CAD APPLICATION PATTERNS AMONG ARCHITECTURE AND INTERIOR DESIGN STUDENTS IN MALAYSIA

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ABSTRACT

Computer-aided design (CAD) became a requisite skill under competitive architecture and interior design market conditions. This pressured higher-learning institutions such as universities and colleges to devote more effort towards cultivating graduates with adequate CAD skills. However, recent research studies noted a disparity between academia's offerings and industry's needs, caused by a general insufficiency of CAD skills among students. This study aims to review CAD applications among students of architecture and interior design in Malaysia, to determine how students’ could be still poor in CAD skills in spite of all the concerted efforts. The research approach is through conducting a survey among seven schools of architecture and interior design in Malaysia, to find out the pattern of CAD usage among 699 students at different levels of study. The findings will reveal that students look for further skills during their study, to acquire additional knowledge in using different CAD applications for the purpose of improving their employment opportunities. However, developing enhanced skills in specific CAD applications is more vital than having basic skills in a large number of CAD applications. The universities and colleges of design should devote more effort and follow a clear criterion for developing students’ CAD skills. Employers looking to employ graduates with high CAD skills rather than creative abilities, find them inadequate and inexperienced yet.

Field of Research: Computer Aided Design, Design process, Design stages, CAD categories

1. Introduction

Recent and ongoing improvement in information technology has brought about changes both in the field of interior and architecture design, as well as in its academia. Computer-aided design and drafting became a requisite skill under competitive architecture and interior design market conditions (Pektaş & Erkip, 2006). Computer aided design and drafting tools (CADD) are not limited only to drafting; it also raises students' ability to generate fresh ideas, and improve decision making skills in several phases of the design process.

The Board of Architects Malaysia (LAM) (2005) expect interior and architecture design students to demonstrate a clear ability to apply different tools in design, from two-dimensional (2D) and three-dimensional graphics (3D) to computer-generated and material models. To align with this, architecture and interior design schools in higher educational institutes in Malaysia offer different CAD courses in line with the school’s vision.

Recent research studies mentioned a gap that exists between academia and industry, caused by the student’s lack in essential skills and an understanding of the industry they are entering (Ball,
More specifically, the inadequacy of students' technical competencies is one of the factors that causes this gap (Zaharim, Omar, Basri, Muhamad, & Isa, 2008). Therefore, increasing attention is being paid to enhancing competitive market skills by encouraging students of design to focus on technical proficiency in using CAD tools (Robertson, Walther, & Radcliffe, 2007). Pektaş and Erkip (2006) observe that the rapidly increasing introduction of computers in design instruction has found academia ill-equipped to develop teaching methods for digital training. Rapid changes in CAD require students to get and polish their computer skills, and adapt to technological advancement (Darus, Ani, Zaharim, Yusoff, & Muhammad, 2007). Mohd-Nor et al. (2009) looked into how higher educational institutions of architecture in Malaysia equip their graduates with the right CAD applications that are actually used by architecture firms. They found a mismatch, and recommended that design education institutes keep abreast with the development of CAD, and consider extra CAD training by including Building Information Modeling (BIM) and simulation tools in their curricula. However, the market is inundated with different CAD applications, and it is neither possible nor necessary for designers to be familiar with all of them (Darus, et al., 2007). Therefore, students of design should be skilled in applying specific CAD applications instead of having just wide and basic CAD knowledge. The difference between a student who has professional skills in CAD and the one who has only basic ability translates to a significant variation in time and quality of the output (Samuel, 2011).

1.1 CAD usage among architecture and interior design students in Malaysia

CAD applications were introduced in Malaysia in the 1980s, and has been widely practised (Mohd-Nor, et al., 2009). Recently, many architecture and interior design educational institutes expanded more effort in integrating CAD with design education, and CAD usage became one of the essential skills for students. Architecture and interior design schools integrated CAD courses in the curricula under the title of “Computer Aided Design for Architecture”. These course are dedicated to provide training and to develop the skills to produce two dimensional (2D) architectural drawings like plans, elevations, sections and detailing through the application of computer aided design software (AutoCAD) (HBP, 2012).

CAD courses are considered fundamental to almost all architecture and interior design programs, while integrated only as an elective course in others. Some faculties provide extra elective courses known as “Advanced Computer Aided Architecture Design”, even though the contents are relevant mainly to beginner and intermediate level (Mohd-Nor, et al., 2009). Mohd-Nor’s et al. (2009) study showed diversity and a blurred criteria of the integrated CAD courses in the curriculum of architecture schools in Malaysia. This causes a lose of CAD potential, and reflects negatively on student’s skills. Therefore, this study begins by classifying the CAD application into six categories, based on the manual attached with the application, and based on previous studies that described their potential in the design process. This helps in emphasizing the importance of CAD in curricula. The categories could be extended to include any future CAD application and is flexible enough to deal with the rapid development of CAD applications. The second part of the study explores student’s attempts to develop more CAD skills. The last part of the study discusses these attempts within the substance of CAD categories, to come up with findings that could assist CAD educators as well as students of architecture and interior design.

2. CAD USAGE AND CATEGORISING

CAD technology consists of two main groups; hardware and software. CAD hardware includes all devices that aids design processes - for instance: scanners, printers, input and output devices. The
other group is CAD software, which has different categories according to the function and the purpose of use. This study focuses on CAD software only because design students are mostly exposed to and affected by CAD applications during the design process. CAD applications are classified into six categories as follows:

2.1 Two dimensional drafting applications (2D):

2D drafting tools help in preparing technical drawings of floor plans, building permit drawings, building inspection plans, interior details and plan layouts, and are more useful in early stages of design (Aliakseyeu, Martens, & Rauterberg, 2006). Many studies maintain that using CAD in the early stages of the design process could hinder creative ideas, compared with manual hand sketches (Ibrahim & Pour Rahimian, 2010). Rough and unstructured hand sketches could stimulate the designer to visualize various designs (Okeil, 2010). However, as the level of design abstraction decreases during the design process, the designer tends to use 2D and 3D CAD applications in the design process (Veisz, Essam, Joshi, & Summers, 2012), specially with a complex forms. Therefore, many designers tend to use manual sketches in the first stage of the design process (Ideation phase), then shift their work to a CAD environment (Okeil, 2010).

2.2 Three dimensional applications (3D):

3D software have a wide variety of applications in a market that offers 3D modelling tools, with lighting and texturing abilities that help in ideation and decision making during the design process (Okeil, 2010). It is viewed as an alternative to a physical model in design education (Zuo & MaloneBeach, 2010). The ideas mature during the design process by converting 2D drawings into 3D digital models, and applying textures and lighting. Rendering systems are one of the major sub-topics of 3D computer graphics. It is the last step in the design process, giving the final appearance to the models, and providing textures and a realistic simulation of light effect (See Figure 1). This is in addition to animation through virtual tours. Rendering capabilities are necessary to heighten the thinking process and the design’s evolution (Brandon & McLain Kark, 2001).

![Figure 1: 3D modeling and rendering of exterior and interior design projects](image)

2.3 Photo editing

Photo editing applications using raster graphics (or bitmap), are used to retouch and enhance photos. Architects and interior designers use photo editing applications to colour and enhance CAD drawings (Onstott, 2005) (See Figure 2), or to tune post 3D rendering work (Alexander, 2011). It can be helpful in the first stages of the design process by preparing the sheets that illustrate the
concept, supported by annotations and text. It can also be applied in preparing textures and bitmaps that could be used in 3D modelling applications (Onstott, 2010).

![Image](image_url)

**Figure 2**: Enhance CAD drawings using Photo editing application (Adobe Photoshop)

### 2.4 Vector Graphics

Vector Graphics applications use paths, points, lines, curves and shapes or polygons to provide designers with the ability to create precise, scalable and layered images. These applications have similar purposes to photo editing, but use different techniques. It is used for illustrating vector architectural artworks (Mohd-Nor, et al., 2009).

### 2.5 Building information modelling (BIM)

The Building information modelling (BIM) process relates to generating and managing a digital representation of physical and functional characteristics of a facility (Graphisoft, 2012). The resulting building information model becomes a shared knowledge resource to support decision-making about a facility through design stages and construction, then through its operational life (Howell & Batcheler, 2005). The undergraduate architecture student will not be exposed to this aspect during the study, as it is of use mainly in the practical aspects of a design process.

### 2.6 Simulation Software

Simulation software uses complex mathematical formulas to simulate a real phenomenon, like ventilation and lighting. It is basically a program that lets the user assess the process interaction through simulation, without the need to really carry out that operation in the real world. This kind of simulation is required for advanced level design solutions (Mohd-Nor, et al., 2009) (See Figure 3).
3. **Research methodology**

A person-to-person paper-based questionnaire survey was the method chosen to explore the use of different CAD applications in architectural and interior design education. A random stratified sample of architecture and interior design programs in Malaysia, as determined by universities, was drawn up using the only accredited programs in seven universities in Malaysia. The seven universities’ stratified sample was to be represented by five programs described in Table 1. This study presents the frequency of using different CAD applications by 700 students, 45.1% Males and 54.9% females. A total of 1000 questionnaire was distributed manually within the design studios. A description and a brief purpose of this study were presented on the first page of the questionnaire, while some clarification and guidance was given to respondents face-to-face, to ensure they would answer the questionnaire comprehensively. Of the 750 returned, 699 responses were valid. Return rates for analysis was (69.9 %). Table 1 shows the population, target sample and course levels of the students.

<table>
<thead>
<tr>
<th>Table 1: List of design programs</th>
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<td><strong>Classification</strong></td>
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<td><strong>Gender</strong></td>
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<td><strong>Program</strong></td>
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<td>Interior design</td>
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<td>Science in Architecture</td>
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<td>Bachelor of Applied Arts and Design</td>
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<td>Bachelor of Interior Architecture</td>
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3.1 **The Structure of Questionnaire Survey**
The questionnaire consisted of six questions on the respondent’s gender, university name, the name of the program, the level of the study, and questions on the CAD applications and rendering system that the student could use. This list was developed from a previous study for Mohd-Nor, et al.

4. RESULTS AND DISCUSSIONS

The results showed that students use a high percentage of three applications namely; AutoCAD for 2D drafting - 86.43%, SketchUp for 3D modeling - 81.57% and Photoshop for photo editing - 79.57% (Figure 4). AutoCAD seems to be the dominant CAD application; it is integrated with the whole design process and serves extensively in 2D drafting and 3D modelling, but the AutoCAD's rendering limitations drive students to use another 3D applications with better rendering features. The high percentage of AutoCAD usage places it first, as the most widely used software in education. Other applications such as SketchUp and Photoshop are also widely used but not as extensively as AutoCAD.

AutoCAD is compatible with most popular 3D design and modelling applications. One of these applications is SketchUp, which follows closely behind AutoCAD in usage, and is probably the easiest-to-use 3D software available on the market. Lately, many CAD developers created different modelling and rendering plug-ins to fill the gaps in this application, providing tools to model organic and complex geometries, in addition to developing rendering systems (RS) tools, which provide high-end 3D renderings. There is an increasing trend among design student to acquire the skills to use RS in their projects, even if the school of design does not integrate that in the curricula. Figure 6 shows the numbers of RS users. It is noted that some students have the skills to use more than one RS tool. Vray recorded the highest percentage of users, at 42.1%. The developer recommends it for architectural use, and the software has broad learning resources and online community. The integration of Vray plug-in with most 3D applications makes it the favourite choice of many designers. Currently, there is fierce competition between RS developers to improve the quality of the output, and reduce the rendering time. In 2010 Lumion 3D was introduced as a stand-alone application to provide real time rendering solutions, adopting a different technology termed ‘graphics processing unit’ (GPU), which supported the advancement of new computer hardware. This technology allows users to create movies and still shots of architecture quickly, simply and efficiently. Lumion holds the second position after Vray, with a usage of 15%. Lumion 3D is more suited to architects and urban planners, and was developed later to fit the interior designers needs. It comes with a default library of objects, materials and light effects, allowing designers to get to grips with the software without needing to import additional content. Since then, Lumion 3D has made its mark and become popular among students and practitioners. In spite of this, none of the mentioned design programs or any RS tools were integrated by design institutes in their curricula.
Figure 4: Percentage of applications usage among student of architecture and interior design of seven universities in Malaysia
Other RS tools are similar to VRay, but have attracted a low percentage of users. This could indicate that VRay is more suited to architectural and interior design works, as it is recommended and used by many experienced architects.

![Figure 6: The numbers of rendering systems users](image)

The third most used application is Adobe Photoshop; it can be used to make plans decipherable to almost everyone. By adding tonality, colour, pattern, and shadow, plans and elevations are transformed into colourful images that are immediately understood (Onstott, 2005). Photoshop is used to retouch final presentation and renderings, in addition to preparing the textures and bitmaps for further use in 3D applications.

3Ds MAX has a low percentage of acceptance, at 30.7%. It is one of the most popular 3D applications, with a long history dating even before SketchUp. In spite of providing many more features comparable with SketchUp, 3Ds MAX’s complex interface alienates many novices. Even CAD lecturers hesitate to advocate its use. 3Ds MAX serves wide sectors of designers, such as artists, movie-makers, industrial designers and architects. The complex interface, designed to satisfy the needs of different sectors, turn students off, particularly when comparing it to SketchUp’s simple interface and ability to deliver high-end 3D rendering.

Adobe Illustrator comes in at an acceptance level of 23.6%. It is a vector graphics based application that has been used to illustrate vector artworks in graphic design. Students customize the tool to serve in architectural and interior design work, similar in purpose to Adobe Photoshop. Photoshop is however more popular, due to its flexibility and ease of use.

Some universities offer training courses for the Artlantis application. It falls in the BIM category, though students of design benefit from the program’s visualization abilities to present their ideas more than the actual purposes of BIM. This application’s appeal stands at 19.4%. Other applications from different categories have a low percentage of use. These applications are represented in six categories as shown in Figure 6.

This study concludes that the three categories with the highest percentage of use are; 3D modelling applications 34.8%, 2D drafting applications 24.2% and Photo editing 22.3%. These results confirm the importance of these categories in the design process for the
architecture and interior design students. Photo editing and Vector graphics serve the same purposes, while tools customization in Photo editing applications for architecture and interior design purposes allows more flexibility. Percentage of BIM applications usage among students is 3.9%. BIM is used mainly to generate 3D perspectives. In fact it is useful in the design process, but the actual purpose of this kind of application is beyond general educational requirements. Simulation applications have the lowest percentage of use at 1.3%, and are only applied in advanced and special architectural projects. It is a helpful application in advanced research institutes and in post graduate studies, more so than in undergraduate education.

![Graph showing percentages of different CAD categories' usage](image)

**Figure 6:** Percentages of different CAD categories’ usage

Even though architecture and interior design schools offer one or two CAD courses in the early stages of the design programs, we found that students have the incentive to acquire more CAD skills during their study (Figure 7), and they are not limited to what is provided by the school. This incentive stems from different reasons; one of these reasons is the student’s desire to be equipped with the largest numbers of CAD programs so that it covers most of what may be required by the market.

![Graph showing progression of different CAD categories over years](image)
Regardless of students’ CAD efficiency level, they randomly seek further skills during their period of study to acquire extra knowledge of different CAD applications, to improve their employment potential (Figure 8). The endeavours of being knowledgeable of many CAD applications aliened the graduates to acquire professional skills. They end with basic CAD skills in many applications rather than specific list with a focused attention on the capabilities. Veisz (2012) claims that, novice CAD users cannot appreciate the capability of CAD tools, compared with experienced users. On the other hand, low CAD skills have negative consequences on graduates when they face market needs, they will not be able to carry out creative design without the help of CAD capabilities (Liu, Li, Pan, & Li, 2011). Therefore, employers in the field of design find high potential in graduates with efficient CAD skills. That was obvious in the Yang et al. (2005) showing that, 2D and 3D graphic ability of the graduates was the preferred competencies required by the market for industrial design even before the creative abilities, being inexperienced so far with the nature of market competition.
5. CONCLUSION

CAD applications are incorporated in design studios— not only to serve as a drafting tool, but also to assist as a decision making tool at different stages of the design process.

Design students receive basic CAD training during the study, and there is a progressive tendency among them to change from the conventional method to the CAD. Many students elect to have extra CAD training through classes or from different resources. However, while this can make them knowledgeable with many CAD applications, but it does not necessarily lead to outstanding skills required to satisfy practical requirements.

It can be concluded that students of architecture and interior design should follow a clear plan to receive advanced training in a specific applications from each CAD category, to become proficient in CAD tools. Three categories of applications namely; 2D drafting, 3D modelling and Photo editing, should receive more attention because they play an important role in different stages of the design process.

This study suggest that, schools of design should provide a solid theoretical overview concurrent with basic training for applications that fall in two categories; Simulation and BIM. Because when the graduates have a solid theoretical background, they will be capable of acquiring more professional skills of using CAD application once they are employed and/or assigned to real tasks in practice.

This study is limited to exploring students’ ability in using different CAD applications. It would be worthwhile if future studies investigate the level of these abilities in depth, and the nature of integrating CAD in design studios and labs.

6. Acknowledgement

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