An Approach to Transitioning an In-Person Software Engineering Class to an Online Live Class using Institution Guidelines

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Abstract

The advances in video conferencing technology and the experiences gained during the COVID-19 pandemic have led many institutions of higher education (IHEs) to transition to online, live (synchronous) classes. This transition at some IHEs involves a well-defined protocol to address poor learning experiences among students taking online live classes during the pandemic.

In this paper, we report on experiences at a large urban university during the transition of a software engineering class from in-person to an online live modality. The protocol at the IHE involved (1) faculty completing an online live faculty professional development workshop, (2) working with an instructional designer to develop the course content that adheres to institution guidelines, including accessibility requirements, and (3) preparing the course for Quality Matters certification. As a result of the protocol followed by the faculty teaching the software engineering class, the course was recently QM-Certified.

To evaluate the impact of the transition protocol, we compared results across in-person and online live class modalities using multiple data points. These data points include class attendance and course learning outcomes. The results show that there is no statistically significant difference in attendance rates between the two modalities. However, there were statistically significant positive changes in learning outcomes reflected in an exam and a semester-long project for the online live class compared to the in-person class.

Keywords: active learning, online synchronous learning, instructional design, course certification

1 Introduction

During the fall of 2019, before the COVID-19 pandemic became a reality, the primary instructional modalities were in-person (face-to-face), hybrid (blended), or fully online (asynchronous). During the pandemic, there was a rapid shift to online synchronous classes at institutions of higher education (IHEs). It is estimated that over 1,102 IHEs and about 14 million students were affected by the closures during the coronavirus pandemic [1]. Cortés-Albornoz et al. [2] in their systematic review found that academic performance was impacted negatively during the pandemic as reflected in various assessment measures. Many factors contributed to the negative performance, including educational, motivational, and socio-emotional factors [2, 3]. Some studies did not find clear evidence that the pandemic caused knowledge deficiencies [4]. Most studies found that the pandemic impacted the pedagogical approaches used in online learning environments [2, 4, 3].

Several studies have been conducted to determine the effectiveness of different instructional modalities used at IHEs, and there is no definitive answer on which modality produces the best student learning outcomes [5, 6, 7]. Instructors' and students' preferences for different instructional modalities are based on various factors. Students favor online synchronous instruction for its potential to support social interaction and the psychological needs identified by self-determination theory [8]. While instructors perceived fewer differences between the different modalities of instruction, especially regarding feedback activities [8].

In this paper, we report our experiences transitioning an in-person software engineering class to an online live (synchronous) class in accordance with institutional guidelines at a large urban IHE, *Florida International University*. These guidelines involved (1) faculty completing an online live faculty professional development workshop, (2) working with an instructional designer to develop the course content that adheres to institution guidelines, including accessibility requirements, and (3) preparing the course for Quality Matters certification [9]. These stages emphasize intentional instructional design practices that align objectives, assessments, and activities, ensuring the course maintains accessibility, innovation, and engagement comparable to the in-person modality. We describe these activities in detail, providing an in-depth perspective on the context and the oversight that ensure the high quality of the online live course. We also describe how the various active learning approaches used in the in-person classes were implemented in the online live classes.

We provide details of the course structure and the assessment methods used to evaluate the students' performance. We assessed student performance in the software engineering course by comparing the in-person and online live class modalities using multiple data points. These data points include (1) the artifacts created during the course, including a project consisting of three deliverables and two presentations, and three exams – two midterm exams and one final exam; and (2) the student attendance in class. We hypothesize that students in online live classes outperform those in in-person classes due to greater flexibility in accessing class materials, including recordings of the online live classes. Finally, we reflect on the experiences of transitioning the course from the in-person to the online live modality.

The remainder of the paper is structured as follows. Section 2 presents a literature review, Section 3 describes the IHE guidelines used to ensure the quality of instruction, and Section 4 details the software engineering course. Section 5 describes the evaluation of the modalities, Section 6 presents the lessons learned, and we conclude in Section 7.

2 Literature Review

In this section, we provide background on the terminology used throughout the paper and the work related to the approach described.

2.1 Background

We define the different modalities used in classes based on the work by Klinger et al. [10].

- *In-person* - also referred to as *face-to-face*, is where the instructor is physically in the classroom with students in real time.
- *Online* - also referred to as *distance learning*, is where there is a physical distance between the instructor and students during instruction. Students primarily use the internet to access the class and complete the required activities. The entire class is taught using a Learning Management System (LMS) or a Course Management System (CMS).
  - *Asynchronous* - students can participate in the course on the days/times that are most convenient to them based on the parameters provided by the instructor.

  - *Synchronous* - this is where the online course exists in the LMS or CMS, and there is an online synchronous time when the class meets the instructor using the appropriate technology, e.g., Zoom. The time is usually equivalent to that of the synchronous in-person classes.
  - *Online Live* - is an intentionally designed instructional format in which approximately 50% of course engagement occurs asynchronously within the learning management system and 50% occurs synchronously through structured, real-time virtual sessions, aligning course objectives, activities, and assessments across both environments.

- *Hybrid* - this is when learning is both online and asynchronous as well as in-person and synchronous. Attempts to combine “the best of both worlds”. A variant of hybrid is *blended*, where the classroom environment and community are extended beyond the walls of the traditional classroom.

In the software engineering course described in the paper, we use active learning approaches that have been shown to improve student learning and engagement outcomes [11, 12, 13]. The active learning approaches used in the course are *Collaborative Learning*, *Gamification*, *Problem-based Learning*, and *Social Interaction*. Collaborative learning occurs when two or more people work together, mutually seeking understanding, solutions, or meanings, or creating a product [14]. Gamification uses game design elements and game mechanics to improve students’ experience and engagement with a system to enhance learning [15]. Problem-based learning in our context allows students to solve problems in small groups under the guidance of an instructor [16]. Social Interaction enhances knowledge acquisition by interacting with students in the learning environment [17].

2.2 Related Work

Fabriz et al. [8] conducted a study that explored whether synchronous or asynchronous teaching and learning setting was associated with certain student learning experiences and outcomes. The study was conducted with 3,056 students and 396 teachers in a large German university. Students who studied mostly in synchronous settings reported more peer-centered activities when compared to students in mostly asynchronous settings. These peer-centered activities include group work or video discussions, which inherently support the social interaction of students. The asynchronous environments were more content-oriented, which facilitated student interaction with the learning materials. On the other hand, teachers perceived fewer differences between the teaching methods in synchronous and asynchronous settings. The authors explain this difference as teachers unintentionally providing feedback without the activity being planned in synchronous settings. Overall, satisfaction rates in synchronous settings were higher than in asynchronous settings, mainly due to social interaction.

Larson et al. [18] performed a study that explores how various modes of instruction impact student achievement and compares students’ stated modality preference with their attendance behavior. The study was conducted with 1059 students in a business course in Fall 2021, where the students were allowed to register using a Hy-Flex course modality: 1-day asynchronous online work, and a 1-day option attending live remote synchronous via Zoom or in-person. The student registrations for the synchronous section were in-person (720) and synchronous live remote (339). The results showed that student behavior aligned with their stated modality preference 74% of the time. Only

47% of those who indicated they preferred in-person instruction attended class in person. Students who attended class using a mixed modality or in person achieved slightly better results than those who attended class live online. The study concluded that providing modality options benefits students, alleviating anxiety and stress, and allowing them to regulate their learning based on individual needs.

Faulconer et al. [19] describe a study that compares the failure rate, grade distribution, and withdrawal rates in an introductory undergraduate Physics course across several learning modes, including traditional face-to-face instruction, synchronous video instruction, and online classes. There were two modes of synchronous video instruction: (1) faculty and students were at home and met once a week, and (2) students used multiple classrooms on campus virtually linked together. The study included aggregate data from 1964 students, mined from the university information system. The results showed that students who took the online version of the class had a significantly lower failure rate than students who took the class via synchronous video classroom. Students who took the in-person class had the highest failure rate (9%). However, the pair-wise comparison yielded no statistically significant differences. Students' withdrawal rates were lowest for those who took the class in person (in-person classroom and synchronous classroom) than for those who took it online (3.65%).

Maxim et al. [20] described their experiences introducing active learning methodologies into a junior level online software engineering course. The authors described various aspects of the course, including: (1) the active learning approaches used in the course and how they were implemented using problem-based learning (PBL), and (2) the course structure, including the delivery mode and course activities. The evaluation of the approach included two instances of the course, in-person (N=40) and online (N=41), and used three data sources from the course management system and course evaluations. The results showed that, for the most part, the course evaluations were similar, except for a significant difference in the typical workload of the course compared to other courses: in-person (4.71/5.0) and online (4.11/5.0). The students found that the projects were the greatest strength of the course. The engagement measures for both classes were similar; the only significant difference was that online students felt more engaged in the class. This finding was a function of the structure of the lectures, which were recorded for the online class, so their meeting times were used for class activities.

The complexities of instructional modalities and their influence on student success depend on many factors. This tenet is described in Paulik's commentary [6] that examines the psychological underpinnings of effective learning, emphasizing the role of motivation, self-regulation, and cognitive strategies through the lens of Achievement Goal Theory (AGT) [21] and Expectancy-Value theory (EVT) [22]. Khan et al. [23] state that student engagement is key to successful teaching and learning, irrespective of the content and modality used in the learning environment. The authors describe how active learning pedagogies and new technologies can be incorporated into online classes to improve student engagement. The work by Clarke et al. [24] describes how learning and engagement strategies, including collaborative learning, gamification, problem-based learning, and social interaction, are integrated into face-to-face and online classes.

The transition of in-person classes to online classes presents several challenges that should be addressed to ensure the quality of instruction. These challenges include academic integrity, hands-on learning, and interactive collaboration on team projects. Motogna et al. [25] state that the transition to online learning has led instructors to change their evaluation methodologies. There is a transition from in-class oral presentations and in-class exams to more project-related evaluations. Instructors reported that whether or not they made the transition, their effort in student learning assessment has increased. Academic integrity is a challenge that is becoming increasingly prominent among students and academic staff, and among students themselves, with the transition to online learning [26]. This challenge has resulted in online proctoring tools being used during online exams and quizzes. As stated in the previous paragraphs, more attention needs to be paid to project-based and collaborative learning in an online environment [27, 28, 24].

3 Institutional Guidelines and Requirements for Online Live Courses

In this section, we present the guidelines and requirements for offering online live courses at Florida International University (FIU). All instructors who planned to teach online live courses are required to do professional development in a semester prior to teaching the class. During the first semester teaching the online live class an instructional designer is assigned to work with the instructor until the course becomes certified by Quality Matters [9] or an internal certification given by FIU [29]

3.1 Instructor Professional Development (PD)

The content of the syllabus for the required online live course for all instructors is shown in Table 1. The syllabus includes *Course Description*, *Course Objectives*, *Assignments*, and *Grading Scheme*. The learning content is centered on a 3-pronged framework that ensures the courses built are effectively using all the tools available for online instruction and provide an enhanced, personal, and engaging experience for learners. The 3 pillars cover how to increase student engagement synchronously online by leveraging the tools already used asynchronously. The 3 pillars are as follows.

- *Equitable Instruction* provides a level of awareness into the course development that promotes accessible and affordable experience while also encouraging students to become engaged stakeholders in their learning journey in an online competency-led flexible learning environment [30, 31].
- *Immersive Communication* strives to promote the intentional integration of technology in Online LIVE to reduce technological frustrations and create a more natural experience for students, leading to meaningful exchanges and interactive, collaborative opportunities.
- *Adaptive Engagement* creates opportunities for online, real-time, interactive dialogue, increasing reflection, promoting authentic exchanges, applying concepts, and deepening understanding of course objectives, creating a vested learning environment [32].

3.2 Instructional Designer Support

After instructors complete the professional development course and are assigned an online section of a course, they are assigned an Instructional Designer (ID) to assist in developing the course. The instructional designers are staff in the FIU Online Division who are trained in pedagogical best practices in online education. These best practices include: creating effective syllabi for online courses; aligning course objectives, assessments, and activities [33, 34, 35]; and ensuring the accessibility of web pages and other course materials for online courses [36, 37]. The ID works closely with the instructor to develop the course until it is certified by Quality Matters (QM) [9]

Table 1: Partial syllabus for the online live professional development course.

Course Description:
This course covers pedagogical learning strategies for fully online courses as well as the educational technology tools instructors can use to support active learning in their courses and maintain student engagement.
Course Objectives:
1. Identify educational technology tools and how they are used to create an environment for online active learning and enhance content retention. 2. Evaluate synchronous and asynchronous andragogical and pedagogical learning strategies as they pertain to online learning. 3. Apply educational technology tools and the learning strategies discussed in your online course that coincide with the three pillars of the online educational experience. 4. Create a course development and design plan for an online course.
Assignments:
• All assignments will be graded as Complete/Incomplete. • You have 6 weeks to complete and submit all deliverables. *3 Pillars Quiz* This quiz will cover the 3 Pillars of Online Live; Equitable Instruction, Immersive Communication, and Adaptive Engagement. You **must** score 100% (15/15 points) on this quiz to unlock the remaining content in the course. You have unlimited attempts. *Course Map* The purpose of a Course Map is to ensure that as an instructor you are intentional with the resources you are providing your learners and what you expect them to accomplish by the end of the course. This is one of the first steps to complete when designing your course. Once you've laid out the foundation, you can then proceed to build out the content and design in the Learning Management system (LMS), and work on your syllabus *Deliverables:* 1. Assignment 1 - Writing and Aligning Course and Module Objectives 2. Assignment 2 - Identifying Asynchronous Activities, Instructional Materials, and Aligning them to Objectives 3. Assignment 3 - Identifying Synchronous Activities, Instructional Materials, and Aligning them to Objectives *Online Live Reflection* Reflecting on the 3 pillars of Online Live (Equitable Instruction, Immersive Communication, and Adaptive Engagement), construct syllabus verbiage that outlines student and instructor expectations for an Online Live course *Online Live Zoom Meeting* You are expected to participate in three (3) Zoom Meetings during the span of this course.
Grading Scheme:
1. Course Map, 1 item, 100 points 2. Online Live Reflection, 1 item, 100 points 3. Online Live Zoom Meetings, 3 items, 300 points

and by FIU Online for internal certification. In this paper, we will focus on QM certification, as the software engineering course described in this paper recently received QM certification.

To achieve QM certification for a course, an institution must follow the QM course review process, guided by the QM rubric [9]. The QM process is designed to help institutions achieve their quality assurance goals for online learning. The QM process addresses all aspects of online education, including course design, course delivery, course content, institutional infrastructure, learning management system(LMS), faculty readiness, and learner readiness. By using the QM rubric, an institution prepares a course for official course review. After the institution submits a course for official review, an official review team is formed, usually consisting of a master reviewer (team chair) and two QM-certified peer reviewers - one is a subject matter expert, and the other is external to the institution submitting the course for review. After the peer review, guided by the rubric, is complete, the team provides feedback on how to improve the course to meet QM standards at the 85% quality level or better.

Before the start of the semester in which the online live course will be taught, the ID meets with the instructor to prepare the course syllabus. Preparing the syllabus involves defining the course learning objectives, selecting the types of assessments to evaluate them, and creating the course activities, including the learning modules. After making the syllabus content for the online live course, a course alignment map is created that identifies the asynchronous and synchronous activities for each week of the semester, the course resources (sources and tools), and the deadlines for assessments (projects, assignments, quizzes, and exams). During the semester, the ID meets regularly with the instructor to create the course web pages, including modules and customized materials (slides, tutorials, etc.). The ID assists the instructor with ensuring that all the materials are accessible to all students [36, 37]. The ID follows the QM rubric and pedagogical best practices for online live courses throughout the semester to ensure the course is of high quality and ready for QM submission soon after the semester ends.

4 Online Live Software Engineering Course

In this section, we describe the online live version of the CEN4010 Software Engineering I course. This description includes the learning outcomes, course activities and materials, assessment, and a brief comparison with previous versions of the course. The CEN4010 course, taught by an author of this paper, recently obtained QM certification [9].

4.1 Learning Outcomes

The catalog description for the CEN4010 course is *software process model, software analysis and specification, software design, and testing*. The longer course description states that the course introduces students to software process models, including the traditional and agile software process models. The phases of the software process model include (1) software requirements elicitation and analysis, (2) system design and detailed design, (3) implementation of a design, and (4) validation and verification of each phase of the process. To support the software process, models will be created using the Unified Modeling Language (UML) [38]. Nine (9) student learning outcomes/objectives specify what students will know, be able to do, or demonstrate after completing the course. There are two prerequisite courses for CEN4010: (1) *Technology in Global Arena* - Legal, ethical, social impacts of computer technology on society, governance, and quality of life, and (2) *Programming II* - An intermediate level course in Object Oriented programming.

4.2 Course Assessment

The students are assessed based on one assignment and two quizzes (3%), two midterm examinations (15% each), a group project (45%), attendance and class participation (7%), and a final examination (15%). The assignment is used as an icebreaker for the class, where students are required to introduce themselves by posting an online profile on the Canvas discussion board [39] (the LMS used for the course). One quiz serves as an attestation of academic honesty, and the other covers how to use the quiz feature in Canvas. The two midterm exams cover the learning outcomes related to (1) software process model, requirements elicitation and analysis, and (2) systems design and detailed design. The final exam covers the learning outcomes on software process models, system design, and software testing. All exams are take-home and open for 12 hours, except the final exam, which is 2 hours. If students are granted a disability exemption, the exam time is doubled.

The project for the class used in this study, consists of three (3) deliverables: (1) Software Requirements deliverable - the software requirements document (SRD), an in-class presentation, and a UML [38] project with all diagrams to support requirements analysis; (2) Software Design deliverable - the software design document (SDD), and the updated UML project with all diagrams for system and detailed design; and (3) Final Software deliverable - the final system documentation (FSD) that includes the requirements model, design model, implementation model and test model, in-class presentation, and the updated UML project including all diagrams developed during the project. The UML diagrams created during the project include: requirement model - use case diagrams, sequence diagrams, and a class diagram; design model - package diagrams (architecture using at least two architecture patterns), deployment diagram, state machines, refined sequence diagrams, and class diagrams (using at least 3 design patterns). Student teams are assigned by the instructor, with a maximum of 8 students per team, depending on the class size.

Students may earn extra credit points for the midterm and final exams by answering questions in class (individually or as a team), completing a learning object assignment in SEP-CyLE (Software Engineering and Programming Cyberlearning Environment) [40], and completing class surveys collectively (the entire class is awarded extra credit if the completion rate is above a predefined percentage). The maximum allowable extra credit points for each exam is 10.

4.3 Course Activities and Materials

The CEN4010 class is held once a week for 75 minutes using Zoom. The course is divided into five modules, these include (1) course introduction and software process models (1 week); (2) introduction to UML, software requirements elicitation and analysis (5 weeks); (3) system design and detailed design (5 weeks), (4) implementation (1 week), and (5) software testing (4 weeks). Each module states its learning objectives, relates the module learning objectives to the course learning objectives, and describes the asynchronous and synchronous activities for the week. There is also a general alignment statement for each module's instructional materials.

The asynchronous activities for each week include the week's reading material, class recordings (tutorials on using design and development tools), a list of upcoming submissions (assignments, quizzes, project deliverables, and exams), and the week in which each submission is due. The synchronous activities state the attendance requirement, the activities to be done during the online synchronous class, and links to the course materials covered in class, including slides, examples, and the recorded class. The links to the course materials for the synchronous class are posted after the class.

5 Evaluation

We describe the evaluation performed between in-person and online versions of the software engineering course (CEN4010) in this section. We hypothesize that students in the online live version

Table 2: Sample of software engineering students used in the study.

Year	*Semester*	*Modality*	*No. Students*	*No. Teams*
2019	Fall	In-Person	18	4
2021	Fall	In-Person	26	5
2022	Fall	In-Person	42	6
2023	Fall	In-Person	20	4
2024	Spring	In-Person	34	6
2024	Fall	Online Live	53	8
2025	Spring	Online Live	52	8
2025	Summer	Online Live	33	6

of CEN4010 outperform students in the in-person classes due to their ability to attend class via a video conferencing platform and the flexibility to access the materials covered in class, including recordings of the online live classes. The specific research questions are as follows.

RQ1 Do students in the online live version of the class attend class at a higher rate than those in the in-person version?

RQ2 How do students in the online live version of the class perform with respect to learning outcomes as compared to those in the in-person version?

5.1 Study Design

In this section, we describe the following aspects of the quasi-experimental study used to investigate RQ1 and RQ2: sample used, data collection process, and the details of the design. The study was covered under the Institutional Review Board (IRB) approval, *IRB-23-0063-AM03*.

Sample: The sample was taken from students in one section of the CEN4010 Software Engineering I class at FIU over several semesters. Table 2 shows a summary of the sample used in the study. Columns from left to right for the software engineering course are year offered, semester offered, modality, number of students enrolled in the class, and number of teams assigned for the project. The in-person class was offered on Tuesdays and Thursdays, 6:25pm - 7:40pm in the fall and spring, and in the summer, 5:00pm - 6:35pm. The online live class was offered once a week on Tuesdays, 6:25pm - 7:40pm in the fall and spring, and in the summer 5:00pm - 6:35pm. The class was open to both full-time and part-time students.

Data Collection: The data collected for the study included the attendance recorded by the instructor (in-person) and using the Zoom platform (online live), the scores from the two midterm exams (Week 6 and Week 10), and the final score on the project. As previously mentioned, there are nine (9) learning outcomes for the course, the first midterm exam covered three of the learning objectives - software process, software process models, and requirements elicitation and analysis; and the second midterm exam covered one learning objective - software design (system design and detailed design). The software project consisted of three deliverables and covered all nine learning outcomes, including implementing the requirements and design, validating a software system, performing a system walk-through, creating system documentation, and working in a team.

Table 3: The mean, standard deviation, and median for the in-person and online-live classes.

Metric	*Modality*	*No. Students*	*Mean*	*Std Dev*	Median
Attendance	In-Person	140	79.5	20.1	85.2
	Online Live	138	78.9	23.5	85.7
Midterm Exam 1	In-Person	140	74.5	19.5	79.3
	Online Live	138	75.6	16.1	79.5
Midterm Exam 2	In-Person	140	67.6	21.7	72.5
	Online Live	138	72.0	19.9	75.5
Final Project Score	In-Person	140	74.9	14.6	76.9
	Online Live	138	80.4	7.6	81.9

Each midterm exam consisted of two sections, one for basic recall of concepts and the other for creating artifacts related to the software process. The artifacts for the first midterm included writing a scenario for a use case and creating an analysis model that included UML diagrams: use case, class, and sequence. The artifacts for the second midterm include the design model with UML diagrams: package (architecture), minimal class (no fields or operations), and a refined sequence with solution objects. The midterm exam for the in-person class was done during a class session for 75 minutes (pencil and paper). The online live class midterm exam was a take-home exam to be completed in 12 hours, and the submission (electronic) included the UML project, depending on the UML tool used. The data are collected from a total of 278 students ($N = 278$), with 140 from the in-person section ($N_{IP} = 140$) and 138 from the online live section ($N_{OL} = 138$).

Analysis: The data analysis will include creating standard descriptive statistics for each metric - attendance rates, midterm exam results, and the final software project final scores. The individual scores for each metric will be analyzed using either a parametric or nonparametric test to determine whether there are significant differences between the in-person and online live groups. We will perform a normality test to determine which statistical tool to use.

5.2 Results

There are two research questions (RQs) we answer based on the data analysis performed on the data collected for the in-person classes and the online live classes. Table 3 shows the means, standard deviations, and median for the metrics for each of the two groups (in-person and online live). The means for the two groups are pretty close for the metrics, *Attendance* ($M_{IP-ATT} = 79.5\%$ and $M_{OL-ATT} = 78.9\%$) and *Midterm Exam 1* ($M_{IP-ME1} = 74.7\%$ and ($M_{OL-ME1} = 75.6\%$). While the means are further apart for the *Midterm Exam 2* ($M_{IP-ME2} = 67.6\%$ and $M_{OL-ME2} = 72.0\%$) and the *Final Project Score* ($M_{IP-FPS} = 74.9\%$ and $M_{OL-FPS} = 80.4\%$). The median values for the metrics are shown in the rightmost column of Table 3.

Based on the mean scores for midterm exam 2 and the final project score, we decided to perform a more in-depth statistical analysis of all the metrics. We first conduct a Shapiro-Wilk test to determine the normality of the data. The data for attendance, midterm exam 1, midterm exam 2, and final project score all had a $p - value < 0.05$ for the Shapiro-Wilk test, indicating it is highly unlikely that the data follow a normal distribution. As a result, we performed a non-parametric test, the Mann-Whitney U test, to determine the significance of any changes in the data.

To answer RQ1, we performed the Mann-Whitney U test on the attendance data for the in-person classes ($Mdn = 85.2$), which *does not* differ significantly from the online live classes ($Mdn = 85.7$), where $U = 9078, z = -0.868, p = 0.384, r = 0.104$. To answer RQ2, we performed Mann-Whitney U tests on the data for midterm exam 1, midterm exam 2, and the final project score. The results for midterm exam 1 for the in-person classes ($Mdn = 79.3$) *do not* differ significantly from those for the online live classes ($Mdn = 79.5$), where $U = 9599, z = 0.089, p = 0.928, r = 0.011$. The results for midterm exam 2 for the in-person classes ($Mdn = 72.5$) *do* differ significantly from those for the online live classes ($Mdn = 75.5$), where $U = 8311, z = -2.011, p = 0.044, r = 0.211$. The results for the final project score for the in-person classes ($Mdn = 76.9$) *do* differ significantly from those for the online live classes ($Mdn = 81.9$), where $U = 6870, z = -4.161, p < 0.000, r = 0.516$.

5.3 Discussion

Based on the data analysis shown in Section 5.2, we can state that, for RQ1, there is no impact on student attendance for in-person or online live classes. This result disproves part of the motivation for the research presented in the paper. The data analysis for RQ2 is more complicated because there is no statistically significant difference between the groups on midterm exam 1. However, there is a statistically significant difference between the midterm exam 2 and the final project scores for the two groups, suggesting that the course's learning outcomes need a closer look.

Since the project covers all the course's learning outcomes, one might assume that students perform better in the online live class than in the in-person class. However, the project is completed in teams of 4 - 8 students for the entire semester, and the teams do not change. It may be more accurate to state that students in the online live class perform better on the learning outcomes: software design (system design and detailed design), implementing the requirements and design, validating a software system, performing a system walk-through, creating system documentation, and working in a team. This statement regarding the impact on the learning outcomes in the online live class can be supported by the fact that in the online live classes, all synchronous lectures are recorded. In addition, as part of the guidance from the instructional designer assigned to the course and the QM process, additional tutorials were created on how to use the UML tool and other aspects of the software development process, e.g., creating system-level test cases to be used during system validation. The entire format of the online live course was structured to be more accessible and student-friendly. This update to the course was reflected in the syllabus, assignments, and other course materials posted in the learning management system.

Limitations of the study: The study was conducted over several semesters in multiple years. This resulted in slight changes to the course content, changes to the project requirements based on feedback from the end-of-semester student survey, and changes in the instructional support personnel. One factor that was consistent for all the classes, both in-person and online live, over the period of the study, was the fact that the same instructor taught all classes. However, there were changes to the instruction support personnel, including different teaching assistants (TAs) when TAs were provided, and only the online live class had learning assistant (LA) support. The changes to the course content included less time spent on software validation. It should be noted that while the in-person classes met twice a week for 75 minutes each, the online live class met once a week for 75 minutes. This would tend to favor better student performance in in-person classes, based on the research literature indicating that students do better in in-person classes.

6 Lessons Learned

In this section, we present lessons learned from transitioning a course from an in-person to an online live class. Although the experiences are presented from the instructor's perspective, they also have implications for the institution as a whole. Before presenting the lessons learned, it is important to remember that FIU is a large urban university with a majority of students from underrepresented populations.

Preparation time for weekly online live class. The weekly preparation time for an online live class is at least twice the amount of time for an in-person class, and can be more during the first semester the class is taught. It is worth noting that the estimate of preparation time for online live classes is for an instructor who is very familiar with the course content and has been teaching the in-person class for over 10 years. This estimate of time is required for several reasons, including checking web pages for accessibility; reviewing the course materials weekly before posting - lecture slides, tool tutorials, and assignments; and grading the increased number of assessment items - assignments, exams, and projects. This extra time is definitely needed to ensure the high quality of the online live course.

Importance of institutional support in changing modality. The authors of the paper include the instructor of the software engineering course and the instructional designer (ID) for the course. As previously mentioned, the course was recently QM-certified with support from the Online department at FIU. This was the second online live course that the instructor and ID certified as QM. In both courses, the QM process went very smoothly, as the ID worked closely with the instructor to ensure the courses met the QM rubric. The QM committee that reviewed the course requested a few changes after the courses were certified. The online live course faculty development sessions were also critical to the courses being certified. These facts reflect the need for strong institutional support when transitioning from in-person to online live courses.

Student's Perception of Teaching Survey. Although not presented in this paper, the students' perceptions of teaching survey (SPOTS) results decreased after the transition from in-person to online live classes. There were several reasons for the decrease in the results. The main reason for the decline appeared to be the perceived amount of work students were required to do each week. This decline could be due to a decrease in the number of sessions from 2 sessions of 75 minutes each for in-person classes to 1 session (70 minutes) per week. Students were not doing the necessary weekly preparation for the weekly class. In addition, a few students attended the virtual office hours to seek assistance with their assignments. The lower SPOTS survey for online classes is a trend in our school and is supported by the literature [41].

Impact of going from 2 sessions per week to one. As previously stated, the reduction from two sessions per week to one session had an impact on students' perceived ability to keep up with the class. The students at FIU are mainly commuter students, and a majority of the population are *first-generation students* - the first in their family to attend college. Many of these students are also working full-time jobs to support their families. All these factors add to the burden of being successful in college. Based on the survey results, the instructor has reduced the course workload by making the project implementation optional and offering it as extra credit. There was also a change from requiring a UML tool (Papyrus [42]) to allowing any drawing tool for the UML diagrams.

7 Conclusion and Future Work

In the paper, we presented an approach to transitioning a software engineering class at Florida International University to an online live class in line with institutional guidelines and support. The guidelines stated that all faculty who want to teach online live classes must first attend a professional development workshop, and the support included working with an instructional designer from the Online department to design the course, with the expectation that it will be certified by a review body. A description of the course was provided, including its learning outcomes, assessment, activities, and materials. To evaluate the transition process to the online course, we present a study comparing student attendance and performance on the learning outcomes. There was no statistically significant change in attendance rates between the online live and in-person classes. However, there were statistically significant changes in learning outcomes reflected in an exam and a semester-long project.

Based on the discussion presented in the paper, we plan to extend the study as follows. Expanding the sample population, and performing a more detailed analysis of: (1) basic metrics such as average grade in the course and success (non-DFW) rate, (2) a more detailed analysis of the artifacts created during the course, including a project deliverables (documents and presentations), and three exams (two midterm exams and final exam); and (3) feedback provided using the students' perception of teaching survey (SPOTS). We would also like to compare the theories that affect students' performance across different course modalities, such as Achievement Goal Theory (AGT) and Expectancy-Value Theory (EVT).

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