

Hybrid Adaptation of Teaching and Learning Strategies For a Civil Engineering Course on Structural Analysis

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Highlights

- Description of the learning outcomes, teaching and learning activities (TLA) of the course
- Presentation of hybrid teaching and learning framework and activities
- Preliminary student survey results on the various TLA

Abstract

Schools have started to return to a face-to-face or onsite mode in the delivery of course as the pandemic gradually becomes manageable. At De La Salle University, Manila, for Academic Year 2022-2023, most of the major lecture-based courses will be delivered through a hybrid mode where a three-unit lecture course with two meetings per week will be delivered onsite for one meeting and online in the other meeting. Because of this hybrid set-up, the teacher is now challenged on how to adapt the teaching and learning strategies and materials used under a pure online platform for the past two years during the pandemic. This paper presents a summary of the adaptation of the course, CESTRUC or Theory of Structures to a hybrid teaching and learning platform. Specifically, the revised syllabus and the various teaching and learning activities (TLA) implemented onsite and online to assure that students learn, understand and master the course will be presented. A preliminary survey on the effectiveness of the adapted syllabus and various teaching and learning activities was conducted.

Key Words: Theory of Structures, Hybrid Learning, Blended Learning, Online Class, Civil Engineering, Outcomes-based Education

1. Introduction

The traditional mode of instruction in the university before the pandemic is an onsite classroom where content is delivered face-to-face to the students using the blackboard, whiteboard or multimedia technology. Students can freely interact with the teacher and their classmates in the classroom through various activities like group projects, recitations and oral reports. When the COVID-19 pandemic came about in 2020, schools shifted to a pure online teaching and learning platform using internet-based learning management systems (LMS) like Canvas and cloud-based video conferencing applications like Zoom or Google Meet for live virtual meetings. As a result, teachers have to develop teaching and learning modules consisting of various electronic resources like lectures, exercises, quizzes and videos that can be accessed by the students in a virtual classroom. For more than two years, teachers and students became comfortable and have adapted to the pure online classroom platform.

Having recovered more or less from the dangers of COVID-19 and its variants, schools have started to open their campuses for a hybrid mode of delivery. At De La Salle University, Manila, Philippines, for Academic Year 2022-2023, the following modes of course delivery will be implemented:

- Type A: pure online learning
- Type B: hybrid learning – half online, half onsite (in-person)
- Type C: predominantly onsite (in-person)
- Type AB: a hybrid class where pure online learners are accommodated

Most of the major lecture-based courses in civil engineering will be under Type B. In a Type B mode, a three-unit lecture course which is scheduled with 1.5 hours of lecture twice a week will have one onsite session where the teacher and students meet in-person and another online session where the teacher and students meet synchronously via Zoom or students learn asynchronously via Canvas LMS. Because of this hybrid set-up, the teacher is now challenged on how to adapt and recalibrate the teaching and learning strategies and materials used under a pure online platform for the past two years during the pandemic. Courses that require an understanding of theory and demonstration of mastery of theory through computations are appropriate to Type B mode. Teaching of theory with visual and realistic examples can be easily done via online mode, while demonstration of mastery of theory through computation problem solving can be assessed in on onsite mode where cheating can be easily controlled. One civil engineering course that fits the Type B mode is CESTRUC, a three-unit course in Theory of Structures. CESTRUC requires an understanding of fundamental concepts in engineering mechanics and theory of structures and this requires detailed derivation of equations that can be easily delivered and learned online. On the other hand, CESTRUC requires students to apply the theory through solving structural analysis problems which, of course can be done in both online and onsite modes. However, the onsite assessment will be more effective since students solve problems based on their stock knowledge without open notes or books as guides. Hence, this paper aims to present a framework on hybrid adaptation of teaching and learning strategies for the civil engineering course on structural analysis, CESTRUC.

2. Description and Learning Outcomes for The Theory of Structures Course

The course with the code, CESTRUC is a three unit course on the Theory of Structures which is required for all civil engineering students before taking structural design courses. Theory of Structures is a fundamental subject in the civil engineering curriculum. The course focuses on the analysis of statically determinate and indeterminate trusses, beams and frames for reactions, internal forces and displacements using classical methods. Among the topics included in the course are: stability and static determinacy analysis of various typed of plane structures (truss, beam, frame), analysis for reactions, internal forces and deflections, influence lines and classical structural analysis methods like method of joints and sections for trusses, virtual work method for deflections, double integration method for beam deflections, force method for analysis of statically indeterminate structures, slope deflection method and moment distribution method.

Outcomes-Based Education (OBE) framework is used in the design of the course where course outcomes are aligned to the teaching and learning activities in the classroom (Biggs 2003). The BSCE curriculum required by the Commission of Higher Education (CHED) consists of 13 student outcomes (<https://www.dlsu.edu.ph/colleges/gcoe/academic-departments/civil-engineering/student-outcomes/>). For CESTRUC, the following student outcomes (SO) are identified:

- a) SO(A) - An ability to apply principles of engineering, science and mathematics to solve complex engineering problems.
- b) SO(E) - An ability to identify, formulate, and solve complex civil engineering problems.
- c) SO(L) - An understanding of at least one specialized field of civil engineering practice.

To achieve these student outcomes, the following course learning outcomes (LO) are formulated. On completion of the course, the student is expected to be able to do the following:

- LO1. Analyze and calculate statically determinate and indeterminate planar trusses for reactions, internal forces and displacements.
- LO2. Analyze and calculate statically determinate and indeterminate beams for reactions, internal forces and displacements.
- LO3. Analyze and calculate statically determinate and indeterminate planar frames for reactions, internal forces and displacements.

For the course assessment to assure continuous quality improvement (CQI), the following performance indicators (PI) and the corresponding assessment method were identified:

- For SO (E) - Problem Sets to assess the PI on “the student can formulate a solution and/or alternative solution in an analytical manner with appropriate validation.”
- For SO (L) – Final Exam to assess the PI on “the student can apply specialized knowledge and skills in solving civil engineering problems.”

3. Hybrid Teaching and Learning Framework

A hybrid classroom basically is equivalent to implementing a “blended learning” strategy which combines in-person teaching with online learning methods. In the hybrid classroom framework, specific teaching and learning activities (TLAs) were identified and used during face-to-face sessions and online sessions. The hybrid teaching and learning framework for the course is shown in Figure 1.

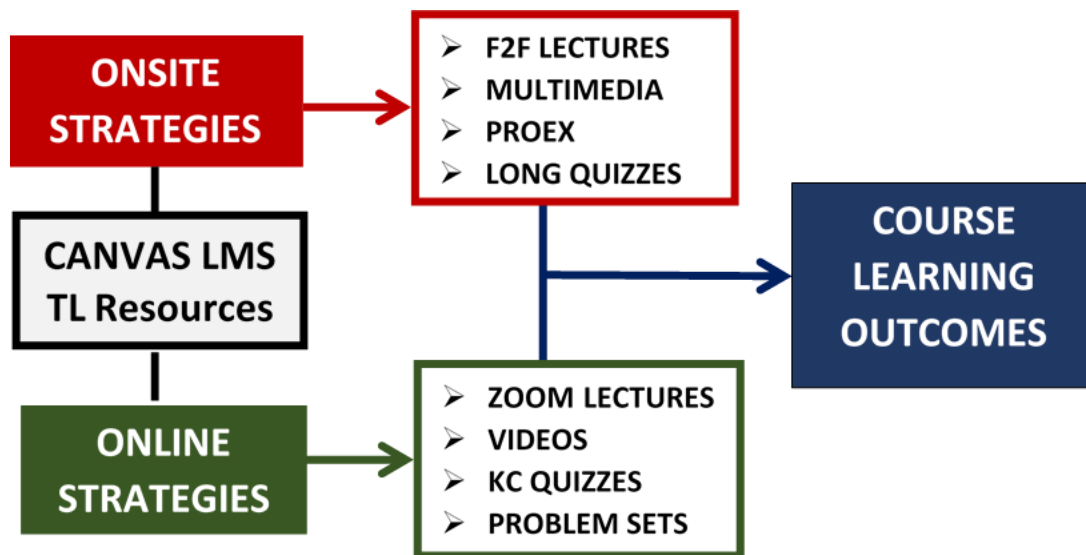


Figure 1. Hybrid Teaching & Learning Framework

The hybrid teaching and learning framework can be described based on the following components of an OBE classroom: (a) Course Content, (b) Course Delivery, (c) Course Assessment.

3.1 Course Content

The course modules and files are uploaded in *AnimoSpace*, the Canvas Learning Management System at DLSU. *AnimoSpace LMS* consists of “various immersive and interactive components” where the faculty can design teaching and learning modules, post announcements and assignments, create quizzes and surveys, conduct conferences or online lectures, record attendance, engage students to do collaborative work, develop videos and monitor student’s mastery of the subject matter. Figure 2 shows the module page of *AnimoSpace LMS* and some of the tools:

- *People* where the list of students can be viewed
- *Syllabus* where the students can read the course syllabus
- *Modules* where the course delivery and content are organized
- *Announcements* where the teacher can post announcements and reminders
- *Files* where the students can download the files shared and uploaded by the teacher
- *Assignments* where the students can submit files
- *Quizzes* where the teacher can design online assessment and surveys with automatic checking
- *Studio* where videos are uploaded by the teacher and then shared to the students

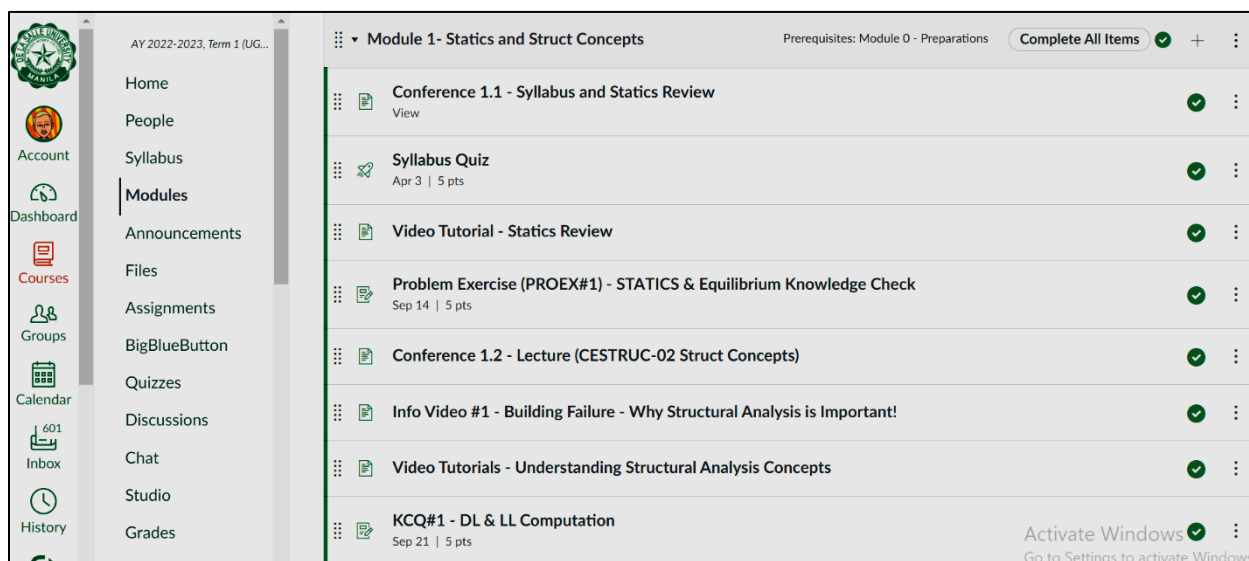


Figure 2. *AnimoSpace* Learning Management System

3.2 Course Delivery

The course content delivery and student engagement integrate the best of two platforms – onsite and online as shown in Figure 1. The *AnimoSpace LMS* is the main repository of teaching and learning resources that are used for both online and onsite teaching and learning. The modules are uploaded and shared for the students to view before any class meeting.

CESTRUC PowerPoint notes are used during onsite lectures and shared as hand-outs to the students. During face-to-face lectures, the course content is delivered via traditional classroom mode using the blackboard or white board and multimedia presentations. Students can download the CESTRUC lectures from *AnimoSpace LMS* before attending the onsite class meeting and simply add remarks in their downloaded notes. Hence, students need not copy word for word the onsite notes delivered on the screen and blackboard.

Figure 3 shows sample slides in one CESTRUC PowerPoint notes. The CESTRUC lectures delivered onsite and/or online are listed in Table 1.

Table 1. CESTRUC PowerPoint and Video Lectures

CESTRUC No.	Topic
CESTRUC-01	Syllabus and Review of Statics of Rigid Bodies
CESTRUC-02	Fundamentals of Structural Analysis
CESTRUC-03	Basic Concepts on Plane Trusses
CESTRUC-04	Analysis of Plane Trusses
CESTRUC-05	Deflection of Trusses
CESTRUC-06	Statically Indeterminate Trusses
CESTRUC-07	Basic Concepts on Beams
CESTRUC-08	Deflection of Beams
CESTRUC-09	Statically Indeterminate Beams
CESTRUC-10	Basic Concepts on Frames
CESTRUC-11	Slope Deflection Method
CESTRUC-12	Moment Distribution Method

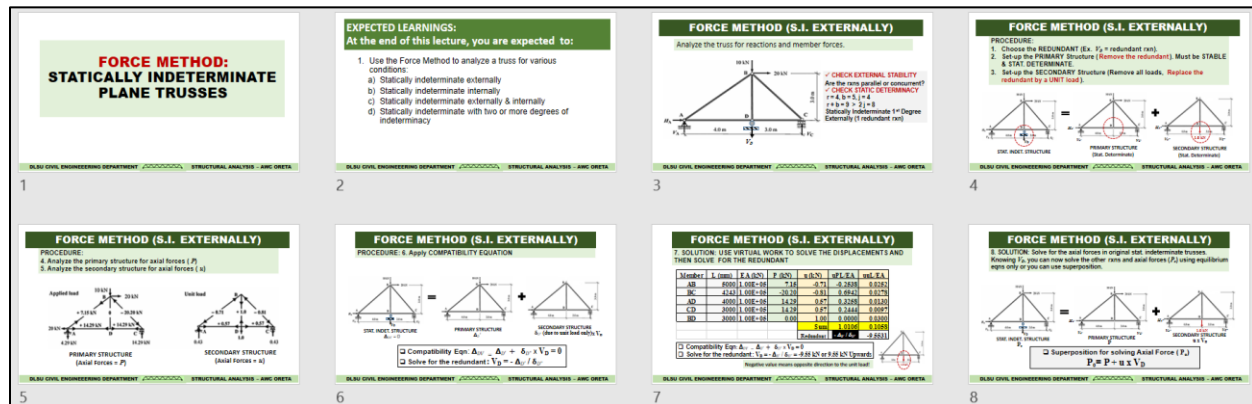
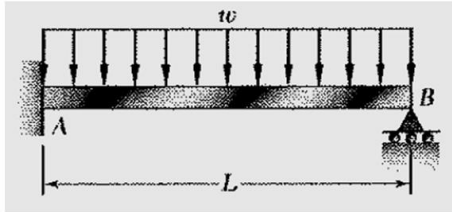


Figure 3. CESTRUC PowerPoint Slides

Student-centered learning and engagement is implemented through individual and/or group problem exercises (PROEX). Problem Exercises (PROEX) are onsite student learning tasks conducted after the lecture. Figure 4 shows a sample PROEX on truss analysis. The teacher selects one or two problems for seatwork and then discuss the solution in class. The students may also solve the PROEX asynchronously after and submit at Canvas and will earn incentive points of 5% for the Problem Sets. The PROEX aside from being a learning strategy also aims to promote interaction among students by engaging them through group problem solving and discussion.

PROBLEM EXERCISE

Solve for the reaction at B using (a) Double Integration Method and (b) Virtual Work Method. $EI = \text{Constant}$



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Figure 4. A Problem Exercise (PROEX) on Truss Analysis

For the online sessions, course content is delivered via Zoom as live or recorded lecture (CESTRUC video lecture). The CESTRUC PowerPoint notes are converted to video lectures and are presented synchronously during online sessions or viewed asynchronously by the students. Video tutorials from YouTube are also listed for viewing asynchronously to supplement the teacher’s lectures. CESTRUC is generally a theory-based course which involves learning, understanding and applying theoretical formula and equations. To enhance the understanding of the theory and relate to real-life civil engineering practice, INFORMATIVE VIDEOS or info-video from YouTube are presented during online sessions. The information videos shared in the class are listed in Table 2.

Table 2. Information Videos

Info-Video	Topic	Link
1 Concepts	<ul style="list-style-type: none"> • Building Failure • Steel Truss Bridge Collapse 	https://youtu.be/MLivv46xdeA https://youtu.be/RBnUpe4qp3o
2 Trusses	<ul style="list-style-type: none"> • Building Roof Trusses • Long Span Trusses • Warren Steel Truss Bridge • Steel Truss Bridge Animation 	https://youtu.be/X6fTaqxeR34 https://youtu.be/YOZrIflr5OU https://youtu.be/APEJNflyqXo https://youtu.be/NqsTf5mdLvU
3 Beams	<ul style="list-style-type: none"> • Reinforcement in a Concrete Beam • Bending failure of an RC Beam 	https://youtu.be/YNJOvkYc60E https://youtu.be/3xw9_33uNJA
3 Frames	<ul style="list-style-type: none"> • RC Building Construction Process • Steel Connections (Beam-Column) • Steel Frame Construction • Steel Structural Failure • Steel Building Collapse 	https://youtu.be/FFo-KeX_AAk https://youtu.be/VWr_nH_0D7I https://youtu.be/dKNKzeR_t3w https://youtu.be/CFU-9fiEw4I https://youtu.be/T569ZlrWnVM



Figure 5. Information Video on Building Failure (<https://youtu.be/MLivv46xdeA>)

Figure 5 is a sample information video shared during the online class. The info-video on building failure aims to inform the students on the effect of loads on the structure and the importance of structural analysis in the design of buildings and other types of structures.

To assure the active engagement of the students during the online lecture which can be synchronous and/or asynchronous, a knowledge-check quiz (KCQ) is conducted. A Knowledge-Check Quiz (KCQ) is an optional online quiz which is conducted during the online session. A KCQ is usually a conceptual quiz (Figure 5) but a KCQ involves also problem solving where the solution is uploaded in Canvas. KCQ may be discussed during the online lecture after the due date. The KCQs will be credited with incentive points of 5% in the Long Quiz. Through the KCQ, the teacher can assess the students' understanding of the subject matter and identify specific topics that needs further elaboration in the next sessions.

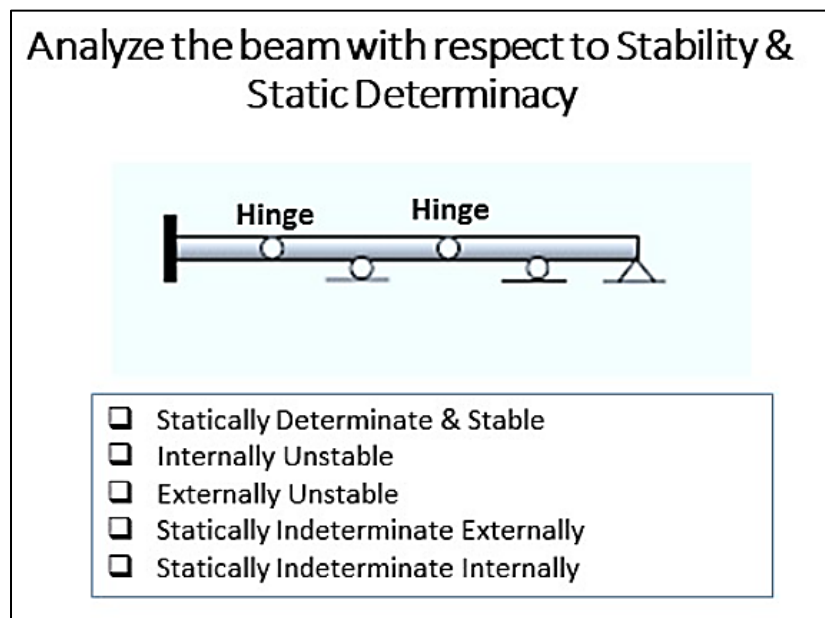


Figure 5. A Knowledge Check Quiz conceptual question

3.3 Course Assessment

Assessment of the achievement of student learning outcomes was done also using both onsite and online platforms. The assessment tasks used in the course are as follows:

- a) Problem Set (PS) is a required individual asynchronous problem solving assignment that must be submitted at Canvas on or before the due date. Late submission will be penalized with 5 points per day late.
- b) Long Quiz (LQ) is a student assessment on the mastery of the student on specific topics which has two parts: a) Problem Solving (70%) – Onsite Quiz and b) Concepts (30%) – Online Quiz via Canvas
- c) Final Exam (FE) is an onsite (or mixed with Online) student assessment on the mastery of the student about the course.

The general average of each student's grade is computed as follows:

- 3 Problem Sets = 15 %
- 3 Long Quizzes = 60 %
- Final Exam = 25 %

The LQ Problem solving part is done onsite and involves manual solution and application of classical methods of analysis of structures. The checking is also done manually by the teacher. The LQ Concepts part is taken online via Canvas and questions of the type like multiple choice, input the numerical answer, true or false or multiple answers are automatically checked. To minimize copying, the questions are generated randomly from a quiz bank so that each student may have a different set of questions.

4. Preliminary Student Survey

After the conduct of the Long Quiz #1, a student survey was requested to be filled-up by the students to assess the effectiveness of the teaching and learning activities. The student feedback aims to guide the teachers on where to make adjustments on the teaching and learning framework.

The first question of the survey was “*What is your self-assessment of your learning and mastery of the lessons so far for this course?*” Rate from 1 to 4: (a) 4 – 90 to 100 %, (b) 3 – 80 to 90%, (c) 2 – 70 to 80% and (d) 1 – 60 to 70%. The survey of six sections in Figure 6 shows that most of the students rated their learning and mastery of the course as 3 (80%-90%) or 2 (70%-80%) which satisfies the targeted outcomes performance under the OBE framework. About 5% of the students in some sections rated themselves below the passing grade (60%). On the other hand, in some sections, 10% to 25% of the students rated themselves with an outstanding score of 4 (90 – 100%).

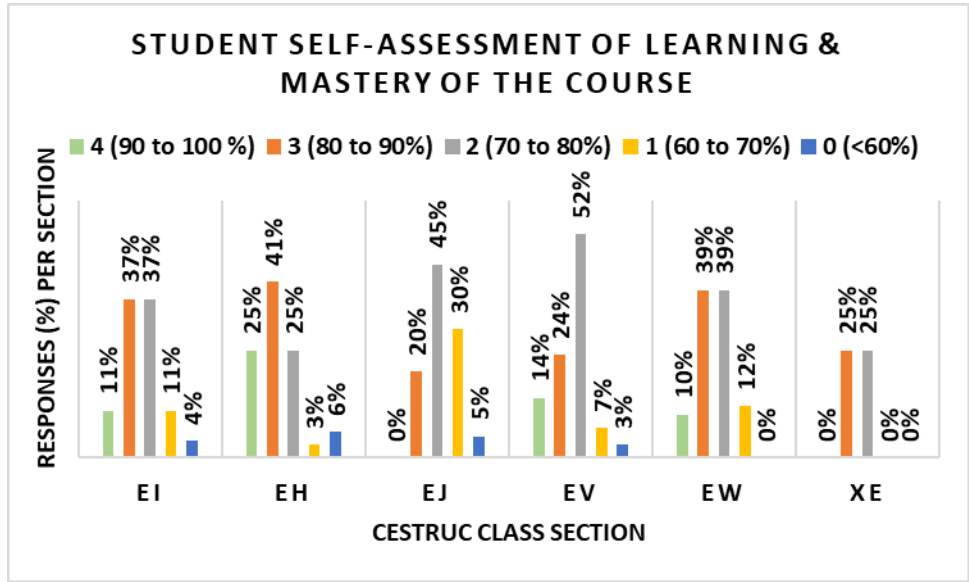


Figure 6. Student self-assessment of learning and mastery of the lessons

How did the students perform in the Long Quiz No. 1? Figure 7 shows the statistics of the results of the Long Quiz No. 1 for the six sections in CESTRUC. The mean score ranges from 48% to 75%. The highest score is 100% for some sections, while the lowest score is 12% in one section. Overall, the general performance of the students for Quiz No. 1 for both the onsite and online quizzes is “Satisfactory.”

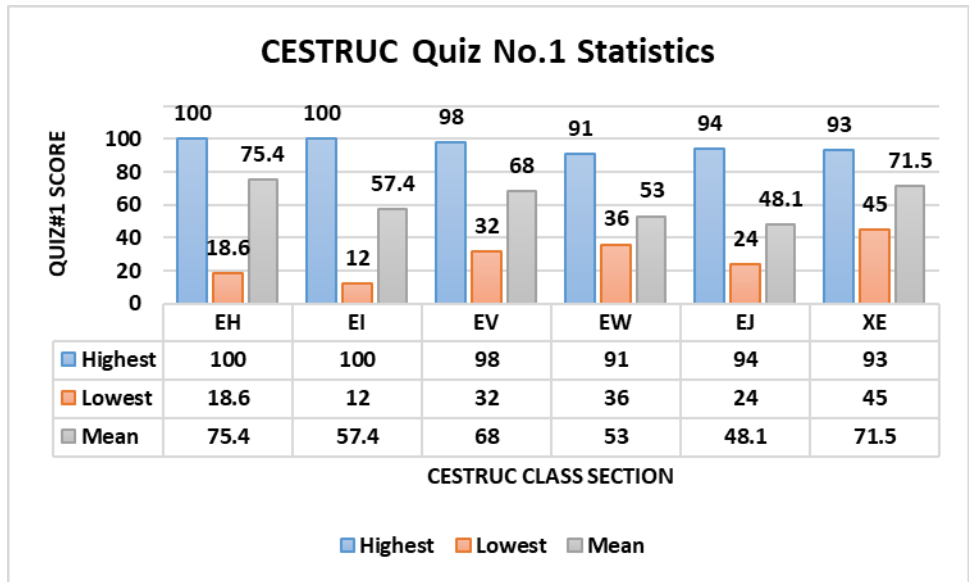


Figure 7. Statistics of CESTRUC Quiz No. 1

The next questions are on their assessment of the onsite and online teaching and learning activity (TLA) with respect to their understanding, learning and mastery of the course content using the rating (a) 4 - Very Effective, (b) 3 - Moderately Effective, (c) 2 - Slightly Effective, (d) 1 - Not Effective and (e) 0 –

Not Applicable. The basic question asked for each TLA was “*What is your assessment of the TLA with respect to your learning and understanding of the course content?*” Figure 8 to Figure 11 presents the student assessment for the two teachers with respect to the type of TLA:

- Figure 8 on Course Delivery: (a) *Face-to-Face Onsite Lectures* and (b) *CESTRUC Online Lectures*
- Figure 9 on Course Content: (a) *CESTRUC Notes* and (b) *Online Resources*
- Figure 10 on Learning and Mastery: (a) *Problem Sets*, (b) *PROEX*, (c) *Knowledge Check Quizzes*
- Figure 11 on You Tube Videos: (a) *Video Tutorials* and (b) *Information Videos*.

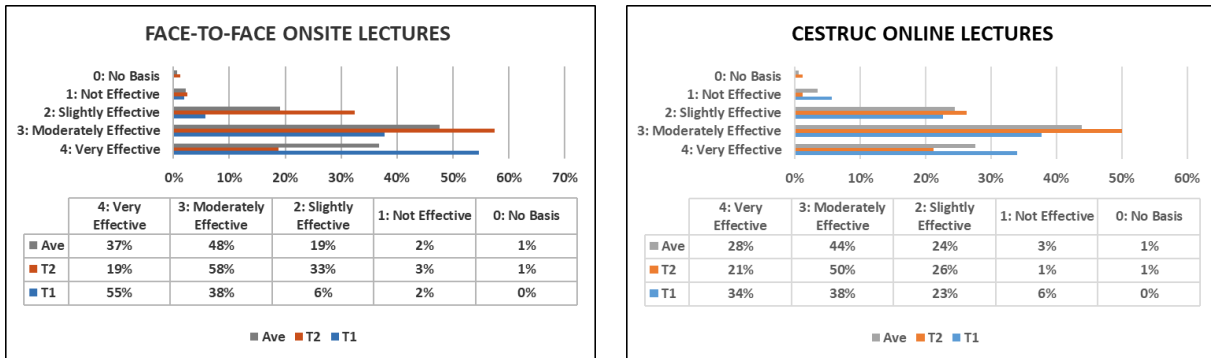


Figure 8. Student Assessment on Course Delivery

On course delivery, both onsite and online lectures rated evenly especially for “moderately effective” at about 44%-48%. For teacher T1, the face-to-face onsite lectures rated a high 55% for “very effective.”

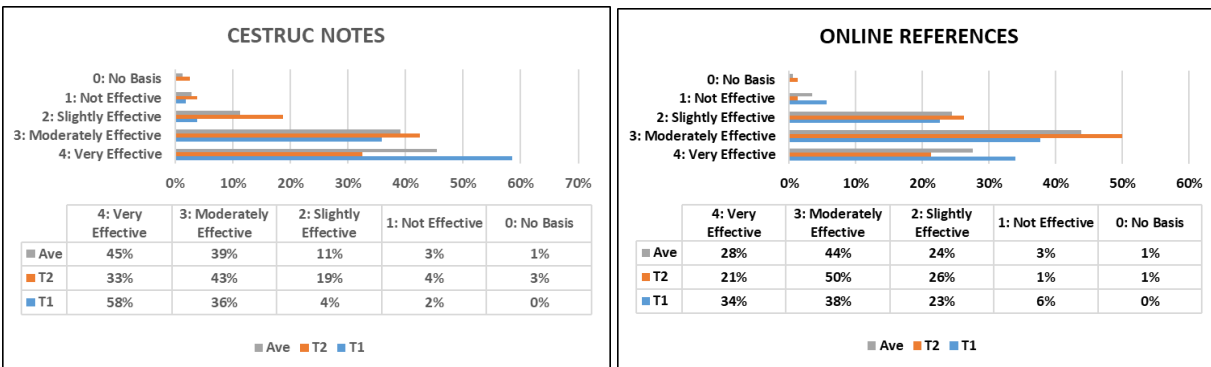


Figure 9. Student Assessment on Course Content

On course content, the shared CESTRUC notes were rated 45% “very effective” compared to 28% for online references.

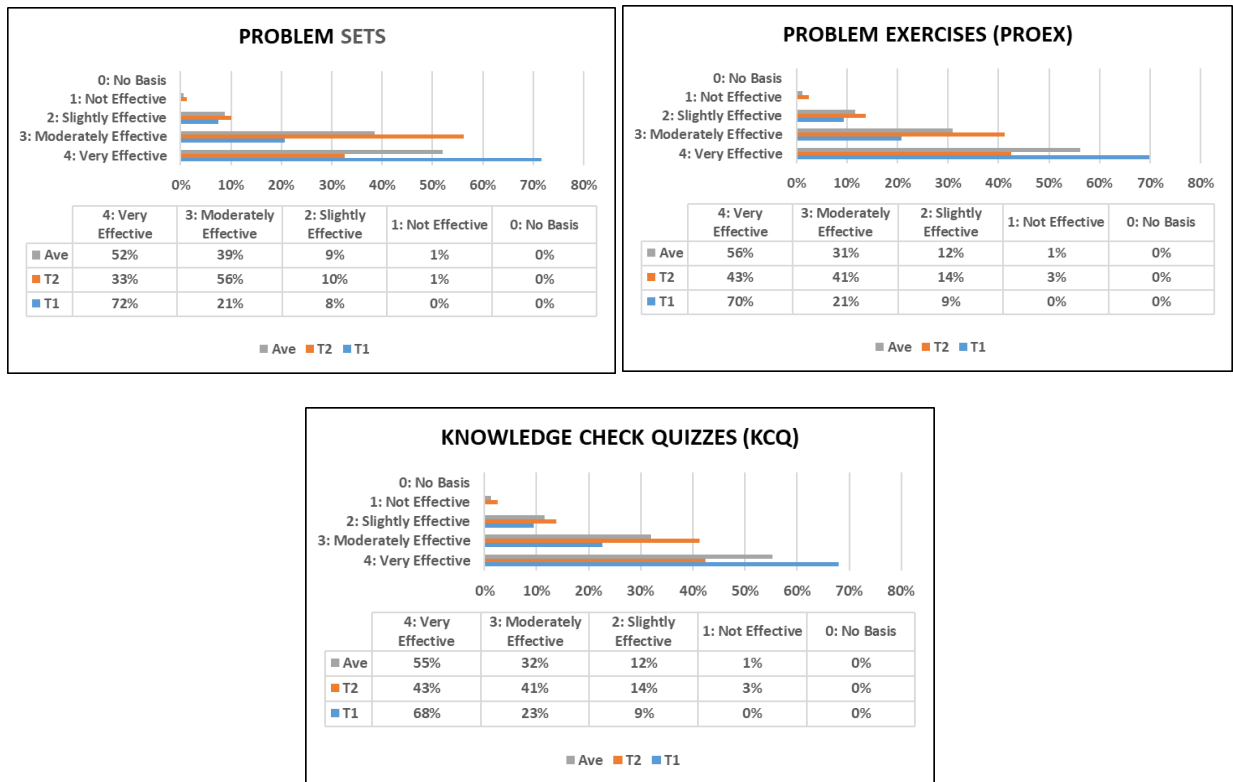


Figure 10. Student Assessment on Learning and Mastery of the Course Content

On students' learning and mastery of the course content, the problem sets, problem exercises and knowledge check quizzes were rated "very effective" at 52% to 56% and "moderately effective" at 31% to 39%.

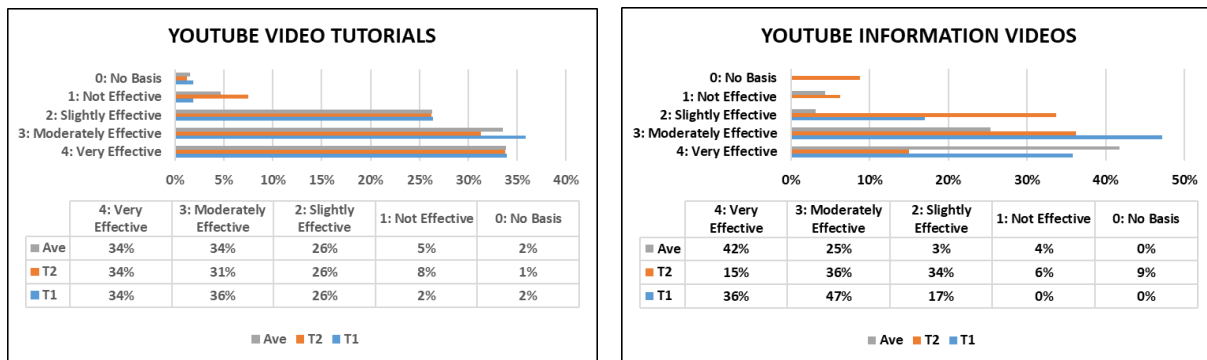


Figure 11. Student Assessment on YouTube Videos

For the YouTube videos shared at Canvas and during online sessions, the students' ratings are 34% "very effective" for the tutorials and 42% "very effective" for the info-videos.

The final question in the student survey was “Which teaching delivery is most effective in your learning and mastery of the course content?” Figure 12 shows the student feedback from the five sections of CESTRUC conducted at DLSU Manila. More than 50% of the students assessed the onsite face-to-face lectures as most effective. The other modes of delivery like Zoom synchronous lectures, Zoom recorded lectures and uploaded CESTRUC video lectures for asynchronous sessions and the YouTube videos were rated moderately effective which ranges from a low of 5% to a high of 30%. The learning experience in an onsite classroom environment seems most effective because the students are more engaged – they are more attentive and active especially in taking down notes, in asking questions and receiving immediate response from the teacher and interacting with their seatmates during problem solving sessions.

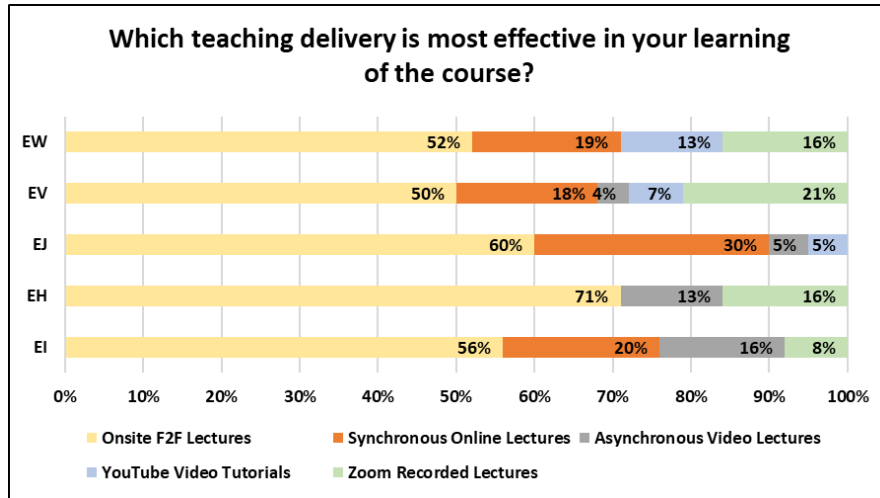


Figure 12. Student Assessment on Teaching Delivery

5. Conclusion

A hybrid teaching and learning framework for the course, CESTRUC or Theory of Structures was designed to adapt to a new classroom platform (Type B) at DLSU where a course is delivered half online, half in-person. The syllabus was revised and the various teaching and learning tasks onsite and online were implemented to assure that students learn, understand and master the course. The onsite or face-to-face sessions follow the traditional approach where lectures and exams are done onsite, while the online sessions used Zoom for online or synchronous lectures and Canvas for asynchronous sessions. A preliminary survey on the effectiveness of the adapted syllabus was conducted and the preliminary feedback shows that students find the onsite face-to-face lectures as most effective in their learning and mastery of the course.

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Acknowledgement

The development of the modular lectures in CESTRUC was supported by the DLSU Office of the Provost's General Curriculum and Instructional Development Grant.