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ARCHITECTURE STUDENTS' ATTITUDE TOWARDS SUSTAINABILITY AND THE USE OF DIGITAL SIMULATION

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Abstract

This study aims to investigate architecture students' attitudes toward sustainability through the learning of digital simulation and their intention of integrating it into their architecture design studio project. The study employs a quantitative study using the survey design of 205 participants year two (2) undergraduate architecture students in a private higher educational institution that uses simulation in teaching sustainability. A total of 188 complete questionnaires were analysed using the quantitative method of descriptive analysis. Technology Acceptance Model (TAM) was used to understand the factors that influenced students' acceptance. In this study, the factor of Attitude (ATT) and Behavioural Intention to Use (BI) are discussed in detail. The results of this study demonstrated a positive attitude among undergraduate architecture students that demonstrated positive behavioural intention to use digital simulation in the architecture design studio. The sample size came from a private higher educational institution that used digital simulation as part of sustainability teaching in architecture education and it is a self-reported construct. The result can be used to improve sustainability teaching in architectural education, incorporating e-Learning /simulation using Building Information Modelling (BIM) by emphasizing integration in studio teaching. The finding discovered that architecture students' sustenance of using digital simulation to create sustainable approaches in design studios can only be achieved through constant motivation and clear guidance.

Keywords: Architecture design studio (ADS); Attitude; Building Information Modelling (BIM); Digital simulation; Technology Acceptance Model (TAM)

1. Introduction

The most essential teaching and learning of architectural education and the fundamental of the architectural curriculum is the architecture design studio (ADS). All the other modules support the ADS to facilitate students to design better. Architecture students will learn technical skills more readily and may willingly incorporate them in ADS projects when the skills are acquired on an as-needed basis in their design projects. Students pay attention to modules that have direct relevance to their ADS. Therefore, technical modules play a crucial role in accumulating knowledge and skills to support ADS as students do work on small and sometimes realistic design projects. This refers to the term integration in architecture education aiming at a higher-order learning outcome of application even in the lower semesters.

Effective integration in architectural education is through embedding sustainability concepts into the curriculum itself and not only in technical modules. Brunton [1] said that student-centred activities and assessments that reward critical thinking and reflective learning, multidisciplinary teaching and learning, and teaching that emphasizes that sustainability is an ongoing process without hard and fast answers. So rationally to instil sustainability in students, it should be integrated into the programme aiming at the core module which is the ADS. Architectural education needs to identify the collaborative nature of multidisciplinary modules such as design, technology, sustainability, community, and construction. The architecture designs in ADS are seen as meaningless without proper demonstration or application of technical knowledge and skills acquired from other modules constituting non-functional buildings. In parallel with the built environment industry, architecture, engineering, and construction educational programmes should also contain sustainability [2], implementation of technology [3], and to also think cross-disciplinary to achieve the student's attraction [4].

The built environment industry is now promoting new methods of information sharing and adopting emerging and fast-growing concepts such as Building Information Modeling (BIM), sustainability, collaboration, and related technologies. Almost fifty per cent of the architecture, engineering and construction industry is now using BIM and twenty per cent of non-users are planning to adopt it within two (2) years as reported in Smart Market Report [5]. BIM is an intelligent model-based process that provides insights into the design, build, and manage buildings and infrastructure. It is the latest software and allows digital simulation in an easier way than other preceding software. The Royal Institute of British Architects [6] as a requirement uses BIM, as it allows for the services, energy, and sustainability proposals to be a key part of the design and build process.

The accreditation organization of the architecture programme for Part One (1) in Malaysia as a requirement, expects students to demonstrate clear and logical architectural designs and academic portfolios, the ability to integrate the knowledge of the principles of building technologies, environmental design, and construction methods [7]. The architecture degree programmes in Malaysia consist of three (3) years of study and are equivalent to Lembaga Arkitek Malaysia (LAM) Part One (1) pre-professional examination as granted by the Board of Architects Malaysia (PAM) and the Lembaga Arkitek Malaysia (LAM). LAM Part One (1) pre-professional examination is the first level of a two-part board examination, and all architecture students are required to pass the LAM Part One (1) and Two (2) Examinations before they are eligible to register as Graduate Architects with LAM [8].

In research on the integration of structural knowledge in a design studio project at the University of Malaya by Aziz, Fahmi and Bane [9], their conclusion stated that "studio assignments be taken and cross-referenced throughout the other technical classes to enhance the student's understanding of a holistic design". Similarly, in America, Bachman and Bachman [10] reported National Architectural Accrediting Board (NAAB), the oldest American accrediting agency stated that the criteria labelling the main goal for an architecture programme are to achieve is architectural projects with creativity and technical mastery.

This problem was also persistent even two (2) decades ago. De Graaff and Cowdroy [11], reported the same issue of technology integration in the Faculty of Architecture at the Delft University of Technology, the Netherlands receiving a negative report from a national review committee that threatened the existence of the faculty. The Royal Institute of British Architects (RIBA) visiting board report of the Birmingham Faculty of Architecture Birmingham Institute of Art and Design Birmingham City University [12] also revealed that the architecture students' work lacks technical knowledge and skills in design. It was concluded that more sensitivity could have been brought to bear by students concerning the spatial, aesthetic, technical and social qualities of design within a wider cultural context. Technical knowledge and skills integration in architecture design studios were seen as a persistent and consistent problem throughout decades and in various contexts by the researchers and reports above.

Thus, the importance of demonstrating technical knowledge in the architecture design studio was an ongoing process requiring the change of curriculum and faculty direction. The curriculum changes occur as a response to many aspects such as the university's direction towards e-Learning in response to the professional industry's need for technology or digital simulation tool. Therefore, it is expected that technology or digital simulation will be used as graduate capabilities by the various local and international accreditation requirements.

1.1. Digital simulation in architectural education

The initiative to integrate a digital simulation tool to teach a technical module related to a sustainable environment in an architecture programme in a private higher educational institution in Malaysia is an attempt to integrate Building Information Modeling (BIM) into the curriculum through e-Learning. Autodesk Revit was used, and it is one of the Building Information Modeling (BIM) software. The BIM is an intelligent model-based process that provides insights to design, build, and manage buildings and infrastructure. It is the latest software that allows digital simulation in an easier way than other preceding software. The simulation model in this software was used to evaluate the shading performance of sun-shading devices of a chosen building as a case study.

Visual communication is vital in designing architecture. Digital simulation allows spatial configuration and scale to be depicted in the design and performance evaluation of an existing building. The graphics portraying visual or spatial data have a distinct advantage over other methods of communicating the same information, especially language, particularly for architecture students as they use space to convey spatially or vice versa. The digital simulation tool allows modelling space in three dimensions (3D) and configures spatial values. Consequently, this emphasizes students would better retention of knowledge and thinking processes by learning it through digital simulations [13]. Modelling digitally allows students to view and review very quickly and any adjustment could be made to the model instantaneously. According to Tversky, Morrison and Betrancourt [14] interactivity allowed students to be in control of the speed of animation, view and review, stop and start, zoom in and out, and change the orientation of parts and wholes of the animation will enhance the advantage of using the digital simulation tool.

Although drawing and modelling manually allow students to do the same, it saves a great deal of time when done digitally and data storage or portfolio compilation is easier. This would rekindle architectural creativity and design thinking in a way that encourages testing, experimenting, and prototype building and may lead to the discovery of innovations in architectural design. These reasons should provide an easier way for students to demonstrate technical knowledge in their architecture design studio through digital simulation. Using digital simulation tools is beneficial for many reasoning however a study of students' attitudes and intentions to use this tool is very critical to support its usage.

This study is based on factor constructs using the Technology Acceptance Model (TAM) model and was satisfactory to fulfil the task of this study. The attitude was judged as an important construct [15] that would provide insights into digital simulation acceptance and the intention to use it in architecture design studios. Using digital tools such as simulation in designing to cultivate design thinking in aiding designing does not equate to the idea of a "virtual design studio" that advocates asynchronous communication [16]. Research that advocates design visualization and analytical tool in computers were discussed about design thinking and retention of knowledge. Thus, the learning process is heightened by using digital simulation tools such as e-learning in architecture teaching and learning of technical modules with listings of benefits of cognitive capabilities and facilities;

i. Simple to use
ii. Visually viable to assist in design thinking [17]
iii. Easy to construct than drawing or physical modelling for testing with a natural environment [17]
iv. Test-retest is simple and fast [17]
v. Knowledge retention is higher for technical knowledge [13]
vi. Documentation of data / digital archive is possible [18]
vii. Data are readily available [18]
viii. Ease of producing an E-portfolio
ix. Acquiring graduate capabilities [19]

1.2. Technical module and sustainability

This technical module addresses sustainability in depth by addressing the basics; incorporating the natural environment in analysing an existing building, as a case study, particularly the effect of the sun on a building. This process is explicitly done in many architectural design projects as an initial exercise called site analysis [20] or site study. This technical module supplements in a way of integration to study the natural environment and its effect on building passively. The project particularly in this technical module studied the effectiveness of the sun-shading element of a chosen case study about its context. It is an attempt to instil critical thinking in architecture students by simulating, evaluating, and justifying the functions to create a thermally comfortable environment for users. This is a basic attempt to curb the internal heat gain to avoid the high energy consumption of air-conditioning is seen as a major issue of sustainability in tropical countries. By modelling a sun-shading element in Autodesk Revit, the function or the internal condition can be simulated by understanding the principles behind the sun path about buildings. The project submission of this module is a visual presentation board for evaluating and justifying the function of the modelled sun-shading element.

The case study project of analysing the function of the sun shading device of an existing building highlights sustainability in a very fundamental approach. The effective design of sun shading devices is an essential element in a tropical climate and are basic design as stated in Malaysian Standard 1525 [21] to deter heat gain in buildings. Lower heat gain will result in low energy consumption of air-conditioning. Sun-shading is the basics and basis of energy efficiency to reduce energy usage in buildings in a tropical climate.

Digital simulation of a sun shading device provides an avenue for capturing images and recording the animations. As the project outcome is a visual board, the students are to capture a series of pictures for the critical dates and times for the analysis of the tropical sun path, synthesis, and justification for their judgements of functionality and aesthetics, which would facilitate design thinking scientifically. Ng and Gunasagaran [22] in their research found that architecture students prefer to represent research and analysis in visual forms, and it is an opportunity to be creative. Animating and analysing sun shading on an existing case study in this technical module were done through careful planning to enhance the learning outcome of the module. Similar execution can be done in the design studio if the programme needs to advance towards digital technology usage in the undergraduate programme. Information about design thinking and technical issues needs to be justified and simplified without jeopardizing the knowledge and skills gained by students or the learning outcome.

The students are required to remodel parts of a case study of a building with simulated sun path movement throughout a year using Autodesk Revit, a Building Information Modeling (BIM) software. The effect of sun and shadow are identified and analysed in terms of heat gain, materials used and the conclusion of the sustainability of the said case study's building fabric design. Becerik-Gerber and Kensek [3], concluded that maximizing the potential of BIM on its usefulness will require the use of both professionals and academicians. The researchers found that this software is more advanced and possible to incorporate nature and the testing of a built environment as opposed to a passive Computer Aided Design (CAD).

Software evolution in Architecture designing has evolved tremendously from being a representational tool for visualization (CAD) to a design generative tool for the derivation of the form [23] and its transformation and testing of the natural environments on the built environment to be sustainable. As computer technology has advanced rapidly students need to be able to adapt to current technology. Architects and designers have used various digital applications and programming techniques to build intelligent, renowned, iconic buildings in the digital era. The application of computational methods to design architectural structures or objects is called Generative Design [24, 25].

1.3. Attitude for learning architectural education

In The Psychology of Attitudes, Eagly and Chaiken [26] provided an abstract definition of attitude as a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour. The further definition encompasses the key attributes of attitudes such as tendency, entity (or attitude object), and evaluation. This conception of attitude is then distinguishing the inner tendency that is attitude and the evaluative responses that express attitudes.

In Technology Acceptance Model (TAM) the inner tendency is the use beliefs, and the evaluative response is the behavioural intention to use. The two-use belief of digital simulation (PU and PEU) will affect the attitude (ATT) that forms the behavioural intention (BI) to use in an architecture design studio (ADS). The attitude factor plays an important role in this study. Horva´th [27] said that the relationships between a designer and the design profession can be seen as attitude. It influences the performance of a designer in many ways and is seen as not innate to the designer. Attitude may be formed and altered according to the perception as new knowledge and skill are gained. In the acceptance of digital simulation use, a positive attitude will be achieved if the students perceived the digital simulation as useful and perceived it as easy to use to achieve their tasks.

Although the use of digital simulation in the technical module was mandatory, the use in the architecture design studio is based on the voluntariness of the students. It is important to cultivate a positive attitude in architecture students to encourage them to integrate technical knowledge and skills in their architecture design studio. Each student will work in a different area that would require various technical knowledge and integration. It is important for students to independently approach their design by integrating the technical knowledge and skills that they have learnt.

Development of attitude however is not directly addressed in teaching of architecture design studio but implicitly assessed in teaching and learning of architecture programs. Therefore, van Doorn, Moes and Fain [28] focused on analysing designers' attitudes and included the development of attitudes in design-based educational programmes. Although attitude development is a continuous process, in their opinion the students can be supported in the development of a good designer's attitude. In an attempt to implement attitude development in designers' education, a clear vision of the most important aspects of designers' attitudes is much needed.

There are many associations between attitude and other capacities such as experience, knowledge, skill, and capability. Cross [19] attributes a good designer's attitude also supporting further development of attitude. Thus, to obtain a good designer, students must develop skills and capabilities in different disciplines by:

i. Acquiring experiences as professional ability depends directly on the number of experiences a student acquires.
ii. Gathering the appropriate knowledge and integrating it into the design process.

iii. Being proactive in problem framing, imposing their view on the design problem and directing the search for solution assumptions.
iv. Being solution-focused, not problem-focused, in handling any design problem.

To implement the development of attitude in design education, the phenomenon of attitude is analysed to obtain a deeper insight into elements that must be addressed during design education. In Technology Acceptance Model, a positive attitude (ATT) towards the use of digital simulation tools will form a positive behavioural intention (BI) to use it in their architecture design studio. The right attitude of designers can be cultivated by using digital simulation tools in architecture education. Students' attitude towards new knowledge and skills using simulation tools if positive would posit the right attitude of being pro-active and being solution focused or critical in thinking. Bakarman, [29] gives the following summary of designers' attitudes that must be addressed:

i. Professional behaviour in dealing with and handling design problems, such as exposure to different types of problems and solutions.
ii. Dedication and motivation to be a professional designer.
iii. Constant acquisition and management of knowledge.
iv. Teamwork and the ability to run the task smoothly.
v. Applying good time management.
vi. Feeling responsible for the outcomes.

Nevertheless, when forming the various elements that form a good attitude, a more organized outline is necessary. Bakarman [29] attributes attitude as a complex integration of related elements that enables the designer to perform different types of design tasks effectively in a multitude of working environments. He further added developing communication skills, for negotiation with others such as clients and team members. The association between attitude and other capacities or capabilities varies among the various elements of attitude. He defines elements of attitude as communication, reliability, trust, motivation, and open mindset while designing capacities as capability, attitude, knowledge, skill, and experience.

Development of attitude in architecture is crucial to create intentional learners among undergraduate architecture students. The researcher anticipates further understanding architecture student's perception towards the use of digital simulation tools by analysing the perceived usefulness (PU) and ease of use (PEU) and if these help in cultivating a positive attitude (ATT) in creating an intention (BI) to use digital simulation in the architecture design studio.

Kimbell and Stables [30] pointed to the following: active participation as task-centred, performing these tasks invoke a 'direct experience', which eventually can lead to a change in beliefs. This meant that a concrete experience might alter someone's beliefs, which can change someone's attitude. Similarly, Demirkan and Demirbaş [31] said that to change someone's beliefs, the concrete experience should be followed by a reflection to conceptualize and learn from the experience. They elaborated further that learning could not take place without any action, because the activity is needed to experience something and especially in design education, experiential learning is considered a crucial theory to develop a designer's competence.

Thus, the TAM model is believed to contribute very significant insights towards the usage of digital simulation as e-Learning in technical studies and in using it in the architecture design studio using Cross's [19] sets of criteria for a good designer's attitude. The attitude, beliefs and behavioural intentions among undergraduate architecture students will be able to be predicted in this study about the use of digital simulation.

2.Method

This study uses a survey and would give the relationship between students' attitudes and behavioural intention to use digital simulation tools in architecture design studios. For a student, the allocation of effort toward learning activities is driven by individual motivational processes, such as personal goals and interests, incentives, individual personality differences, and metacognitive knowledge that form the using belief and use of digital simulation tools in architecture education. Use and belief are the fundamental factors of Perceived Usefulness (PU) and Perceived Ease of Use (PEU) that form the attitude of architecture students. Positive attitude (ATT) will result in the behavioural intention to use digital simulation tools in the architecture design studio.

Since the introduction of the Technology Acceptance Model (TAM) a few decades ago, the application domains, its many extensions and refinements have widened out in several areas including educational technology. This study aims to investigate the factors that influence behavioural intention to use digital simulation tools among undergraduate architecture students. The TAM used in this study adheres to the original structure.

The results of this research would contribute to whether the use of digital simulation tools in the technical module is related or not to the intention to use it in an architecture design studio (ADS) in an attempt to integrate technical knowledge and skills. It would also provide an evidence-based understanding of the student's attitudes towards using the digital simulation tool and sustainability. This would provide information to further enhance the quality of the undergraduate architecture programme towards LAM Part One (1) and as well as RIBA Part One (1). By understanding architecture students' attitudes to embracing digital simulation, the researcher will gain information that would lead to the development and improvement in the usage of digital simulation tools in technical studies and architecture education.

To identify user acceptance the data for this study was collected using a survey questionnaire administered to 205 participants of year two (2) undergraduate architecture students in a private higher educational institution that uses simulation in teaching sustainability. A total of 188 complete questionnaires were analysed using the quantitative method of descriptive analysis. Table 1 contains the sample profile for this study.

The survey adhered to the Technology Acceptance (TAM) constructs and used a five-point Likert scale (1 for strongly disagree to 5 for strongly agree). The survey was distributed after submission for their technical module upon acquiring new technology. SPSS application (Version-20) was used to analyse data. The instrument used for this study was designed based on the objectives of the study to determine if the student's attitude (ATT) towards using digital simulation in an architecture design studio will have a positive effect on their intention (BI) to use it in the architecture design studio.

The TAM for this study is illustrated in Fig. 1. Cronbach Alpha value for the pilot study is 0.882 for 28 items. A pilot study had a total of 100 questionnaires distributed with 60 being filled. Upon review of two experts from an architectural education, the entire survey consists of 35 items intended to measure students' acceptance of digital simulation tools and behavioural intention to use them in the architecture design studio. In this study, the Attitude and Behavioural intention will be discussed in detail.

Table 1. Sample Profile.

Characteristics		N	%	Valid %	Cumulative %
Gender	M	97	51.6	51.6	51.6
	F	91	48.4	48.4	100.0
	Total	**188**	**100.0**	**100.0**	
Year	2	184	97.9	97.9	97.9
	3	4	2.1	2.1	100.0
	Total	**188**	**100.0**	**100.0**	
Semester	3	99	52.7	52.7	52.7
	4	86	45.7	45.7	98.4
	5	3	1.6	1.6	100.0
	Total	**188**	**100.0**	**100.0**	
Grade	A	87	46.3	46.3	46.3
	B	69	36.7	36.7	83.0
	C	16	8.5	8.5	91.5
	D	8	4.3	4.3	95.7
	F	8	4.3	4.3	100.0
	Total	**188**	**100.0**	**100.0**	
Personal choice of study	Y	158	84.0	84.0	84.0
	N	30	16.0	16.0	100.0
	Total	**188**	**100.0**	**100.0**	
Intention to further architecture study	Y	172	91.5	91.5	91.5
	N	16	8.5	8.5	100.0
	Total	**188**	**100.0**	**100.0**	

3. Results and discussion

In this survey, factors such as level of study and grade for the technical projects were analysed. High learning motivation contributes to a positive attitude in using digital simulation, but students still need to first possess enough knowledge so that while proceeding with the learning and operation of the digital simulation, they could attain sufficient knowledge most efficiently. Thus, it is crucial to indicate the knowledge gained through the grades acquired in the project. The total number of students achieving grade A and B for this project consists of 83% while grade C is 8.5% and grade D and F is 8.6%. The grade distribution is criterion-referenced thus the graph does not show normal distribution. The students passing this project are 91.5%. The grading was done using the rubric assessment of the project given. Elton and Johnston (2002, 13) state that the "normal practice in universities would appear to be a mixture of criterion and norm reference however the mark distributions seem to be referred back to psychological measurement which is assumed to give normal distributions".

The high grades were achieved because the project was a case study based and highly instructional. The distribution of grades showed higher grades meaning that a high number of students achieved the learning outcome for the project. The implication here is that their knowledge and skills have been accumulated on tropical climate-responsive architecture as part of sustainability studies thus preparing them well to apply digital simulation tools in the architecture design studio and that it should be possible. At least 70% - 90% of the students were highly motivated in their sustainability studies according to the grade's distribution. In Table 1; 16.0% (not first choice of study) and 8.5% (not furthering architecture studies). Students passing the project are 91.5% and those achieving high grades are 83%. But grades and intention to further study alone may not be enough to explain the behavioural intention to use digital simulation in the architecture design studios.

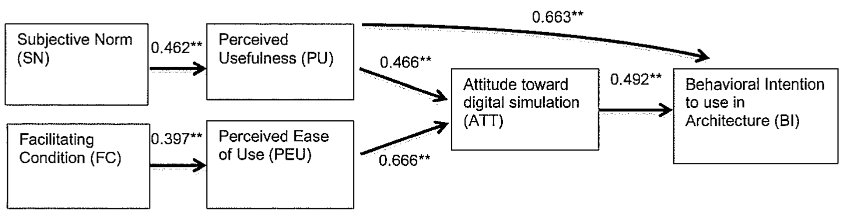

Fig. 1. Technology Acceptance Model for this study with a summary of the "r-value" of Pearson's Correlation.

Correlation analysis was conducted to test the relationship and its strength among variables. The highest p-value is 0.001, implying that the difference in means is statistically significant at the 0.05 and 0.01 levels ($p = < .001$) and $n=188$. The correlation between perceived usefulness and attitude shows a moderate positive value, $r = 0.466$. Judged by its direct relationship with attitude and behavioural intention to use in the architecture design studio, $r =0.663$, perceived usefulness was found to be the most significant factor influencing students' use of digital simulation tools. However, it is noticed that perceived ease of use has a direct and positive relationship with attitude towards the use of digital simulation with a strong positive correlation, $r = 0.666$. Students' views of perceived ease of use had even stronger influences on attitudes than usefulness.

Attitude and behavioural intention have a moderate positive relationship, $r = 0.492$. To further understand how to encourage a more positive relationship between attitude and behavioural intention use a closed-ended question, SN5, with a nominal scale, 'This reason will encourage me to use digital simulation in my architecture design studio (choose one)', 56.9% of students did not have a response or chose others without stating a reason (refer Table 2). However, 28.7% of the students responded that they would use digital simulation in an architecture design studio (ADS) as incorporating technical knowledge and skills in ADS because they understood the importance of sustainability. 6.9% of the students chose only if the design instructor makes it compulsory, 4.3% said only if someone helps them to understand how to do it in software while 3.2% said only if marks were allocated for it. Thus about 14.2% of the students would use it if it was compulsory, 28.7% to apply sustainability in the architecture design studio and 56.9% have no opinion on this matter.

To understand the motivated student's demography of grades and motivation to further their study in the architectural field, a crosstabulation is presented in Table 2. Of the students who have received a pass in the technical study project, 47 students have the intention to further their studies in architecture and the intention to integrate digital simulation tools in their architecture design studio. Thus, a further initiative by the programme is needed to cultivate the right attitude for the intention to use digital simulation.

Table 2. D4 * SN5 * D6 crosstabulation count.

D6			SN5					Total
			TUTOR	MARKS	SUSTAIN.	HELP	NONE	
Y	D4	A	4	2	18	5	52	81
		B	1	1	24	1	34	61
		C	3	0	5	1	6	15
		D	1	1	2	1	2	7
		F	1	0	3	0	4	8
	Total		**10**	**4**	**52**	**8**	**98**	**172**
N	D4	A	1	1	1	0	3	6
		B	1	1	1	0	5	8
		C	0	0	0	0	1	1
		D	1	0	0	0	0	1
	Total		**3**	**2**	**2**	**0**	**9**	**16**
Total	D4	A	5	3	19	5	55	87
		B	2	2	25	1	39	69
		C	3	0	5	1	7	16
		D	2	1	2	1	2	8
		F	1	0	3	0	4	8
	Total		**13**	**6**	**54**	**8**	**107**	**188**
	Percentage (%)		6.9	3.2	28.7	4.3	56.9	100

4. Conclusion

Although motivated students or intentional learners are crucial in architecture design studios, there should be clear pedagogical guidelines about the use of digital simulation tools. It would be very dangerous to leave it to the interpretation of an individual student. Without guidelines, the data can be misinterpreted, and green washing can happen. As 107 students in Table 2 answered NONE to question SN5. At some point, students were not sure of the faculty's stand on the usage of digital simulation in the architecture design studio (ADS) and it was not made known to them explicitly the terms and conditions of digital simulation usage to demonstrate sustainability technical skills in the architecture design studio. The direction of faculty towards:

- e-learning
- digital simulation to demonstrate technical skills, and
- use in ADS as integrating technical skills.

need to be elaborated and explicitly made known to students promoting the benefits of digital simulation to draw students' interest to use it in the architecture design studios. All faculty members need to help students confirm or enhance their perception positively through digital simulation.

In conclusion, enough encouragement and assurance need to be provided by the faculty to motivate students to use digital simulation as this will then facilitate students' perceived usefulness of digital simulation tools since it is not very strongly evident in the findings of this research study. The areas identified through this research that need to be worked at to move towards excellence are;

- Architecture students need to be motivated to achieve the perceived usefulness of using digital simulation and are generally capable in technical knowledge and skills as undergraduate students,
- Architecture students need to acquire digital simulation/computer skills as graduate capabilities,
- Architecture undergraduate programme needs to be moved towards educational excellence to fit the learning outcome of the programme and University standards of teaching and learning, and
- Architecture undergraduate programs need to comply with the accreditation boards and adhere to the international standards of teaching and learning.

References

1. Brunton, K. (2006). Education for sustainable development: principles for curriculum development in business subject areas. *Investigations in University Teaching and Learning*, 3(2), 36-46.
2. Manoliadis, O. (2009). Education for sustainability: experiences from Greece. *Journal of Professional Issues in Engineering Education and Practice*, 135(2), 70-74.
3. Becerik-Gerber, B.; and Kensek, K. (2010). Building information modeling in architecture, engineering, and construction: emerging research directions and trends. *Journal of Professional Issues in Engineering Education and Practice*, 136(3), 139-147.
4. Adeli, H. (2009). Vision for civil and environmental engineering departments in the 21st century: *Journal of Professional Issues in Engineering Education and Practice*, 135(1), 1-3.
5. McGraw-Hill. (2009). SmartMarket Report, The business value of building information modeling: getting building information modeling to the bottom line. New York. Retrieved from https://images.autodesk.com/adsk/files/final_2009_bim_smartmarket_report.pdf
6. Royal Institute of British Architects (RIBA) (2012). Guide to Sustainability in practice 2012. Retrieved from http://www.architecture.com/Files/RIBAProfessionalServices/RIBAGuidetoSustainabilityinPractice.pdf
7. LAM (2016). Appendix A| Accreditation |Board of Architects Malaysia. Retrieved 19 July 2015, from http://www.lam.gov.my/accreditation/appendix-a
8. LAM (2016). Registration | Graduate Architects | Board of Architects Malaysia. Retrieved 19 July 2015, from http://www.lam.gov.my/index.php/registration/graduate-architects.html
9. Aziz, A.A.; Fahmi, M.M.; and Bane, L.T. (2010). Integration of structural knowledge in design studio project: Assessment study of curriculum in architecture course in university of Malaya. *Journal of Design and Built Environment*, 7, 59-74

10. Bachman, L.R.; and Bachman, C. (2009). Designing student learning outcomes in undergraduate architecture education: Frameworks for assessment. *Enquiry: A Journal for Architectural Research*, 6(1), 49-67.
11. De Graaff, E.; and Cowdroy, R. (1997). Theory and practice of educational innovation through introduction of problem-based learning in architecture. *International Journal of Engineering Education*, 13(3), 166-174
12. Royal Institute of British Architects (RIBA). (2010). Report of the RIBA visiting Board to the Birmingham School of Architecture and Landscape, University of Central England: 1-24. UK. Retrieved from http://www.architecture.com/files/ribaprofessionalservices/education/validation/2010/confirmedreportbcu.pdf
13. Lin, T.-J.; Duh, H.B.-L.; Li, N.; Wang, H.-Y.; and Tsai, C.-C. (2013). An investigation of learners' collaborative knowledge construction performances and behavior patterns in an augmented reality simulation system. *Computers & Education*, 68, 314-321.
14. Tversky, B.; Morrison, J.B.; and Betrancourt, M. (2002). Animation: can it facilitate? *International Journal of Human-Computer Studies*, 57(4), 247-262.
15. Kim, Y.J.; Chun, J.U.; and Song, J. (2009). Investigating the role of attitude in technology acceptance from an attitude strength perspective. *International Journal of Information Management*, 29(1), 67-77.
16. Kvan, T. (2000). Teaching architecture, learning architecture. *Proceedings of the Fifth Conference on Computer Aided Architectural Design Research in Asia,* Singapore: 181-190.
17. Yan, W. (2007). Design thinking visualization, *Proceedings of Computer-Aided Architectural Design Research in Asia* (*CAADRIA*), Nanjing, China, 210-217.
18. Bender, D.M.; and Vredevoogd, J.D. (2006). Using online education technologies to support studio instruction. *Educational Technology and Society,* 9(4), 114-122.
19. Cross, N. (2003). *The expertise of exceptional designers*. Expertise in Design, Creativity and Cognition Press, University of Technology, Sydney, Australia: 23-35.
20. Kvan, T.; and Jia, Y. (2005). Students' learning styles and their correlation with performance in architectural design studio. *Design Studies*, 26(1), 19-34.
21. Malaysian Standard 1525. 2007. Code of Practice on Energy Efficiency and use of Renewable Energy for Non-Residential Building
22. Ng, V.F.P.; and Gunasagaran, S. (2010). ‘Exhibiting’ Research: The Value of Integrating Research, Field Trip and Creative Outcomes as Teaching and Learning Approaches in Architecture. Emerging Trends In Higher Education Learning And Teaching: 105.
23. Kolarevic, B. (2000). Digital architectures. *Proceedings of the ACADIA 2000 Conference*, *ACADIA.*
24. Krause, J. (2003). The creative process of generative design in architecture. GA2003 (6th) Generative Art Conference / Exhibition / Performances. Milano, Italy. Retrieved from http://www.generativeart.com/

25. Al-Qawasmi, J. (2005), Digital media in architectural design education: reflections on the e-studio pedagogy. *Art, Design and Communication in Higher Education*, 4(3), 205-222.
26. Eagly, A.H.; and Chaiken, S. (2007). The advantages of an inclusive definition of attitude. *Social Cognition*, 25(5), 582-602.
27. Horva´th, I. (2006). Design competence development in an academic virtual enterprise. *Proceedings of the International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*, 42578, 383-392.
28. van Doorn, E.; Moes, N.; and Fain, N. (2008). Attitude development in designer's education. *Proceedings of the TMCE* 2008. Kusadasi.
29. Bakarman, A.A. (2005). Attitude, skill, and knowledge: (ASK) A new model for design education. *Proceedings of the Canadian Engineering Education Association*, Retrieved from http://library.queensu.ca/ojs/index.php/PCEEA/article/view/3894
30. Kimbell, R., and Stables, K. (2007). *Researching design learning: issues and findings from two decades of research and development*. Springer Science and Business Media.
31. Demirkan, H., and Osman Demirbaş, Ö. (2008). Focus on the learning styles of freshman design students. *Design Studies*, 29(3), 254-266.