

INTEGRATION OF ENVIRONMENTAL BIM ANALYSIS WITH DESIGN PROJECTS IN THE PEDAGOGY OF ARCHITECTURAL EDUCATION

Aliyah Nur Zafirah Sanusi^{1*}, Fadzidah Abdullah², Aida Kesuma Azmin³, Zeenat Begam Yusof⁴, Nayeem Asif⁵

¹Asst. Prof. Dr., International Islamic University Malaysia, MALAYSIA, aliyah@iium.edu.my

¹Assoc. Prof. Dr., International Islamic University Malaysia, MALAYSIA, fadzidah@iium.edu.my

¹Asst. Prof. Dr., International Islamic University Malaysia, MALAYSIA, aida_kesuma@iium.edu.my

¹Asst. Prof. Ts. Dr., International Islamic University Malaysia, MALAYSIA, zeensoni@iium.edu.my

¹Asst. Prof. Dr., International Islamic University Malaysia, MALAYSIA, nayeem@iium.edu.my

*Corresponding author

Abstract

In the curriculum for Bachelor of Science in Architectural Studies, Architectural Design subjects are the main subjects, which are supported by other theory subjects. The Architectural Education pedagogy was programmed with integration of the Architectural Design subjects with the theory subjects at all level. However, the current situation of Covid-19 pandemic has made it a challenge to integrate the environmental conscious design subjects with design subjects. The theory subjects were taught with very minimal or no integration with Architectural Design subjects. The Architectural Education pedagogy was programmed to In the Department of Architecture, quality education is not only educating the students to design with aesthetic value but also with an environmentally conscious attitude. This study evaluated the impact of integrating environmental BIM analysis with studio design project in Semester 5, final year architecture programme. This study consists of two objectives. The first objective is to evaluate the students' perception on the importance of integrating the environmental BIM analysis with their studio design project in Semester 5. The second objective is to evaluate students' perception on how the environmental BIM analysis improved their knowledge in architecture. The case study was the Department of Architecture, International Islamic University Malaysia. Part of the University's mission is to provide quality education and produce responsible graduates and khalifahs. The selected sample students were Year 3 final year students who have completed basic Revit modelling course in Year 2. A quantitative analysis was conducted by distributing survey questionnaires to the students and 42 students responded to the survey. In conclusion, students found that it is important to integrate the environmental BIM analysis with their studio design project. They also agreed that the environmental BIM analysis improved their knowledge in architecture, particularly in environmental science and passive design strategies. This integrated environmental BIM analysis has guided the students into becoming responsible architects, designers and decision makers, for a sustainable future.

Keywords: Building Information Modelling, Environmental Analysis, Architectural Education.

1 INTRODUCTION

Ludwig Mies van der Rohe has stated the importance of education in producing responsible graduates in his quote *"If teaching has any purpose, it is to implant true insight and responsibility. Education must lead us*

from irresponsible opinion to true responsible judgement. It must lead us from chance and arbitrariness to rational clarity and intellectual order." (Mies van der Rohe, 1938).

This quote is in-line with the higher-education mission in preparing the next generation of thinkers and responsible decision makers with lifelong skills. This study is intended to tackle several issues. In response to the United Nations Sustainable Development Goals no 4 Quality Education, 11 Sustainable Cities and Communities and 13 Climate Change, this study is intended to promote quality education in providing future-skilling for the future thinkers in this digital era. This study is also intended to produce responsible designers that implement environmental conscious in their design process. Besides that, this study is to guide the students to become Role Players that integrate climate change measures into planning and decision making.

1.1 Problem Statement

The first issue was related to the students' awareness on the importance of designing an environmental responsive building project. The second issue was related to the students' inability to integrate their environmental science knowledge with their architectural knowledge when designing a building project.

1.2 Aims and Objectives

This study aims to evaluate the impact of integrating environmental analysis into the students' design project with the aid of BIM Revit Insight environmental software. The first objective is to evaluate the students' perception on the importance of integrating the environmental analysis with their studio design project in Semester 5. The second objective is to evaluate students' perception on how the environmental BIM analysis improved their knowledge in architecture.

2 LITERATURE REVIEW

2.1 Integration of studio-based project with theory courses

Architectural Design Studio courses as the core architectural courses. They require careful planning to determine the contents and delivery method. Environmental sciences and social sciences in the built environment, apart from planning its hierarchy strategy of learning scale (of size and complexity) and from one level to another, Architectural Design courses also require proper management for suitable delivery according to the level of study for every semester. Each semester includes the management and preparation of the project content as "problem-based" or the "case study" that should be in accordance to the level of study and indicated in the course outline; management on the process of its delivery and monitoring, including briefing, studio trips, input lectures, and workshops; management of setting assessment standards, conduct assessment, rationalization of the marks and management of the resources itself -staff and students, so that content and process is integrated and taught in every student as the focus. (Nawawi et al., 2014)

To maintain the relevancy of the offered theory courses with that of the counterpart of studio projects, each theory course is coupled with a specific level of studies for effective integration with concurrent studio projects. The integration allows greater flexibility and diversity in the teaching delivery method and allows students to relate their knowledge to the industrial practice through problem-based design studio tasks.

In this context, for example, the integration of the theory course Environmental Conscious Design with relevant studio projects is vital as each studio at the undergraduate level, from year one until year three, the students are required to apply appropriate environmental and climatic considerations based on the location of their project. The range of applications can start from passive design strategies to avant-garde technological solutions so that the project's outcome is sensitive towards the sustainable issues arising rapidly in the current century. Within the limited period of the design studio, where the students are to learn to ideate their design solution until formal visual presentation, it is not always feasible to go into the details of environmental issues related to the project. This is where the aid from theory courses like Environmental Conscious Design comes in handy and lets the student explore in great detail how to design a contextual building by considering the location, climate, and other relevant issues for the project.

2.2 Environmental Conscious Design Course

This course is one of the core courses for Bachelor of Science in Architectural Studies at IIUM. It encompasses the study of energy-conscious development in designing a safe and environmental-friendly architecture as inspired by the Quran and Sunnah. It emphasizes energy-efficient design relying on natural resources such as wind, solar, water, and building material by energy transformation, conservation, and application in buildings. The study will focus on sustainable ecological studies, energy conservation, and

architectural passive design strategies. There are three expected learning outcomes of this course. Learning Outcome 1 is able to describe the responsibilities of architects in supporting ecological and energy conservation in their design. Learning Outcome 2 is able to display skills based on site measurements, lab or computer experiment in solving environmental conscious problem. Learning Outcome 3 is able to apply simple energy-conscious design solution inspired by the *Quran* and *Sunnah*. Enhancing the quality of design projects of their current design studio projects of the semester using state of the art technology (Department of Architecture, 2018).

2.3 The Significance of Environmental BIM Analysis in Architecture Education

The twenty-first century has posed the building and construction industry the challenge to adopt an effective climate-friendly practice as part of the sustainable development goals set by the United Nations. Undeniably, adopting a practical approach should start from academia, where the next generation of architects and built environment professionals are trained. Building information modelling (BIM) proves to be the new spearhead to achieve climate-sensitive designs from the very beginning of the design process until the final product through its integrated environmental analysis tools. (Alhamami et al., 2020) . Sadly, the adaptation of these tools is happening in the field of construction industry rather than within academia. As a result, the new wave of graduates in built environment discipline fails to equip themselves with practical tools and training when they step into the industry.

Successful integration of environmental BIM analysis in architecture education depends on several aspects, i.e., the infrastructure provided by the institution, curriculum, available expertise, etc. On top of these, the vision and mission of the institution must also support a dynamic paradigm of pedagogical changes to incorporate the needs of the ever-evolving built environment industry. (Fadjar Maharika et al., 2020). Another issue is a lack of study on how to effectively integrate the course that deals with environmental BIM analysis in architecture education within the existing curriculum. Hence, the attempts remain subjected to continuous improvement based on trial and error. Prior study shows that such integration is challenging and complex. One possible way to accommodate the topic is to update existing courses closely related to studying the environmental aspects of building design and the courses that teach computer-aided design. (Abdirad & Dossick, 2016; Besné et al., 2021).

The built environment industry has seen a rapid transformation in the design and implementation process in the last half-century due to BIM development. (Sampaio, 2021). How long will academia sustain without playing a part in this rapid transformation? Young graduates in the built environment discipline can now have more tools for environmentally conscious design available in their hands compared to the last century, which offers greater automation and flexibility. (Abdelhameed, 2018; Salgueiro & Ferries, 2015) . Suppose the curriculum lags to equip the students with proper tools. In that case, it's only a matter of time before the traditional pedagogy will lose its relevancy in the dynamic field of the built environment in contemporary time.

3 METHODOLOGY

The methodology was structured to achieve two objectives; to evaluate the students' perception on the importance of integrating the environmental analysis with their studio design project and to evaluate students' perception on how the environmental BIM analysis improved their knowledge in architecture. Fig. 1 shows how the course plans for both subjects, Architectural Design and Environmental Conscious Design Courses were integrated. However, prior to receiving the Architectural Design project brief, the students were trained to use the BIM software, Autodesk Revit with Plug-In Insight.

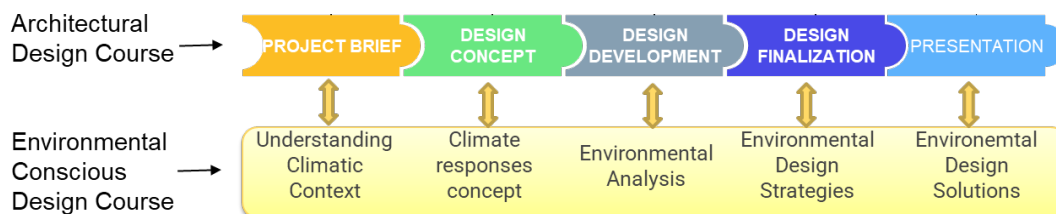


Fig. 1. The integrated design process for Architectural Design Course with Environmental Conscious Design Courses

The methodology chart is shown in Fig. 2. Assignment was given to the students at the same time of them receiving the project brief. Students are able to understand the climatic context using the 3-dimensional sun path analysis tool in Revit Insight (Fig. 3).

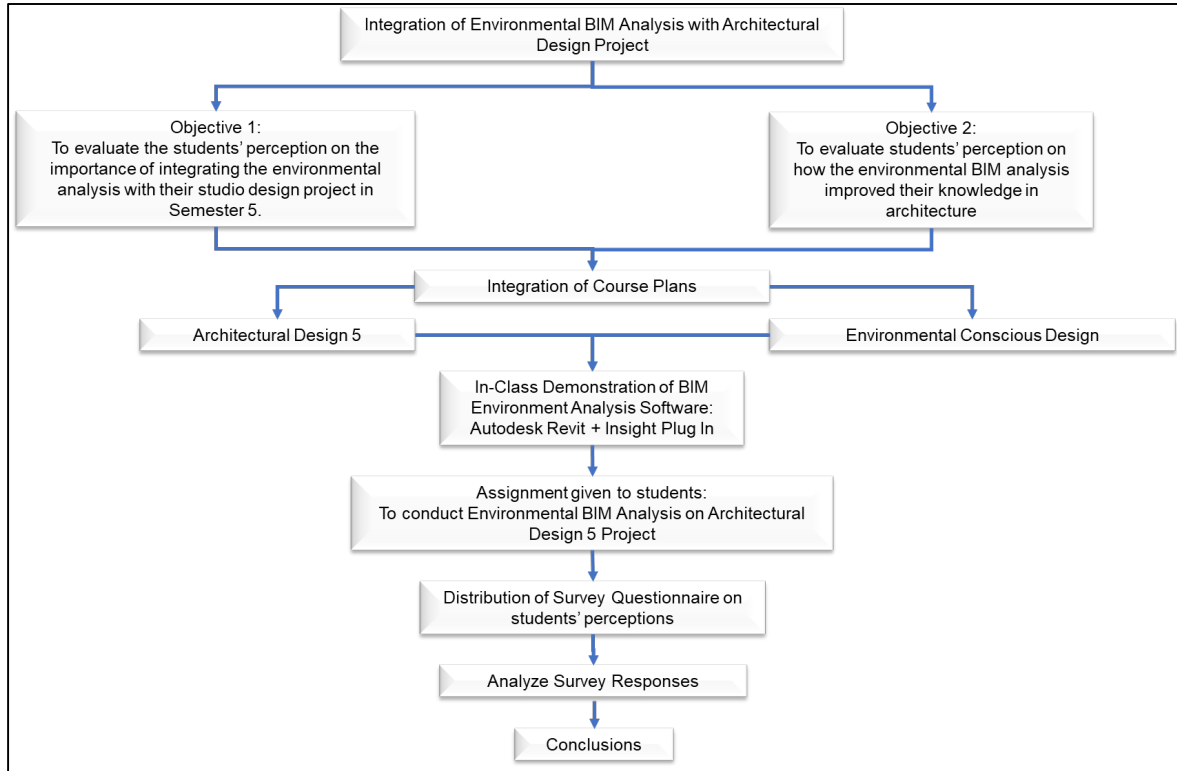


Fig. 2. The methodology chart



Fig. 3. In Class exercise on understanding the climatic context with Autodesk Revit and Plug-In Insight.

After completing the demonstration of Autodesk Revit Insight, the students were assigned to an assignment which was integrated with the design development of the Architectural Design Project. Students were given the assignment to conduct Environmental BIM Analysis on their concurrent Architectural Design Project. After they submitted their assignment at the end of semester, survey questionnaires were distributed to the students. The survey responses were then analyzed and discussed. Finally, conclusions were made based on the data analysis and discussions.

3.1 Sample of Studies

The sample of studies consists of Semester 5 Architecture students from Department of Architecture, International Islamic University Malaysia (IIUM). The total number of responded samples was 44 students.

4 FINDINGS

4.1 Students Sample Works

Prior to the Architectural Design Project, the students carried out an environmental BIM analysis on a case study building. Fig. 4. shows the product of the environmental analysis.

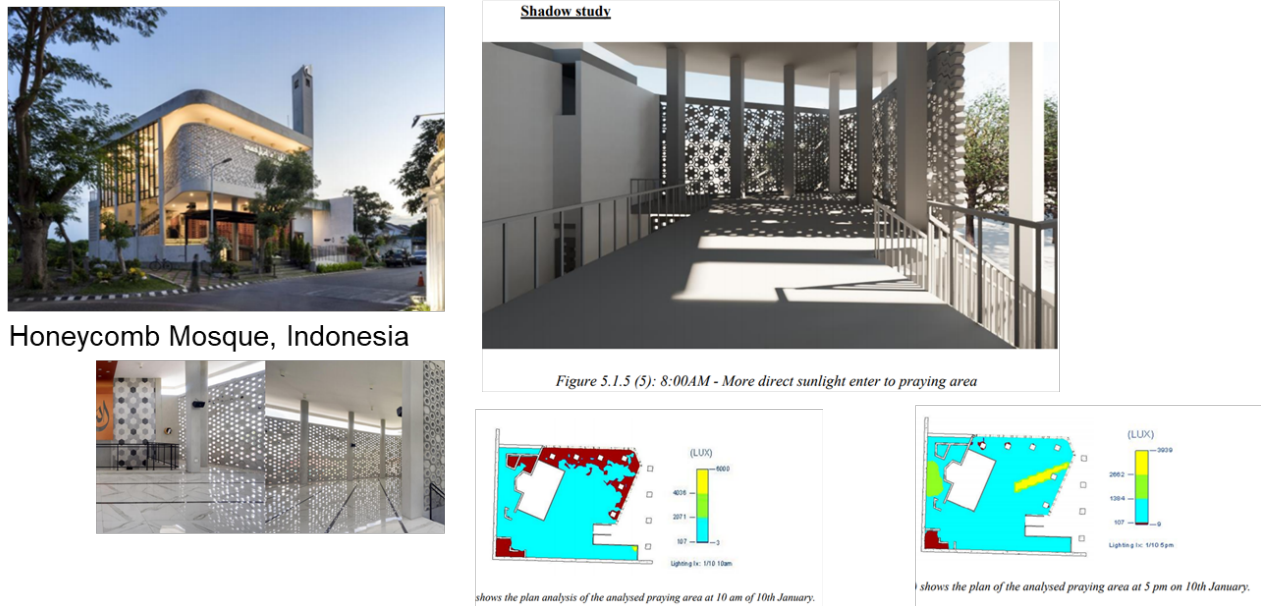


Fig. 4. Environmental BIM analysis on case study building, The Honeycomb Mosque in Indonesia, using Revit Insight.

At the end of Architectural Design Project, students are required to produce a poster of Environmental Conscious Design studies which consists of the integrated environmental BIM analysis on the architectural design project. Fig. 5. shows a sample of the assignment product.

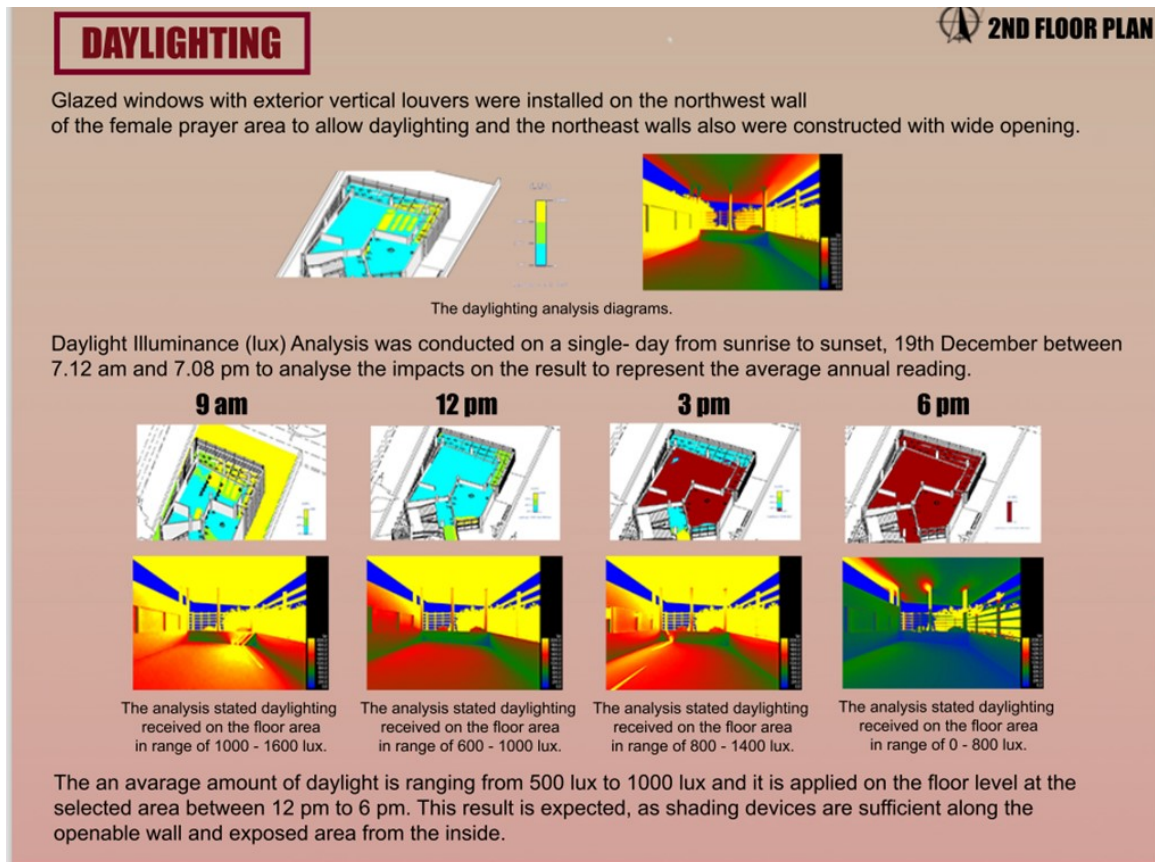


Fig. 5. Sample of student's work on the integrated environmental BIM analysis on the design project. (Source: Sali Amalia, 2020)

4.2 Students' Survey Feedback

Overall students' responses are positive. This paper focused on the responses from the three survey questions. The first question was *How important are the assignments given for AAR 3180 Course to your architectural knowledge overall?* Fig. 6. shows that all of the respondents finds the assignment important to the architectural knowledge.

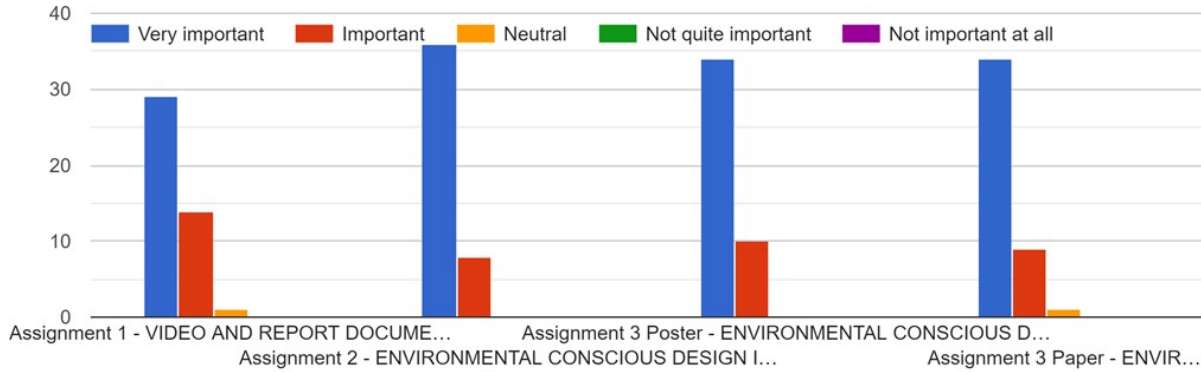


Fig. 6. The responses to Question 1 How important are the assignment given for AAR 3180 Course to your architectural knowledge overall?

The second question was *How important are the assignments given for AAR 3180 Course to your Studio Design Project?* Fig. 7. shows that all respondents agreed that the assignments are important to their studio design project.

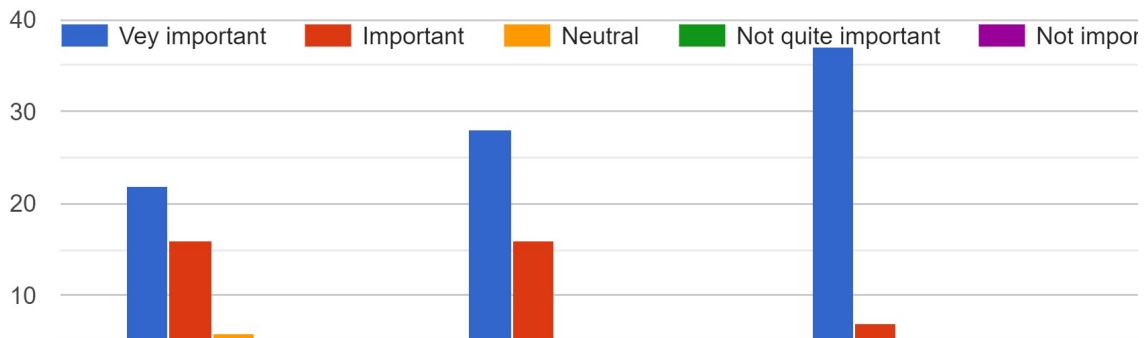


Fig. 7. The respondents to Question 2 How important are the assignments given for AAR 3180 Course to your Studio Design Project?

The third question was *How much have the assignments given for AAR 3180 Course improved your knowledge in Architecture?* Fig. 8. shows that all respondents finds that the assignments given have improved their knowledge in architecture.

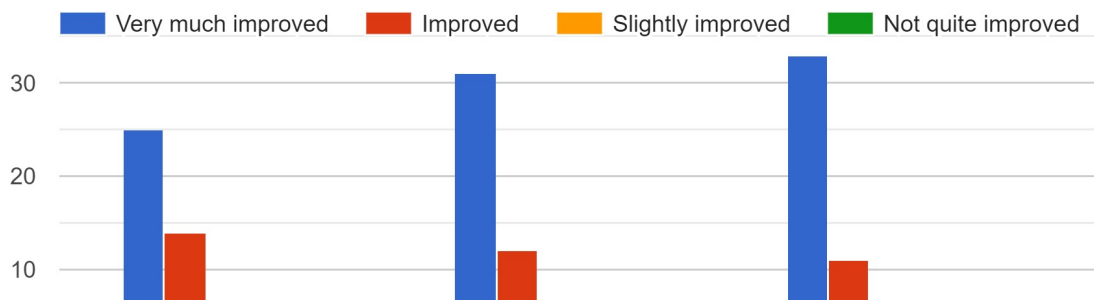


Fig. 8. The respondents to question 3 How much have the assignments given for AAR 3180 Course improved your knowledge in Architecture?

Table 1. Other additional comments from the respondents

Respondents	Other Additional Comments
Respondent 1	"Every lecture and input that madam give to us very useful and informative to guide us in our design studio and ecd assignments"
Respondent 2	"Everything is good during the process :D"
Respondent 3	"Thank u so much madam. It was very interesting class. I really enjoy it using the revit insight"
Respondent 4	"Fun course overall :)"
Respondent 5	"I love this subject. New thing I had learn especially the insight revit, very useful for my design project, thank you for teaching us, ❤️"

Table 1 shows the additional comments given by the respondents. From the comments, it can be seen that the students not only gained knowledge but also felt satisfied, positive and happy with the teaching and learning experiences of the integrated assignments.

5 CONCLUSIONS AND RECOMMENDATION

The first conclusion answers the first objective which is to evaluate the students' perception on the importance of integrating the environmental analysis with their studio design project. After going through the integrated design and learning process, majority of the students found that it is important to integrate the environmental BIM analysis with their studio design project. The second conclusion answers the second objective, which is to evaluate students' perception on how the environmental BIM analysis improved their knowledge in architecture. After completing both the Course Assignment and Design Project, the students agreed that the environmental BIM analysis have improved their knowledge in architecture, particularly in environmental science and passive design strategies. This integrated environmental BIM analysis have guided the students into becoming responsible architects, designers and decision makers, for a sustainable future. As quoted by Plutarch, "The mind is not a vessel to be filled, but a fire to be kindled" (Sanusi et. al, 2013).

6 ACKNOWLEDGEMENT

The Department of Architecture would like to acknowledge and express gratitude to Autodesk for the technical support in providing free Autodesk software to the education community member worldwide, which consists of Higher Education students and educators.

REFERENCE LIST

- Abdelhameed, W. (2018). BIM in architecture curriculum: a case study. *Architectural Science Review*, 61(6), 480–491. <https://doi.org/10.1080/00038628.2018.1483888>
- Abdirad, H., & Dossick, C. S. (2016). BIM curriculum design in architecture, engineering, and construction education: A systematic review. *Journal of Information Technology in Construction*, 21(August), 250–271.
- Alhamami, A., Petri, I., Rezgui, Y., & Kubicki, S. (2020). Promoting Energy Efficiency in the Built Environment through Adapted BIM Training and Education. *Energies*, 13(9), 2308. <https://doi.org/10.3390/en13092308>
- Besné, A., Pérez, M. Á., Necchi, S., Peña, E., Fonseca, D., Navarro, I., & Redondo, E. (2021). A Systematic Review of Current Strategies and Methods for BIM Implementation in the Academic Field. *Applied Sciences*, 11(12), 5530. <https://doi.org/10.3390/app11125530>
- Department of Architecture. (2018). *Course outline*. Kulliyah of Architecture and Environmental Design, IIUM.
- Fadjar Maharika, I., Irsan, A., Ismailiyah, S., Athas, A., Susanto, A., Abma, V., & Yuriandala, Y. (2020). Building Information Modelling (BIM) Adoption Model for Architectural Education. *Journal of Design*

and *Built Environment*, 20(3), 22–42. <https://www.scopus.com>

- Mies van der Rohe, L. (1938) *Speech to Architecture Students*. Armor Institute. Chicago.
<https://www.scribd.com/document/91739267/Mies-speech-to-architecture-students-IIT-1938>
- Nawawi, N. M., Abdul Rahim, Z., Denan, Z., Majid, N. H. A., Abdul Rahim, A., Abdullah, F., Sopian, A. R., & Hamat, S. (2014). The journey of murabbis in architecture pedagogy: The case of studio teaching as laboratory of passion and duty to future khalifas of the built environment. *World Applied Sciences Journal*, 30(30 A), 148–166. <https://doi.org/10.5829/idosi.wasj.2014.30.icmrp.22>
- Salgueiro, I. B., & Ferries, B. (2015). An "Environmental BIM" Approach for the Architectural Schematic Design Stage. *International Journal of Architectural Computing*, 13(3–4), 299–312. <https://doi.org/10.1260/1478-0771.13.3-4.299>
- Sampaio, A. Z. (2021). *BIM Education Required in Construction Industry*. Springer.
https://doi.org/10.1007/978-3-030-35533-3_1
- Sanusi, A. N. Z., Denan, Z., & Mohd Ariffin N. A. (2013). Ecotect Analysis: Integration of Architectural Studio Project with Theory Classroom Assignment through Computer Simulation. In *Proceeding: The European Conference on Education 2013, ECE in Brighton, United Kingdom, 11th – 14th July 2013*.