Adapting Pedagogy in the Pandemic Environment: A Work-in-Progress Analysis of the Impact of Remote Learning in an Architectural Engineering Technology Program

Mr. Eugene Kwak, State University of New York, College of Technology at Farmingdale

Architect, LEED AP, urban designer, passive house designer; as a student at Columbia, earned the Lucille Smyser Lowenfish Memorial Prize; running research and grant-based projects; working for Cookfox Architects and Dattner Architects, focused on technology-based green and sustainable work including 150 Charles St. and New Housing New York Legacy Project; his entry for the Intersection: Grand Concourse 100 and Reinventing Grand Army Plaza Competition was selected to be included in a public exhibition; taught architectural design studios, urban design seminar, and various workshops at Parsons The New School (SDS and SCE), Pratt Institute (Interior Design) and New York Institute of Technology (MAURD). Received B.Arch. from Carnegie Mellon University; and M.S. Architecture and Urban Design from Columbia University.

Adapting Pedagogy in the Pandemic Environment: A Work-in-Progress Analysis of the Impact of Remote Learning in an Architectural Engineering Technology Program

Abstract

During the unprecedented COVID-19 pandemic crisis, classrooms across the globe have abruptly pivoted to virtual learning strategies. This change has posed many challenges with both the pedagogical methodology for instructors and the learning environment for students. Moreover, this transition has prompted the emergence of new virtual instructional techniques. Due to the extenuating circumstance of the pandemic, the author's institution introduced a wide range of virtual teaching modes while holding a limited number of face-to-face classes. Among these courses, Introduction to Graphics is considered to be a critical course that requires in-person learning strategies, as it includes manual drafting with hands-on exercises. In the Fall 2020 semester, the author had a unique opportunity for a comparative analysis with two concurrent graphics course sections: a section that used traditional face-to-face teaching and a section that adopted live-stream remote instruction. This work-in-progress paper will compare the two groups' performances in the Introduction to Graphics course, which shared identical course content. A spatial reasoning test was used to provide quantitative results for the control and test groups. Also, the performance indicator outlined by the department and accreditation body [1] was used for the assessment data. This paper defines various remote teaching methods and evaluates their effectiveness, comparing them to active learning strategies. As graphics courses are common in Architectural Engineering Technology programs, this paper strives to contribute to the wider body of knowledge about the effectiveness of various teaching methods.

Introduction

At the author's institution, Farmingdale State College, State University of New York, the Department of Architecture and Construction Management is comprised of three programs: Architectural Engineering Technology, Construction Management Technology, and the newly added Civil Engineering Technology. Each program is defined by a distinct program-specific curriculum that emphasizes the topical contents of its discipline. Students gain technical expertise while taking the core-curricular classes, which are mostly upper-level courses. Before enrolling in their core courses, freshman across all three programs take mandatory foundation-level courses. Among these common introductory courses, Introduction to Graphics is considered to be essential for students to build a fundamental skill set for the architectural industry. It is critical for students to acquire the basic proficiencies of graphic representation to communicate their design ideas. While the graphics course focuses on drafting skills, it shares many lesson materials with other technical courses such as Materials and Methods of Construction. For example, students' drafting exercises are based on a construction detail drawing as shown in Figures 1.1 and 1.2. The figures illustrate examples of construction details in orthographic projections and axonometric drawings. Concurrently, the same detail drawing is used in the technical course to explain the building construction process and assembly. These intertwining lessons help students gain skills to visualize, understand, represent, and synthesize [2]

Figure 1.1

Figure 1.2

The graphics course begins with a visual representation of two-dimensional (2D) orthographic drafting which is coupled with three-dimensional (3D) axonometric drawings. Even with numerous drawing exercises, many freshman students struggle with 3D interpretation and representation. Therefore, the graphics course implemented hands-on exercises with physical models to help with 3D comprehension. This work-in-progress paper compares the effectiveness of a hands-on learning experience in an in-person learning environment with a remote learning environment. Performance on the exam, in-class exercises, and assignments were used as a form of measurement. In addition, this research adopted a spatial reasoning test to examine students' abilities to interpret 3D forms and to compare the effects of the two teaching modes.

Background

The COVID-19 pandemic crisis created the need for drastic changes in the teaching environment; more than 1.2 billion learners in 186 countries were affected by the pandemic [3]. The author's institution swiftly pivoted to a remote teaching mode during the Spring 2020 semester. This abrupt shift was unexpected by all and online learning became the only option for the institution. Many students made their best effort to learn in this less than ideal learning environment, having no other alternatives. As the pandemic was expected to continue affecting the learning environment in the Fall 2020 semester, many remote teaching methodologies quickly emerged. The disadvantages of distance learning were being addressed with new remote equipment and technologies. Farmingdale State College SUNY hosted many training events, workshops, and round table discussions to support successful online teaching. The sessions mainly focused on effective online teaching techniques and increasing student engagement. Strategies included organizing breakout sessions to promote discussions in a private environment, utilizing a web-based messaging platform to exchange ideas, and working collaboratively with interactive virtual media which aligns with active learning strategies [4]. Meanwhile, many round table discussions focused on the advantages and disadvantages of distance learning, including a radical idea of permanently replacing certain in-person classes with a remote teaching mode. Online teaching has been perceived as a temporary response to the global health crisis but it warrants careful assessment and consideration as a viable teaching

method for the next generation of students. The author's institution deployed diverse modes of instruction for the Fall 2020 semester, including asynchronous, synchronous, hybrid, live stream, and in-person courses. Table 1.1 shows the definitions of the various instruction types, as stated by the institution [5]

Instruction Type	Definition
Distance Learning "Online" Course	This course would be one that is considered a traditional FSC approved distance learning course.
Remote Learning course	This course would be a synchronously offered course that would adhere to the days/ times listed in the fall schedule. Instructors would be required to attend a basic orientation/training session to become familiar with the remote learning tools available for use.
Live Streaming	This course would be taught on campus during the regularly scheduled days and times. Students in the course would be able to attend the class on assigned days to help maintain social distancing with the remaining students accessing the course remotely through a live stream.
Hybrid/flex Restricted to: laboratories, clinicals, studio courses & existing hybrid courses	Using an A/B schedule, students would be assigned days to attend in-person sessions to maintain social distancing with simulation type experiences scheduled via remote learning for students not present on campus that day. Face to face time for the 15 week semester would equal 7 sessions per student.
Larger remote learning lecture courses with smaller on campus recitations	This type of course would assist with in-person applied learning group work / projects. Social distancing would need to be maintained and the course days and times would need to be adhered to for on campus activities. Remote lecture component could be asynchronously offered.
No Change Necessary	Course is already offered in online format; independent studies; internships
Other	For unique situations; please describe in "Comments" column

Table 1.1

The author was assigned to teach two sections of the foundation graphics course, Introduction to Graphics. This is a mandatory prerequisite course for freshmen students before enrolling in core classes, including the Architectural Design I and Construction Design courses. The two sections of the graphics course were offered to students with two distinct modes of instruction and with two different class schedules. One section was offered as an in-person course once a week. The other section was offered twice a week, one day with live-stream mode and the other day with a fully remote synchronous mode. The live-stream mode class was taught on campus with streaming equipment to broadcast the live sessions to the students who joined the class remotely. For this mode, 7 out of 13 students, attended in-person to maintain social distancing and the remainder attended the session through an online platform. The two distinct sections provided a unique opportunity for the author to compare the different instructional types and their impact on student learning.

Learning environment

The in-person section was set up in two different classrooms. A standard lecture classroom was assigned for manual drafting lessons and a computer lab was used for the digital drafting lessons with AutoCAD and Revit. Both spaces required lower capacity for proper social distancing. The enrollment of the sections was limited to 14 students which is lower than the standard capacity of 30 students. The department launched more sections to reduce class sizes to accommodate the low-capacity requirement.

For the live-streaming mode, the section was assigned to the upgraded Technology Enhanced Classroom which includes additional technical equipment such as a teaching station webcam and document camera linked to the projector, as shown in Figures 2.1 through 2.3.

Figure 2.1

Figure 2.2

Figure 2.3

All instructors are required to complete a mandatory training session for the Learning Management Systems (LMS) for asynchronous and synchronous teaching. LMS allows the instructors to post course content, including the syllabus, exams, and assignments. Also, the video conferencing tool is embedded in the LMS and it is similar to popular conferencing tools such as Zoom, Google Meet, and MS Teams. The Distance Learning and Information Technology Department provides computing and communication support for the courses through webpages, recordings, and live virtual sessions. Another resource for the students is virtual computing with Virtual Desktop Infrastructure (VDI) which allows the students to access school computers from home. This supports students in need of a high-performance personal computer and those in need of the drafting software.

Course background

The graphics course covers a wide range of topics including manual hand drawing/drafting, Computer-Aided Drafting (CAD), and Building Information Modeling (BIM). The following is the catalog description of the Introduction to Graphics course:

Introduction to architectural and construction graphics using hand drawing/drafting and Computer Aided Drafting (CAD). Hand drawing/drafting topics include: lettering, technical sketching, use of drafting instruments, the fundamentals of orthographic projection, plan, section, elevation development and pictorial drawings to develop the student's abilities to visualize and describe objects graphically. CAD topics include software commands and drawing strategies for 2-D and 3-D CAD work, plans, sections, elevations, and details, information management, assembly of drawings and scales. Note: This course includes a required laboratory designed to provide extra time for the studio experience. Credits: 4

The two sections shared the same lesson content but the main difference was with the hands-on learning exercise. The author believes the fundamental knowledge of orthographic and axonometric can be acquired with hands-on building exercises with the colored modular wooden blocks. This learning strategy [6] has been implemented in the graphics course by the author for many years. For the axonometric drawing lesson, the instructor distributes 10-15 pieces to each team of 3 people who will assemble a wooden structure of their design, as exhibited in Figures 3.1 through 3.3. Then the teams will translate the figures into manual hand drafting of orthographic projections and isometric drawings. Students are also required to draft the structure in AutoCAD with assigned color layers.

Figure 3.1

Figure 3.2

Figure 3.3

Comparison of the wooden block exercise

The main difference between the two sections with this exercise is the experience of the student. The in-person learning environment allowed the students to interact with teammates while maintaining proper social distancing. The student teams experimented with various combinations and this process encouraged them to find an ideal design. Each block was measured, analyzed, documented, and shared by the team members. These exercises focus on kinesthetic learning [7] which allows the students to have a tactile experience with the 3-dimensional form. This experience also helps students to visualize and internalize the 3D volume before drafting.

While the in-person section maximized the experiential learning, the live stream section relied on a digital platform for students to learn the course content. In the live stream course, 6 out of 13 students regularly accessed the course through the online remote platform. They participated virtually in the wooden block exercise and they were paired with students on campus to form a team of 2 people. This team structure is suggested to have at least one member participate in-person, avoiding the advantage of any one group having an all in-person team. The team built the wooden block structure relying on a single team member being present on campus. The teams communicated through the discussion board in the institution's LMS and mobile group messaging applications such as GroupMe, Discord, and WhatsApp. The advantage of the mobile applications is the convenience of registering team members with only their user IDs, without their phone numbers. Most students used the phone app instead of the computer for communicating with the group. Once the structure was finalized, the student on campus documented and shared the photo with the teammate who was attending remotely. After, the teams produced drawings similar to Figures 3.4 and 3.5.

Figure 3.4 orthographic and isometric CAD drawing of the wooden block exercise

Figure 3.5 hand-drafted isometric drawing of the wooden block exercise

Results

	In-person section	Live-stream section
Number of Students	14	13
Wooden block exercise- average score for manual drafting	74.1	70.6
Wooden block exercise- average score for CAD	80.1	85.0
Mid-term exam average score	88.9	79.7
Semester grade average score	74.1	70.6
Percent of students who met ABET performance indicator target	86	77
Spatial reasoning test average score	64	58

Table 2.1

Analysis of the results

The wooden block exercise

The quantitative results for the two instructional types, the in-person and live-stream mode for the wooden block exercise are shown in the above Table 2.1. This is the score based on the evaluation of the quality of the drawings. The sample size is small which makes the analysis difficult to quantify and have meaningful determination. The results can be interpreted with the assumption that the higher average score for the manual hand drafting for the in-person section resulted from the tactile experience with the wooden blocks. The group work encouraged cooperative learning [8] with team members and formulated design exploration that has much influence on the 3-dimensional understanding. The hands-on learning of manual drafting with drafting equipment such as T-square, tracing paper, triangles, and lead pencil relates to the cognitive preparation for the 3-dimensional translation. Contrary to this assumption, the live-stream instructional mode resulted in a higher average score for CAD with the wooden block exercise. The assumption can be made that the higher scores resulted from the electronic documentation process and digital workflow which fostered an ideal setting for the drawing translation. Communication and digitization were an integral part of the design process and that presented an advantage for the students to get a head start. Also, the live-stream setting forced students to use their own computer immediately for CAD which prepared the students to gain the familiarity of their computer.

Mid-term exam

The hand drafting mid-term examination used a question regarding an orthographic projection and isometric interpretation. The following Figure 3.6 shows the 3D form, similar to the wooden block structure, used for this exam. The instruction of the exam is described below.

Hand draft the following drawings in $\frac{3}{32}'' = 1'-0''$ scale using the below image (Dimensions are in feet and they are for reference only). Scan the drafted drawings and upload a PDF file on Blackboard.

- All four orthographic views (Front, left, right, back)
- Two additional isometric views of the sides (Indicated with arrows in the top view)

Figure 3.6

Assessment of the mid-term exam

The hand drafting mid-term exam can be an apt measurement to evaluate the effectiveness of the wooden block exercise with the two different instructional methods. The Table 2.1 shows the average score of the mid-term exam. These quantitative data illustrate the better performance of the students in the in-person learning mode. Collection of data and bigger sample size is needed to further evaluate the significance of this determination. However, the consistent result with the better performance in the block exercise and the mid-term exam for the in-person section leads to a reasonable assumption that a hands-on learning methodology can support more effective learning, particularly with manual drafting.

Final semester evaluation

The overall semester grade can serve as a resource to evaluate two different instructional methods. The result of the assessment is exhibited in Table 2.1. The semester score includes diverse evaluation categories with the following grade distribution.

- 10% Class Participation
- 15% Mid-Exam (Hand drafting, and CAD)
- 25% Final Exam (Hand drafting and BIM)
- 50% Projects, assignments, and in-class exercises

Although the wooden block exercise is a portion of the many lesson topics in the semester and no evidence directly links it to the overall performance, the author believes the hands-on learning exercise coupled with the in-person learning environment had a positive impact on student performance. The evaluation of the semester grade can be a testament to the effectiveness of the in-person method.

Student Outcomes assessment for ABET

Annual assessments will be performed to continue to evaluate the Student Outcomes for ABET. The Introduction to Graphics course is included in the following category, as shown in Table 2.2

College Strategic Goals & Objectives*	Program Educational Objectives	Student Outcomes	Program Courses Assessed
Goal 1: Be recognized as a center of excellence in teaching and applied learning			

Objective 1: Create a distinctive identity in preparing students as highly qualified professionals through expanding mentoring, research, service, and experiential learning	Graduates will have broad background in one or more areas of design: architectural, construction, site and structural in addition to history, theory and technology. Graduates will assume professional positions in architectural and building construction industry.	SO1. An ability to apply knowledge, techniques, skills, and modern tools of mathematics, science, engineering, or technology to solve broadly-defined engineering problems	Introduction to Graphics
---	---	---	--------------------------

Table 2.2 Annual Assessment

The assessment value of Student Outcomes for the two sections of the graphics course is shown in above table 2.1. The assessment data shows that the target has been met which is 70% of students score 70 or above. Although it is difficult to validate the direct correlation of the wooden block exercise to the BIM skillset, this result consistently aligns with the mid-term exam and the final semester evaluations in which the in-person section outperformed the live-stream section.

Post semester assessment - Spatial Reasoning Test

To further evaluate the comparison of the two different instructional modes, the students were asked to complete a spatial reasoning test. [9] Below Figure 3.7 shows a sample question from the test. This test can be directly linked to the block exercise, determining students' abilities to comprehend 3D volume.

1.

Which cube cannot be made based on the unfolded cube?

Figure 3.7

The quantitative data are shown in above table 2.1. The spatial reasoning test can serve as a helpful instrument to evaluate students' 3-dimensional understanding. The drafting exercises alone can lead to better performance on this test, as the drafting requires the person to visualize all sides of the form. However, the tactile experience with a physical model with students being prompted with the multi-sensory engagement leads to an improved learning outcome. The result of the spatial reasoning test supports the benefit of the in-person mode and hands-on exercises.

Conclusion

The learning environment has changed significantly due to the global health crisis, and this change has catalyzed various remote teaching methods. This emerging pedagogy calls for a comparison of the traditional in-person teaching mode with the remote teaching mode. In addition, a comparative study can evaluate the advantages of remote technology and distance learning techniques. Although this work-in-progress paper cannot determine a statistically significant result, due to the small sample size, the consistent results throughout the assessment can serve as a guide to the next step of collecting more data for future assessments.

References

- [1] ABET, *ACCREDITATION POLICY AND PROCEDURE MANUAL*, Baltimore: ABET.
- [2] B. Bloom, *Taxonomy of Educational Objectives: The Classification of Educational Goals*, New York: David McKay Company, 1956.
- [3] UNESCO, "Education: From disruption to recovery," UNESCO, 2021. [Online]. Available: <https://en.unesco.org/covid19/educationresponse>. [Accessed 2021].
- [4] D. W. Johnson and R. T. Johnson, *Active Learning: Cooperation in the College Classroom*, MN: Interaction Book Company, 1998.
- [5] S. Farmingdale State College, *Proposed mode of instruction*, Farmingdale: Farmingdale State College, State University of New York, 2020.
- [6] R. F. a. R. Brent, "Learning by Doing," *Chemical Engineering Education*, vol. 37, no. 4, pp. 282-283, 2003.
- [7] J. V. TRANQUILLO, "KINESTHETIC LEARNING IN THE CLASSROOM," in *ASEE*, Pittsburgh, 2008.
- [8] R. F. a. R. Brent, "Cooperative Learning," in *ACS Symposium Series*, Washington DC, 2007.
- [9] 1. test, "Spatial reasoning test," 123 test, [Online]. Available: <https://www.123test.com/spatial-reasoning-test/>.