This supports the arguments of Vlachopoulos (2024) and Ajjawi et al. (2024) that authentic and reflective tasks can strengthen students' higher-order thinking in mathematics. Thus, the achievement of CLO 1–4 among students can be partly attributed to the presence of authentic assessment components that encourage deeper engagement with mathematical concepts.

The scientific contribution of this study lies in its demonstration of how constructive alignment can be realized in a theoretical mathematics course—an area where misalignment is commonly reported. The study also identifies the institutional mechanisms that enable effective alignment, particularly the use of FGDs, peer validation, and structured lecturer training. These mechanisms are rarely described explicitly in earlier studies on OBE implementation in Indonesia. In addition, the study highlights the distinction between structural and functional alignment, revealing that well-formulated CLOs may still fall short if assessment instruments do not fully capture the intended cognitive processes.

From a practical perspective, the results suggest several improvements for curriculum mapping and assessment design. CLOs should be expressed using operational verbs that clearly reflect the intended Bloom level, and a detailed learning blueprint is needed to ensure that teaching methods align with expected outcomes. Assessment design also requires refinement, especially for CLOs targeting C5-level or evaluative competencies, which should be measured using tasks that require justification, analysis, and reflection. Developing analytic rubrics for evaluating proofs and reasoning will help strengthen the validity of scoring. Finally, a systematic feedback loop based on student performance should be established to continuously refine SLPs, assessments, and teaching strategies.

Theoretically, these findings reinforce the constructive alignment model proposed by Biggs and Tang (2011), showing that alignment is effective only when intended outcomes, learning activities, and assessments are consistently connected. The results also extend the model by emphasizing that constructive alignment is not merely a design framework but an ongoing institutional practice that requires feedback mechanisms, collegial dialogue, and professional development. Without these supporting structures, alignment risks becoming superficial and limited to document compliance. The experience of the Real Analysis course demonstrates that when these elements are present, constructive alignment can meaningfully support students' development of higher-order thinking skills in mathematics.

## 4. CONCLUSION

The analysis of CLO achievement reveals a varied pattern of student performance across the four Sub-CLOs. Sub-CLO 01 and Sub-CLO 04 show the strongest results, with 100% of students achieving Excellent in CLO 01 and 80% in CLO 04. These findings indicate that students demonstrate solid mastery of structurally well-defined and procedural material, such as the construction of real numbers and foundational calculus concepts.

In contrast, Sub-CLO 03 displays the weakest performance profile, with only 8% of students reaching Excellent and a notable proportion (20%) falling into the Enough category and 4% into Less. This suggests persistent conceptual difficulties in understanding limits, continuity, and real number lines—topics that inherently require higher-order abstraction and evaluative reasoning. Sub-CLO 02 also reflects moderate achievement, with most students performing at the Good level, indicating that foundational concepts like sequences, absolute values, and completeness are understood but not yet fully internalized at the intended cognitive depth.

Overall, these results highlight a misalignment between the higher-order cognitive expectations (C5) stated in the curriculum and actual student performance, particularly in conceptually demanding areas. The pattern suggests that instructional and assessment practices may lean too heavily on procedural tasks, underscoring the need for more reasoning-oriented learning activities and authentic assessments to better support the development of reflective and evaluative thinking in Real Analysis.

## 5. ACKNOWLEDGEMENTS

The authors would like to extend their sincere gratitude and appreciation to the Mathematics Education Program, Universitas Ahmad Dahlan, for its invaluable support and for providing the academic environment that made this research possible.

## 6. REFERENCES

Ajjawi, R., Rees, C., & Boud, D. (2024). *From authentic assessment to authenticity in assessment.* Assessment in Education: Principles, Policy & Practice.

Alyasin, A. (2023). Assessing learning outcomes in higher education: Mapping learning outcomes to assessment. TEM Journal, 12(4), 1593–1604.

Asbari, M., & Nurhayati, W. (2024). Outcomes-Based Education in Indonesian Higher Education: Empowering Students' Learning Competencies. International Journal of Social and Management Studies, 5(5). https://doi.org/10.5555/ijosmas.v5i5.445

Auras, R., et al. (2023). Mapping class learning outcomes of the core curriculum to university learning goals at Michigan State University's School of Packaging. Perspectives in Teaching & Learning (Wiley). https://doi.org/10.1002/pts.2712

Bickerton, R. T., & Sangwin, C. (2020). Practical online assessment of mathematical proof. arXiv:2006.01581.

Biggs, J., & Tang, C. (2011). Teaching for quality learning at university (4th ed.). McGraw-Hill Education.

Davies, B. (2022). Comparative judgement, proof summaries, and proof comprehension. International Journal of Mathematical Education in Science and Technology / Research in Mathematics Education (Springer).

Directorate General of Higher Education. (2020). Guidelines for the preparation of learning outcomes for study program graduates. Ministry of Education and Culture.

Handayani, N. U., Wibowo, M. A., Christiani, S. D. K., & Ulkhaq, M. M. (2024). Implementation of Outcome-Based Education from the perception of lecturers and students. Journal of Education Technology, 8(3). https://doi.org/10.23887/jet.v8i3.76621

Harden, R. M. (2007). Outcome-based education: The future is today. Medical Teacher, 29(7), 625–629.

Hasibuan, J. (2024). Integrating an outcome-based education (OBE) framework in higher education. Al-Ishlah: Jurnal Pendidikan, 16(1), 1–12.

Higher Education Quality Council of Ontario (HEQCO). (2015). Learning Outcomes Assessment: A Practical Guide for Educators. HEQCO.

Hodds, M. (2014). Self-explanation training improves proof comprehension. Journal for Research in Mathematics Education, 45(1), 62–96.

Karyanto, Y., Asmaul, R., Roziqi, Z. F. M., Junaidi, A., & Sabur, F. (2025). Evaluating the dynamic alignment of higher education curriculum with the evolving industry landscape: a multi-dimensional analysis in the context of Indonesia. International Journal of Teaching and Learning.

Kristianto, H. (2021). Design of student and course learning outcomes measurement in OBE system in Indonesian higher education. Jurnal Pendidikan Indonesia, 10(2), 100–110.

Kushari, B. (2022). A learning outcome assessment information system to support OBE: evidence from Indonesian higher education. Jurnal Pendidikan Tinggi, 7(1), 45–62.

Labouta, H. I., et al. (2019). Investigating the alignment of intended, enacted, and experienced curriculum in STEM programs. International Journal of Science Education, 41(7), 923–942.

Lithner, J. (2017). Principles for designing mathematical reasoning tasks: Lessons from research. Mathematics Education Research Journal, 29(1), 1–23. https://doi.org/10.1007/s13394-016-0189-3

Loughlin, C., Lygo-Baker, S., & Lindberg-Sand, Å. (2020). Reclaiming constructive alignment. European Journal of Higher Education, 10 (2), 119–136. https://doi.org/10.1080/21568235.2020.1816197

Mejía-Ramos, J. P., Fuller, E. J., Weber, K., & Samkoff, A. (2012). An assessment model for proof comprehension in undergraduate mathematics. Educational Studies in Mathematics, 79(1), 3–18.

Mufanti, R., Carter, D., & England, N. (2024). Outcomes-based education in Indonesian higher education: Reporting on the understanding, challenges, and support available to teachers. Social Sciences & Humanities Open, 9, 100873.
https://doi.org/10.1016/j.ssaho.2024.100873

Muthmainnah, N., & Setyono, P. (2022). Evaluating curriculum alignment in Indonesian mathematics education programs under OBE framework. Indonesian Journal of Mathematics Education, 7(1), 45–57.

Nordin, N., & Zubairi, A. M. (2015). Outcome-based education: Implementation assessment in higher education. International Education Studies, 8(3), 27–36. https://doi.org/10.5539/ies.v8n3p27

Nuraini, S., & Khasanah, I. (2023). Integration of course learning outcomes and graduate outcomes in mathematics education: Challenges and strategies. Jurnal Cakrawala Pendidikan, 42(1), 33–47.

Rahman, R.A, Yusof, N., & Hashim, S. (2021). Assessing curriculum alignment in outcome-based education implementation. Journal of Education and Learning, 15(2), 178–188.

Samkoff, A., & kolega (2015). Teaching proof comprehension in undergraduate Real Analysis. Journal of Mathematical Behavior, 37, 1–15.

Spady, W. G. (1994). Outcome-based education: Critical issues and answers. American Association of School Administrators.

Stylianides, G. J., & Stylianides, A. J. (2016). Research on proof and proving in mathematics education. (book chapter / review)

Suprapto, N., Wahyudi, & Hidayat, R. (2023). Evaluating conceptual alignment in theoretical mathematics courses under OBE framework. International Journal of Instruction, 16(2), 201–218.

Tall, D. (2004). Building theories: The three worlds of mathematics. For the Learning of Mathematics, 24(1), 29–33.

Tam, D. T. M. (2021). Alignment between course learning outcomes and Bloom's taxonomy: Cross-disciplinary evidence. Teaching in Higher Education, 26(6), 1–18.

Vlachopoulos, D. (2024). A systematic literature review on authentic assessment in higher education. Assessment & Evaluation in Higher Education (review).

Weber, K. (2015). Effective proof-reading strategies for comprehending mathematical proofs. International Journal of Research in Undergraduate Mathematics Education, 1, 289–314.

Yusof, M., Ismail, M., & Abu, R. (2012). Aligning course learning outcomes with program outcomes: An OBE approach. Procedia — Social and Behavioral Sciences, 56, 80–87.