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IMPACT ANALYSIS OF DIGITAL-BASED ARCHITECTURE CURRICULUM ON STUDENTS' LEARNING

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Abstract. This paper reports the findings of assessing the impact of current digital-based architecture curriculum in architecture at KFUPM on students' learning primarily from students' perspectives. The paper addresses both generic and specific impacts of current digital-based architecture curriculum on students' learning. The specific impacts include: level of achieving better understanding of the architectural issues of buildings, and impacts of media qualities on understanding architecture. The paper introduces a performance improvement plan aimed at enhancing students' learning in the digital-based architecture curriculum and to accommodate the evolving nature of information technology applications in the building and construction industry.

Keywords. Digital architecture curriculum; students' learning; impact analysis; digital design education.

1. Introduction

Since the late 1980s architecture and architectural education have witnessed an important transformation with the introduction of computers and information technology (IT) in which they have become pervasive in all aspects of architectural practice and education. The pervasiveness of information technology in architectural education and practice has been manifested in the growing proportion and importance of IT related courses in the curricula of architectural schools. Many schools have increased IT content in their curriculum and are investing resources to acquire computing facilities to ensure that they provide their students with the necessary skills and competitive advantage. At the same time, the debate within the profession has shifted from the rel-

evance of drawing in pencil and ink to the relationship between digital media and architecture itself. Furthermore, how are computers transforming the way architects learn to design and build? (Cuff, 2001)

At the architecture undergraduate program of KFUPM and similar to most of the architecture schools, the design work in final reviews of projects done by architecture students is increasingly if not entirely computer-generated with colourful and wonderful presentations. However, it was observed that the focus seems to have changed from quality design to quality presentations. Focusing on critical thinking, creativity, design analysis, climatic and contextual considerations, and concern of structural and building systems seems to be paying the cost of shifting the focus to digital presentations. This is rather an alarming remark about the impact of digital-based curriculum on students' learning in architecture. Therefore, it has become imperative to analyse the impact of digital-based curriculum on undergraduate students' learning in architecture at KFUPM and to identify ways and means to enhance student's learning.

2. Digital technology and its impacts on students' learning

Pedagogy is any conscious activity by one person designed to enhance the learning of another (Mortimer, 1999). While pedagogy can be a personal matter it is more often conceived as the art or science of teaching; a set of principles and practices to improve learning. Educational technology, as a subset of pedagogy, is the sound use of any technology to support and improve learning. Information technology, on the other hand, focuses more on the digital delivery of information. Technical issues tend to take precedence. Christie and Ferdos (2004) argued that educational and information technologies cannot be separated. For better or for worse they impact upon one another. When one seeks to improve learning using digital media, pedagogical considerations are always an issue. The same fundamental questions that are asked of traditional university pedagogy need to be asked of digital-based curriculum but, in addition, the potential for a radically different, more innovative pedagogy has to be explored. Good pedagogy can inform and be supported by good IT. Poor pedagogy can subvert the very point of using good IT. A combination of bad pedagogy and bad IT is a disaster for the future of students' learning. Tien and Fu (2008) found that most undergraduates perform at the middle average level in terms of IT knowledge.

Ever since computers were deployed in earnest in the 1960s, researchers have been trying to use information technology to improve learning. And yet, except for a few cases, there is little proof that such exercises actually improve learning (Dertouzos, 1997). A major problem many researchers face

in this area is the difficulty in isolating and quantifying learning improvements resulting from the use of information technology among a myriad of other factors. Thus, one has to evaluate possible benefits that information technology can provide for delivery of education at a conceptual level. To measure the impact of new information technologies on delivery of education, one can look at how advances in information technology can enrich or facilitate various facets associated with delivery of education. Some of the major areas are providing access to information, improving communication means with a human tutor, customising information provided to a student based on students past performance and using specific information presentation schemes to enhance understanding (Ginige and Ginige, 1998).

2.1 DIGITAL-BASED ARCHITECTURE CURRICULUM AND STUDENTS LEARNING

The inclusion of advanced IT in Architecture curriculum depends on pedagogical ways through which technology can be used in interacting with demanding clients and society, delivering knowledge to learners or in representing ideas and alternatives through analysis and critiques. Kalay (1986) analysed the impact of Computer Aided Design (CAD) on architectural design education; in which he even asked if CAD had any impact at all. Kalay presented the following justifications for CAD in schools of architecture across the USA; (a) it assists students in reducing difficulties of expressing certain architectural forms, (b) it allows students to explore more alternatives and arrive at better solutions in a shorter time, (c) it allows students to appreciate the visual and numerical implications of the design decisions and to integrate aspects of e.g. (of cost, energy) into designs, and finally (d) it allows students to explore "new" ideas without fear of having to reproduce an entire drawing should things go wrong. But Howes, (1986) pointed to a report which indicated that the level of computer utilisation in architectural education was quite low compared to other disciplines. Howes also proposed an uncompromising minimum level of contact with computers by students of architectural design (they should understand and appreciate what the computer could do especially in the practical world of design at the least); hence it was agreed in general that all graduates ought to be computer literate and would be expected by the industry to be able to approach keyboards and manuals with little fear. As such, the minimal contact should ideally include 'hands-on experience in drafting' even if it is at the basic level.

A decade later, Qaqish and Hanna (1997) conducted a worldwide questionnaire survey on the applicability of computers in architectural education. Their survey covered 51 institutions in seven countries and among their key

findings is that virtually all (92.15%) the of studied institutions had CAD programs in their curricula that were implemented for over 13 years as of the time of the survey; which was quite a significant improvement on the scenario a decade earlier. 42.63% of respondents could be regarded as CAD users while 57.37% were users of traditional media. As of that time, only 31% of respondent institutions had introduced virtual reality into their curriculum. Furthermore, Kvan (2000) addressed design learning and illustrates how computer tools have been used to support learning. Pentilla (2003) summarised the analysis of data on European architecture schools, collected in the eCAADe-conferences during the 1990s. Computer-Aided Design has developed into architectural information and communication technology (ICT), to become commonplace in architectural education. However, the general held views on new media use in the schools seems to be slightly optimistic. Most recently, Gecu and Ozdener (2010) demonstrate that using dynamic geometry software has a significant place in geometry instruction and results in improvements in achievement and retention of knowledge.

3. Impact analysis of digital-based architecture curriculum students' learning

In order to assess the impact of current digital-based curriculum in architecture at KFUPM on students' learning primarily from students' perspectives, a structured questionnaire sample was developed and a small group of junior and senior students enrolled in the undergraduate architecture program at KFUPM was interviewed for a pilot study to fill out the structured questionnaire sample in order to clarify the issues addressed in the questionnaire in case of ambiguity and introduce necessary modifications prior to conducting the actual survey. The final structured questionnaire was filled out by current (junior and senior) students from the undergraduate architecture program in order to analyse the impact of current digital-based curriculum in architecture on students' learning primarily from students' perspectives. Other structured questionnaires were developed to acquire graduated students, teachers and industry perspectives on this regard. All structured questionnaires include close-ended and open-ended questions. Due to the limited length of this paper, the focus will be on analysing the impact of digital-based architecture curriculum on students' learning from students' perspectives.

3.1. KEY FEATURES OF THE DIGITAL-BASED ARCHITECTURE CURRICULUM AT KFUPM

The focus of the curriculum is on computer aided modelling and presentation

rather than on computational designing. Digital-based courses in the architecture curriculum are taken as courses with information technology specified as a major component of their teaching and learning process. Such courses are reflected in the curriculum as both core and elective courses. The total credit hours of the core digital-based architecture courses represent 10% of the curriculum requirement of the program and are as follows: Computer Aided Architectural Design, Virtual Reality in Architecture, Virtual Design Studio, and Construction Documents. There are three elective courses that fall into the category of digital-based architecture courses and are as follows: Computer Presentation Technique, Knowledge Based Systems in Architecture, and Special Topics in Computer Aided Design.

The curriculum requires a student specialising in CAD minor to take at least two of the CAD elective courses. A student completing the program but specialising in an option other than CAD would take digital-based architecture courses that represent a minimum of 10% and a maximum of 11.33% of curriculum requirements. A student specialising in the CAD option would take digital-based architecture courses that represent a minimum of 12.66% and a maximum of 14% of curriculum requirement. This analysis raises questions of the amount and representation of digital-based architecture courses required to constitute a focus in an architecture program and also of the percentage of curriculum requirements that would constitute a minor area of specialisation.

3.2. GENERIC IMPACTS OF DIGITAL-BASED ARCHITECTURE CURRICULUM ON STUDENTS' LEARNING

The students were asked to respond to sets of questions regarding the impact of IT on their learning. Figure 1 shows the responses received. Most noticeably among the responses are the following: 56% 'agreed' that use of IT enhanced their learning, while 32% 'strongly agreed' to this proposition. 44% 'strongly agreed' that IT enhances their designs while 32% 'agreed' to this; meanwhile 12% 'disagreed' completely with this suggestion. However, as for the whether IT enhances their presentations, 76% of all students 'strongly agreed' while 20% 'agreed' with this notion. 44% 'strongly agreed' that core courses should inculcate the use of IT; while 24% 'agreed' to this suggestion. 16% were indifferent to this suggestion and the same proportion of students 'disagreed' totally with this idea. As for use of IT in design studios, 44% 'strongly agreed' while 20% were 'neutral', while equal numbers (16%) both 'agreed' and 'disagreed'. 48% of respondents 'strongly agreed' that email is important for communication, and 36% simply 'agreed' to this notion while 16% were 'neutral'. When it came to the issue of whether the web enhanced their learning, most (36%) were indifferent or neutral to this suggestion. However, 32% 'agreed'

while 24% 'strongly agreed' to this concept. Meanwhile 40% of respondents 'strongly agreed' that they were skilled enough to use basic web-based learning methodologies; 32% 'agreed' while 12% disagreed that they possessed this ability.

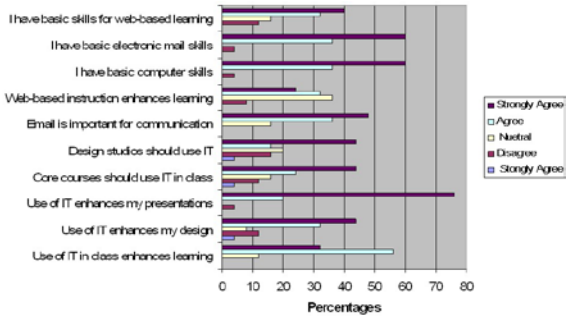


Figure 1. Students' responses on the generic impact of IT on their learning.

3.3. SPECIFIC IMPACTS OF DIGITAL-BASED ARCHITECTURE CURRICULUM ON STUDENTS' LEARNING

3.3.1. Levels of achieving better understanding of the architectural issues of buildings

Students were asked to rate how much they agreed that certain architectural issues were better understood through use of digital-based architecture curriculum (in instruction, resources and delivery). Understanding is exemplified in four measures: Reflective (monitoring and thinking about); Constructive (integrative, deep and creating own response); Thoughtful (deep processing); and Creative (exploration and generation of innovative ideas). The architectural issues include: form, purpose, spaces, circulation paths, artificial light, air quality, social context and scale. The results illustrated in Figure 2 show an agreement that a better understanding of the architecture of buildings is achieved through the digital-based architecture curriculum especially of high percentages for the issues of form and scale. On the other hand, there is a disagreement in the students' responses for achieving better understanding of the architecture of buildings in the current digital-based architecture curriculum on the issues of purposes of the building (12% strongly disagreed); air quality (16% strongly disagreed); and social context (16% strongly disagreed). There is however some students opted to stay neutral when rating some architectural issues such as purpose, spaces, circulation and use of artificial lights, which all had 12% neutral rating from respondents who could not tell whether or not

these architectural were better understood by the use of digital-based architecture courses.

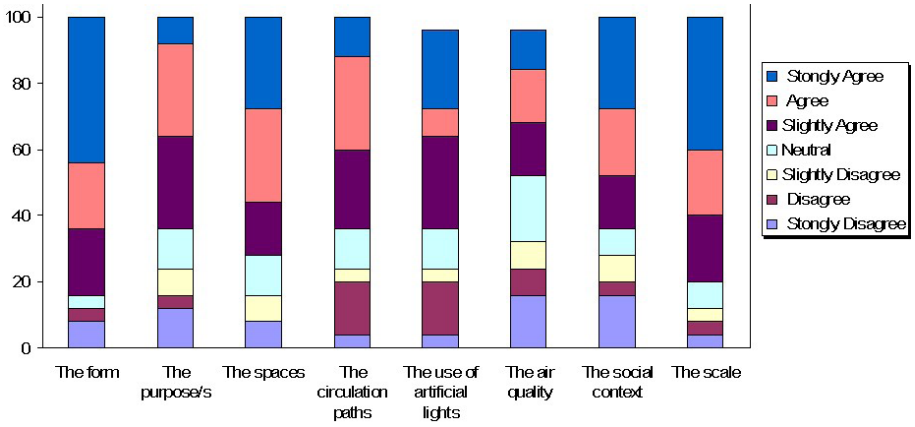


Figure 2. Students' responses on how one set of architectural issues were better understood through use of digital-based architecture curriculum.

Similarly, students were requested to rate how much they agreed that another set of architectural issues were better understood through use of digital-based architecture curriculum (in instruction, resources and delivery). The second set of architectural issues include: colour scheme, immediate surroundings, views, construction methods, materials and texture, cost, context and air movement/ventilation. Figure 3 reveals that there is a general agreement with this notion for colour scheme, immediate surrounding and views. Quantitatively, 8%, 32% and 24% were recorded for colour scheme in terms of slightly agreed, agreed and strongly agreed with impact of digital-based architecture curriculum in understanding colour scheme. Meanwhile immediate surrounding had 20%, 24% and 24% respectively; views had 16%, 24% and 20%. However, construction methods, materials/texture, cost, context and air movement/ventilation had more respondents opting to strongly disagree, disagree or slightly disagree with the notion that digital-based architecture curriculum has aided their comprehension of design through these architectural issues. Specifically, construction method and context had 20% of respondents each, strongly disagreeing with the notion. 24% of respondents strongly disagreed that the utilisation of digital-based architecture curriculum enhanced their understanding of the cost aspect of architecture.

3.3.2. Impacts of media qualities on understanding architecture

The impacts of media qualities on students' understating and learning archi-

tecture within the digital-based architectural curriculum was put to test by subjecting several factors of media qualities to the scrutiny of students. They were asked to assess the following media qualities: accessibility of information, clarity of information, interesting/appealing representations, coherence/correctness of information, organisation/structure of information, completeness of information, immersion, and others (time-saving). The factors of accessibility of information, clarity of information, interesting/appealing representations had 12%, 4% and 20% votes respectively from respondents who strongly agreed with their influence on understanding the architecture of buildings as shown in Figure 4. Nevertheless these same factors had 4% 12% and 4% respectively votes from respondents who strongly disagreed with these respective factors having an influence on the understanding the architecture of buildings.

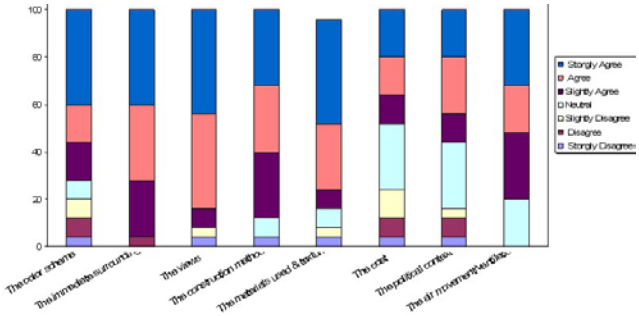


Figure 3. Students' responses on how another set of architectural issues were better understood through use of digital-based architecture curriculum.

4. Improvement plan for the current digital-based architecture curriculum at KFUPM

Based on a thorough review of the impact analysis of current digital-based architecture curriculum on undergraduate students' learning at KFUPM, a set of three initiatives has been identified to improve and enhance students' learning. For each proposed initiative, priority, duration, responsibility for implementation, tasks for the proposed initiative, and key performance measures are articulated. The set of three initiatives includes:

- Establish a clear and sound vision for IT adoption in the architecture curriculum at KFUPM
- Develop a change scheme to introduce CAD as design medium in the architecture curriculum in a set of carefully selected Design Studios to practically shift the utilisation paradigm of CAD from drafting and modelling to substantially include designing and creativity.

- Introduce curriculum revisions to accommodate advanced utilisation of IT for real life situations and industry needs, e.g. virtual collaboration and group work, office automation, construction cost, and management of building life cycle, etc.).

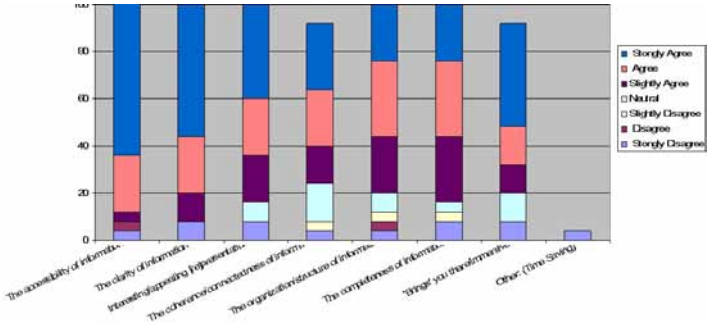
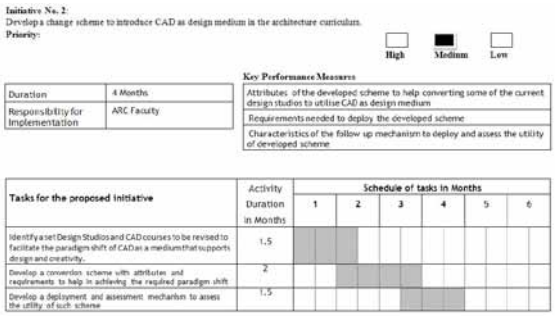


Figure 4. Students' responses to the importance of media quality factors in understanding the architecture of buildings through use of digital-based architecture curriculum.



Initiative No. 2:
Develop a change scheme to introduce CAD as design medium in the architecture curriculum.
Priority:

High Medium Low

Duration	4 Months
Responsibility for Implementation	ARC Faculty

Key Performance Measures

Attributes of the developed scheme to help converting some of the current design studios to utilise CAD as design medium
Requirements needed to deploy the developed scheme
Characteristics of the follow up mechanism to deploy and assess the utility of developed scheme

Tasks for the proposed initiative	Activity Duration in Months	Schedule of tasks in Months 1	2	3	4	5	6
Identify a set Design Studios and CAD courses to be revised to facilitate the paradigm shift of CAD as a medium that supports design and creativity.	1.5						
Develop a conversion scheme with attributes and requirements to help in achieving the required paradigm shift	2						
Develop a deployment and assessment mechanism to assess the utility of such scheme	1.5						

Figure 5. An example of the proposed initiatives in the improvement plan of current digital-based architecture curriculum at KFUPM.

5. Conclusion

The inclusion of advanced IT in architecture curriculum depends on pedagogical ways through which technology can be used in interacting with demanding clients and society, delivering knowledge to learners or in representing ideas and alternatives through analysis and critiques. Therefore, it is quite important to analyse the impact of digital-based curriculum on undergraduate students' learning in architecture and to identify ways and means to enhance student's learning. The findings of an impact analysis of digital-based curriculum on students learning in architecture showed that there is a need to: establish a clear and sound vision for IT adoption in the architecture curriculum, develop a change scheme to introduce CAD as design medium in the archi-

tecture curriculum in a set of carefully selected design studios to practically shift the utilisation paradigm of CAD from drafting and modelling to substantially include designing and creativity, and introduce curriculum revisions to accommodate advanced utilisation of IT for real life situations and industry needs. It is anticipated that the process and results of such analysis are not only potentially useful to KFUPM but also the benefits can be extended to the many of the digital-based architecture curricula around the globe.

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