06

ONLINE LEARNING EXPERIENCES FOR INTEGRATED MULTIDISCIPLINARY COURSE DURING THE COVID-19 PANDEMIC

*Fadzli Irwan Bahrudin, Asiah Abdul Rahim and Nur Ulfah Awatif Umairah Alias,
Kulliyyah of Architecture and Environmental Design,
International Islamic University Malaysia

ABSTRACT

Integrated Multidisciplinary Project at the Kulliyyah of Architecture and Environmental Design (KAED), International Islamic University Malaysia (IIUM), generally requires students to solve relevant real problems related to the built environment. The course presents a short-term architectural development project to a cohort of students from various programmes of the Built Environment to tackle these challenges with innovative and creative solutions. The course is conducted annually as a face-to-face workshop-based activity, but during the Movement Control Order (MCO) for COVID-19, the course runs online. Transitioning to online learning can be challenging for architecture and design students as the lack of a physical studio environment limits intensive design discussion. The course requires students to work in groups to produce the design solutions for the multidisciplinary project. Therefore, this paper investigates online studios' learning experiences and challenges for Integrated Multidisciplinary Projects during the COVID-19 pandemic. A qualitative method of research was adopted for the short study. The experiences were investigated by reviewing students works and conducting a semi-structured interview with the project leaders. The findings of the study point to a range of difficulties and advantages of online studio sessions. The overall online students' performance, although positive, was lacking in physical cues. The online interaction technical limitations also hindered in-depth practical design discussion. Students expressed satisfaction with their learning experience but highlighted the need for physical interactions. Though the online studio was convenient, the students expressed the need for more interactive, stimulating, and efficient design discussions where the physical interaction would ease the division of tasks and the overall project management.

Keyword:
Architecture Design Studio; Online Learning; Multidisciplinary Project
*Corresponding author: fadzliirwan@iium.edu.my

INTRODUCTION

International Islamic University Malaysia (IIUM) was established on May 20, 1983, inspired by the 1977 'First World Conference on Muslim Education' outcomes in Makkah, Saudi Arabia. The university aims to become a leading international centre of excellence in education, research, and innovation to restore the ummah's dynamism and progressiveness for the betterment of human life and civilisation. It has come a long way since its establishment in 1983. From a relatively nondescript University, IIUM has become a Premier Global Islamic University, pioneering and championing the Islamicisation of human knowledge (IoHK) in all fields of studies (Rashid, 2014).

One of the major disciplines offered by the university is programmes in the built environment. Hence, the Kulliyyah of Architecture and Environmental Design (KAED) was established on June 1, 1996, to offer architecture and built environment programs. It was also during the same period when Malaysia's architecture scene was gaining traction as Putrajaya was progressively developing (Mohidin & Ismail, 2014). KAED aims to pioneer in integrating tawhidic and the Islamic worldview in its educational approach to producing holistic professionals in the built environment.

To achieve its aspirations, IIUM has outlined several transdisciplinary flagship projects in which KAED's community is involved. The projects address the three aspects of sustainable development: environment, economics, and social. The projects include Gombak Heritage and Cultural Living Lab, IIUM Low Carbon Campus, River of Life and Jungle School Gombak. Some of these projects were adopted as the semester's Integrated Multidisciplinary Project.

THE INTEGRATED MULTIDISCIPLINARY PROJECT

The project-based studio approach is the core of architecture and design education. In executing a design process, students are guided through design thinking activities to generate rough ideas through sketching, drawing and building up the design representation in digital and physical models (Dam & Siang, 2021). The process involves simultaneous reflective thinking, intuitive decision making and learning by doing. KAED's Integrated Multidisciplinary Project (KIMP) course focuses on developing students' skills in working with other design and construction team members. Students participating in such projects could expand their professional skillset, including leadership, communication, and management.

KAED IMP course was established in 2000 to simulate a real-world working environment for students from architecture, landscape architecture, urban planning, quantity surveying, and applied arts and design programmes. The cohort of students for each programme varies from as early as the first-year level to the third-year level. The course instructors are from the various departments of KAED. The students are required to work together in teams to propose design solutions that meet the requirements of a particular project stipulated in the project brief.

Multidisciplinary is common in real-life. Studies showed that exposure to a multidisciplinary project enhances students' critical thinking and inculcates collaboration (Trisdiono et al., 2019). Thus, the course provides a basis for cross-discipline integration, where students can learn about the construction industry's complexity (Kattwinkel et al., 2018). Therefore, students are expected to work in groups and undertake tasks appropriate to their study backgrounds and levels. They are required to demonstrate the ability to develop architectural and built environment projects within industrial, economic, social, Islamic, and sustainable considerations. The results of the assignments were presented formally to the members of the Kulliyyah for assessment.

The objectives of the course are as follows:

1. To expose students to the various fields of the built- environment.
2. To expand students' knowledge and skills through hands-on experience in the fields of the Built-environment.
3. To enhance students' leadership, communication, and teamwork skills.
4. To familiarise students to work with other built-environment disciplines

The course expected students to develop their psychomotor and practical skills by doing site inventory and field observations of the project site, its location and its surrounding context. The students must demonstrate critical thinking in appraising the project needs and deciding on appropriate design concepts as part of the process. Students' leadership skills and teamwork are continuously assessed in the overall execution of the project that operates within organisational management.

THE PROJECT BRIEF

Projects chosen for the Integrated Multidisciplinary Project course are based on real-life projects that emerged from issues and problems of students and the IIUM community that typically concern the university's infrastructure development, including refurbishment projects and students' facilities. Previous projects include Heritage Malay Village, KAED's courtyard, Al-Ghazali Walk, Wood Village, Convocation Square, KAED's logo and bus stop. In line with the university's aspiration, there were also community-based projects, such as a public housing project in Ampang and a tourism centre at Orang Asli's settlement in Batu 16, Gombak Selangor. Such projects aim to create positive social impacts; importantly, students get the opportunity to engage and collaborate with broader stakeholders.

For the academic year 2021, the university is progressively pursuing its targeted Sustainable Development Goals (SDG) by implementing one of its flagship projects, the Low Carbon Campus Project. The university has entrusted KAED with the task of developing and leading the implementation of the master plan. Phase 1 of the project is the construction of a bicycle lane on the campus's main ring road. Unfortunately, the implementation of the tender stage was temporarily halted since early last year due to the government's imposition of the Movement Control Order. Nonetheless, Phase 2 of the development project has to commence, and the project was selected for the Integrated Multidisciplinary Project, Semester 3, 2021. The project proposal was vetted and thoroughly deliberated among the multi-discipline lecturers. The project comprises bicycle storage structures (shed and hub) and repair facilities strategically located on campus (see an example of the proposed location in Figure 1). The summary of the project is shown in Table 1.

Figure 1: Proposed Location of a Bicycle Shed Near Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia

Table 1: Summary of the Project

Project: IIUM Bicycle Shed and Hub
• Propose a rack design to accommodate road bikes and mountain bikes with space-saving configurations.
• Provide additional protection for the bicycles from natural elements like the weather.
• Consider incorporating a canopy or roof.
• Adopt a Sustainable Design approach.
• Propose an aesthetically pleasing storage structure in harmony with the surroundings.
• Adequate illumination fixture points.
• Incorporate a well-designed landscape element, either vegetation (softscape), hardscape or a combination of both.
• Propose built-in fittings for bicycles security.
• Include an adequate number of washrooms, showers and clothes-changing facilities.
• The total cost of the project should not exceed RM500k

ONLINE ARCHITECTURE AND DESIGN STUDIO

A studio is typically associated with a painter, photographer, designer, or sculptor. A studio is an artist's workplace or where art and design works occur. In the design education sector, a studio is for teaching and learning sessions where students are facilitated to undertake a project individually or in a group. Unlike the typical class, studio assessment encompasses a broad set of indicators (Harpe et al., 2009). Learning architecture and design, the studio focuses on the design process and does not merely rely on the final product (Maani et al., 2021). The early years of a degree education typically involve the lower level of bloom's taxonomy. However, design education challenges students to demonstrate their abilities to propose or produce design solutions, even in their junior years.

Since Malaysia's first Movement Control Order (MCO) in 2020, the university has moved its teaching mode to online classes and lectures (IIUM Sejahtera Council, 2020). Face-to-face examinations have also been replaced with an online examination, evaluation and remote assessment procedures. For Integrated Multidisciplinary Project, online interactive studios were conducted twice a week for about one and a half hours per session for each student's group. Frequent discussions and student engagement were also done via WhatsApp messages and emails. Before the MCO, the course was conducted physically two days a week, where a whole day was dedicated to project consultations. Teaching and learning architecture with design sessions are typically conducted in the physical studio. These sessions are conducted in a physical space (Morkel, 2011b) with large walls for idea presentation, and students are allocated individual cubicles or work areas. The course instructor, lecturer or tutor takes the facilitator's role at the centre stage. In the studio, students participate actively in their respective groups or work passively to meet project deadlines.

However, the shift to online studio because of Covid-19 has challenged such traditional pedagogy. According to Broadfoot and Bennet (2003), a virtual or online studio refers to a network of participants doing a design process in digital mode in various locations. The nature of the virtual studio is highly interactive and collaborative (Walpole, 2012), and the studio scenario is different from a physical studio. For example, the student's responsibility to tidy up their place in a design studio is no longer necessary. Anyone can initiate and set up the online class, and the transition of time becomes elusive, especially if the course instructor talks throughout the class session.

Students may enjoy the convenience of attending the online studio as it increases the ease with which a design discussion or critique can be held at any time. Hence, students can be in the comfort of their bedroom or any remote place while attending the studio. Moreover, the students can switch off the web video camera, giving the course instructor a different experience of talking to the black or fun-animated screens instead.

The course instructors must be prepared for the session and learn fast to adapt to the various information and communication technology encountered. Undeniably, a vast selection of digital and online tools can be brought right away into online classes and studios to facilitate the transmission of design knowledge. One such example is a simple online platform such as Facebook that enhances horizontal (peer-to-peer) and vertical (students-to-lecturers) communication in an architecture studio (Morkel, 2011a).

The online studio conducted in a synchronous or asynchronous mode. The latter refers to a design discussion or presentation without the simultaneous presence of one of the parties. Thus, sharing experiences, problem observations, site analyses, and case studies may be conveyed at great distances digitally. Disseminating information using digital resources is straightforward, although some may argue that textbook's physical and sensorial experience has no substitution. The students have quick and direct access to vast information, giving them an enriched diverse knowledge perspective on top of the linear lecturer-student interaction in a mainstream face-to-face classroom.

Despite the apparent benefits of online courses, much literature has raised concern about the limitations of online learning for architecture, art, and design studios. There is also little proof of the success of active online learning (Yu & Silva, 2021). In a virtual environment, students are expected to be more responsible and have independent thinking in attending online studios (Maani, 2019) so that their works reflect a deep and critical thought process (Light et al., 2009).

Other prominent limitations of an online studio are communication and design representation. For the former, often, information is misinterpreted, especially during asynchronous classes. Further, one-way communication in the form of images and even long presentation slides may not convey the actual learning messages. Thus, asynchronous studio delays communication and hinders effective design critiques. Students tend to be easily distracted and lost focus in an online studio (Kamil & Sani, 2021). The experience is less dynamic and lacks non-verbal communication, such as facial expressions and body gestures. Such communication cues are essential in design critics and discussions as to how a design object project is appraised that involves unique semantic interpretations intertwined with emotional expression. In virtual mode, communication, collaboration, and social constructivism are jeopardized when more time is spent in computer labs than in physical studios (Morkel, 2011b).

The conduct of the Integrated Multidisciplinary Project studio, with an example of the architectural and design firm, is shown in Figure 2. Within each design firm, Architecture students would lead the design direction, including defining the functional features and form of the buildings. The Urban Planning students assist with these tasks. The Applied Arts and Design students design the interiors with a particular focus on designing habitable spaces, materiality, and colors. Meanwhile, the Landscape architecture students design the environment, encompassing the hardscapes and softscapes that enable impactful outdoor spaces. Finally, all costs and material estimation process is done by the Quantity Surveying Students.
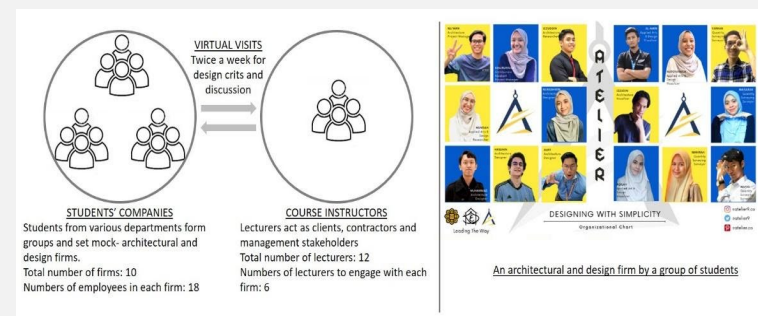

Figure 2: The Conduct of Integrated Multidisciplinary Project and An Example of Students' Architectural and Design Firm

In design representation, the online studio lacks the real-life experience of the location and the sensorial experience of its surroundings, for which the outcome is reflected in the designed objects as soul-less. Although the proposed architectural, interior or product design could be represented with realistic animated renderings, students did not get the opportunity to grasp the physical sense of the designed objects holistically. As a result, students may lose the sensitivity to experience the many sensorial dimensions of the site to evaluate physical spaces and tangible objects (Niculae, 2011). In summation, the outcome has no tactile experience, sun glare or sense of breeze in a beautifully rendered project, even though it is enhanced by virtual-reality technology.

METHODOLOGY

A qualitative research approach was adopted for this research. The investigation is about people's experiences, and qualitative research reveals meanings rather than hard facts (Creswell, 2014). The approach helps explain how students and course instructors interpret and perceive their experiences (see Grbich, 2013). In addition, the researchers aim to recognise the subjects' perceptions and unique viewpoints (Castleberry & Nolen, 2018). The overall methodology for this research is shown in Figure 4.

First, a set of video recordings of five (out of 10) student groups were reviewed. Video provides unique analytical perspectives and uncovers the breadth of learning sessions (Ramey et al., 2016). Also, video analysis enables researchers to uncover multiple perspectives (Derry et al., 2010) and the dynamic of knowledge interaction that other study approaches cannot capture (Hall & Stevens, 2016). The video analysis in this study focused on reflecting pertinent scenarios, especially issues highlighted by the course instructors and students' performance during the conduct of the virtual studio.

Five video recordings encompass early online project discussion meetings, two checkpoint meetings between the design firms (students) and the project developers or clients (course instructors) and the final presentation meeting. This semester, lecturers and students from Universitas Tanjungpura, Indonesia, were invited as external reviewers (see Figure 3). The meetings were conducted and recorded via Microsoft Teams, and each session lasted an hour. An open approach is adopted in analysing the 24 video footage to allow discoveries without preconceived patterns of subjects' experiences. The recorded videos are replayed, and the emerging codes are identified (Vermeeren et al., 2002).

Second, a few days after the final presentation, an interview session with five group leaders (cum the firm managers) was held. Video recording can be complemented with a think-aloud approach or interview to understand an experience (Mussgnug et al., 2017). Hence, during the interview session, students were asked to express their thoughts while reflecting on the course's experiences. Students need to recall their experiences retrospectively (see Kuusela & Paul, 2000). Also, the think-aloud interview sessions were selected as they did not demand a sophisticated thinking process (Charters, 2003). The semi-structured interview started with 'how do you feel about the course?' to trigger the respondents' appraisals. Asking about the emotional state is an effective strategy to understand the overall experience, as feelings or affections are the central points of user experience (Norman, 2004). The interview was transcribed verbatim, and the transcript was thoroughly analysed.

In this study, the video review and interview data were thematically analysed to capture a holistic picture of the student's learning experiences. Thematic analysis helps untangle intricate meanings within data (Guest, 2012). The analysis encompasses "identifying, analysing and reporting pattern" of themes within data (Braun & Clarke, 2006). The findings of a study are concluded after data is collected or compiled, disassembled, reassembled, and interpreted (Yin, 2011). The emerging codes and the relationship between codes are thoroughly observed and justified (Castleberry & Nolen, 2018). Finally, the findings from the data analysis were also deliberated among the researchers. Figure 5 shows an example of the interview transcript coding process.
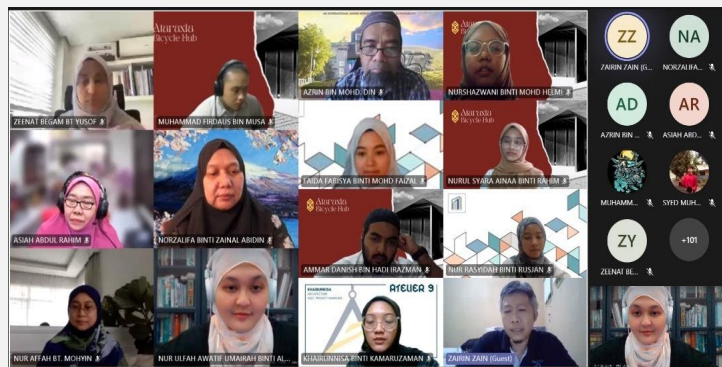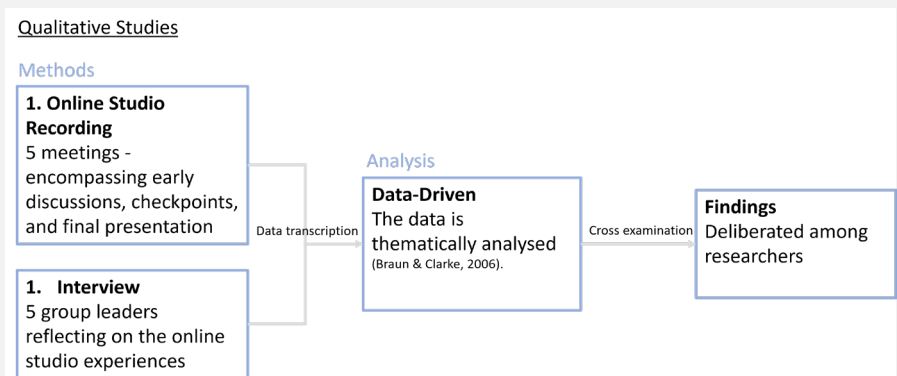

Figure 4: The Overall Methodology

Figure 3: Final Presentation of the Integrated Multidisciplinary Project of KAED, IIUM Attended by Lecturers and Students from Universitas Tanjungpura, Pontianak, Indonesia.

Figure 5: The Interview Transcript Early Coding Process.

FINDINGS AND DISCUSSION

The following section presents the findings of the video analysis and semi-structured interviews.

Meetings And Critique Sessions

After reviewing the video recordings, the research grounded the analysis by breaking the experiences into three phases, encompassing the generic design development process (adopted from ISO/TR 14062:2002) as shown in Figure 6.
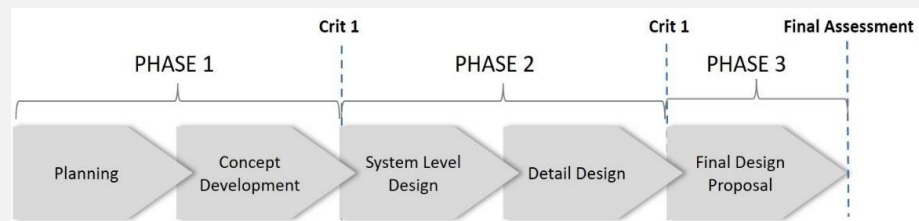

Figure 6: The Three Phases of Project Execution within the Integrated Multidisciplinary Project

During the planning phase, the students had no difficulties establishing the organisational structure with departments within their firms. Each 'firm' comprises equal numbers of students from Architecture, Landscape Architecture, Urban and Regional Planning, Quantity Surveying, and the Applied Arts and Design programmes. Architecture students led all firms, with the design department as the largest department in their respective firms. The presentation quality from all the 'firms', where some groups even presented their company's websites, was beyond expectation. During the few initial meetings, students reacted proactively in proposing specific sites and enquired about the details of the project requirements.

Moving forward to the concept development phase, the mood in the meetings for all firms seemed tense. The course instructors started to play their roles as clients and project developers of the projects. Some project leaders responded to the inquiries professionally, indicating that the firms had prepared well to justify their early ideas. Nevertheless, there were less-prepared groups, with what may be speculated as there may be a communication problem between the department members of the particular firms was ineffective. The communication breakdown can be attributed to the fact that the students did not know each other before attending the course. Moreover, they were from different programmes and different intake cohorts. Hence, it is challenging for the students to build their social rapport, which is an essential management success factor, especially for the project leader.

Notably, during the concept development phase and the first critique session, lagging wifi, internet freezes, and lack of appropriate computer tools and software by both lecturers and students hindered the smooth design discussion. For example, the Whiteboard in Microsoft Teams allows meeting participants to draw, sketch, or annotate on a shared digital canvas. However, the functions work great with tablets such as Wacom and Microsoft Surface, and Tablets. Furthermore, design critiques and appraisals are spontaneous and intuitive activities. Shifting from one app to another, even changing files to be projected to the shared screen, need time and affects the flow of the design discussion. Pointing direct comments on specific design features on a large architectural drawing was also challenging for the course instructors.

During several meeting sessions, including the first critiques, some course instructors felt disappointed with such communication hiccups as the instructors could not express their design critiques effectively. When this course was conducted in the second year of the MCO, the instructors were more settled into the routine of online teaching. However, their preferences for manual sketching and annotation remain intact. Indeed, spontaneous manual sketching and writing afford cognitive fluency that is so far irreplaceable by digital means.

At the beginning of the second phase, the students proceeded to the proposed concept design phase, including designing the layout zones, facility types, building structures, and roof shapes. Interestingly at this stage, students showed a good understanding and appreciation of the project through their products. The primary reason for the performance is that although there were no physical site visits, they were familiar and well-versed with the location and its surroundings where they wanted the bicycle hub or shed to be built. Also, they understood the need for recreational facilities at IIUM. Such understanding was reflected in their proposed concept. As they were the target users of the project, the user-experience considerations in the design were also sufficiently good. Hence overall, in the second phase, all groups were progressing well. The works of each department within each firm are no longer segmented. Smooth inter-departmental communications started to exist. For example, the quantity surveyor in the firms quickly revised their project budget, including the procurement plans, once they were informed of the design changes.

Nevertheless, some groups were still lagging and lacking in defining the dimension of spaces and material selections. During several meetings, including the second critique session, some groups could not justify the specific sizing of amenities such as the washroom, pathway, door opening, and staircase. Several project leaders seemed to struggle to respond to the 'clients' inquiries on such facilities' proposed size and scale. It seems that their prior knowledge is inadequate. Perhaps, full online project development limits the students' focus on such details as the digital environment has no clear spatial and physical sense. Also, the digital tool is flexible and much easier for students to change the materials for the architectural components. However, this is where the speed of the digital approach jeopardises reflective and intuitive thoughts fundamental to the design process. In education, digital means are powerful and effective only if the students have passed the learning blocks and can control the technology.

Within the third phase, all firms were given ample time to accomplish their project proposals. The virtual studio visits or casual meetings by the instructors were conducted to get the projects' updates and provide guidance and tutorial on professional architectural project presentation through engaging graphics, realistic renderings, and videos. At this stage, the students were focused on completing the project as per submission requirements. The pertinent issue was only about the limits of the project budget, of which several groups needed to adjust the number of facilities.

The final presentation was successfully held with a maximum number of attendees, including guests from Universitas Tanjungpura. All instructors expressed satisfaction with the proposed bicycle shed and hub design. Many praised students' efforts, given that the duration of the projects was relatively short for such a big project. Similarly, comments received from the lecturers of Universitas Tanjungpura were positive and constructive.

The students enjoyed the session, realising that they had overcome the limitations of the online studio and performed well. Nevertheless, a technical glitch happened to one of the group's video presentations, and the problem took a while to resolve. Examples of the design proposals are shown in Figure 7 below.

Figure 7: Examples of the Bicycle Hub Design

Semi-Structured Interviews

The project leaders mostly expressed positive emotions of pleasure and enjoyment when asked to reflect on their experiences throughout the course. However, some of the project leaders acknowledged their concerns and worries in the early part of the semester because of their impression of the project as complex and had no knowledge of their team members' capacity. 'We were also a bit worried as this work is a concerted effort from different departments,' said a project leader. The themes of their responses encompass (i) ideation and development, (ii) communication, (iii) cooperation, and (iv) suggestion for improvement.

For the first theme, several group leaders expressed that the online meeting limits free and spontaneous ideation where the group can sketch ideas immediately. To the students, attending online meetings and sketching and sharing the notes or sketches back to the meeting members are separate tasks and, therefore, less efficient than the meetings if they were to be conducted face-to-face. Another issue highlighted is the mastery of 3D modelling and rendering software. A project leader showed concern that some students were in their early years of study and were yet to learn the 3D software. Also, another group mentioned the difficulties of obtaining free software for architectural ideation. Although manual sketches can be utilised to present ideas and design development, digital design representation eases discussion and communication through online platforms.

Concerning communication, two project leaders expressed dissatisfaction over the internet hiccups that his group faced during online meetings. As the students stayed in their hometown, they had to deal with poor internet connections. Despite challenges in communication, all project leaders appreciated the cooperation and teamwork shown by the group members, indicating that they had overcome the digital barriers and developed mutual trust. '…everyone is working alongside each other' and 'all group members cooperated very well…' expressed two project leaders.

The groups consistently stated that they learned new knowledge from other disciplines. Furthermore, the course is considered an essential exposure for them to understand the practice of the built environment in the real world. Finally, during appraisals of the course, the project leaders unanimously mentioned aspects that could be improved, such as effective way to streamline the design works and the cost-estimating tasks and to includes a flow diagram of the project development progress requirement in the brief. The instructors responded that each firm could generate and use the flow diagram internally. The project planning process is typically tabulated in a mind map, process map and Kanban board as part of project management. In order to streamline the work between the design team and the quantity surveyors, it was suggested that a shared information board like Padlet could be used to update all members on the project's progress. Notably, the issue raised by the project leaders highlights that a proper setup of a virtual office environment is necessary at the beginning of the semester, especially the system, tools and resources.

CONCLUSION

The Integrated Multidisciplinary Project of the Kulliyyah of Architecture and Environmental Design, IIUM, brings together students from Architecture, Landscape Architecture, Urban and Regional Planning, Quantity Surveying, and Applied Arts and Design programmes to work on an architectural and built environment projects. In the academic year of 2021, the students were required to propose a bicycle shed and hub within the university campus. As the country was still implementing the Movement Control Order (MCO), the teaching and learning sessions for the course were conducted online. Through analysis of the project meeting recordings and an interview with the project leaders, it is found that internet hiccups hindered the immediacy and good flow of discussion. Individual ideation and eureka moments cannot spontaneously be shared among the students. Digital tools and technology also limit design critics and two-way discussions. Additionally, the development of rapport and trust needs more time. Nevertheless, the course outcome, including the students' performances and cooperation in accomplishing the project goals, is exceptional. This situation could be explained by the fact that students were familiar with the project sites, understood the projects' problems and needs, and had various expertise related to built environment design. Therefore, it can be concluded that the course has met its program learning outcomes, despite being conducted online. In the future, the course could take some advantages of online sessions but, ideally, be conducted in physical studios to enable effective design critiques and discussion and ensure students get the physical experience of a design process beyond a smooth digital screen. Design is about senses, and architectural and built-environment students need to physically engage with and immerse in their projects as they design tangible objects.

ACKNOWLEDGEMENT

REFERENCES

Broadfoot, O., & Bennett, R. (2003). *'The Architectural Studios: Online? Comparing the traditional face-to-face architecture studio with the Internet-based studio.'* COFA, The University of New South Wales.

Dam, R. F., & Siang, T. Y. (2021). *5 Stages in the Design Thinking Process*. Interaction Design Foudation. https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process

Harpe, B. D. La, Peterson, J. F., Frankham, N., Zehner, R., Neale, D., Musgrave, E., & McDermott, R. (2009). Assessment Focus in Studio: What is Most Prominent in Architecture, Art and Design? *The International Journal of Art and Design Education*, *28*(1), 37–51.

Kamil, M. J. M., & Sani, M. N. A. (2021). The Challenges and Initiatives of Teaching Product Design's Course Online During the COVID-19 Pandemic in Malaysia. *Asia Pacific Journal of Educators and Education*, *36*(1), 113–133.

Kattwinkel, D., Song, Y., & Bender, B. (2018). Analysis of Ecodesign and Sustainable Design in Higher Education. *DS 92: Proceedings of the DESIGN 2018 15th International Design Conference*, 2451–2460.

Light, G., Calkins, S., & R, C. (2009). *Learning and Teaching in Higher Education: The Reflective Professional*. Sage.

Maani, D. Al. (2019). *Exploring transition toward independent learning: student experiences in the first year of architecture school*. Cardiff University.

Maani, D. Al, Alnusairat, S., & Al-Jokhadar, A. (2021). Transforming learning for architecture: online design studio as the new norm for crises adaptation under COVID-19. *Open House International*.

Morkel, J. (2011a). Facebook Enhanced Face-to-Face Learning: The Architecture Studio. *5th International Computer & Instructional Technologies Symposium*.

Morkel, J. (2011b). The Social Dimension of Studio Space: Face-to-Face and Beyond-Exploring The Learner Experience. *Design Vision*.

Niculae, R. L. (2011). The virtual architectural studio—an experiment of online cooperation. *Review of Applied Socio-Economic Research*.

Walpole, H. (2012). Preparing to Teach Architecture Online: The Hurdle of the Design Studio. *Future Challenges, Sustainable Futures. Proceedings ASCILITE, 2012*.

Yu, F., & Silva, E. R. da. (2021). Design for robot assembly: Challenges of online education. *Procedia CIRP*, 482–487.