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Curriculum Design and Development

A Case for Higher Education in India

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Curriculum Design and Development: A Case for Higher Education in India

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Abstract: The purposeful, intentional, and structured arrangement of curriculum (instructional blocks) within a class or course is referred to as curriculum design. It is a method for teachers to prepare their lessons. Teachers plan instruction by determining what will be done, who will do it, and what timeline will be followed. Curriculum design focuses on the development of the overall course blueprint, including how to create a course outline and build the course, as well as how to map the curriculum to learning outcomes. Assessment tools, exercises, material, subject matter research, and immersive experiences are used to meet each learning outcome. This article covers the entire process of analyzing an existing course, finding the gaps, and applying the constructive alignment principle to fill those gaps. This article covers not only the background of constructive alignment but also the steps needed to apply the principle for designing assessments, evaluating assessments, and designing teaching-learning instructions and outcome-based education. The article concludes with a discussion on the use of constructive alignment for the various gaps found in the existing course curriculum.

Keywords: Curriculum Design, Constructive Alignment, Backward Design, Grading, Feedback

Background

The term *curriculum* has Latin origins and means “race course” (Leyendecker 2012). The definition is now much broader, encompassing schools or educational institutions’ scheduled learning experiences. The curriculum must be in a format that allows it to be shared with those who are connected to the learning institution, open to criticism, and easily converted into practice. The program is organized into three levels: what is required of learners, what is available to learners, and what learners have witnessed (Hume and Coll 2010). Curriculum development is the product of individual initiative. It is based on a set of assumptions and principles about what students should know and how they should go about learning it. By endorsing models, curriculum creators have attempted to bring some harmony and logic to the process of designing a curriculum. Prescriptive models suggest what curriculum planners could do, while descriptive models tend to reflect what they really do (Oliveira and Marco 2017). These models help explain two more important aspects of curriculum design: declarations of purpose and meaning. Figure 1 and Figure 2 show the steps involved in the prescriptive and the descriptive models, respectively.

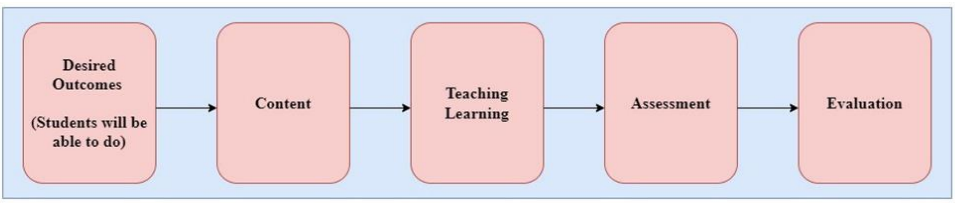

Figure 1: Prescriptive Model

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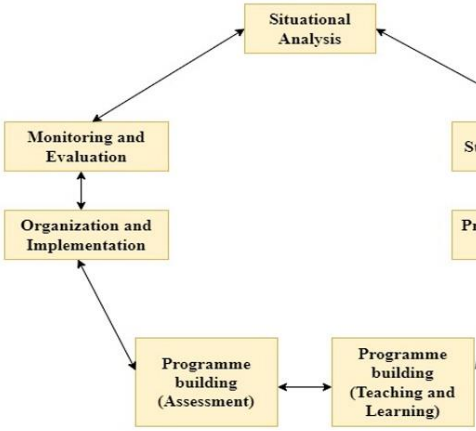

Figure 2: Descriptive Model

Backward design is the process of creating a lesson, unit, or course by first defining the desired goals, arranging assessment strategies, and then deciding on methods of instruction and assignments. It enables teachers to design classes and courses with a focus on student learning. Backward design assists teachers in developing courses and units that focus on the result (learning) rather than the method (teaching). It provides educators with a structure to follow when designing a curriculum and structuring their teaching process because starting with the end is frequently a paradoxical approach. For designing courses and subject classes, Grant Wiggins and Jay McTighe (Bowen 2017) outlined a "Backward Design" framework. When it comes to course planning, instructors often take a forward development strategy, which means they consider learning experiences (how to teach the content), create benchmarks based on specific learning activities, and then try to relate the tests to the objectives of course learning. Educators who are using the backward style method, on the other hand, address the course's learning objectives first. These learning goals represent the skills and experience that teachers expect their students will have by the end of the course. The second stage includes research consideration after the learning targets have been identified. According to the backward architecture scheme, teachers should think about these general learning expectations and how students will be assessed before thinking about how to teach the content. As a result, backward design is regarded as a much more deliberate form of course design than conventional approaches. The three stages of backward design are (Korotchenko et al. 2015):

- Identifying desired results
- Determining acceptable evidence
- Planning learning experiences and instruction

Outcomes-based education, analogous to paradigm of the goal, begins with a basic premise that the program should be determined by the student outcomes. Some academicians understood this quite narrowly, culminating in a list of acceptable and inappropriate verbs to use when writing the so-called behavioral objectives. This model has received some critique, such as the fact that constructing behavioral goals is complex and time-consuming, and the model restricts the program to a limited collection of student abilities and experience. The situational model proposed by Malcolm Skilbeck (Burnard 2019), which emphasizes the role of circumstance or meaning in curriculum design, is an ongoing example of a descriptive model. Curriculum authors use this model to critically and consistently analyze the circumstances in which they live and how this influences their work in the classroom. The effects of both external and internal considerations are evaluated, and the curriculum consequences are calculated. Since all measures in the situational model must be taken (including situational analysis), they do not have to be performed in any specific sequence. Curriculum design can start with a detailed examination of the current state of the curriculum or the desired goals, expectations, or results, but it can also be prompted by doing a content analysis, reevaluation, or detailed audit of measurement data. What is achievable in the design of a curriculum is highly informed by the context in which it happens. A debate among curriculum planners about their ideas on how learning happens is a crucial element of the curriculum creation process. Curriculum planners, being educators with diverse backgrounds and experiences, provide a variety of perspectives on the best method for a curriculum to support learning. Educators analyze assumptions and attitudes, review prior experiences, and develop suitable explanations for learning that are relevant to the program under revision to generate the optimal curriculum for a certain program, staff, and learners. The choice of a relevant viewpoint on how learning takes place directs the consistency of goals, course objectives, assessment, and evaluation. Learning outcomes show whether or not the aims and objectives were fulfilled and offer feedback on the educational processes. Furthermore, the professional performance of the learners offers an essential measurement of the educational program. Learning theories provide frameworks for understanding how information is utilized, knowledge is generated, and learning occurs. Learning designers may use these frameworks to tailor their instructional practices to diversify learning and learner demands, allowing them to make better-informed judgments about which instructional practices to employ. Learning theory explains how students absorb, process, and maintain information. Teachers must be familiar with academic concepts to integrate them into the classroom. Teachers can communicate with a diverse range of students because of their knowledge of learning topics. Instructors should target various learning styles to meet the needs of different students, resulting in instruction tailored to each student's unique strengths and interests. There are four main learning theories: behaviorism learning theory, constructivist learning theory, humanism learning theory, and connectivism learning theory (Padgett 2020).

Behaviorist learning theory (or behaviorism) is based on B. F. Skinner's theory of learning as a set of incentives or penalties (Weegar and Pacis 2012). According to the behaviorism-learning hypothesis, a student's behavior is influenced by their interactions with their surroundings. It means that external forces, rather than internal forces, manipulate and teach patterns. Figure 3 shows the steps involved in the behaviorist learning theory.

Constructivism's learning philosophy is based on detailed cognitive development research by Swiss psychologist Jean Piaget and Russian psychologist Lev Vygotsky (Yoders 2014). For cognitive constructivist educational practices, the theory of constructivism is an important basis (Weegar and Pacis 2012). Figure 4 depicts the steps involved in the constructivist learning theory. Constructivism is a learning philosophy that claims students build their own understanding based on their prior experiences. They build their own world by combining what they have learned with their prior understanding and experiences. This learning philosophy emphasizes each student's learning as a unique and personal experience.

Cognitive learning is an active learning approach that focuses on teaching how to maximize the potential of the brain. It facilitates the integration of new knowledge with previously held beliefs, improving memory and recall ability. Figure 5 depicts the cognitive learning theory.

One of the most current instructional learning philosophies is connectivism. Connectivism is a relatively recent learning theory that proposes that students link their thoughts, theories, and general knowledge in a meaningful way. It recognizes that technology is an important aspect of the learning process and that our continual connectivity allows us to make choices about our learning. It also encourages group cooperation and debate, allowing for multiple points of view when making decisions, solving problems, and making sense of information. Connectivism encourages learning that occurs outside of a person, such as via social media, internet networks, blogs, or knowledge databases. Figure 6 shows the connectivism learning theory.

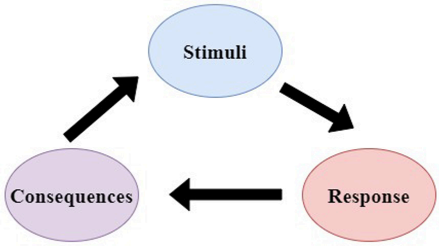

Figure 3: Behaviorist Learning Theory

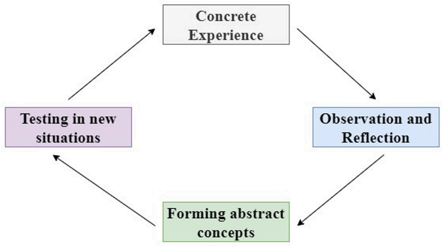

Figure 4: Constructivist Learning Theory

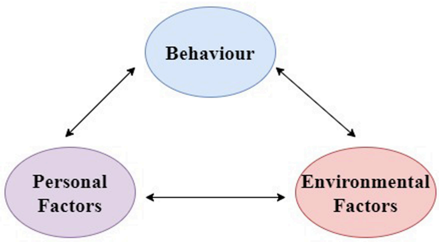

Figure 5: Cognitive Learning Theory

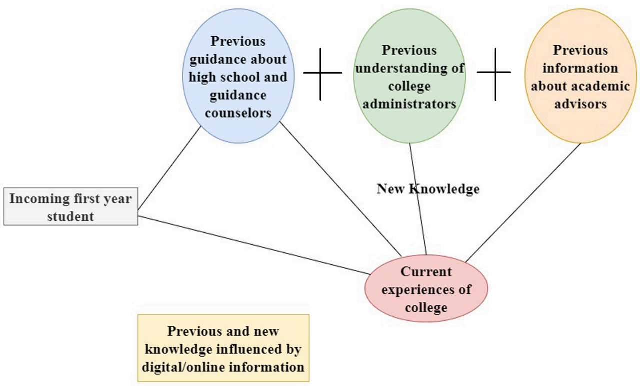

Figure 6: Connectivism Learning Theory

Curriculum development and implementation rely heavily on learning theories. Learning theories are concerned with the principles that govern the production, transmission, and retention of information and give a framework for a curricular basis. Learning theories provide information on what increases learning effectiveness and how pupils learn. These theories help curriculum designers not just in making acceptable decisions, particularly in the selection of teaching techniques, but also in developing methodologies for assessing learning outcomes. They differ in their expositions of learning and specify the relationship between what is learned and the conditions under which learning happens. Varied learning theories result in different curriculum implementation strategies and outcomes.

Purpose of this Study and Research Queries

With many universities' decision to integrate more subject-specific degrees into their undergraduate profiles in an effort to draw greater numbers of students each year, course design has become more nuanced. This move also resulted in more undergraduate programs being offered, owing to expanded intra and cross-faculty cooperation. Furthermore, the reforms have increased the strain on timetables, requiring institutions to become more mindful of key abilities, choices, and program learning outcomes, especially in cases where units/modules and courses are shared with other faculties/schools. This article has focused on the constructivism learning theory, which advocates learning as a process of doing where learners combine what they have learned with their prior understandings and perceptions to create a new world tailored to them. The article describes the approach followed for curriculum development and the design of a course that has been surveyed. The survey consisted of two different types of questions, multiple choice questions and open-ended questions. The results of the survey have suggested significant improvements to be made in the curriculum design of the subject. Curriculum design consists of different instructional strategies, a connection between the learning and the course outcomes, different types of assessment, and feedback criteria. The enhancements done are based on the use of an outcome-based approach, in which learning outcomes convey the intended learning to students and others, recognize variables that contribute to effective teaching and learning, and describe the consequences of curricular change. In this study, the following research queries will be addressed:

- RQ1: How does feedback from the different stakeholders help with understanding the gaps in the preexisting course?
- RQ2: What are the different ways in which the existing curriculum is modified?
- RQ3: How does constructive alignment help in curriculum design?
- RQ4: Why is the backward design process useful for curriculum design?

Methods

The idea of constructing an optimal curriculum using a constructive alignment strategy is important in higher education. Constructivism is a philosophy of how humans learn that is found on experimentation and experimental analysis (Zhou and Wang 2017). It implies that students build their own knowledge and understanding. Meaning, reflection, and context are all heavily emphasized in the constructivist hypothesis, and education is all about providing context. In higher education, this provision provides for the facilitation of desired learning outcomes. This idea was first suggested about thirty years ago, and it is not new to higher education. Biggs presented the basic principle in his text *Teaching for Quality Learning at University* (1999), which was amended in 2003 and is now generally highlighted as an essential idea in higher education (Jaiswal 2019).

Current curriculum specifications, as well as declarations of future learning results, and evaluation criteria are all guided by the concept of constructive alignment. Constructive alignment can be of two streams:

- From the students' perspective, constructive alignment entails what they do to understand.
- From the viewpoint of the students, constructive integration involves the synchronization of the teachers' instructional activity schedules with the learning results.

Figure 7 shows the steps of constructive alignment.

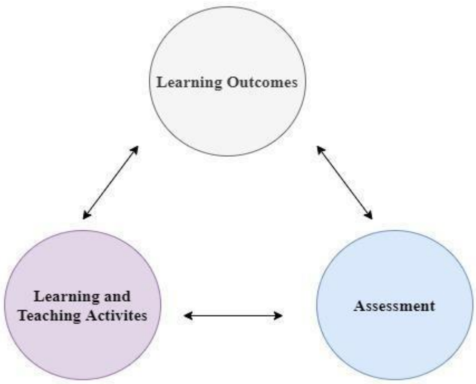

Figure 7: Constructive Alignment

The constructivist philosophy and aligned teaching are combined in constructive coordination. Both instruction and evaluation must be aligned to the desired learning outcomes, according to the term "alignment."

The methodology followed in this article focused on constructively aligning the course under survey. The areas of improvement were established by taking a survey. Mainly the steps followed are categorized as follows:

- Data collection
- Data analysis and findings
- Improvements in the existing curriculum

Once the data was collected, it was analyzed for reliability and validity. After further study of the data, observations were made and used for improvements in the curriculum.

Data Collection

The first step in the curriculum design process is to provide an outline of the learners/audience, course/subject area, and learning environment. Following this review, the instructor:

- Becomes familiar with the general features of the students who will be in the class, and
- Understands the course outcomes for the group of students, as well as how the academic environment affects teaching and learning.

There are a variety of ways in which an existing curriculum can be analyzed. A survey was conducted for the subject titled "Computer System Architecture," which is taught in the third semester of bachelor of technology in computer science. Students learn the contemporary state-of-the-art computer hardware, including the internal working of processors, memory, and input-output devices in this subject. The survey was conducted through a Google Form. Sixty-two respondents participated, and a Likert scale was used to collect the responses. The respondents included all major stakeholders, such as the existing students involved in the subject, faculty members who taught the subject, alumni who had participated in the subject, industries/organizations where the students are going to work, and academicians with years of experience in the domain. The survey included two types of questions: multiple choice and open-ended. The data collected was tested for validity and reliability. It was then studied further to determine the percentage of respondents who gave various replies. After carefully analyzing the feedback received, five observations have been made, which are further discussed.

Analysis and Findings

Reliability and Validity of the Dataset

The data collected was tested for reliability and validity using the IBM SPSS software.[2] The validity was checked using the Pearson correlation and calculated using parameters shown in Table 1.

Table 1: Parameters for Calculating the Validity of the Data Set

Parameters	*Values*
Sample Size (N)	62
Degree of Freedom, Df (N-2)	60
Critical Value for Df (60)	0.250

The validity of the entire data set was calculated, and each of the survey questions had a value greater than 0.250. The reliability of the data set is tested through Cronbach's alpha. Cronbach's alpha is a measure of internal consistency or how closely linked a group of things are; it is regarded as a scale dependability metric. The value of Cronbach's alpha should be close to 1, which means that the data is highly reliable. In our dataset, the value of Cronbach's alpha is 0.844; therefore, it can be concluded that the data is reliable.

Observation 1

A curriculum is more than a checklist or a set of norms and procedures. In reality, addressing it as if it were a "contract"—a frequent comparison in higher education—is not the best method to design a successful curriculum. An ideal curriculum, therefore, has authenticity and sets the stage for a semester of learning. The syllabus establishes the tone for the class. A successful syllabus, rather than emphasizing what learners cannot do, is a guarantee that learners will be able to accomplish a variety of things for the first time or better than they did before because of the course. Syllabi should be as succinct and focused as feasible and explain the course's nature in a straightforward and logical manner. The issue observed through survey results was that the course content was too lengthy to be covered in a single semester and was not properly structured. Figure 8 shows the pie chart of Observation 1.

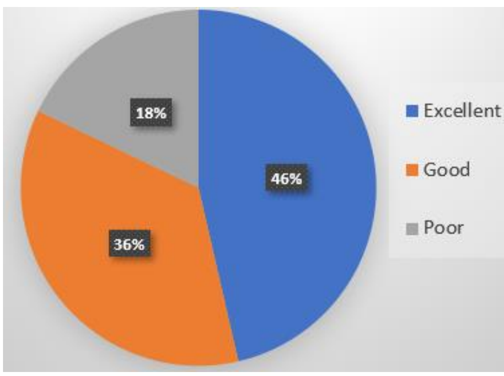

Figure 8: Observation 1 (Course Content Length and Structure)

Observation 2

Course outcomes are declarations of particular, measurable behaviors that a student should be able to execute after a certain amount of time has elapsed (a lecture, course, or curriculum). They describe what the faculty wants from students in terms of measurable or visible success. Module learning

[2] Survey data has been compiled on GitHub; see: https://github.com/avita1/Curriculum-Design-Dataset.

outcomes (MLOs), unlike course learning outcomes (CLOs), are time-limited and can be completed in a matter of hours or days. MLOs assist in scaffolding the course so that the specified CLOs can be achieved incrementally. According to the survey, the CLOs were not clear. In addition, the absence of MLOs made the objectives and importance of the modules/units being taught unclear to the students. Figure 9 shows the pie chart of Observation 2.

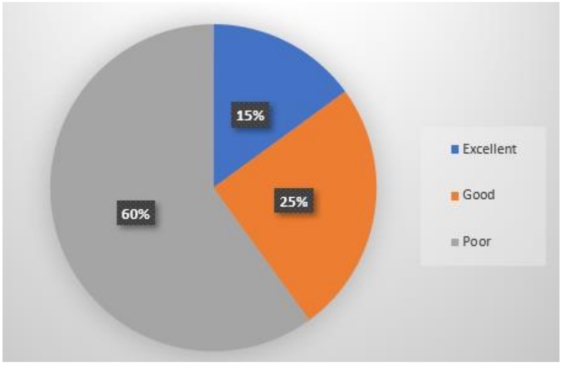

Figure 9: Observation 2 (CLOs and MLOs)

Observation 3

The instructional strategies are followed by teachers to assist learners in becoming self-directed and strategic learners. Interactions and engagements in learning activities enable learners to practice, self-assess, receive input, develop retention, and transition their knowledge. One observation from the survey was that the instructional strategy followed was monotonous and required significant changes. Figure 10 shows the pie chart of Observation 3. It can be seen that 48 percent of the respondents marked the instructional strategies as poor.

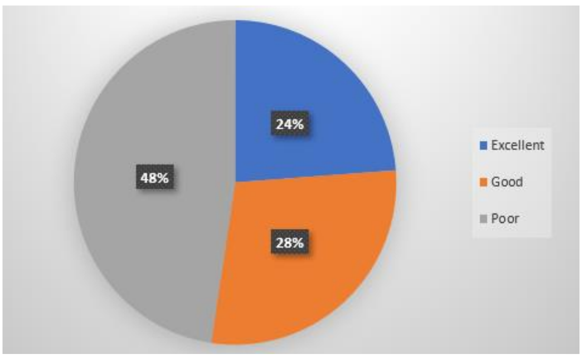

Figure 10: Observation 3 (Instructional Strategies)

Observation 4

Assessment offers a framework for disseminating and communicating developmental goals with the learners as well as tracking their success. The evaluation also generates input knowledge. Students use this knowledge to enhance their learning and accomplishments. Teachers use this information to realign their teaching to suit the needs of their learners (Nicol and Macfarlane 2004). It is also important to use feedback to learn effectively. It assists students in recognizing the topic at hand and provides specific instructions about how to enhance their skills. Rubrics are another important part of assessments that aid the process of feedback. They help students consider what characteristics their work can have. Fewer assessments, rubrics, and opportunities for feedback from faculty members to practice the skills required in the course were key issues. Figure 11 shows the pie chart of Observation 4. It can be seen that 50 percent of the respondents mark the assessments and feedback as poor.

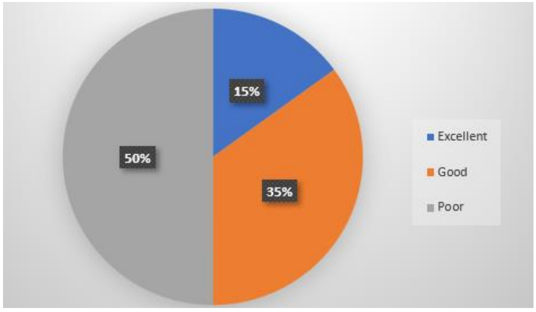

Figure 11: Observation 4 (Assessments and Feedback)

Improvement in Existing Curriculum

Structuring of Course Content

A curriculum is a type of instructional tool that establishes a standard for what is anticipated to occur over the whole course session. It specifies the ideas on which students will be assessed in the final exam. It is essentially a contract between students and professors that comprises functions and ideas that are utilized for student evaluation. The curriculum quality is a good predictor of the quality of teaching and learning that will occur in a course (Woolcock 1998). As a result, educators should make an effort to create a high-quality curriculum. The outcomes of such work might benefit both the instructor and learners. The curriculum's goal should guide the selection on what information to include. It should serve three major purposes: an agreement, a lifelong documentation, and a learning tool (Parkes and Harris 2010). The regulations for the course should be clearly stated in the curriculum. It should outline what is expected to happen throughout the semester, specify the duties of students and the teacher, and describe acceptable processes and course regulations.

A curriculum should include details about what is going to be taught in a course, at what level it is being taught, and how much credit the course is of. For the existing course, length of the content to be covered was made according to the number of lectures to be held in the semester. In addition, it was found that the lecture plan needed to be restructured; some of the topics that were acting as a foundation for other higher-level topics were covered toward the end of the semester according to the course plan.

Course and Module Learning Outcomes

A true education system should be concerned with the basic part of education—learning—rather than the transfer of information from teachers to students. Learning is the process of acquiring new mental schemata, intelligence, talents, expertise, and other abilities that can be used to solve problems more effectively. Course outcomes describe what faculty wants from students in terms of measurable or visible success. These comments describe students' willingness to show that they have understood what was required. As a result, course outcomes are an effective guide for improving course design and instruction. Learning taxonomies are a helpful method for categorizing learning targets. Bloom's taxonomy of thinking abilities is a valuable and widely used guide when writing student-learning outcomes, and it is a classification of the various goals that teachers set for their learners (learning objectives) (Lajis, Nasir, and Aziz 2018a)

Bloom described the stages in this order: information, comprehension, implementation, examination, synthesis, and assessment (Armstrong 2010). For each class, the taxonomy is presented in Figure 12, along with sample verbs.

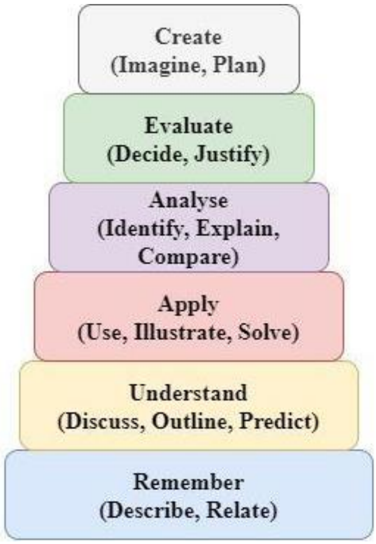

Figure 12: Bloom's Taxonomy

Writing MLOs is similar to writing CLOs in that a verb is coupled with an object. The level of precision narrows as module learning results are written. MLOs are time-limited and can be completed in a matter of hours or days. The following points should be considered while composing MLOs:

- Achievement Time: Can learners attain the desired outcome by the end of the learning module or unit?
- Assessment: How will the learning outcome be assessed or observed?
- Activities: What activities will allow learners to practice and gain feedback before assessments?
- Instructional Material: What learning materials and tools do learners need to equip and provide them with foundational knowledge to achieve the desired outcome?

The first step followed is the preparation of the MLO and mapping of them in a backward direction with CLOs and further with program outcomes (POs) and program-specific outcomes (PSOs). POs, formerly known as graduate attributes, are what is expected from a graduate over the course of their four years of study. PSOs are statements that describe program outcomes that help students realize that the learned skills and knowledge from a course have a direct impact on the advancement of society and its sustainability. The CLOs are changed on the basis of the feedback received from the various stakeholders (Observations 1 and 2).

Table 2 shows the existing CLOs of the "Computer System Architecture" course.

Table 2: Existing CLOs for the "Computer System Architecture" Course

CLO 1	Identify functional units, bus structure, and addressing modes
CLO 2	Design digital components including decoder, multiplexer, and arithmetic circuits and design arithmetic and control unit
CLO 3	Design the hardwired and microprogrammed control unit
CLO 4	Identify the memory hierarchy and its performance and interface I/O devices

Table 3 shows the modified CLOs.

Table 3: Modified CLOs for the "Computer System Architecture" Course

CLO 1	Design and functionally analyze common combinational and sequential digital circuits like adders, subtractors, decoders, encoders, multiplexers, demultiplexers, counters, and registers
CLO 2	Describe the various functional units of the computer system, their connectivity through buses, and addressing modes
CLO 3	Understand the architecture and functionality of the central processing unit (CPU) with a focus on the execution of instructions and interrupts
CLO 4	Design the hardwired and microprogrammed control unit
CLO 5	Identify and analyze the memory hierarchy, its performance, and I/O devices

By comparing Table 2 and Table 3, the following differences can be noted:

i. CLO 2 has been brought to the first position in the modified list with the addition of higher levels of cognition as per Bloom's taxonomy. The design of digital components also necessitates functional analysis, which enables students to determine which digital circuit is appropriate for a certain circumstance and how it operates.

ii. CLO 1 has been brought one position lower, i.e., to CLO 2. CLO 1 has been modified because it is not clearly written which functional units are to be identified. These computer system functional units are clearly mentioned in the modified CLO.

iii. A new CLO has been added, i.e., CLO 3, which was not a part of the old list. It is almost impossible to design a hardwired or microprogrammed control unit without having a clear understanding of how instructions and interrupts are executed in the central processing unit (CPU). Though this module is a part of the curriculum, the course learning outcome was missing from this portion, which covers seven to eight lectures.

iv. CLO 4 from the old list has been modified because just identifying memory and input-output devices would not be enough. The student is required to analyze the components at each level of the hierarchy to understand how the costs and performances of the computer are affected.

In the backward design process, the CLOs are to be mapped with POs and PSOs, which are standardized by the approving body for a particular course (technical/non-technical). Table 4 shows the mapping of CLOs with POs and PSOs.

Table 4: Mapping of Course Outcomes with POs and PSOs

POs CLOS	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CLO 1								2							
CLO 2							1								
CLO 3								2							
CLO 4									2						
CLO 5												2			
Average							1	2	2			2			

Note: 1 = weak; 2 = moderate; 3 = strong

Table 5 shows the mapping of the modified CLOs with the MLOs for Module 1.

Table 5: Mapping of MLOs and CLOs

CLO-MLO Mapping	MLO1: By the end of this module, students will be able to *utilize* the concepts of the number system and K Map for designing various digital circuits.	MLO2: By the end of this module, students will be able to *explain* the construction of the truth table and logic gates.	MLO3: By the end of this module, students will be able to *explain* the concepts of digital electronics.	MLO4: By the end of this module, students will be able to *design* various combinational circuits like encoders, decoders, adders, subtractors, multiplexers, and demultiplexers.	MLO5: By the end of this module, students will be able to *design* various sequential circuits like latches, flip flops, registers, and counters.
CLO 1: *Design* and functional *analysis* of common combinational and sequential digital circuits like adders, subtractors, decoders, encoders, multiplexers, demultiplexers, counters, and registers.	X	X	X	X	X
CLO 2: *Describe* the various functional units of the Computer system, their connectivity through buses, and addressing modes.				X	X
CLO 3: *Understand* the architecture and functionality of the CPU with focus on execution of instructions and interrupts.			X	X	X
CLO 4: *Design* the hardwired and microprogrammed control unit.				X	X
CLO 5: *Identify and analyze* the memory hierarchy, its performance, and I/O devices.			X	X	X

Instructional Strategies

Teachers use instructional strategies to assist students with becoming self-directed and strategic learners. These tactics are becoming increasingly popular. When students choose suitable learning methods on their own and use them successfully to complete assignments or achieve expectations, they are said to be independent learners.

Interactions and engagements in learning activities enable learners to practice, self-assess, receive input, develop retention, and transition their knowledge. The three categories of interactions involved are learner-content interaction, learner-learner interaction, and learner-instructor interaction:

- Learner-content interaction involves self-paced study materials, self-assessment quizzes, matching, drag-and-drop, electronic textbooks, videos with self-assessment quizzes, laboratory and fieldwork, testing materials, etc.
- Learner-learner interaction involves peer analysis, discussion forums, group networking, neighborhood boards, wikis, file sharing, breakout rooms, information sharing, etc.
- Learner-instructor interaction involves synchronized sessions, working hours, bulletin boards, rubrics for grading, comments on assignments and official announcements, etc.

Evaluating the styles of interaction that can lead to a better understanding of the instructional content gives learners the ability to practice and record unique processes and strategies, encouraging learners to interact with their colleagues and develop skills with helpful input from the instructional team when deciding the required learning experiences for the course. The monotony of the lectures and the dropping interest of the students in the analyzed course required significant changes (Observation 3). Blended learning was introduced for the subject that consisted of two face-to-face lectures and one asynchronous lecture on Blackboard once a week. The content for the asynchronous lecture included learner-learner interactions with the help of discussions; learner-content interactions with the help of lecture videos and short quizzes; and learner-instructor interactions with the help of feedback given for the quiz and discussion attempts. Blended learning combines traditional face-to-face seminars, remote learning, and learning with technology to offer the most successful learning environment possible. The aim is to find a balance that can both encourage and assist students in learning the course.

Two foundational approaches to blended learning education are the program-flow framework and the core-and-spoke model (Birchall 2005). The program-flow model is made up of measures that the student follows in a well-defined linear order. An experiment or an evaluation is used as a final measure to determine the learning outcomes. This model is particularly useful when switching from face-to-face learning to the blended learning model is required (Thorne 2003). Typically, the paradigm is built by substituting e-learning activities for some live experiences that students complete on their own. In the core-and-spoke model, the instructor creates a single primary solution and then provides materials, digital functionality, software, and experiments as external components. Each function or element (spoke) may be mandatory or optional, and it functions in accordance with the key strategy. The flow model is a more formal, linear solution. The learner moves through an orderly series of learning activities, which include a number of sources, each of which is appropriate for the task. Learners begin by completing step one and then move on to step two, and so on. It can be done all at once, or the series can be built out one step ahead of the learners. Consistency of the perception can be accomplished using the flow model. Because everyone has a series of common and perhaps contemporaneous memories, it may result in substantial cohort groups of learners.

Assessments and Feedback

Assessments

Assessment offers a framework for disseminating and communicating developmental goals with learners as well as tracking their success. The evaluation also generates input knowledge. Students use this knowledge to enhance their learning and accomplishments. Teachers use this information to realign their teaching to suit the needs of their learners (Nicol and Macfarlane 2004). After defining MLOs, it is important to determine how teachers will assess the knowledge learners have gained, the skills they have mastered, and their ability to determine and construct meaning. Assessments are generally categorized as discussed below (Widiastuti 2018):

- *Formative Assessment*: Formative tests can be taken at any time during a course and can be cumulative or sequential, building on each other. Instructors may use formative tests to see how students are improving, how they do at certain benchmarks, and how they interact with the curriculum. These types of formative tests also encourage instructor-student interaction, necessitate active input, and spark interest in an online or hybrid course.
- *Summative Assessment*: Summative tests are performed at the completion of a course or a sequence of modules, and they normally result in a grade or a ranking. Summative assessments decide whether a student has reached the best possible learning outcome at the completion of a course or module.

- *Non-graded Assessment*: Assessment is becoming more important, and many professors are searching for appraisal practices that go beyond offering a midterm and final test. The idea of non-graded classroom evaluation, in particular, is gaining momentum.

A utility formula was developed to determine the usefulness of assessments, incorporating elements of authenticity, durability, educational effects, cost-effectiveness, and acceptability as:

Utility = R x V x E x A x C (Chandratilake, Davis, and Ponnamperuma 2009)
(R = Reliability, V = Validity, EI = Educational impact, A = Acceptability, C = Cost)

While the rigor of evaluations is determined by their quality, reliability, and instructional impact, the methods used to maintain rigor should be weighed against the interpretation and cost-effectiveness of using an assessment tool in a specific situation, as well as the acceptability of the evaluations by stakeholders:

- *Reliability*: The capacity of an evaluation outcome to be repeated under the same or similar circumstances is referred to as reliability.
- *Cost-effectiveness*: The cost of the evaluation is a balance between the knowledge elicited and the examination's resource requirements. However, since the appraisal is what drives instruction, investing in testing is also an investment in teaching and learning, and resource-intensive assessment approaches can pay off in the end. As a result, the cost-effectiveness of measurement seems to be more important than the cost itself when comparing the benefits of a given calculation to the cost.
- *Acceptability*: Some people may perceive a test to be appropriate, whereas others may not. Both examiners' and examinees' views and behaviors toward evaluation cannot necessarily be consistent with analysis and scientific evidence. As a result, certain tests could not be appropriate for all. Both examiners and examinees can be more committed if necessary evidence is provided and a desire to negotiate is seen. The survival of evaluation procedures is jeopardized if the views, thoughts, and behaviors of examiners, examinees, and approving bodies of the organization/institution are not taken into account when selecting and planning tests.
- *Educational Impact*: Educational impact refers to the educational message or the educationally beneficial direction that teachers want students to take, which the test communicates to the student.
- *Validity*: Validity is determined by assessing what is supposed to be measured, using suitable measurement tools, and accurately representing guidance.

If any of these above-mentioned factors become zero, the assessment's utility value is null or zero; hence, all components should be part of an assessment.

As per Observation 3, the students lacked the skill practice required for the subject. Non-graded assessments were added to incorporate the solution for the aforementioned problem. A non-graded system reduces test anxiety while creating opportunities to make corrections. It offers more engaging educational opportunities, enhances independent and individualized learning, and provides opportunities for academic development and academic freedom. It emphasizes the benefits of not having grades (Barcelona 2017).

Table 6 enlists the various formative and summative assessments to be taken up for the course along with their utility value +, +/-, and - (+ indicates full inclusion, +/- indicates partial inclusion, and - indicates not included).

Table 6: Formative and Summative Assessments for the Course with Their Utility Value

	Utility Formula Factors				
Methods of Assessment	Reliability	Validity	Educational Effect	Acceptance	Cost Efficiency
Quizzes	+	+	+/-	+	+
Written Exam (Mid-Semester + End of Semester)	+	+	+	+	+
Assignments	+	+	+	+/-	+
Discussions	+/-	+	+/-	+/-	+
Questioning	+	+	+	+/-	+/-

Table 7 shows the mapping of the assessment with the MLOs of the module/unit. Further, these assessments are mapped with new CLOs according to the principle of constructive alignment.

Table 7: Assessment with the MLOs of each Module/Unit

Module Aim: Design and functionally analyze *common combinational and sequential digital circuits like adders, subtractors, decoders, encoders, multiplexers, demultiplexers, counters, and registers.*									
Module Credits = 11 hrs (9 hrs synchronous + 2hrs asynchronous)									
MLO	*Module Content*			*Assessment*					
				Formative				*Summative*	
	Teaching	*Learning*	*Task*	*Quiz*	*Questioning*	*Discussion*	*Assignment*	*Mid Term Examination*	*End Term Examination*
MLO 1	Number system conversion and concepts of Sum of Products and Product of Sum for K Map designing.	Conversion of binary to decimal or decimal to binary and concepts of 2 variable, 3 variable, and 4 variable K Map.	Questions of number system conversion and designing of K Map.				x	x	x
MLO 2	Methods to design the truth table and logic gates.	Construction of truth tables and different types of logic gates.	Questions related to the construction of truth tables and different types of logic gates.		x		x	x	x
MLO 3	Different concepts of digital electronics.	Learn the concepts related to digital electronics.	Discussion about the working of digital circuits.	x		x		x	x
MLO 4	Design methodologies for combinational circuits.	Learn the concepts of decoders, encoders, multiplexers, and demultiplexers.	Questions related to combinational circuits designing.	x			x	x	x
MLO 5	Design methodologies for sequential circuits.	Learn concepts about the latches, flip flops, registers, and counters.	Questions related to sequential circuits designing.	x		x		x	x

Feedback

Academic learning is directly related to success rather than any other teaching behavior. Academic feedback, according to Bellon, Bellon, and Blank (2016), is more strongly and persistently connected to accomplishment than any other teaching behavior. This is truly independent of grade, financial background, race, ethnicity, or educational setting.

Rubrics are another key component of evaluations that help in the feedback process. They assist students in considering what traits their work could have. This argument is often made based on students' perceptions of the learning objectives and performance metrics. As a result, rubrics aid teachers in teaching, planning curriculum and grading, and assisting students in learning. The opportunity to measure a student's success or skill is the primary objective of a rubric. Rubrics may be adapted to each task or the whole course to help measure the learning goals. Since rubrics can be personalized and customized, they can be used for almost any task and course; in other words, a rubric can be a one-size-fits-all method. The different types of rubrics that were initially missing as a part of curriculum design were added (Observation 4). The rubrics used are as follows (Dawson 2015):

- *Holistic Rubric*: A single scale makes up a holistic rubric that considers all of the measurement parameters at the same time. In a holistic rubric, the rater assigns a single score to the student's work based on an aggregate evaluation (usually on a 1- to 4-point scale or 1- to 6-point scale).
- *Single-point Rubric:* Since single-point rubrics divide the elements of an evaluation into various criteria, they are similar to analytic rubrics. They differ in that they only define proficiency requirements; they do not attempt to describe all of the ways in which a pupil might fall far short nor do they specify how a student might achieve such requirements.
- *Analytic Rubric:* An analytic rubric divides an assignment's characteristics into smaller pieces, helping the scorer itemize and classify which elements are good and which need to be improved.

Table 8 shows the feedback plan for different assessments or activities.

Table 8: Feedback Plan

Monthly Plan	*Activity/Assessment*	*Method of Feedback*	*Method to Provide Feedback*	*Material to Prepare*
1	Lectures (face-to-face and asynchronous)	Automated feedback during the lecture using the online Polling Blackboard (online tool) and a questionnaire in the classroom (questionnaire)	Automatic through the online tool and the instructor	Creation of poll and questionnaire
	Discussions/Questionnaire	Peer review	Peers	Rubric
	Quiz 1	Automated feedback during the lecture using the Blackboard (online tool)	Automatic through the online tool	Rubric: holistic
2	Lectures (face-to-face and asynchronous)	Automated feedback during the lecture using the online Polling Blackboard (online tool) and a questionnaire in the classroom (questionnaire)	Automatic through the online tool and the instructor	Creation of poll and questionnaire
	Discussions/Questionnaire	Peer review	Peers	Rubric
	Assignment 1	Written feedback	Instructor	Rubric: single point
	Mid-semester examination	Oral feedback	Instructor	Rubric: single point
3	Lectures (face-to-face and asynchronous)	Automated feedback during the lecture using the online Polling Blackboard (online tool)	Automatic through the online tool and the instructor	Creation of poll and questionnaire
	Discussions/Questionnaire	Peer review	Peers	Rubric
	Quiz 2	Automated feedback during the lecture using the Blackboard (online tool)	Automatic through the online tool	Rubric: holistic
4	Lectures (face-to-face and asynchronous)	Automated feedback during the lecture using the online Polling Blackboard (online tool)	Automatic through the online tool and the instructor	Creation of poll and questionnaire
	Discussions/Questionnaire	Peer review	Peers	Rubric
	Assignment 2	Written feedback	Instructor	Rubric: single point
	End of semester examination	Oral feedback	Instructor	Rubric: single point

Table 9 shows the analytical rubric for the assignments.

Table 9: Analytical Rubric for the Assignments

Criteria	*Adequate (50–59%)*	*Competent (60–69%)*	*Good (70–79%)*	*Excellent (80–100%)*
Knowledge of the number systems and K maps for designing the combinational and sequential digital circuits	Uses limited knowledge of the number systems and K maps for designing combinational and sequential digital circuits	Demonstrates some knowledge of the number systems and K maps for designing combinational and sequential digital circuits	Demonstrates considerable knowledge of the number systems and K maps for designing combinational and sequential digital circuits	Demonstrates thorough and insightful knowledge of the number systems and K maps for designing combinational and sequential digital circuits
Able to understand the functionalities of combinational and sequential digital circuits like flip flops, encoders, multiplexers, etc. and successfully design them	Utilizes critical and creative thinking skills but only to a small extent	Moderately successful in applying analytical and creative thinking skills	Effectively employs analytical and creative reasoning skills	Uses critical and strategic thinking skills to great impact
Able to utilize the concepts of common bus and computer registers to solve numerical problems depicting the understanding of CPU	Communicates knowledge of common bus and computer registers procedures to reach the final results with limited clarity	Communicates knowledge of common bus and computer registers procedures to reach the final results with some clarity	Communicates knowledge of common bus and computer registers procedures to reach the final results with considerable clarity	Communicates knowledge of common bus and computer registers procedures to reach the final results with a high degree of clarity and with confidence
Capable of describing and differentiating different architectures of computer systems like Von Neumann, Reduced Instruction Set Computer (RISC), and Complex Instruction Set Computer (CISC)	Writing is vague and contradictory, and the argument is simplistic and unoriginal	Writing is moderately straightforward and concise, and the argument takes on a rational and intended stance	Writing is simple and concise, and the argument is nuanced and unique	Writing is solid, fluid, and creatively cohesive, and the argument is nuanced and original
Knowledge of hardwired and microprogrammed control unit to execute different instructions and interrupts in a computer system	Uses limited knowledge control units for explaining the flow of execution of instructions and interrupts	Demonstrates some knowledge control units for explaining the flow of execution of instructions and interrupts	Demonstrates considerable knowledge of control units for explaining the flow of execution of instructions and interrupts	Demonstrates thorough and insightful knowledge control units for explaining the flow of execution of instructions and interrupts
Able to differentiate between different computer instructions and addressing modes	Uses limited knowledge of different computer instructions and differentiate between them	Demonstrates some knowledge of different computer instructions and differentiate between them	Demonstrates considerable knowledge of different computer instructions and differentiate between them	Demonstrates thorough and insightful knowledge of different computer instructions and differentiate between them

Table 10 shows the single-point rubric for a quiz.

Table 10: Single-point Rubric for a Quiz

Criteria or Standards	*1*	*2*	*3*	*4*	*Feedback (Strengths and Concerns)*
Understood the functionality of CPU components and able to use that knowledge for solving critical thinking questions on instructions and interrupts					
Able to distinguish between hardwired and microprogrammed control units and understand the generation of control signals in microprogrammed control units					
Capable of solving numerical problems having an in-depth understanding of memory hierarchy and workings of RAM, ROM, and cache memory					

Table 11 shows the holistic rubric for the end of semester examination.

Table 11: Holistic Rubric for End of Semester Examination

Score	*Criteria*
4 (80–100%)	1. Demonstrates the complete and proper use of K maps and number systems to design various sequential and combinational circuits 2. Demonstrates a complete understanding of CPU components for the execution of instructions and interrupts of the CPU and execution of the assigned objectives 3. Able to critically distinguish between hardwired and microprogrammed control units and shows complete understanding of the generation of control signals in microprogrammed control units 4. Capable of solving numerical problems, showing an in-depth understanding of memory hierarchy components and input-output devices and their workings
3 (70–79%)	1. Demonstrates considerable use of K maps and number systems to design various sequential and combinational circuits 2. Demonstrates a considerable understanding of CPU components for the execution of instructions and interrupts of the CPU and execution of the assigned objectives 3. Able to critically distinguish between hardwired and microprogrammed control units and shows considerable understanding of the generation of control signals in microprogrammed control units 4. Capable of solving numerical problems, showing an acceptable understanding of memory hierarchy components and input-output devices and their workings
2 (60–70%)	1. Demonstrates some use of K maps and number systems to design various sequential and combinational circuits 2. Demonstrates some understanding of CPU components for the execution of instructions and interrupts of the CPU and execution of the assigned objectives 3. Able to distinguish hardwired and microprogrammed control units to some extent and shows some understanding of the generation of control signals in microprogrammed control units 4. Capable of solving numerical problems, showing some understanding of memory hierarchy components and input-output devices and their workings
1 (50–59%)	1. Demonstrates limited use of K maps and number systems to design various sequential and combinational circuits 2. Demonstrates a limited understanding of CPU components for the execution of instructions and interrupts of the CPU and execution of the assigned objectives 3. Able to distinguish hardwired and microprogrammed control units superficially and shows limited understanding of the generation of control signals in microprogrammed control units 4. Capable of solving numerical problems up to some steps, showing very little understanding of memory hierarchy components and input-output devices and their workings

Discussion

Biggs' (2003) 3P model of learning and teaching influenced the articulation of the five program design concepts. The 3P model's elements (presage, process, and product), student characteristics, instructional background, learning-centered behaviors, and learning outcomes are all related. Since they are all part of a scheme, Biggs (2003) claims that all of these elements of teaching and learning are mutually beneficial. Each is an important part of the overall structure.

Biggs (2003) also claims that good teaching is all about maximizing what we have control over., Researchers must design courses in such a manner that students have access to learning and teaching materials, activities, and experiences to improve the outcomes of student learning that:

- are genuine, meaningful, and timely;
- are proactive, logical, and interconnected;
- enable students to utilize and interact in higher-order cognitive functions as they advance;
- are all in step with one another and the expected outcomes; and
- provide learning challenges, curiosity, and inspiration.

The result of applying these concepts is that the learning system is manipulated in a way that learners are forced to use a deep learning approach to fulfill the course's evaluation criteria, therefore, satisfying the desired outcomes.

The process of obtaining CLOs, POs, and PSOs begins with the development of suitable CLOs for each course of a four-year engineering degree program from the first to fourth year. Each faculty member writes the course outcomes using Bloom's taxonomy (Lajis, Md Nasir, and Aziz 2018b) and Anderson and Krathwohl's (2005) recommended action verbs for learning stages. Then, on a scale of 1 to 3, a correlation between CLOs and POs is formed, with 1 denoting a low mapping, 2 denoting a moderate mapping, and 3 denoting a significant mapping. This mapping creates a link between the entire course and program the learner has undertaken. In this respect, a mapping matrix is created for each curriculum, including the elective subjects. Before they are finalized, a group of senior faculty members reviews the written course results and their mapping with POs regularly. The teacher makes a conscious effort to connect the learning objectives with both the learning activities and learning evaluations. This endeavor offers the learner with a clearly defined goal, a well-designed learning activity that is appropriate to accomplish the objective.

In the beginning of the semester, a course attainment target is set for the class (e.g., 40% of the students will attain the highest level). During final evaluation, the actual course attainment is calculated for all the components of continuous evaluation (formative assessments), mid-semester examination, and end of semester examination. The calculated attainment is checked, corresponding to each of the course outcomes. If the attainment level is lower in comparison to what has been set, remedies, suggestions, and action plans are given for the next cycle.

The entire "Computer System Architecture" course was modified on the basis of the feedback received and was constructively aligned. The CLOs have been modified and mapped with the newly designed MLOs. The CLOs and MLOs are mapped with the assessments, and three types of rubrics are introduced to provide feedback to the students.

RQ1

Students are a pillar in educational communities; therefore, their input is constantly required. Teachers need to hear from them to direct their instructions and base their curriculum on what students really need. They may not have professional knowledge, but when discussing and engaging in meaningful environments, students' views become highly valuable. Alumni-based assessments are becoming more widely recognized as a vital component of the continuing curriculum review process. They offer insights on undergraduate learning and students' preparedness for jobs. Alumni assessments, when combined with the viewpoints of other stakeholders such as workers, students, employers, and clients, can provide helpful input to curriculum designers. Industry engagement in curriculum design and delivery at institutions and universities is critical for preparing students for employment. This bridges the gap between industry and institutions, allowing students to be industry-ready. This also minimizes the amount of time, effort, and money spent on students at industries before they begin working on real projects. Having all the important stakeholders as respondents in the survey helped to establish the curriculum gaps well.

RQ2

The existing course is modified in a number of ways. Previously, the course did not have MLOs. These are important as they can act as a sort of checklist, outlining what learners should know and be able to accomplish after finishing each section of the course. The existing course outcomes were also modified as previous course outcomes did not clearly depict the structure and outcome of the course. The assessments were also not sufficient to provide feedback to the students.

RQ3

Constructive alignment provides good academic achievements for a diverse group of learners through the alignment of well-organized, consistent, and clear teaching and learning goals and obvious and visible methodologies. Alignment may also encourage us to evaluate if our intended values of accessibility and inclusion are being represented and acted upon in practice. How well a lesson or course is organized and handled is evaluated by how the curriculum's principles are addressed at the start of the course and continuously brought into the classroom throughout the semester. CLOs were aligned with the MLOs. Assessment tasks were designed to measure the attainment of the learning outcomes. Learning activities that allow students to gain the necessary skills, information, and understandings outlined in the desired learning goals were planned and measured by assessment.

RQ4

Backward design helps teachers create courses and units that focus on the outcome (learning) rather than the technique (teaching). It gives educators a framework to work with when developing curricula and organizing their teaching process. Because starting at the end might be a contradictory approach, it provides educators with a structure to follow when developing curricula and organizing their instructional process. It assists teachers in determining what content is required for students to fulfill the given learning objectives. Another advantage of employing backward design is that students value inherent transparency. When an instructor discusses course aims and objectives with their students, they understand what is expected of them. Students benefit from the matching of learning objectives and learning evaluations. The backward design was employed to modify the curriculum of the subject under survey.

Conclusion

Faculty can assist students by using deep methods that allow them to vicariously experience the sense of the subject. The exercise of mapping assessments to MLOs and CLOs demonstrates how structural architecture aids in course preparation until the CLOs are written. This approach makes it simple to determine whether or not the course is meeting its objectives and making necessary improvements. The whole process of evaluating a single module in the sense of relational alignment strengthens the perception of the interconnectedness of learning outcomes at different levels. The review is also a step toward being a reflective practitioner, as it helps one to see the whole course in its entirety and comprehend the effect that each activity within a classroom has on the ultimate goal. Biggs' (2003) ideas help to know how to prepare for students' behavioral issues and schedule accordingly. In this article, the importance of constructively aligned backward curriculum design is discussed by implementing the whole process on a preexisting course that was analyzed to find gaps. Based on the collected data, observations have been made that provide details about the scope of improvement in the course. The course has been modified based on findings obtained after analyzing the survey data.

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