MULTIMODAL COURSE DESIGN AND IMPLEMENTATION USING LEML AND LMS FOR INSTRUCTIONAL ALIGNMENT

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ABSTRACT

Traditionally, teaching has been centered around classroom delivery. However, the onslaught of the COVID-19 pandemic has cultivated usage of technology, teaching, and learning methodologies for course delivery. We investigate and describe different modes of course delivery that maintain the integrity of teaching and learning. This paper answers to the research questions: 1) What course delivery method our academic institutions use and why? 2) How can instructors validate the guidelines of the institutions? 3) How courses should be taught to provide student learning outcomes? Using the Learning Environment Modeling Language (LEML), we investigate the design and implementation of courses for delivery in the following environments: face-to-face, online synchronous, asynchronous, hybrid, and hyflex. A good course design and implementation are key components of instructional alignment. Furthermore, we demonstrate how to design, implement, and deliver courses in synchronous, asynchronous, and hybrid modes and describe our proposed enhancements to LEML.

KEYWORDS

Face-to-Face, Synchronous, Asynchronous, HyFlex, Hybrid, LEML, LMS, Microsoft Teams, Zoom, Moodle, Canvas, Southern University and A&M College, Southern University at Baton Rouge (SUBR), Baton Rouge Community College (BRCC)

1. INTRODUCTION

In this paper, the authors investigate course delivery modalities, teaching and learning methodologies, and describe and share their years of experiences in academic course delivery at their respective institutions. In designing, implementing, and delivering a course, it is important to learn about the different teaching and learning environments and modes, or modalities, hence, the term "multimodal" instructional design. Why? The answer is to fulfill the objectives of the courses and student learning outcomes.

The emergence of the COVID-19 [1] pandemic caused a shift from the traditional, or face-to-face classroom, to online synchronous, online asynchronous, and hybrid course delivery modalities. Our academic institutions, like many others in the U.S., have undergone this shift. Southern University and A&M College at Baton Rouge (SUBR) [2] and Baton Rouge Community College (BRCC) [3] progressively shifted to online asynchronous, online synchronous, and then hybrid. This progressive shift has been driven by two factors: student learning outcomes and the need to reduce exposure to the COVID-19 virus. However, apost-COVID survey of 3,052 college students revealed that although some improvements were made as instructors became more

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competent with remote course delivery, most students simply were not seeing the value of their investment in higher education, with 58% saying that their education has not been worth the cost of tuition, and fewer than half are engaged in their coursework [4].

In the online asynchronous modality, courses are fully delivered online, without any physical contact between instructors and students, using technology (Internet and computing devices) and learning management systems (LMSs) such as Moodle [5] and Canvas [6]. Currently, SUBR and BRCC use Moodle and Canvas, respectively. In addition to the technology and LMS used in the online asynchronous modality, online synchronous course delivery uses virtual conference platforms such as Zoom [7], Microsoft Teams [8], etc., allowing instructors and students to interact with one another online, in real-time. Hybrid or blended course delivery combines traditional face-to-face classroom activities with online (asynchronous and synchronous) activities. HyFlex is a hybrid course delivery that gives students the option of attending sessions in the classroom, online, or both, and provides the flexibility to students to change their mode of attendance weekly, or by topic, according to need or preference [9].

Therefore, we strive to answer the following research questions, given the numerous e-learning options: 1) What course delivery method our academic institutions use and why? 2) How can instructors validate the guidelines of the institutions? 3) How courses should be taught to provide student learning outcomes? The answers to these questions should be addressed as function of designing and implementing curriculum and course syllabi in academia. To address the answers to the above questions, we structure this paper as follows: Section 2 provides some literature review and discusses the motivation and intellectual merit of the paper. In Section 3, we investigate and discuss common course delivery modalities. In Section 4, we describe the criteria for selecting course delivery modality and results of surveys used to select or validate the course delivery modality. Section 5 describes the underlying design principles of courses using Learning Environment Modeling Language (LEML) [10] while Section 6 discusses selected course requirement. In Sections 7 and 8, we describe the design and implementation, respectively, of one selected course and showed usage of three of our four enhancements to LEML and provide a summary of the work in Section 9.

2. LITERATURE REVIEW AND MOTIVATION

For learning to occur, we must understand *what*, *how*, *when*, and *where* learning takes place. In academia, the curriculum design broadly and briefly describes *what* should be learned via the course name or title. For example, in the Department of Computer Science at SUBR, the curriculum broadly refers to the course named "CMPS 201B" as "Data Structures" course [2]; therefore, the title of the course becomes "CMPS 201B – Data Structures". This indicates that the course covers data structures, but it does not provide specifics or details on the types of data structures, such as arrays, vectors, lists, etc. Each course in the curriculum is listed in the "Course Catalog" along with its description, and the course "Syllabus" summarizes and provides the answers to the "*what*, *how*, *when*, and *where*" questions.

The *how* in the learning process leads to the learning outcomes based on *what* needs to be delivered. How learning is provided depends on the learning environment. For example, in a face-to-face classroom environment, students and instructors can physically and directly interact with one another via one-to-one, one-to-many, and/or many-to-many exchanges using tools such as a black and white boards, pens and pencils, laboratories, etc. This environment provides a quick peer-to-peer learning environment. However, when using an online asynchronous learning environment, there is no physical interaction between students and the instructor, nor among students, and it has other drawbacks, as we discuss in Section 3 below. The *when* and *where* in

the learning refer to *when* learning takes place (active vs. passive) and *where* (face-to-face classroom vs. online), respectively.

Regardless of the modality, courses should be designed based on student-centered learning. Leamnson [11] considers learning as a biological occurrence common to all human beings. As such, the usage of student-centered (learner-to-learner, learner-to-instructor, and learner-to-contents) learning because changes should occur in students' brains. Greenblat [12] defines four key elements involved in getting students to learn from simulations or hands-on activities: 1) finding and using techniques to create motivation before sending out information; 2) making the learners active participants rather than passive recipients in the learning process; 3) individualizing instructions in a way that learning is at the appropriate pace for each learner; and 4) obtaining and providing real-time feedback on success and deficiencies. For instance, Hertel and Millis [13] explain how simulations can be used to promote learning in higher education. Using simulation transfers substance-specific information into real-life problems in a more meaningful way that provides learning. As a Chinese Proverb states: "*I hear and I forget, I see and I remember, I do and I understand*."According to Cohen [14], instructional alignment refers to a high degree of agreement among the objectives, assessments, and the content in a learning experience. It also includes deriving objectives from and aligning them to sets of relevant external frameworks or standards. The Computer Science program at SUBR is accredited by the Accreditation Board for Engineering and Technology (ABET), which is an ISO 9001 certified organization that accredits college and university programs in applied and natural science, computing, engineering, and engineering technology [15].

According to [10], "Creating great learning experiences begins with designing the learning environment". Therefore, in this paper, we use the Learning Environment Modeling Language (LEML) by the LX Studio Solution at the University of Central Oklahoma to demonstrate the design of our courses at both SUBR and BRCC. However, based on our literature review and to our knowledge, there are currently no articles available on course design and implementation which we could use to compare our work with. However, through the results our surveys, we show the positive impact on student's learning of well-structured or designed course based on students' learning preferences. Therefore, the main motivation of this paper is to investigate and describe different modes of course delivery that we have been using at our academic institutions to maintain the integrity of teaching and learning and provide answers to the above research questions. Furthermore, using the LEML, we investigate how to design and implement courses that can be delivered in the following environments: face-to-face, online synchronous, asynchronous, hybrid, and hyflex. An adequate design and implementation of the course design is a key component to instructional alignment. Furthermore, we demonstrate how to design, implement, and deliver courses in synchronous, asynchronous, and hybrid modes, and describe our proposed enhancements to LEML. Curriculum and course design, like for any object design, should go through the following phases: *planning*, *designing*, *implementation*, *assessment*, and *improvement*. In the following sections, we describe these phases.

3. COMMON COURSE MODALITIES

In this section, we describe and contrast the following modalities for course delivery: 1) **Face-to-Face**; 2) **Online Asynchronous**; 3) **Online Synchronous**; 4) **Hybrid**; and 5) **HyFlex** as described in [16] [17].

3.1. Face-to-Face

Face-to-face learning is an instructional method where the course contents and learning materials are taught in person in a classroom. This allows for a live interaction between a learner and an instructor. It is the most traditional type of learning instruction. ***Advantages***: 1) learners benefit from a greater level of interaction with their instructor and student peers; 2) face-to-face learning ensures a better understanding and recollection of lesson content; 3) face-to-face gives class members a chance to bond with one another physically; 4) students can receive immediate feedback from their instructor; and 5) face-to-face learning provides real-time usage of onsite tools and technology. ***Disadvantages***: 1) In face-to-face learning, students are held accountable for their progress at the class's specific meeting date and time; 2) face-to-face learning is essentially a teacher-centered method of education and tends to vary widely among cultures; 3) some information disseminated by the instructor may not be available for later review by the student; 4) course materials are provided in class, and students may need to make their own copies; 5) physical classrooms may be more difficult to access for some students ; and 6) there may be expenses associated with commuting to the campus or school.

3.2. Online Asynchronous

Asynchronous learning is an instructional method, whereby, course contents and learning materials are not taught in person in a classroom but provided via Learning Management Systems (LMSs), such as Moodle, Canvas, Microsoft SharePoint, YouTube, etc. Asynchronous learning refers to a shift in a learning environment, where emphasis is placed on establishing the curriculum, methods, and the media through which course content will be delivered, rather than focusing on all learners receiving information and performing class activities simultaneously, as with synchronous course delivery. ***Advantages***: 1) Asynchronous learning is a student-centered teaching method that uses online learning tools and platforms to facilitate lectures and assessment activities outside the constraints of a physical classroom; 2) there are many resources and technologies that have been developed to support online interaction between students and their instructors, allowing users to access course material and participate in discussions; 3) students are not held accountable for their progress at a class specific meeting date and time; 4) there are no expenses associated with commuting to the campus or school. ***Disadvantages***: 1) the student-centered nature of asynchronous online learning requires students to take more responsibility for the process of their own learning; 2) it requires students to become proficient with the technology required for the course and use new methods of communication with their peers and their instructors; 3) it creates physical and social isolation; 4) it requires using strategies in creating assessments to reduce cheating; and 5) some students, particularly students with disabilities, may not thrive with instruction delivered online when there is a lack of the Americans with Disabilities Act (ADA) compliances [18].

3.3. Online Synchronous

Online synchronous learning is when courses are delivered from a distance in real-time. In this course delivery model, students and instructors engage with the content at the same time, but from separate locations. Synchronous online learning is where instructors rely on virtual conferencing software with live chat features, such as Microsoft Teams and Zoom, and other real-time tools and platforms to deliver their virtual class. ***Advantages***: 1) students can ask questions and collaborate with their classmates and instructor in real-time; 2) it has the power to strengthen a sense of community among students and their instructors, thereby, reducing isolation; 3) students can receive instant feedback from educators, teaching assistants and their peers. ***Disadvantages***: 1) it creates physical isolation; 2) students are held accountable for their progress at the class specific meeting date and time; 3) it requires students to become proficient

with the technology required for the course and to use new methods of communication with their peers and their instructors; 4) it requires usage of technology and software for remote proctoring and integrity safeguards for online testing and assessment (quizzes, tests, and exams); 5) it requires using strategies in creating assessments to reduce cheating; and 6) some students, particularly students with disabilities, may not thrive with instruction delivered online due to the lack of ADA.

3.4. Hybrid and Blended

Hybrid learning is where students learn through a mix of in-person and online activities. Students are encouraged to learn from one another during in-class instruction sessions, where as the multimedia shared online enhances and reinforces discussions in class. It is a synchronous learning model that teaches both in person and online learners simultaneously. Hybrid learning is synonymous with blended learning. Hybrid learning is most effective when it occurs before, during, and after class. Hybrid learning refers to web-based learning activities that are used to complement in-person instruction. Blended learning encompasses all education that integrates digital technologies, especially web-based learning tools. ***Advantages***: 1) students spend less time seated in a classroom listening to lectures and are instead encouraged to explore online and learn from their peers; 2) there is an interaction with peers and instructors; 3) students are more involved in a course; and 4) there is an interactive learning environment. ***Disadvantages***: 1) it may require usage of technology and software for remote proctoring and integrity safeguards for online testing and assessment (quizzes, tests, and exams); 2) it may require using strategies in creating assessments to reduce cheating if the assessments are not provided in class; and 3) students may become confused about when they are to participate in person vs online.

3.5. HyFlex

The HyFlex model is a method of educational content delivery in which students can continuously choose between participating in face-to-face lessons in a traditional classroom environment, participating in lectures synchronously online in real-time, or asynchronously where they watch pre-recorded lecture content. The HyFlex model refers to a style of teaching and learning where students can choose between a variety of delivery modes, adapting their learning strategy to suit their needs and preferences at any time, without sacrificing the efficacy or quality of their own learning. ***Advantage***: it offers students the maximum amount of choice possible within a formal learning program. ***Disadvantages***: 1) more work for designing and implementing instructional materials and assessments; 2) it may require usage of technology and software for remote proctoring and integrity safeguards for online testing and assessment (quizzes, tests, and exams); and 3) it may require using strategies in creating assessments to reduce cheating if the assessments are not provided in class.

4. COURSE DELIVERY MODALITY SELECTION – ANSWERS TO THE RESEARCH QUESTIONS

In Sections 1 and 2, we highlighted the main motivation of this paper and the research questions we are going to answer in this section.

Question 1: What course delivery method our academic institutions use and why?

Answer: Southern University and A&M College at Baton Rouge also known as Southern University at Baton Rouge (SUBR) official document entitled: “Policy and Procedures for Online Programs and Course Delivery” [2] describes the best practices and strategies for online/distance

learning and course delivery. Section II-B of the document defines the "Fully Delivered Online Course (FDOC)" as course delivery method in which **80 to100%** of the instruction is entirely delivered online and describes two variances of delivery: 1) Students and instructors meet exclusively only and the course is delivered entirely online. The entire curriculum is delivered and course orientation as well as evaluation and performance testing are all conducted online using course management software with asynchronous and synchronous tools of communication. 2) Students and instructors only meet on-campus for orientation and/or evaluation and performance testing. Section II-C describes "Hybrid Course Delivery (HCD) or Blended Course Delivery (BCD)" as course delivery in which **20 to 50%** of the instruction is entirely delivered online. SUBR defines Hybrid as a course in which **20 to 50%** of its curriculum is delivered online. Section II-D defines "Asynchronous Communication" as a mode of telecommunications in which a simultaneous presence of individuals is not required for communication to take place. Examples are e-mail, discussion forums, text messaging, and recordings. Finally, Section II-E defines "Synchronous Communication" as a mode of scheduled direct telecommunication in which a simultaneous presence of individuals is required for communication to take place. Examples are web-based tools such as online Chat and web conferencing.

Question 2: How can instructors validate or implement the guidelines of the institutions?

Answer: The answer to Question 1 above defines and describes the SUBR's standards/guidelines for course design, instruction, associated support services, evaluation, and assessment, use and distribution of course materials, the rights and responsibilities of parties and all related matters associated with online/distance learning. Additionally, the SUBR institution allows instructors to make reasonable decision to validate or implement those guidelines. Therefore, in our courses, during the first week of classes and before designing the courses' syllabi, we conduct students' surveys of course delivery preference. Figure 1 shows our sample course survey implementation using Moodle Learning/Content Management System (L/CMS) and Figure 2 shows the result of this survey for a class or sample size of 23 students.

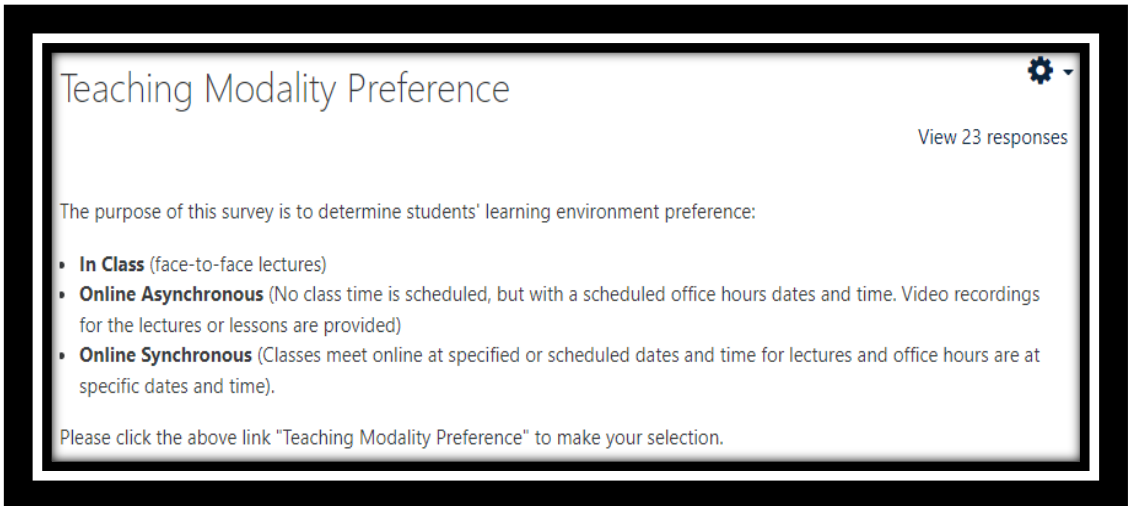


Figure 1. A sample course survey implementation

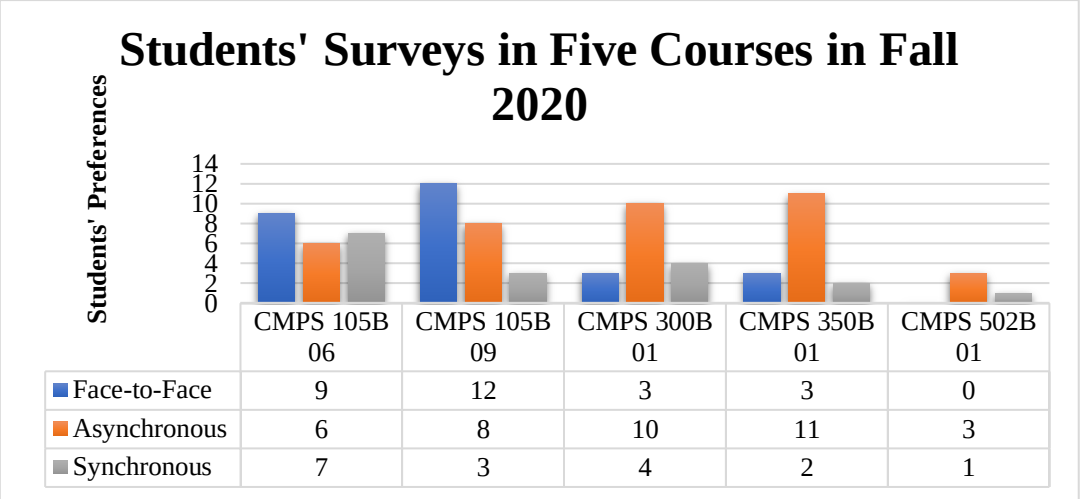
Teaching Modality Preference

Responses

Choice options	In Class (face-to-face lectures)	Online Asynchronous	Online Synchronous
Number of responses	12	8	3
Users who chose this option			

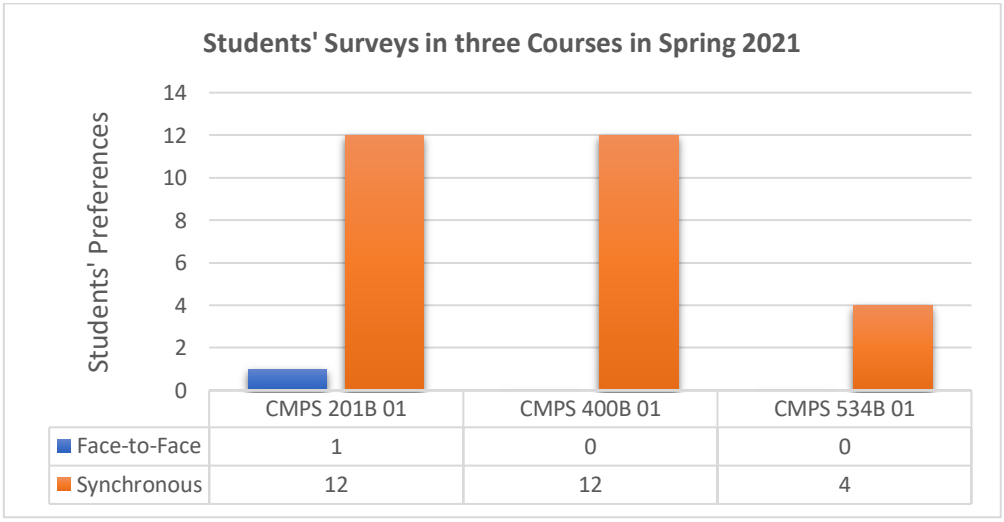
Figure 2. Result of the sample survey shown in Figure 1

The results of our course surveys show that for the fall 2020 semester, as shown in Figure 3 below, for class sizes of 22 and 23 students in CMPS 105B 06 and CMPS 105B 09 Introduction to Computer Technology courses, respectively, which are the SUBR service courses, most students prefer face-to-face course delivery while the institution, SUBR, selected course delivery mode was "Hybrid". Therefore, the survey results validate the institutional choice or decision for the hybrid delivery as discussed in "Answer to Question 1" above. However, for the courses CMPS 300B 01 – Programming Languages, CMPS 350B 01– Web-Based Programming, and CMPS 502B 01 – Computer Organization, with class sizes of 17, 16, and 4 students, respectively, students' choice for asynchronous delivery invalidates (null hypothesis) the SUBR's hybrid as students did not want to be physically in class and with an established time of meeting. For the spring 2021, as shown in Figure 4, although the SUBR's decided to adopt hybrid delivery, students' surveys in the following three computer science major courses CMPS 201B 01 - Data Structures, CMPS 400B 01 - Operating Systems, and CMPS 534B 01 - Digital Data Networks, show that students prefer the online synchronous delivery mode over the face-to-face. Note that each delivery mode, face-to-face and online synchronous, includes the asynchronous components, for examples, assignments, Practice quizzes, take home tests, etc. which do not involve established meeting time. Students simply prefer not to be physically in class, but each course will meet at specified time period.



	CMPS 105B 06	CMPS 105B 09	CMPS 300B 01	CMPS 350B 01	CMPS 502B 01
Face-to-Face	9	12	3	3	0
Asynchronous	6	8	10	11	3
Synchronous	7	3	4	2	1

Figure 3. Students' preferences in five courses taught in fall 2020



	CMPS 201B 01	CMPS 400B 01	CMPS 534B 01
Face-to-Face	1	0	0
Synchronous	12	12	4

Figure 4. Students' preferences in three courses taught in spring 2021

Question 3: How courses should be taught to provide student learning outcomes?

Answer: The SUBR official document discussed in Answer to Question 1 above also describes the guidelines for the curriculum and instruction of online/distance courses which are comparable in rigor to the curriculum delivered on the SUBR campus. The following principles will apply: • *Course Overview and Introduction* – the overall design of the course will be made clear to the students at the beginning of the course. • *Learning Objectives* – learning objectives should be measurable and clearly stated. They should clearly describe what students are expected to know or should be able to do by the end of the course. • *Assessment and Measurement* – Assessment strategies should be designed to evaluate student progress by reference to stated learning objectives; to measure the effectiveness of student learning; and to be an integral part of the learning process. • *Instructional Materials* – institutional materials will be sufficiently comprehensive to achieve stated course objectives. • *Learner Interaction and Engagement* – forms of interaction incorporated in the course should be designed to motivate students and to promote learning. • *Course Technology*– course navigation and technology will support student

engagement and ensure access. • *Learner Support* – the course should facilitate student access to institutional support services essential to student success. • *Accessibility* – the course will demonstrate a commitment to accessibility for all students.

5. LEARNING ENVIRONMENT MODELING LANGUAGE

In computer programming courses, students learn to write or develop programs or software using a program development cycle or phases as shown in Figure 5. Phase 1: the ***program requirements*** or ***specifications*** are defined in a document that describes what the program should do, the service or services that it provides, and the constraints on its operation. Phase 2: ***designing*** the program involves understanding the requirements and describing the steps that must be taken to perform the tasks or logical steps using tools such as flowcharting or pseudocode. Phase 3: ***writing*** the program involves translating the design into a programming language, such as C, C++, Java, Python, etc. Phase 4: ***compiling*** or ***interpreting*** the program requires using another program called "Compiler" or "Interpreter" which compiles or translates the program into an executable format. Phase 5: the programmer must correct any ***compiler*** or ***syntax errors*** in the program displayed in Step 4. Phase 6: ***running***, ***executing***, or ***testing*** the program consists of loading into the computer's memory the binary code from the secondary storage or hard drive produced in Phase 4, then running it to produce and display the result. Phase 7: the programmer must correct any runtime or execution errors in the program displayed in Phase 6. Phase 8: the programmer analyzes the result of the program execution for ***logical errors*** or ***bugs*** and if necessary, updates the program requirements in Phase 1.

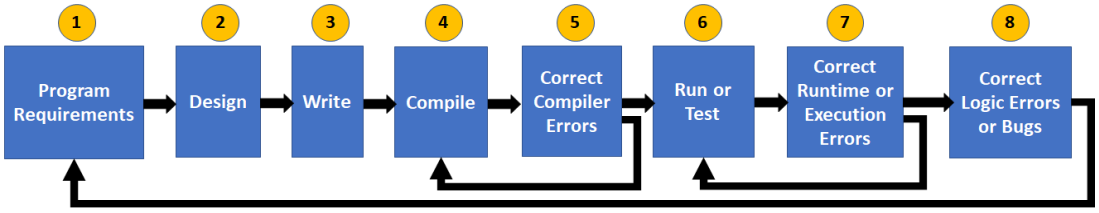


Figure 5. Computer program development cycle

In addition, when developing a computer program using object-oriented programming (OOP), programmers use the Unified Modeling Language (UML), which is a graphical language used to make software blueprints. More information about UML design can be found at [19]. Creating or developing any object, such as airplanes, cars, computers, chairs, courses, training materials, etc., whether it is tangible or intangible, requires using a specific development cycle or phases. Therefore, to create a course, a team from the Institute for Learning Environment Design at the University of Central Oklahoma developed the Learning Environment Modeling™ (LEM), which is a visual planning system that makes designing learning experiences like courses and education programs simple and effective. This learning environment design is technically an architectural process like the UML design. Learning Environment Modeling, or LEM, provides a simple system for designing learning environments that uses an easy-to-understand language combined with a visual modeling process. LEM is used for improving understanding, decision-making, and communication within learning environment design experiences. The system or language used to create this model is called the Learning Environment Modeling Language (LEML). The article [20] provides more information about the LEM and LEML. As described in [21], learning is arguably one of the most complex human phenomena to understand and support because humankinds simply learn differently. Therefore, what helps one person learn might hinder or obstruct another person's learning, and what motivates one person to learn may be a demotivator for another. In addition, learning something new is inherently connected to our past learning

experiences, which are unique to each person. As a result, this complexity and diversity of how people learn helps us answer the question of "Why learning environments matter?" The LEML is made up of building blocks, which along with learning contexts, actions, and notations, can be configured to represent virtually any learning experience. In this section, we provide a brief overview of the LEML building blocks, contexts, actions, and notations.

5.1. LEML Building Blocks

LEML building blocks represent the components or system nodes of a learning environment. Each building block is composed of three components: *description*, *type*, and *method*. The building block ***description*** is listed at the top of the building block and its purpose is to briefly describe *what* is done or discussed. The building block ***type*** signifies the purpose, function, or task of an element in a learning environment by defining the task to be carried out. LEML has five types of building blocks that can be configured to represent the design of any learning environment: ***Information*** – it represents a learning environment element that presents information to the learner (for example: syllabus, textbooks, lectures, videos, websites, animations, articles, images, etc.); ***Dialogue*** – it describes communication, reflection, or collaboration elements within a learning environment, and it can involve self-communication (reflection), communication with other individuals, or group communication (for example: class discussion, problem solving on the board by the instructor and students, Q&A, peer debate, group discussion, reflections, etc.); ***Feedback***– it represents opportunities for instructors to comment or critique student work in a learning environment. The intent of feedback is enhancing performance and application of knowledge or skills (for example: instructor, teaching assistant, peer-to-peer, or automated); ***Practice***– it provides opportunities to rehearse and practice skills in a learning environment. This building block is often used to represent formative assessment opportunities (for example: Quizzes, tests, hands-on, assignments, etc.); and ***Evidence*** – it represents opportunities where evidence of learning is presented in a learning environment. Evidence is frequently associated with a stated learning outcome and is used to represent summative assessment opportunities (for example: individual or group presentations, essays, individual or group projects, examinations, etc.) Each building block type is represented by a graphical symbol in the middle of the building block. The ***method*** is located at the bottom of each building block and its purpose is to identify *how* the element is represented in the learning environment or *what* task is carried out. Figure 6 shows the LEML building blocks. The building blocks in LEML make up the core ingredients of learning environments.

Figure 6. LEML building blocks

5.2. LEML Contexts

The Contexts in LEML are mainly used to describe the areas, spaces, or places in which the LEML building blocks reside in learning environments. It shows the spaces where learning occurs and where building blocks are located. There are four contexts represented in LEML: ***Classroom***, ***Online Synchronous***, ***Online Asynchronous***, and ***Experiential***. The contexts are

represented by shaded container boxes to differentiate them, and the label is placed at the top in the box. Figure 7 shows the representations of the contexts.

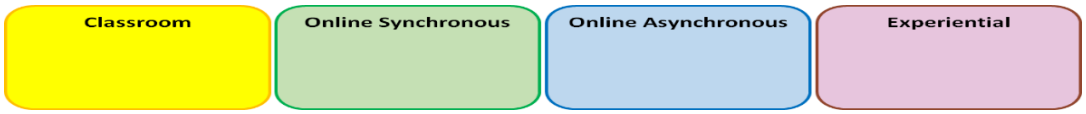


Figure 7. LEML contexts

5.2.1. Classroom

The Classroom context is used to describe an interaction that occurs in real time within a physical learning space, for example, a formal classroom space, training or conference room, lecture hall, etc.

5.2.2. Online Synchronous

The Online Synchronous context specifies the elements that are delivered online in real-time, such as, online webinar platforms, instant messaging, or video chat tools.

5.2.3. Online Asynchronous

The Online Asynchronous context is used to picture situations in which interactions in the learning environment are conducted online at different times. The most common example of this in educational settings is usage of a learning management system, such as Moodle or Canvas, to access online courses. Additionally, most online social media platforms, such as, YouTube, Facebook, Twitter, etc. constitute this type of context.

5.2.4. Experiential

The Experiential context describes informal learning spaces in which the experience plays a major role indefining the learning environment, such as, learning commons, laboratories, workplaces, on-the-job training, or on-site field research sites. Learning commons, also known as scholars' commons, information commons, or digital commons, are learning spaces, like libraries and classrooms, that share space for information technology, remote or online education, tutoring, collaboration, content creation, meetings, socialization, playing games or studying [22].

5.3. LEML Actions

The Actions in LEML identify the connections and transitions between building blocks and who or what is responsible for those transitions. Actions in LEML provide a way to show the flow and structure within learning environments. There are three types of actions in LEML: *Learner Action*, *Facilitator Action*, and *System Action*. Figure 8 shows the representations of these types of actions.

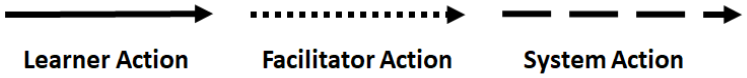


Figure 8. LEML actions

5.3.1. Learner Action

The Learner Action is used to identify transitions in the learning environment that are the responsibility of the learner. This type of action includes, for example, a learner navigating through a self-paced online lesson or uploading an assignment to an online assignment submission system.

5.3.2. Facilitator Action

The Facilitator Action is used to describe transitions that a facilitator or instructor manages within a learning environment. Some examples of facilitator actions are instructor-provided feedback and an instructor moving from one topic to the next topic in a workshop.

5.3.3. System Action

System Actions are used to note automated or system-based actions within a learning environment. Examples of system actions include automatic notifications or automated feedback to students and conditional release criteria placed on content based on learners' performance on an assignment.

5.4. LEML Notations

Key elements in a learning environment can be annotated in LEML. In addition, the LEML includes notations to enhance the meaning and usefulness of the learning environment model. Two primary notation elements are used: 1) ***Start-Stop*** – represents the starting or beginning and stopping, ending, or termination points within a learning environment, respectively. For example, a classroom or online lecture, a webinar, and a workshop have the start and end. 2) ***Objective ID*** – is to represent a learning objective or outcome in a learning environment. For example, the learning outcomes or objective of a course can be represented using this notation. Additionally, other notations can be added to learning environment models as needed to extend the meaning or to add explanation to models. Figure 9 shows the start-stop and objective-ID notations.

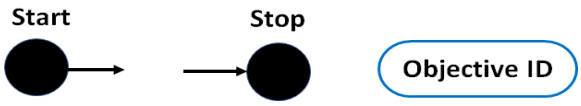


Figure 9. Start-stop and objective-ID notations

5.5. The Modeling Process

The learning environment modeling (LEM) can be used for two general purposes: 1) ***diagnostic modeling*** – existing learning environments are used to create new models with added improvements and better understanding; and 2) ***Design modeling*** – is used as a tool to create an entirely new learning environment.

Like the computer program development cycle shown earlier in Figure 10, we use the design modeling cycle shown in Figure 11 to create our courses. In phase 0, although optional during the implementation because the instructor can address the welcome message verbally instead of written, the instructor welcomes students, introduces herself or himself, etc. In phase 1, for each course, we create a syllabus, as it is called at our institutions, or a plan of work, as it is called in high school or other institutions. In phase 2, we design the requirements specified in the syllabus

using LEML and in phase 3, we implement the design in Canvas or Moodle Content/Learning Management Systems (CMS/LMS) depending on the institution, as detailed in Section 7. The feedback or loop in Figure 10 provides the means for improvements. Additionally, note that Phases 0 and 1 are integrated into Phase 2 during the implementation. However, we have separately shown them in the modeling cycle to mainly highlight the welcoming and course requirements components. The course requirements phase is the baseline of the overall design and implementation of the course. Therefore, in Section 6 below, we describe key contents of the syllabus or plan of work.,

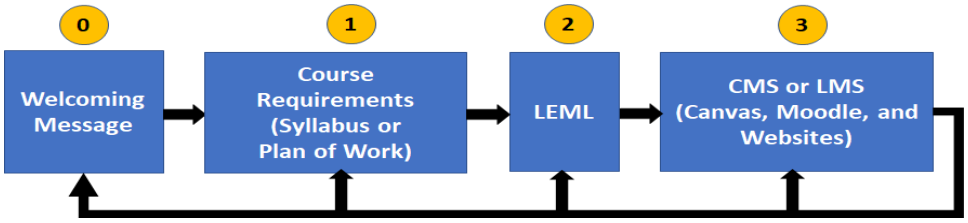


Figure 10. Authors' defined course modeling cycle

6. COURSE REQUIREMENTS

As shown in Figure 10 above, the syllabus is used as the first key material for our classrooms; therefore, we use the first day of classes to go over it. Typical contents of our syllabi are shown in Table 1. The semestrial course schedule highlights are shown as bolded texts (non-italic and italic) in the first, second, and third columns. The bolded italic text in this table represents the key elements in the LEML design. The HyFlex mode is not italicized in the third column of the table, but it represents the flexibility option the instructor provides to the course. Remember that the HyFlex mode is the Hybrid mode with added flexibility in which students can weekly change their class attendance from face-to-face to online synchronous and vice versa. In the fourth column, the "Objectives" define the purpose or input to the course, the "Learning Outcomes" define the result or output from the course, and the "Course Outline" represents the more detailed version of the "Objectives" in the format of lessons to be covered in the course. Each element of the "Course Outline" can cover one or more elements of the "Objectives". In Section 7, we describe how to use LEML to design a course.

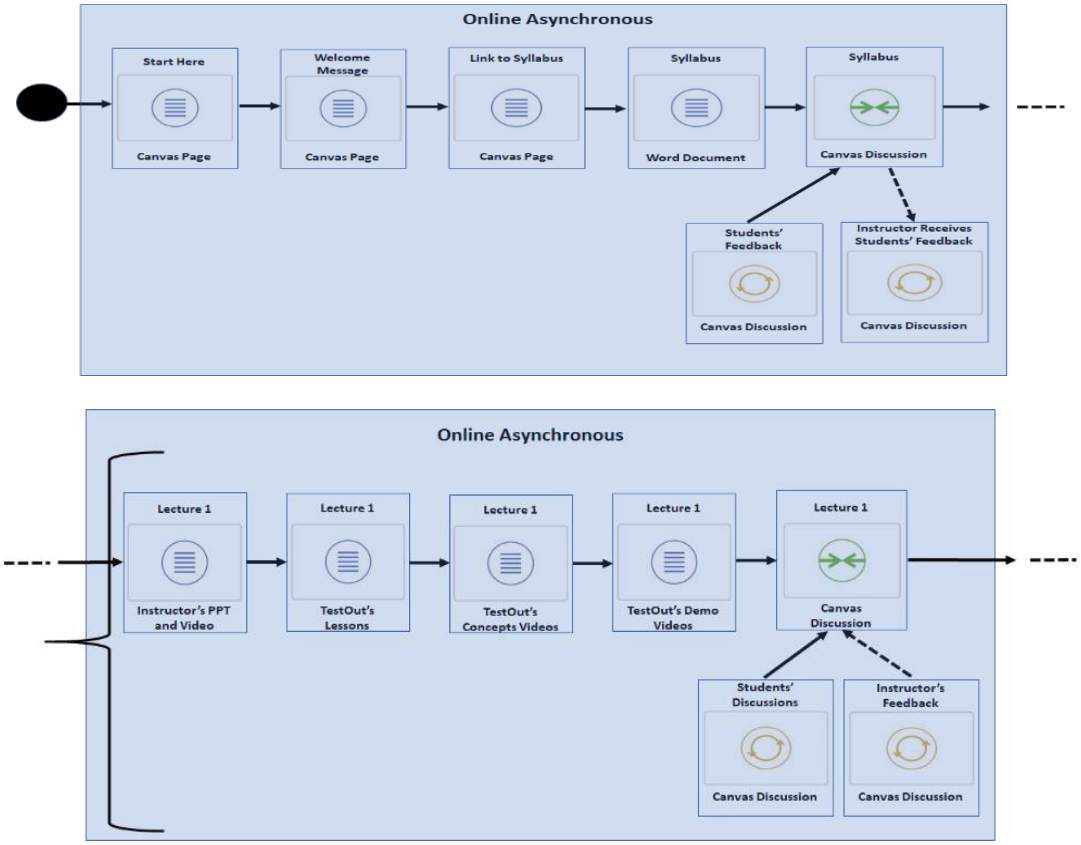
7. COURSE DESIGN USING LEML

In this section, we describe the design of the course entitled "CNET 2103 M01 - Introduction to Computer Networking", which the first author of this paper teaches at BRCC, in the five (5) delivery modes described in Table 1 above. However, due to the availability and usage of technology and online resources in the classroom, the traditional and purely face-to-face classroom delivery has become outdated, therefore, it is being incorporated in the Hybrid and HyFlex designs. The design of the course using the LEML describes how the course is taught, the flow or logic of the course, and the materials, technology, online resources, and online platforms used in the course. The logic, materials, technology, online resources, platforms, etc. are defined in the syllabus as discussed above. Figures 11 to 14 show the LEML of the CNET 2103 course delivery in online asynchronous, online synchronous, hybrid, and hyflex modes, respectively. Note that when a course is taught in online synchronous mode, the design will include asynchronous components, as shown in Figure 12. The pair of curly braces means repetition. For example, the modeling of Lecture 1 is the same as Lectures 2, 3, etc.

Table 1. Typical contents of a course syllabus

Instructor Personal Info	Course Info	Course Delivery Mode	General Info
Full Name Office Location Room Number Office Phone Email Address Office Hours	**Course CRN** **Course Day and Time** **Semester** **Credit Hours** **Course Location** Website Links Textbook(s) Required Materials	***Face-to-face*** ***Classroom*** ***Online*** ***Synchronous*** ***Online*** ***Asynchronous*** ***Hybrid*** HyFlex	Communication IT Helpdesk Disability Services Safety Emergency Notification Plagiarism and Cheating Makeup Policy Withdrawal Deadline Class Rules Student Services Attendance Policy Grading Scale Weight of Grades ***Objectives*** ***Learning Outcomes*** ***Course Outline*** Student Contract:

7.1. Online Asynchronous Modality



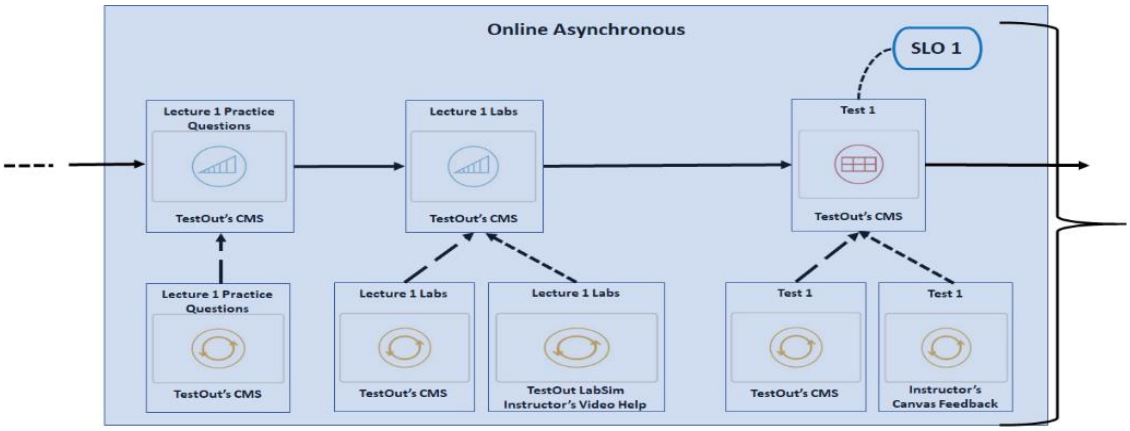
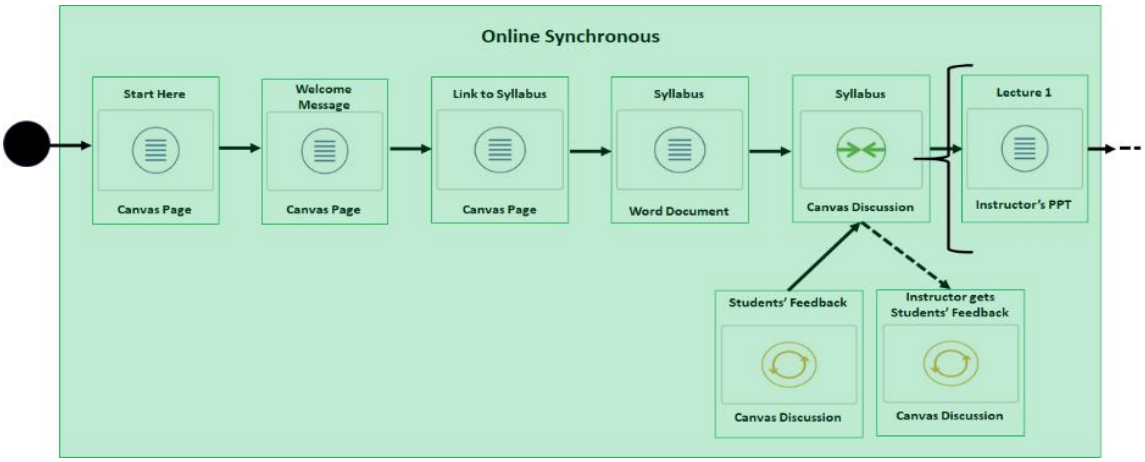
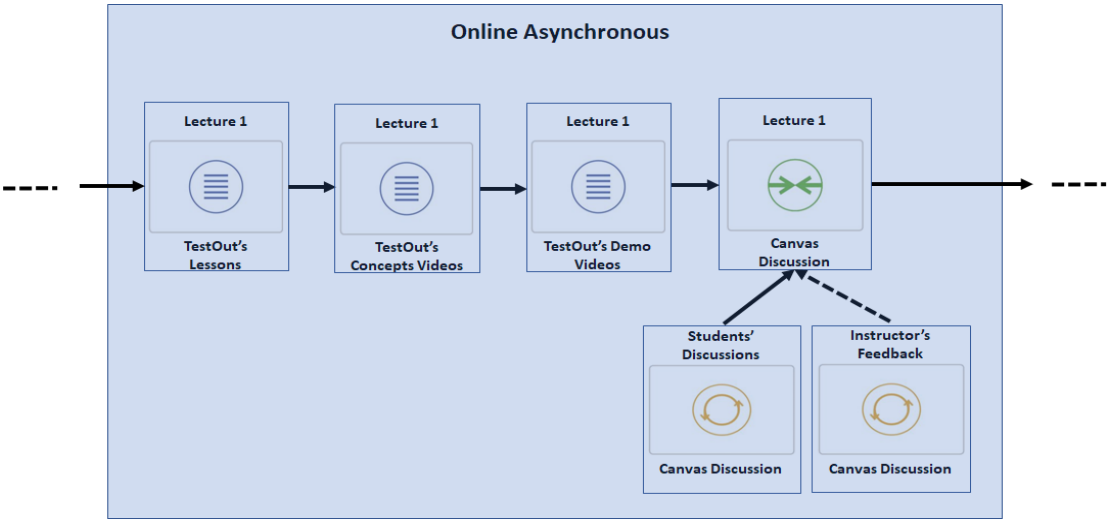


Figure 11. LEML of the online asynchronous modality

7.2. Online Synchronous Modality





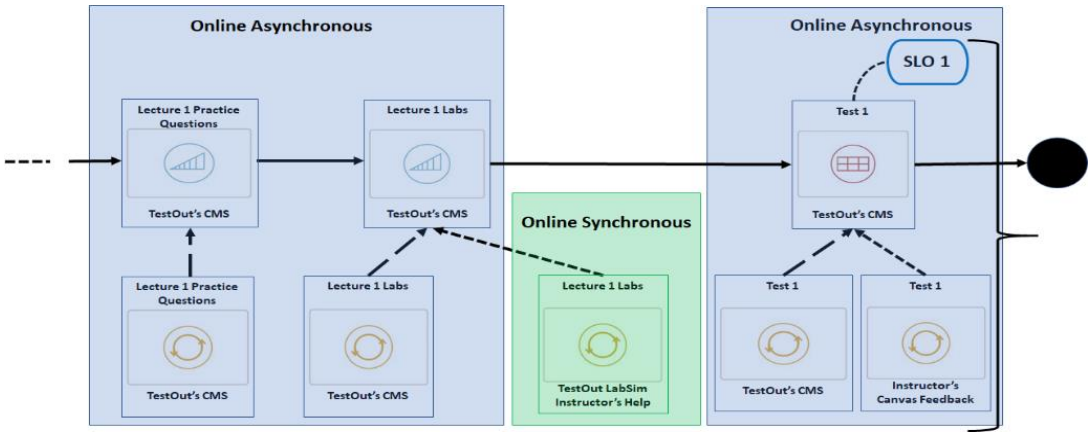
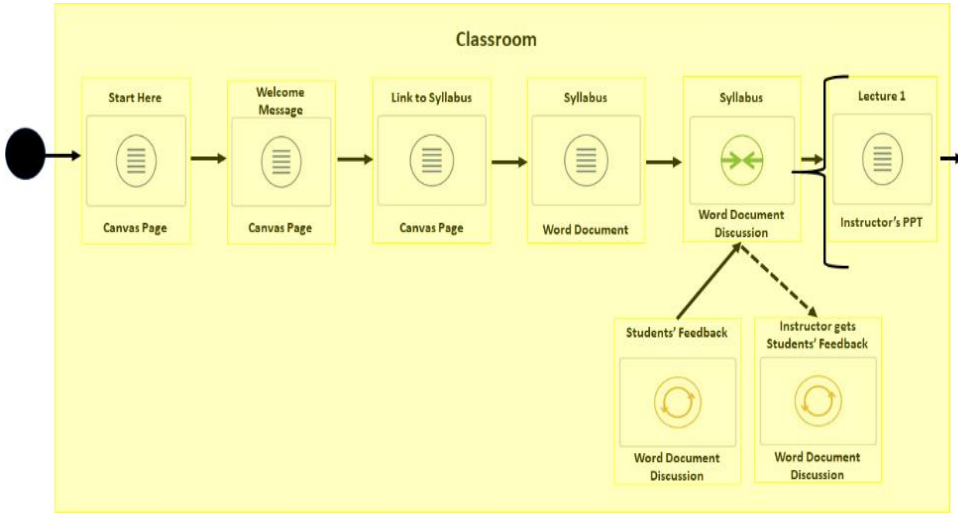
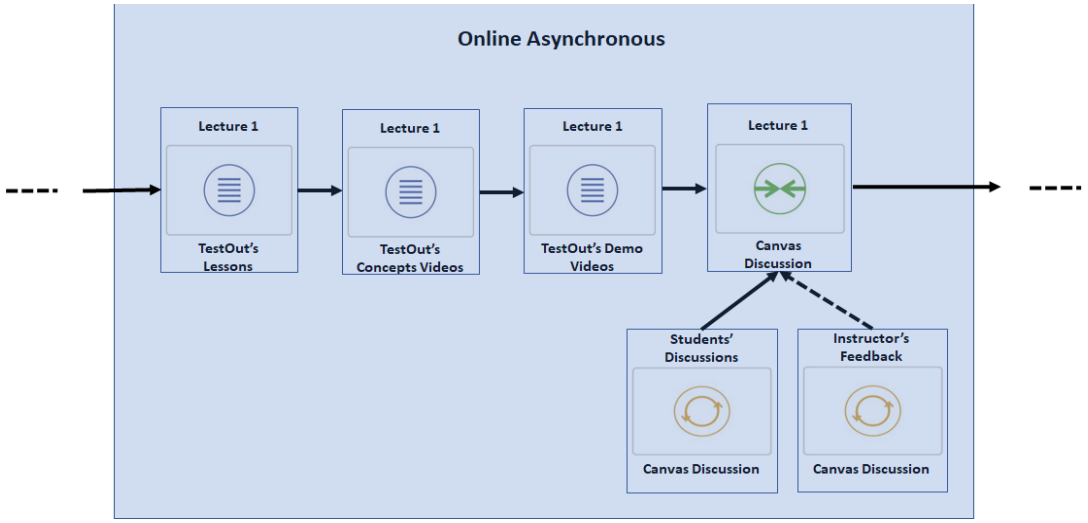


Figure 12. LEML of the online synchronous modality

7.3. Hybrid Modality





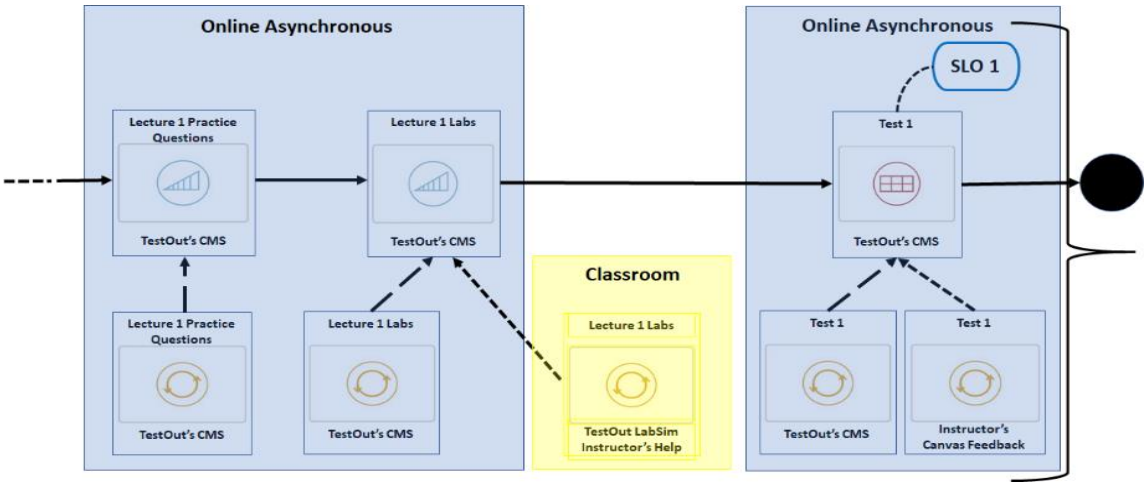
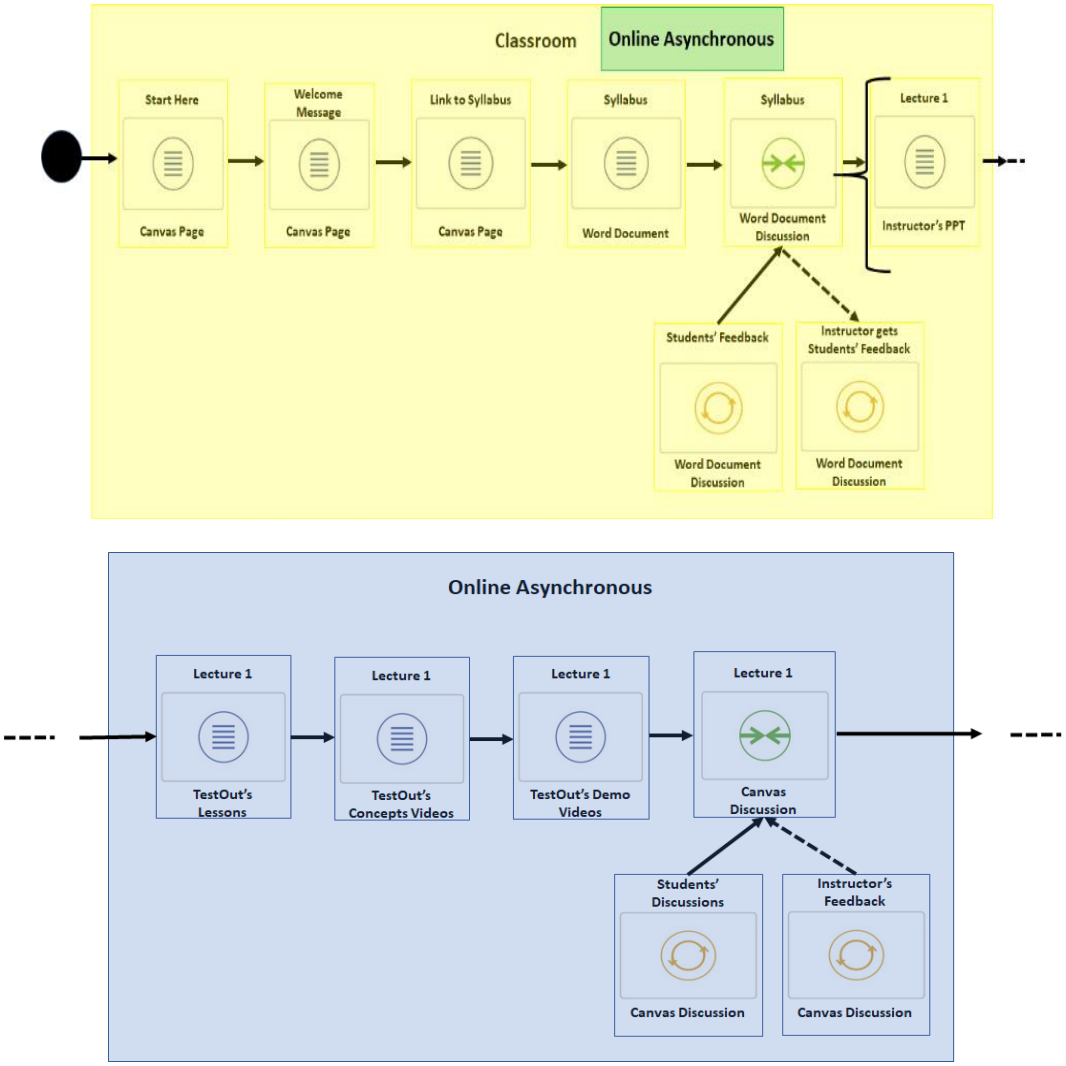


Figure 13. LEML of the online hybrid modality

7.4. HyFlex Modality



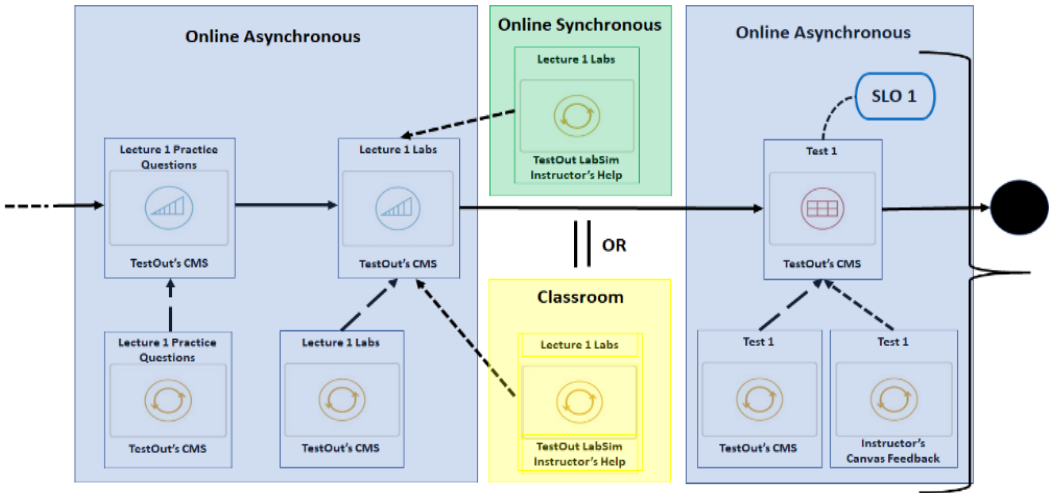
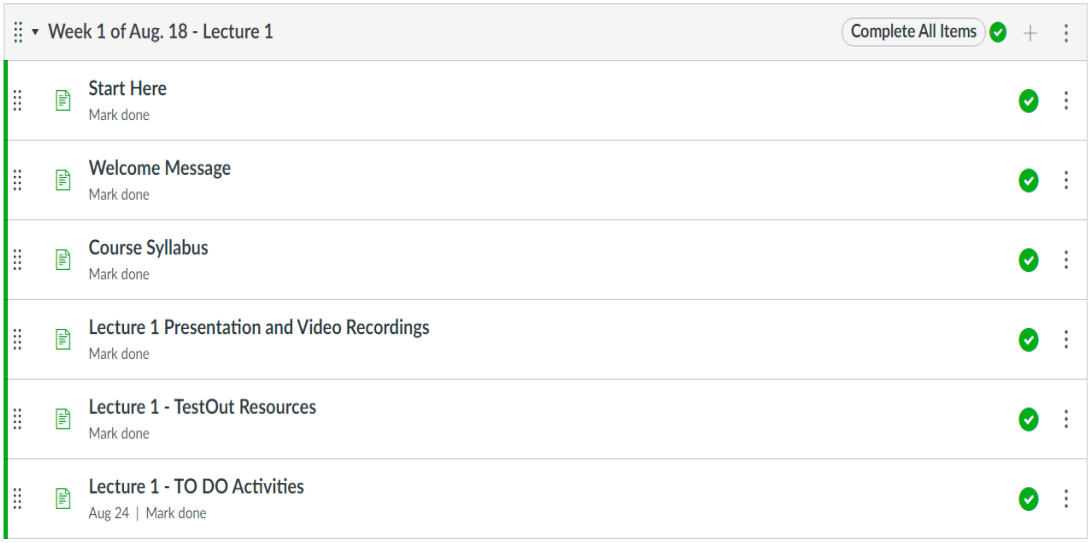


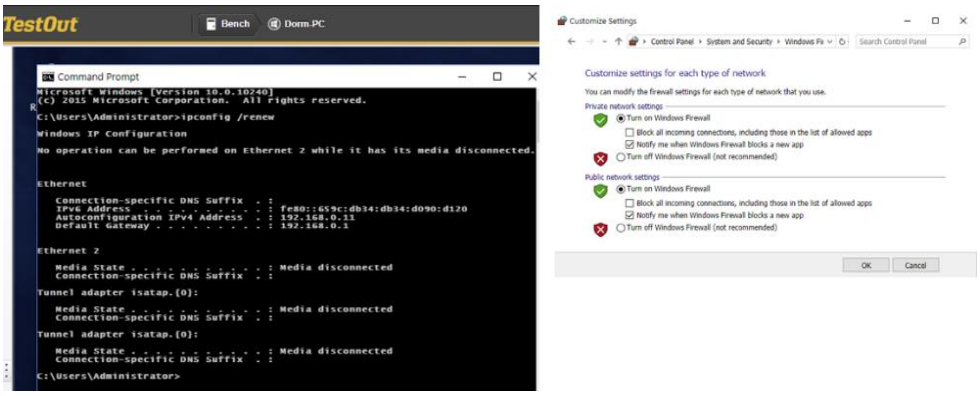
Figure 14. LEML of the online HyFlex modality

8. LEARNING MANAGEMENT SYSTEMS

We used Canvas learning management system, used at BRCC, to implement the designs of the CNET 2103 course shown in Figures 11 to 14. Figure 15 shows a portion of the implementation in Canvas and TestOut [23]. Note that we also use Moodle to implement courses at SUBR. Unfortunately, we cannot share the full implementation to keep this paper to the permissible length.



(a)



(b)

Figure 15. Partial implementations in a) Canvas and b) TestOut, Inc

9. COMPARATIVE STUDIES AND FINDINGS

In Section 4, we answered to the three research questions and presented the results of the surveys of students' preferences for the course delivery modes for the fall 2020 and spring 2021 semesters courses at SUBR. In Section 8, we presented the CANVAS asynchronous implementation of the CNET 2103 course for the fall 2020 based on the online asynchronous modality in Section 7.1.

As discussed in Section 2, there are currently no articles available on course design and implementation which we could use to compare our work with. However, through the results our surveys, presented in Section 4, we showed the positive impact on student's learning of well-structured or designed course based on students' learning preferences. Compared to post COVID-19, the motivation rate and overall class performance increased from 75% to 94% during the pandemics due to 1) flexibility of teaching, learning, and stress-free learning assessments; 2) chain of communications or interactions via emails, web announcements, forums, etc.; 3) access to a variety of teaching and learning resources; 4) reduced expenses associated with commuting to the campus or school; 5) increased rate in completing and submitting course activities; and 6) well-structured, designed, and implementation of the courses. Before COVID-19, all courses were delivered in face-to-face. As discussed in Section 3.1, face-to-face course delivery is mainly teacher-centered learning. However, our surveys validate student-centered learning based on students' preference for online asynchronous which is exactly a student-centered teaching methodology, as discussed in Section 3.2. The online asynchronous turns out to be the optimum or better and safe course delivery and teaching solution during the COVID-19 pandemics. Students succeeded learning at their own time, they have access to course video recordings and presentations as opposed to being present in class, listening, and taking notes; and they enjoy

stress-free environment by taking quizzes, tests, etc. anywhere they chooseand by benefiting from a series of make ups for missed assessments which are designed self-graded or automated grading.

10. CONCLUSION

The Center for Disease Control and Prevention (CDC) confirmed the first U.S. laboratory-confirmed case of COVID-19 in the U.S. from samples taken on January 18, 2019, in Washington state [1]. At the beginning of COVID-19, spring, summer, and fall 2019 and spring 2020, most courses were delivered in face-to-face mode. In fall 2020 and spring 2021, most courses were delivered in hybrid mode. In fall 2021 and spring 2022 most courses were delivered in face-to-face mode and others in hybrid or blended (online and face-to-face) mode.

In summary, we discussed, designed, and implemented different course delivery modes at our institutions, we answered three main research questions, and in Figures 11 through 14, we described and used our four enhancements to LEML: 1) the process continuation symbol (---); 2) the choice (|| or OR) symbol; 3) the "Asynchronous" context, as show in the top or first diagram in Figure 14, to mean that the design of the "Asynchronous" environment is the same as the "Classroom" environment design; and 4) the optional ([ ]) symbol, although not shown in Section 7's figures, can be used to provide options, for example, optional bonus points activities. We discussed in Section 9 the positive impact on student's learning of well-structured or designed course based on students' learning preferences. Compared to post COVID-19, the motivation rate and overall class performance increased from 75% to 94% during the pandemics due to 1) flexibility of teaching, learning, and stress-free learning assessments; 2) chain of communications or interactions via emails, web announcements, forums, etc.; 3) access to a variety of teaching and learning resources; 4) reduced expenses associated with commuting to the campus or school; 5) increased rate in completing and submitting course activities; and 6) well-structured, designed, and implementation of the courses. Now that we are back to the face-to-face delivery, we see a decline in motivation for learning to 85%. We study this decline in our future work. In conclusion, to fulfill courses' objectives and student learning outcomes, the design and implementation of every course should follow the institution standard or guidelines and be centered on student learning regardless of the course delivery modes designed and implemented. As a result, sampling or surveying students' opinions to determine their preferences for learning and learning environment is essential in accomplishing course objectives and student learning outcomes.

ACKNOWLEDGEMENTS

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