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Navigating the Virtual Landscape: Implementing a Pedagogical Framework in a Virtual Summer Engineering Course to Enhance Students' Academic Development

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NAVIGATING THE VIRTUAL LANDSCAPE: IMPLEMENTING A PEDAGOGICAL FRAMEWORK IN A VIRTUAL SUMMER ENGINEERING COURSE TO ENHANCE STUDENTS' ACADEMIC DEVELOPMENT

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NAVIGATING THE VIRTUAL LANDSCAPE: IMPLEMENTING A PEDAGOGICAL FRAMEWORK IN A VIRTUAL SUMMER ENGINEERING COURSE TO ENHANCE STUDENTS' ACADEMIC DEVELOPMENT

In this evidence-based practice paper, the recently established CIRE educational model was incorporated, and modified, to establish an alternative pedagogical framework for a virtual, fast-paced summer engineering course in a private university in Texas. Transitioning to fully online courses in the wake of COVID-19 required a rapid modification of traditional pedagogical methods to overcome challenges such as the lack of academic resources and established campus practices, while simultaneously ensuring the academic and social development of students. In this regard, a pedagogical framework known as the CIRE model – which is the acronym for Communication, Initiation, Reduction, and Extension – was recently designed and implemented in a Rigid Body Dynamics Fall semester course, which generated favorable results. In this study, the CIRE model was adopted for a virtual Statics-Strength of Materials summer [six-week] course to test its effectiveness in a slightly different timeframe. However, the Initiation and Extension components of the model were modified to adapt to the fast-paced structure and allow the students to enhance their academic preparation despite the virtual setting. As such, rather than initiating homework sets during the lecture, as established in the CIRE model, step-by-step examples were instead performed during lecture sessions to strengthen the intuitive nature of solving homework problems. Similarly, the last component of the model was tailored for exams during the fast-paced summer course rather than for every assignment as stated originally. A survey was conducted with a cohort of twenty-four students to gauge responses and understand their perspectives regarding the pedagogical framework adopted. Results indicate that the implementation of the CIRE model, with its two modified components, allowed engineering students to have a holistic understanding of the course material despite the fast-paced timeframe. Students were able to successfully complete assignments individually and correlate theoretical aspects with engineering applications.

I. BACKGROUND AND MOTIVATION

Since the emergence of COVID-19, faculty members have been on a transitional period modifying conventional [instructional] methods to enhance student engagement, comprehension, and scholarship abilities for online instruction, and thus overcome two types of ongoing challenges: 1) student's lack of accessibility to academic resources and campus practices, and 2) retention rates in engineering education (e.g., not the focus of this paper). According to research efforts, the effectiveness of conventional practices primarily depends on two elements: 1) classroom environment, and 2) students being able to access campus resources such as study spaces, books, outdoor recreation programs, advising programs, computer labs, and internet services [11], [12], [13], [19].

Though Problem-based learning (PBL) [17], Project-based learning [27], [28], and visual cuing [7], [8], [9], [10] are several effective pedagogical practices implemented in the classroom, the most impactful towards strengthening student learning, engagement, and success is classroom environment [5], [14], [15], [16], [17]. Studies reveal that the climate, tone, or ambience that influences the setting minimizes classroom power relations, strengthens student-instructor communication, fosters an active learning environment, and increases student collaboration [11], [12], [13], [23], [24], [25], [26]. Pascarella *et al.* further concluded that the social and academic

fabric of institutions are necessary for students to experience academic success [18], [21], [22]. Research efforts suggest that retention rates, opportunities to support academic programs, and student recruitment are benefits of campus facilities and outdoor recreation programs in higher education [1], [3]. As such, institutions have further allocated resources to assist disadvantaged students overcome academic preparedness and cultural capital [2], [21]. Several initiatives include peer tutoring services, stress management centers, time management workshops, academic advising, and personal and career counselling [1], [4], [6], [20].

To address the lack of accessibility to academic resources and campus practices during the outbreak of COVID-19, a model termed CIRE (acronym for Communication, Initiation, Reduction, and Extension - Figure 1), was designed and implemented by Marquez and Garcia [15] during a semester-long engineering course.

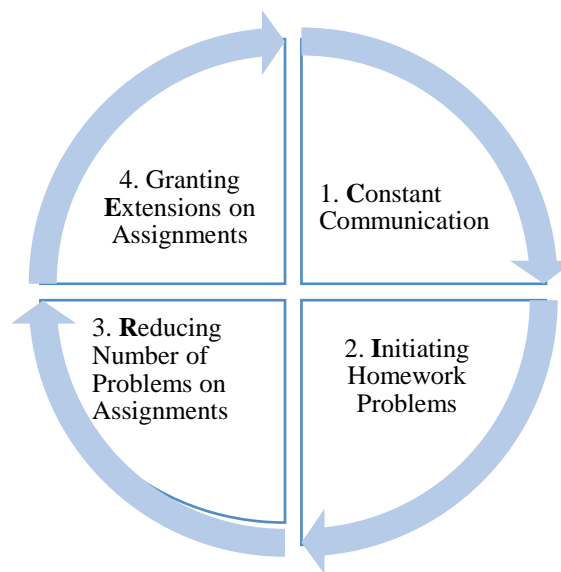


Figure 1. CIRE Model: Introduced in 2020

The model was introduced in a private university in Texas who transitioned to remote instruction and whose students were mandated to seek off-campus housing [15]. It consists of four major pedagogical strategies: 1) constant communication, 2) initiating homework problems during the lecture, 3) reducing the number of problems on homework and exams, and 4) granting extensions on homework assignments [15]. According to the model's first strategy, the instructor established constant communication with the students via email and CANVAS portal to ease the transition from in-person instruction to online learning and consequently eliminate the amount of confusion transpiring in a very short timeframe [15]. Subsequently, the instructor decided to initiate several of the homework problems during lecture sessions [15]. This procedure was primarily established to accommodate 1) students who would find it challenging connecting to virtual office hours, and 2) students who were unable to coordinate remote study groups [15]. Further, the third strategy involved reducing the number of problems assigned on homework sets and exams. According to the model, this precaution was further considered given that all other divisions of study transitioned online simultaneously, and the process of implementing alternative pedagogical strategies for remote instruction was nonexistent [15]. The fourth strategy of the established model involved

granting extensions when submitting homework assignments. Given the rapid transition to remote instruction, it was anticipated that a considerable representation of students, particularly those from underserved and challenging communities, would encounter personal and/or academic challenges amidst the unprecedented crisis. As such, the instructor of the course clearly emphasized, via email and during lecture sessions, the willingness of granting extensions to those experiencing personal and family distress, internet disruptions, or difficulty completing homework sets [15].

Based on its assessment, Marquez and Garcia reported that students exposed to the CIRE model were academically and personally satisfied with the implementation of the four practical strategies, which addressed the challenges associated with remote instruction and learning [15]. Given that the model emphasized quality over quantity, it was reported that students were able to conceptualize and master course objectives during the period of remote instruction and thus allocate study time to other areas of their coursework [15]. Results additionally revealed that stress and anxiety levels were reduced with the implementation of the CIRE model during the transition to online learning [15].

II. PROPOSED WORK

Given the affirmative results of the CIRE model, the authors decided to enforce most of its content in this study. For this study, nonetheless, two of its four pedagogical strategies were modified to generate an effective framework for a virtual, fast-paced [six-week] summer engineering course in a private university in Texas. Previously, the model was incorporated during a regular semester length course. Particularly, the *Initiation* (Strategy 1) and *Extension* (Strategy 2) components of the CIRE model were modified to adapt to the fast-paced structure of the course and allow students to enhance their academic preparation despite the virtual setting. This modification of the CIRE model was effectuated based on four critical aspects: a) a combination of teaching practices employed by the author during lecture sessions; b) post-course evaluation of CIRE model; c) literature on instructional best practices; d) sensitivity of circumstances surrounding students during COVID-19. The combination of experiential knowledge, post-course reflection and scholarly literature provided a framework through which the model was modified and implemented.

Modified CIRE Strategy 2

For this modified strategy, rather than initiating homework sets during the lecture sessions, as established in the CIRE model, step-by-step examples were performed during lecture sessions to strengthen the intuitive nature of solving technical problems. This procedure was enforced to promote problem solving skills during homework sets, rather than students having to depend on the faculty instructor to initiate problems repeatedly. The step-by-step examples performed during class covered major concepts essential to complete homework sets. The goal in this modification was for students to identify problem formulation patterns that would be implemented for each problem set, starting from drawing free-body diagrams (FBDs) correctly, labeling reference frames, establishing mathematical conditions, generating assumptions, and understanding solutions. Rather than solving examples by neglecting multiple steps, it was determined to display detailed solutions to provide a template to formulate and solve problems.

Initiating step-by-step examples during lecture was additionally introduced for those students who would find it challenging attending virtual office hours or communicating/participating via online platforms, and would need a reference to complete homework assignments.

Modified CIRE Strategy 4

When the CIRE model was established, its fourth component included granting extensions on homework assignments and allowing a total time of three to five hours to complete online, closed-book closed-note exams. In this study, nonetheless, the model was modified to include a 24-hr exam window. Given the intensity of the fast-paced summer course, the exam window was extended for three reasons: 1) for those students who would encounter anxiety and/or wellbeing issues due to COVID-19, 2) for students who would experience internet disruptions during the process, and 3) to observe the academic performance of students during exams when granted additional time. The third reason is of interest to the authors, particularly in observing student performance on exams. Generally, faculty members issue exams two ways for in-person/hybrid modality: 1) during the allotted class time, or 2) evening exams, which are granted an approximate timeframe of two or three hours. During the course duration, the instructor posted lecture notes, homework assignments, and homework solutions on the CANVAS portal as supplement to assist students with course material. Additionally, all lectures were saved and recorded in the Zoom cloud in case students needed to review lecture concepts independently. However, during the exam window, the instructor removed all student access to lecture notes, homework assignments and solutions, and recorded lectures to enforce academic integrity.

Correlation of Study with Overall Research Objective

This research study adds to the nascent research of exploring rapid responses by faculty to address issues associated with remote instruction and document effective instructional practices. It further stems from the overall research objective of the authors which is to increase retention rates in engineering education, enhance academic preparation, and to increase the number of minorities in STEM fields and graduate school (Figure 2). These research objectives are believed to be attained by identifying, designing, and implementing effective pedagogical methods that will enhance student engagement, comprehension, and scholarship abilities.

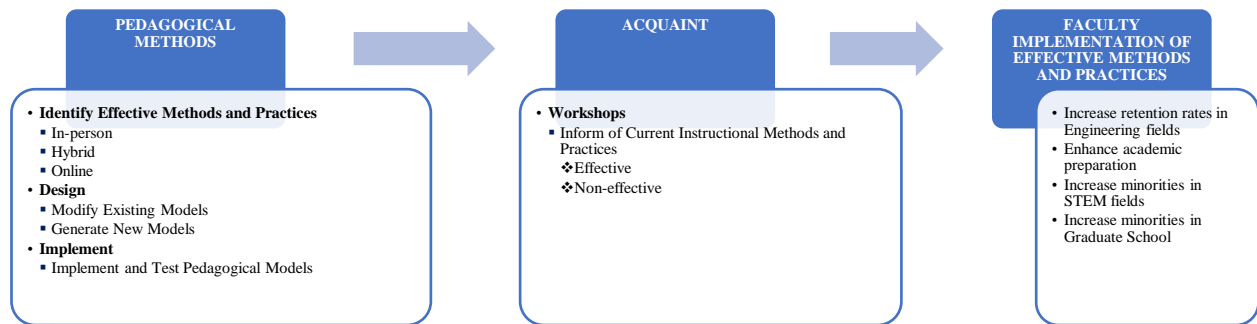


Figure 2. Overall Research Objective

Further, this study was intended to concurrently understand the following two aspects of the modified CIRE model:

Aspect 1: Communication during the fast-paced summer course

It was imperative to establish constant communication via online platforms for the fast-paced summer course. Having constant communication was critical to the instructor and was accounted since the first day of class. The instructor utilized two platforms to recurrently communicate: 1) email, and 2) CANVAS portal. The following topics were recurrently communicated via email or the CANVAS portal:

- a. Accessing Zoom link for lectures and office hours
- b. Class structure
- c. Virtual office hours
- d. Homework and exam format
- e. Grading policies
- f. Submission policies for homework and exams
- g. Accommodations

Aspect 2: Reduction on number of problems on assignments

For the authors, it was necessary to reduce the number of problems on assignments for two main reasons: 1) short-duration and fast-paced course, and 2) lack of access to campus resources or study groups. As such, approximately eight problems were assigned per homework set without sacrificing the academic rigor of the course.

III. METHODS AND ANALYSIS

To help contextualize this study, the authors draw upon a social constructivist theory to guide the research and meaning making process. Social constructivist theory posits that knowledge is actively constructed by individuals through engagement in different social settings and interactions [23]. This perspective on knowledge views the learners as active participants in the learning process and positions educators as facilitators to create the conditions that support and nurture relationships, inquiry, and collaboration [23]. This theoretical position provides a framework through which student experiences are examined and learning environments are structured and enacted by the educator.

For this study, a small, self-developed survey was generated as the primary data collection method, in which questions were intended to understand classroom experiences regarding the pedagogical framework of the modified CIRE model for a fast-paced [six weeks] summer course. A total of twenty-four students enrolled in a Statics-Strength of Materials course at a small private university in Texas participated in the survey after the end of the course. Further, it is noted that descriptive statistics were employed for analysis and presentation of data results. Nonetheless, the study poses

the following limitations: (a) small sample size; (b) self-developed survey instrument; (c) convenient sampling procedure.

The administered survey consisted of five open-ended questions:

Question 1: How do you feel about the professor's communication regarding HW assignments, class updates, or announcements via email/CANVAS or Zoom?

Question 2: The professor worked step-by-step examples during class given the challenges posed by remote instruction. Share your thoughts about this approach.

Question 3: Given the challenges of remote instruction and of the short summer semester, the professor reduced the number of problems on homework assignments, and removed a semester project. With these changes, do you still think you learned the course material?

Question 4: In a regular semester with face-to-face instruction, exams are facilitated in a classroom setting with a 3-hour allotted time. For remote instruction, rather than having classroom exams, the professor decided to give take-home exams with a 24-hour timeframe. How do you feel about this change?

Question 5: How was your overall experience with course this summer? (e.g., lectures, assignments, office hours, etc.)

These questions were aimed towards exploring the perceptions of students regarding the classroom experiences relating to the CIRE model as a whole, together with the modification of the *Initiation* (Strategy 1) and *Extension* (Strategy 2) components.

IV. RESULTS

Communication Effectiveness (Question 1)

Based on the data collected from the study, it was evident that communication was an essential component in students' learning experiences. Repeatedly, timely communication afforded students opportunities to stay on pace with class assignments and address any queries that surfaced throughout the course. Students indicated that the professor established a clear, consistent, and adequate form of communication. Student responses are listed below:

“Good! Kept us up to date, responsive to questions/concerns. A few small moments of confusion here and there, but nothing that couldn't be easily cleared up or worked around.”

Other students echoed the comment shared above by stating the following:

“Communication was great, and deadlines were very clear and doable. The deadlines allowed enough time for all assignments but also did not allow for idleness and lack of challenges in the course.”

“Communication was clear; I enjoyed how communication occurred over zoom and in the form of canvas announcements.”

“The communication was clear and concise, and I never had any questions regarding assignments or updates as a result.”

These results highlighted the need for instructors to be proactive, flexible, and responsive to ensure students were provided with timely, individualized support.

Instructional and Pedagogical Supports (Question 2)

Due to the shift to online, remote instruction, the professor responded by employing several instructional and pedagogical strategies to help address some of the challenges students of learning off-campus. The second open-ended question on the survey stated the following: *The professor worked step-by-step examples during class given the challenges posed by remote instruction. Share your thoughts about this approach.* Overall, student responses illustrated a significant level of satisfaction regarding instructional supports offered by the professor. Several students noted how this strategy benefited their experience with classwork:

“I thought this was really beneficial since oftentimes professors give students the theory but do not really show how to apply it in different examples. This was probably my favorite part about lecture since we got to apply the knowledge, we had previously learned right then and there.”

“This was a great approach for the harder problems since it gave a foundation for us, additionally the purpose of homework is to prepare for exams and practice concepts that we will be applying as engineers. Therefore, it is more important to know how to solve a problem than to waste too much time trying to figure it out with no progress. Personally, the way I learn better is by seeing an example then by repetition of other problems like it so this approach was great.”

As evidenced by student responses, the professor’s strategic decision to intentionally work step-by-step problems during class, greatly aided students’ understanding of theoretical concepts and their related applications. Moreover, this pedagogical technique helped address and mitigate several obstacles of remote learning and instruction.

Instructional and Pedagogical Supports (Question 3)

As mentioned in the previous section, the professor implemented several pedagogical and instructional strategies to respond to the new learning environment. This included the decision to reduce the number of homework assignments and removed a semester project without compromising academic standards. Based on student responses, this strategy was well received as indicated by the following open-ended comments:

“Most definitely! I think the homework problems were quite diverse in nature and were very thorough in asking us about multiple topics in one single question. I think the work we were assigned this semester was the perfect balance between learning in lecture and applying our knowledge in homework.”

“Yes, I thought the amount of work was adequate for a summer course, and I was still able to learn the material sufficiently.”

One student response illuminated the value of the aforementioned strategies in not only comprehending course material, but also afforded the opportunity to engage in personal research efforts.

“I know I learned the course material and I absolutely enjoyed the experience. It even led me to do my own research on topics that weren’t necessarily needed for the course, but I just found interesting as an aspiring mechanical engineer.”

As indicated by the results above, the intentional decision to decrease course workload by decreasing the number of assignments had a positive effect on overall student learning and comprehension. By emphasizing quality over quantity, students learned and mastered course-learning objectives. Additionally, by lowering course workload, students were empowered to allocate valuable study time to other areas of their coursework.

Instructional and Pedagogical Supports (Question 4)

Another pedagogical strategy implemented to proactively address challenges of remote instruction was to include a 24-hr window when taking exams. As indicated by the comments below, the inclusion of additional time greatly benefited students by mitigating some of the potential challenges associated with remote learning. Moreover, increased time helped to alleviate additional stress and anxiety.

“I really appreciated having the 24-hour window to complete the exams since it allowed me to take a break from the exam if I was stuck on a problem and come back to it later with fresh eyes. I also take long to work through problems because I doubt myself sometimes so I try to work out problems in different ways to see if I can get the same result using different methods.”

“It made the exams much easier, I’m not sure whether this is a good or bad thing. One of the challenges of many exams is that you know the materials/methods, it’s just a matter of accessing your memory quick enough to remember the appropriate tools to solve the problem. Having a longer test time resolves this constraint.”

“This change was extremely helpful, I very much appreciated the ability to take a step back and think through problems over the course of a full day, and to look at tricky problems with fresh eyes. I also appreciated the increased flexibility given other summer commitments such as travel.”

“I enjoy a larger time span, not only for comfortability but because it allows me to check my work as thoroughly as possible. This is essential as an engineer because I assume that in industry, it is far more important to produce quality work than fast work.”

Based on the responses collected, increased time to complete exams was appreciated and welcomed by the students. This enabled students to carefully navigate through this new learning format. Thus, the pedagogical supports implemented by the professor proactively addressed challenges associated with remote instruction and learning.

Overall Experience (Question 5)

The final question posed to students participating in the study was to gain insight into their overall summer course learning experience. Student responses indicated positive experiences despite the logistical and pedagogical challenges posed by remote instruction. The following statements illustrate students’ overall course experiences:

“I really loved it!! I'm so glad I decided to take the course this summer...I felt like I learned a lot despite the fast-pace of the course.”

“I enjoyed the course, it made me eager to learn more about mechanics of materials later in the mechanical engineering curriculum.”

“Excellent! The class seemed useful in the long term, was clear and easy to retain knowledge. There are some inherent limitations to online classes, such as Zoom fatigue, which did get to me near the end, but the instructor kept it fun and engaging so it wasn't so bad in that regard.”

“I had a great experience in the course this summer. It was my first mechanical engineering course and it helped solidify my interest in this career path. The lectures were easy to understand, the assignments were relevant to the topics covered in class and helped develop my knowledge of statics, and office hours were always there for if I had a question about something regarding the course.”

“Overall, I enjoyed the class more than I expected. This class allowed me spend more time on statics topics and assure that I have a strong foundation with this subject in the future as an aspiring mechanical engineer.”

As indicated by the responses above, the pedagogical and instructional approaches modified in the CIRE model applied for the fast-paced summer course afforded students the opportunity to effectively engage and effectively learn course material.

V. CONCLUSION

The outbreak of the coronavirus threw institutions of learning into a state of confusion and disarray by completely upending traditional learning contexts and environments. Most institutions

responded by canceling in-person classes and shifting to remote instruction. This new, uncharted landscape required both educators and students to engage differently and consider novel approaches to respond effectively to the different learning environment. As such, the COVID-19 pandemic challenged educators reimagine, reassess, and reconfigure their courses and develop strategies to meet course objectives and student needs.

For this study, two of the four pedagogical strategies developed in the CIRE model were modified to generate an effective framework for a virtual, fast-paced [six-week] summer engineering course in a private university in Texas. Particularly, the *Initiation* (Strategy 1) and *Extension* (Strategy 2) components of the CIRE model were modified to adapt to the fast-paced structure of the course and allow students to enhance their academic preparation despite the virtual setting. Findings indicated that students were highly satisfied with the implementation and modification of these practical strategies. Collectively, the modified CIRE pedagogical framework served as an academic support to address both instructional and socioemotional challenges that many students encountered during the shift to remote instruction. As such, this study and its findings add to nascent research exploring rapid responses by faculty to address issues associated with remote instruction and document effective instructional practices. It further stems from the overall research objective of the authors which is to increase retention rates in engineering education, enhance academic preparation, and to increase the number of minorities in STEM fields and graduate school. These research objectives are believed to be attained by identifying, designing, and implementing effective pedagogical methods that will enhance student engagement, comprehension, and scholarship abilities.

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