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Student-Centered Learning: A Mixed Modality Course Redesign Approach with Innovative Teaching Techniques

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Abstract

Active involvement and participation of students in Engineering courses in Higher Education are essential to ensure students get the knowledge and skills needed. In this paper, we examine how the integration of Robert Gagne's Nine Events of Instruction and constructivist principles in course design enhances instructional strategies, promotes a deeper understanding of concepts, and improves information retention among learners. A dynamic mixed modality course delivery method was used to redesign a Senior-level Engineering course. This modality provided an adaptable, flexible, and effective online learning environment to learners.

Students' performance is collected and compared to the performance of students before improvement for the same course. Analysis shows that performance increased by 19.3%. And the number of students that score less than 70% or less in the final exam is reduced by 69.1%. Students' feedback is also collected, and results indicate that students are more engaged and delighted with the learning experience.

Introduction:

Online education is growing in numbers, and universities are expanding their online course offerings. Online courses are gaining popularity due to their flexibility and availability, but they often need more interactivity. One main challenge in such courses is maintaining students' engagement and motivation [1]. The level and frequency of faculty-student interactions can also be affected by the course modality [2].

The need to offer asynchronous or synchronous online courses depends on the specific course, institution, and student population. Some students may prefer asynchronous courses for their flexibility, while others may prefer synchronous courses for the opportunity to engage in real-time interactions with instructors and classmates. Ultimately, the popularity of each format may depend on the learners' individual needs and preferences and the course's goals [3]. Recent studies have shown evidence of the effect of each modality on students' motivation and engagement [4]. Increasing students' attention will lead to improved student performance in projects and exams and reduce the withdrawal rate [5].

The Mixed Modality model blends hybrid and asynchronous learning and is more flexible. This allows students to choose between attending face-to-face classes, attending live lectures (synchronous), watching recorded lectures (asynchronous), or flexibly doing all, without any negative impact on their learning, based on their individual needs and availability [8]. So, a student might attend face-to-face one week and online the following week.

Using a mixed modality approach makes the course more sustainable and helps instructors design one course that can be used to teach in different modalities. This ensures a high return on the investment made in terms of instructor time and cuts down the amount of time spent on redesigning courses for each separate modality. Sustainable course design, therefore, aims to build an online course with "sustainable" components that can be adapted to suit different teaching modalities [6]. This involves creating a course with flexible content and assessments that can be hidden or released as necessary, depending on the modality of the course. By doing so, the course can be used in various teaching modalities, including face-to-face, hybrid, synchronous, asynchronous, and mixed [7].

In this paper, we examine how integrating Robert Gagne's Nine Events of Instruction and constructivist principles in course design enhances instructional strategies, promotes a deeper understanding of concepts, and improves information retention among learners. A dynamic mixed modality course delivery method provided learners an adaptable, flexible, and effective online learning environment.

Course Design Methodology

The Facilities Design course is redesigned to combine Robert Gagne's Nine Events and Constructivist principles in its course elements. This combination of instructional strategies and principles is a practical approach to help students grasp complex engineering concepts and develop practical skills. The course under study is one such course. Apart from using these instructional strategies in its course design and teaching, it is also a mixed modality course, which allows students to attend this course either entirely online, completely Face-to-face, or in the Hybrid modality. This allows learners to attend class without restrictions on place and time. This course is a senior-level course that contains Lab elements to teach AutoCAD skills and applications. The lab sessions are held once a week in person and virtual via MS Teams and recorded so students can watch it and complete their related activities at any time during the week. All students have access to AutoCAD through the college computer lab or the virtual lab. Students are urged to be actively involved in their learning process, and the teacher functions as a mentor, coach, and guide who helps students develop and assess their understanding and learning. Different forms of assessment are provided to enhance students' interaction and engagement. For example, a group project is designed to encourage students to apply concepts and analysis learned in the course. Forming and managing group projects in mixed modality courses is challenging, but the "Group" tool is used to enroll students, and private group discussions are created to help students communicate and track their work.

Robert Gagne's Nine Events of Instruction

Robert Mills Gagne was an American psychologist who pioneered the science of instruction. In his Nine Events of Instruction, he focuses on building higher-order thinking skills through retention and recall, sharing information, providing guidance, eliciting performance, providing feedback, assessing performance, and transferring newly acquired knowledge to other relevant contexts.

Gagne's theories were largely influenced by behaviorist psychology, especially the work of B.F. Skinner. His focus on systematic instructional design and the sequence of events in learning reflects a behaviorist perspective, emphasizing observable outcomes and carefully planned steps in instruction [20]. It is at times argued that Gagne's Nine events were hardly original, and the same concepts and applications could easily be drawn from John Milton Gregory's "Seven Laws

of Teaching" published fifty years before Gagne came on the scene. We must remember that they lived and worked in different centuries, and while there may be some shared principles in education, the differences in their theoretical foundations and the historical contexts in which they developed suggest that Gregory did not directly inspire Gagne. Instead, Gagne's work was more aligned with the behaviorist psychology that dominated educational thinking during his time [20].

However, It is worth noting that educational theories often build upon or react to those that came before, so there may be indirect influences or shared themes in their work. Both Gagne and Gregory contribute valuable insights to the field of education, but Gagne's approach is more structured and aligned with systematic instructional design [18], while Gregory's laws emphasize the teacher's role in adapting to the learner's needs and interests [22]. The choice between these approaches may depend on the specific educational context and the preferences of educators. For the course under study, the instructor and the instructional designer focused on Gagne's systematic instructional design and the sequence of events in learning to structure the course for online teaching and learning.

Gagne events are recommended when developing online content [9]. Gagne's events of instruction consist of nine events presented in Figure (1).

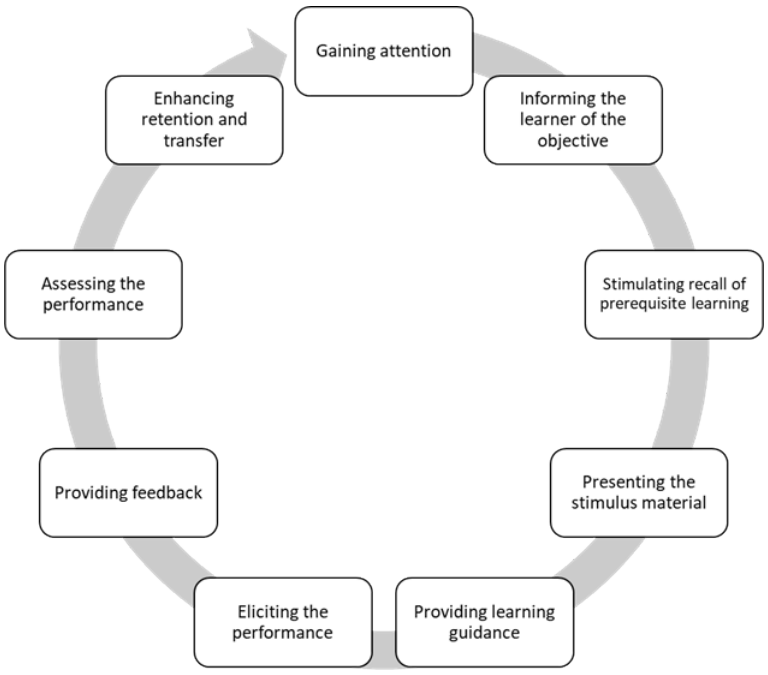

Figure (1): Gagne's "Events of Instruction"

The course begins with a Start Module open to all students regardless of modality, ensuring that students have all the relevant information related to class logistics and institutions available at their fingertips at all times.

- The course follows Gagne's Nine Events of Instruction broadly as different modalities provide different opportunities to gain student attention (Gagne's Event #1) and engage them in a scenario or problem related to facilities design, layout, or handling to spark interest and curiosity.
- The course has clear learning objectives (Gagne's Event #2) for all modules that align to the overall course objectives. Students always have access to these module objectives and course objectives in the LMS.
- The course encourages students to share their prior knowledge and experiences, thus stimulating recall of prior learning (Gagne's Event #3) by engaging in meaningful discussions. This creates opportunities for students to draw on their existing understanding of engineering concepts.
- The course material presented in the LMS (Gagne's Event # 4) covers critical concepts and principles. It is presented through various resources like class lectures, textual material, PowerPoint slides, Case studies, in-class activities, and Labs to deliver content effectively.
- The instructor facilitates and provides learning guidance to students (Gagne's Event #5) by encouraging them to apply concepts and principles and providing a to-do list to serve as a checklist for designing facility layouts through a group project. This encourages active engagement from students and creates a dynamic discussion environment.
- The course provides many opportunities for students to apply their knowledge to elicit performance (Gagne's Event #6). This is done by applying problem-solving tasks and group projects that require students to apply their abilities in a hands-on manner. The discussion questions and case studies in the course encourage collaboration,

experimentation, and creativity and encourage students to solve real-world problems in simulated environments.

- The course instructor has a clear plan to offer constructive feedback (Gagne's Event #7) during discussions and project milestones and after students have submitted assignments. This emphasizes the importance of self-assessment and encourages reflective thinking in students about the concepts they have learned during the course. The course design incorporates online resources and encourages students to seek guidance from the instructor by meeting her during office hours, emailing her directly, attending classes, and asking questions for clarification on complex topics.
- The course provides many opportunities to assess student performance (Gagne's Event #8) through quizzes, Exams, in-class graded activities, homework assignments, project work, Labs, and discussions to measure students' understanding of the course material.
- The course provides multiple opportunities for learners to enhance retention and transfer (Gagne's Event #9) by connecting their learning to real-world scenarios and industry. Students discuss case studies and draw and illustrate to apply concepts they have learned.

The instructor maintains a learner-centered approach throughout the course through all modalities, fostering a collaborative and supportive learning environment [10]. The application of Gagne's Nine Events helps students not only acquire knowledge but also develop skills required for real-world environments.

Principles of Constructivism

Principles of Constructivism recognize learning as making sense of information and experiences and focus on "meaning making" during the learning process. "Learning constructively requires an environment in which learners work collegially and are situated in authentic activities and contexts [11]. The author suggests that learners and their learning cannot exist in isolation and can only be understood in the context of society, their background, and their experiences. In a constructivist environment, the focus shifts from the professor to the students, where the teacher is no longer an expert or the "information giver." Students are urged to be actively involved in their own learning process and the teacher functions as a mentor, a coach, a guide who helps students develop and assess their own understanding and learning [23].

Before we proceed to the details of the course under study, we would like to address some valid concerns raised by critics about the potential limitations of constructivism and the fear that using this approach may lead learners into thinking that they can learn scientific concepts and work towards "meaning making" without considering the objective reality of the world around them, especially in the field of engineering. We also want to emphasize the importance of support and guidance from the instructor in the classroom, which is an underlying pillar of constructivism [15]. It is essential to recognize that the constructivist approach doesn't negate the existence of an objective reality that engineers must submit to [15]. Rather, it emphasizes that learners actively engage with and interpret this reality, shaping their understanding through personal experiences [15]. When Vygotsky was working on his ideas of social constructivism, he emphasized the role of the adult, the "more capable peers," the person necessary to guide learners who are in the zone of proximal development (ZPD) by using the scaffolding process (though Vygotsky never used that term) [15],[17]. Vygotsky's constructivist ideas were influenced by Marxist ideology and although he conceded to individual having autonomy in relation to external and social contexts, his ideas of constructivism were somewhat rooted in heteronomy where learners were allowed to shine in the received brilliance of those who have gone before them [15].

Moreover, the importance of "information givers" resonates with Vygotsky's emphasis on the social and cultural aspects of learning [23]. While constructivism celebrates individual exploration, it doesn't discount the value of learning from others [23]. As course designers, we embrace a balanced perspective, acknowledging that learners can construct their own ideas while recognizing the significance of building upon the wealth of knowledge provided by those who have gone before. Using a constructivist approach only amplifies the fact that educators can foster a learning environment that combines individual exploration with the valuable insights gained from shared experiences and accumulated knowledge [17]. In this course, the instructor was present and enabled learners to explore concepts related to facility design through content dissemination, practical labs, projects, and group work. Using the constructivist framework does not disregard the role of the instructor in a classroom. This framework allows learners to develop more sophisticated cognitive structures as they encounter new information, which aligns with the idea that students can think and develop their own ideas while still acknowledging the influence of received knowledge [23].

Constructivism is a way of teaching where instead of just telling students what to believe, instructors encourage them to think for themselves. This means that instructors need to believe that students can think and come up with their own ideas. In a constructivist classroom, the primary responsibility of the faculty is to create a collaborative problem-solving environment where students become active participants in their learning. Because classrooms are gradually changing, and the teacher is no longer the “sage on the stage” but a “guide on the side,” students do not expect the teacher to pour knowledge into their ears through information-giving sessions. In the constructivist model, students are urged to be actively involved in their process of learning. Because constructivism focuses on knowledge as a dynamic, ever-changing view of the world, the classroom reflects that ever-changing worldview. In the higher education environment, curriculum, objectives, and student outcomes are fixed. Still, the way the material is taught in a classroom is defined by the academic freedom provided to faculty. This allows faculty to have a dialogue with students, pursue student questions and interests, and gives them the space to experiment with constructivist principles.

In this course, the instructor ensures that students develop learning interactively and build on what the student already knows [12]. The course design incorporates group work on projects, which allows students to build on prior knowledge and adjust to new knowledge - which is called scaffolding - a key feature of constructivism, where the teacher adjusts the level of help in response to the learner's level of performance. This allows students to interact, negotiate, and build something new in the process. Most problems students work on are real-life problems, and the constructivist classroom provides them with the opportunity to work in a high-fidelity environment. A high-fidelity environment gives them the chance to solve real-world problems in a group, through peer learning and interaction, within the safety of a classroom. Assessments include student work, observations, points of view, tests, and Lab work, and the process of learning becomes as essential as the product they develop. In this class, the teacher's role is interactive and rooted in negotiation, guidance, and mentoring.

Results:

In this study, we present the results of our analysis comparing students' performance and feedback before and after the new design of a senior-level engineering course.

Students' performance:

Students' final exam grades are used to evaluate the student's understanding of the material and overall performance. Final exam grades before the improvements in Fall 2020 are compared with final exam grades after improvements in Fall 2022. Both Final exams before and after improvement are at the same level. Results indicate that the new course design improved students' performance by 19.23% in the final exam. T-test is performed, and the results indicate a significant difference (p-value = 0.0096). The data also show a reduction in the percentage of students who scored 70% or less on the final exam by 69.1%. While the control group that took the class in Fall 2020 was completely online with no face-to-face option due to COVID-19, there is little to no impact of that condition on the students' performance since this course was already designed as a mixed modality with a high percentage of students online before COVID-19. Additionally, several studies reported a positive and/ or no impact on students' grades during COVID-19 [13],[14]. Other factors that might impact students performance

Table 1: Students' performance in the final exam before and after the course redesign

	Number of students	Final grade average and standard deviation	percentage of students got 70% or less
Fall 2020 (Control group)	27	71.3 (31.1)	33.3%
Fall 2022 (Test group)	39	85.0 (20.2)	10.3%

Although attending classes in mixed modality courses is not mandatory, it has been noticed that students excel by attending lectures in person and/ or virtually. Comparing the average final grade achieved by students who regularly attend (90.3%), it is greater than the average final grade obtained by students who do not show up (83.2%). This observation suggests that live lectures are more effective in enhancing students' comprehension and achievement, primarily due to the availability

of immediate feedback and the opportunity for collaborative learning among students through in-class group activities.

Students feedback:

Students' feedback on the new course design is also collected using the Survey tool on D2L. 21 responses were collected from the test group with a response rate of 21/39 (53.8%). Students in the survey answered three questions. The questions and summary of answers are stated as follows:

1. What would you like us to continue doing in this course?

   Students generally liked the course structure; they enjoyed the in-class activities and found the video quizzes helpful and engaging. Students also positively commented on the class discussion and thought it was engaging. A few students also reported that this course was the best in terms of the activities and structure.

2. What would you like us to stop doing in this course?

   Most students thought the course was well organized and liked the way it was. Some downsides were identified as well; the group project was stressful to a fully online student, and according to the student, it was challenging to schedule a time that all students in the group are available, and this is due to work, family constraints, and time differences. As stated by three students, the other area for improvement of the course structure is the online discussion. Even though the in-class discussions were good for catching students' attention and getting them to work together and be part of the learning process, participating on the discussion board was not pleasant to those students, mainly because students only commented on other posts because they had to, and few effective conversations took place. Turning these discussions into reflections could be effective in enhancing students' participation and responses quantity-wise and quality-wise.

3. What would you like us to start doing in this course?

   This question was asked to help identify improvement actions in the future. Students generally were satisfied with the course material and assignments. A few students suggested a guest speaker and more examples.

Conclusion:

The course was restructured and designed by integrating two well-known instructional strategies to enhance students' engagement and academic performance. It was also offered in a mixed format which allowed students to attend and complete the course in a flexible manner. When comparing results from courses before and after the course redesign and modality offerings, it shows a significant improvement in both student satisfaction and performance. To conclude, the new design of the course provides a great example of how a mixed modality course can be taught successfully using Gagne's Nive Events of Instruction and Constructivist principles. From the student success data, it becomes evident that using Robert Gagne's Nine Events of Instruction can be a highly

effective approach to help students grasp complex engineering concepts and develop practical skills. Combined with the use of Constructivist principles, which emphasizes that learners actively construct their own knowledge and understanding of the world through their experiences, interactions, and reflections, the course allows students the agency to participate in their own learning and knowledge-building process. Both instructional models emphasize the importance of learner-centered approaches, hands-on activities, and collaborative education to facilitate meaningful and authentic learning experiences. One limitation of this study is the small samples. It is unclear whether the redesign of this course will still be effective for larger classrooms. More studies are needed to investigate the combination of Robert Gagne's Nine Events of Instruction and constructivist principles in senior-level engineering mixed-modality courses.

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