# THE EFFECTS OF INTEGRATING MOBILE AND CAD TECHNOLOGY IN TEACHING DESIGN PROCESS FOR MALAYSIAN POLYTECHNIC ARCHITECTURE STUDENT IN PRODUCING CREATIVE PRODUCT

Isham Shah HASSAN
Unit Seni bina, Politeknik Port Dickson, Km. 14 Jalan Pantai 71050 Si Rusa
ishamnurul1@hotmail.com

Mohd Arif ISMAIL
Fakulti Pendidikan , Universiti Kebangsaan Malysia

Ramlee MUSTAPHA
Fakulti Pendidikan , Universiti Perguruan Sultan Idris

**ABSTRACT**
The purpose of this research is to examine the effect of integrating the digital media such as mobile and CAD technology on designing process of Malaysian polytechnic architecture students in producing a creative product. A website is developed based on Caroll's minimal theory, while mobile and CAD technology integration is based on Brown and Campione's learning with technology theory. This study utilized a quasi-experimental method. Final semester students of four (4) polytechnics are chosen as a research sample where sixty (60) students are in the treatment group and another sixty (60) students are in the control group. Final product is evaluated by an expert in architecture field using the validated instrument developed by researcher based on Creative Product Analysis Model (CPAM). The inferential statistics namely T-Test and Pearson Correlation Analysis with a significant level p = 0.01 were utilized. Research outcome shows that there is a significant difference between the treatment group product (M=79.1) and control group product (M=70.5). This research contributes to the use of real case in the development of an architectural website, in the use of mobile technology as media information sources, the use of CAD technology integration in designing process and in the construction of validated instrument which is used to evaluate creative architectural products.
**Keywords**: real case, mobile technology, CAD technology, design, creative product

## INTRODUCTION

Architectural design is a complex and open process. Design process starts from the abstract stage to solve a design problem until it reaches the design solution in the form of design product. Designing activities is a repetitive problem solving process (Demirkan 1998). Watanabe (1994) describes designing process as a process to fulfill human needs through new idea produced. According to French (1998), architecture design is a response to human special needs which is refuge and comfort. Lawson (1997), states that architectural design is a process where an architect produced a space, place and building which has a big amount of effects on the quality of human life. Most architects agreed with Sanders (1996) whom stated that architectural design is a repetitive process where the process scheme can be recognized, valued, repeated, explored and repaired until the best solution is achieved. In the context of this research, architectural design is a systematic process through few stages in producing a new product that can be valued from physical aspect and providing benefits to human life and environment. For architectures' diploma students in Malaysian polytechnic they will learn on how to design from the architecture modules that being taught in four semesters. Decision making activities in architectural design process happens at sketching stage, schematic design stage and final design stage. At the details stage, design process is focused on producing drawings activity and planned building construction activity. This research concentrates on schematic stage of the design process which involves activities such as collecting the information needs for the design process and producing new ideas. Producing new ideas consist of two main activities which are synthesis and simulation. Technological development nowadays, has given chances for mobile and CAD technology to be integrated in the design process. Mobile technology gives chances for students to have access to the information without time and place limits. Websites referring to real cases provide opportunity to gather quick information for design process purpose. Media variety in design process also can give more choices to designer in creating new ideas. The recent developments in computer technology allow CAD technology to be used in decision making during the design process and not only for producing drawing (Husain 2007). According to Dong & Gibson (1998), CAD technological development in three dimensional drawings, three dimensional digital model and computer simulation can provide new approach for designers to find more solution in schematic design process. This research wanted to see upon how the integration of mobile and CAD technology can help the polytechnic students in learning the architectural design process to produce creative product.

**Problem Statement**

Schematic design stage is a process involves two important activities which are creating design informations and creating new ideas to solve the design problems. There are some weaknesses for these two activities. According to Yunus et al.(2006) many of the design layout that being produced by the students in polytechnic do not show any maturity. Yunus et al. (2006) also said that majority of the design products do not have any concrete design concept. Hamdan (2005), also mentioned that intellectual values for the design ideas not up to level of the diploma student. The design products from the polytechnic students also do not have a strong creativity element. All the problems mentioned above cause by the students design approached. New approaches in teaching architectural design are needed in order to rejuvenate the students in creating creative design product. New strategy is needed to help the student to get the design information anytime and anywhere while new strategy also needed to help students in creating creative ideas during design process. Web site for design information developed on real case approach based on mobile device can be a good approach to help students to obtain focus information at anytime and anywhere. Digital model offered by the CAD technology can be a good approach to help students to create new ideas in a short period of time. Digital model allows the students to create many design ideas during the design process. Therefore this research want to see the quality of design information produced when web site build on real case based on mobile device being integrated in the design process. This research also wants to study what effects it will have on the design product when CAD technology being integrated into the design process.

**Research Purposes**

The purposes of the research are as follow:

i. To identify the interest of the student in finding informations need in the design process through web mobile or conventional method
ii. To study the effect of integrating web site based on mobile device at the developing designs' information needs activity in the design process
iii. To study the effect of integrating CAD technology at the synthesis activity in the design process
iv. To study the effect of integrating CAD technology at the simulation activity in the design process
v. To study the effect of integrating mobile and CAD technology in producing the final product of architectural design

**Research Questions**

The research questions used for this research are as follow:

i. Does the real case web mobile increase the information searching activity?
ii. Does the real case web mobile allow the students to gather the information easily?
iii. Is there any significant different between the informations produce from the treatment group compare to control group?
iv. From the synthesis activity in the design process which group produces more early design ideas?
v. From the synthesis activity in the design process which group produces more 3D models?
vi. Is there any significant different between the new ideas produce from the treatment group compare to control group in the synthesis activity?
vii. Is there any significant different between the ideas produce from the treatment group compare to control group in the simulation activity?
viii. Is there any significant different between the treatment group compare to control group in producing creative product?

**REVIEW OF RELATED LITERATURE**

**Real Cases as a Design Educational**

With architecture being a much more complex career, real case approach as a lecturing method has starts to be an effective method among architectural lecturers. According to Vijayalakshmi (1997), real architecture cases involve construction and designing process of completed buildings. Oren (1990) says that information usage based on real project will helps student to analyse, make comparison and validate important aspects from studied buildings. With the use of real case method, researcher will develop a web site which is related to the same buildings type that will be designed by students. Important links from this web site will be connected to additional information for students. According to Oren (1990), links from a web site can increase students' knowledge towards issues that being studied. For this research, the use of real case in the development of the web site is expected to make the student information searching activity ease and focus to the project needs.

Focused in searching information is suitable to be used in a web site based on a mobile technology with regards to the proven ability of the mobile device to be used at anytime and any place.

**Web site Based on Mobile Device**

There were different opinions in defining mobile learning process. Lehner and Nosekabel (2002) describe mobile learning as a service that provides electronic information generally and educational content which helps information searching without time and places limits. Vavoula and Sharples (2002) explains that there are three ways where learning can be mobile which is learning is mobile in a space, learning is mobile in different aspect of life and learning is mobile without time and places limits. According to Anna et al. (2003) education based on mobile technology is a learning method using small media, mobile and did not produce inconvenience in every aspect of life. From definition above, a conclusion can be made that education based on mobile technology is an educational approach that are capable of conveying information at every time and places based on student needs. Learning activities can be achieved even when students and lecturer are in mobile position. Refering to Chen and Kinshuk (2005), educational service based on mobile technology is a movable learning sources and can be access by students without time and places constraints. In order to make a dynamic mobile technology based learning atmosphere, learning system has to be made ready in providing information without time and places constraints (Chen and Kinshuk 2005). Learning system also has to be designed, where the information provided can be chosen by students according to their needs. Educational system design based on mobile technology has to be dynamic, can be changed easily and can be used at every time and places. According to Bottentuitista et al. (2007), web site usage through mobile technology can attracts more students to use the internet. The effective use of web site based on mobile device in developing information has been supported by the studies of Catangay (2009) which showed on how students in selected schools in Philiphine acquire more new informations for science subject when web site based on mobile device being integrated in the learning process. In conclusion, if interactive multimedia web site that refers to real case is developed using mobile technology, information searching process will be easier where information can be reached by students without time and places constraints. Through faster information reaching process, students creativity can be generate with sufficient amount of information and it can also fasten the student skills for creating new ideas in design process.

**Computer Aided Design**

Computer aided design or CAD technology capability in producing architectural design are gaining importance because there were so many benefits including cost and time reduction in designing process. CAD technology also enables people who involves in architectural design industry to sketch and develop their work on computer screen, it can be saved and printed for future use in making changes and editing. According to Husain (2007), nowadays CAD is recognized as computer aided design not as computer aided drawings anymore. This is because of the facts that CAD technology can actually did more than drawings. CAD technology also enables the producing of high visual impact digital model and gives freedom to the architect to think about object, space and shape in the same screen. Refering to Salman (2004), rapid development for CAD technology has changed the concept shaping from two dimensional to three dimensional. CAD technology development nowadays has proved that the real strength on today's technology is not towards drawings process but in creating new ideas using visual CAD technology impact (Dong & Gibson 1998). CAD technology existence in architecture has two primary objectives which are to applied human cognitive design process through the computing smart technology and to become an idea representative media in architectural design process (Koutamanis 2003).

**Three Dimensional Digital Models**

Three dimensional digital models is another representation media that can be built using CAD technology. According to Wei Dong and Gibson (1998), digital model gives chances for architect to think, pictures, communicate and making assumptions in designing process. At concept development stage, digital model can be used to analyse overall shape, space planning and to decide space height. In schematic design stage, digital model can be used to study the suitable type of construction material, colour and lighting for the designed buildings. At the final stage of schematic design, digital model can be used to produce a high visual impact design representation. Digital model with the use of CAD technology can produce a visual impact similar to real environment in construction sites. According to Jiangyin (2003), digital model has the ability to represent photo realistic situation with regards to environment details. As a conclusion, compared to conventional model, digital model give chances for architectural students to study about the designed building component in details, suitable finishing materials for each space designed and lighting condition for building's interior. With the CAD technology capabilities, designing process will be simpler, faster and it will give more chances for students to develop their ideas in the design process.

**Computer simulation**

Simulation is a popular teaching technic amongst educators. According to Micheal (2000), simulation helps student to understand a situation, a process and the replication of real situation activities. Menn (1993) says that 90% of the students learned by doing the activities himself even with the helps of simulation methods. In architectural context, computer simulation brings in the real situation in building design. With the capability of CAD technology nowadays, student can use software such as 3D Studio Viz to observe building detailed effect, lighting and movement in a space through animation just like in a real situation. 3D Studio Viz software capabilities is predicted as it can increase students' visual capabilities towards space. Computer simulation eases students to choose suitable building details, lighting and space arrangement for the designed building. The advantages of computer simulation in designing process is that it can boost designers visual capabilities towards space and helps designers to quickly evaluate the quality of designed space. If computer simulation is integrated in learning design process at polytechnic, it is predicted that students can produce a much more creative space design. There was not much empirical research which can proves that computer simulation can increase student's creativity. However, there are several researchers such as Betz (1996), Gokhale (1996), Harkow (1996), Micheal (2000) and Lawson (2007) whom has made an assumption that computer simulation can increase student creativity. Through this paperwork, researcher hopes that it can strengthens previous research outcomes on computer simulation capabilities via three dimensional digital models which can produce a much more creative architectural design product.

## RESEARCH METHODOLOGY

**Research Design**

This research consists of two main activities in the design process which is designs' informations development activity and creating new ideas activity. Information searching for design purposes on web site based on real case is provided by researcher using mobile device while for creating new ideas activity, CAD technology is used. The web site used in this research developed by the researcher using Caroll's minimal theory. In applying Carroll's Minimalist theory when developing the web site the researcher follows the recommendations by Kearsley (1994) as shown below:

i. Allow learners to start immediately on meaningful tasks.
ii. Minimize the amount of reading and other passive forms of training by allowing users to fill in the gaps themselves
iii. Make all learning activities self-contained and independent of sequence.

The web site that being developed for this research can be referred at the address http://www.kajian_senireka.param.mobi. The integration of the web mobile and CAD technology in the design process for this research is based on Brown and Campione (1996) learning with technology theory. With this theory the integration should be done with the latest equipments required to get the accurate results. Through this study, researcher wants to see the differences in final product designed using mobile and CAD technology integration with the final product build using conventional method. Researcher also wants to see upon how is the effect of integrating web site based on mobile device in the design information development activity. This is a quantitative research to study the effects of mobile and CAD technology integration in the design process to produce architectural creative product. Quasi experimental method is used to study mobile and CAD technology integration effects in design process.

**Research Samples**

Research has been made on final semester students of diploma architecture from four (4) polytechnics in Malaysia. All the students selected have the same basic understanding of the design process. The students also have the basic skill for using ACAD 2007 and 3D Studio viz software. Both skills have been learned from previous semester. Research duration is for six weeks involving one hundred twenty students (120) students as research samples. In this research, research samples have been asked to design a kindergarten building. Sixty (60) students from POLIPD and PMM were selected to design with the integration of mobile and CAD technology and they are used as treatment group while the other half of the students are from PUO and POLISAS perform the design process using conventional method and they are used as control group. All the four polytechnics selected are using the same curriculum for diploma in architecture which being developed by the Malaysian ministry of higher education. This research has been conducted by two lecturers from each polytechnic selected. Design process for treatment group and control group has been conducted simultaneously. Products for every activity from both of the design processes have been evaluated by selected lecturers using the research instruments provided.

**Research Instruments**

To evaluate the product for each activity in the design process three instruments have been developed by the researcher. For information analysis product instrument for analysis activity being developed based on requirements being put by Laseau (2001) and Ching (1979), while for product from synthesis activity instrument being developed based on requirements being put by Laseau (2001) and Koberg & Bagnall (1981) and for product from simulation activity instrument being developed based on requirements being put by Laseau (2001) and Mills (2005). The evaluation instrument for the final product is developed by researcher based on Creative Product Analysis Matric (CPAM) model (Besemer and Treffingger 1981). Researcher has been using CPAM model as a guide to evaluate the creative architectural design product. Based on CPAM model the creativity of the design product is based on three main criteria which are uniqueness, practicality and product's detail

**Pilot Survey and Reliability of Research Instrument**

A pilot test was carried out from 27th October 2008 to 8th December 2008 with 30 students from POLIPD. The reliabilities coefficients of the instrument are shown in Table 1. Data from this pilot test not being used for the final analysis. All the instruments used have high reliabilities coefficients.

Table 1 Reliability Coefficients of Researchs' Instruments

| No | Instrument | Items | Cronbach's Alpha Coefficients |
|---|---|---|---|
| 1 | Information Analysis Product | 20 Items | 0.9242 |
| 2 | Synthesis Product | 18 Items | 0.9201 |
| 3 | Simulation Product | 20 Items | 0.9570 |
| 4 | Final Product Based on CPAM Model | 31 Items | 0.9577 |
| 5 | Questionnaire | 48 Items | 0.9652 |

**Analysis of Data**

The main data analysis based on the instruments evaluation forms using inferential statistics (Independent t-tests) and being supported by the data from questionnaire being analysed using descriptive statistics (Means, Standard Deviations, and Frequencies). Raw data from lecturers was used and analyse via computer. The analysis is done using Statistical Package for Social Sciences (SPSS) version 11.5.

**FINDINGS**

The finding for this research being divided into five categories which are identifying students interest in finding design information, inferential data to compare design information created through analysis activity, inferential data to compare design product from synthesis and simulation activity and inferential data to compare final design product through conventional method compare to integrated method.

**Student interest in finding information**

In identifying student interest to find information needed in designing process whether it is via mobile technology based website or via conventional method, research outcomes show in Table 2.

Table 2 Descriptive statistics in finding information activity

| No | Name of polytechnic | Finding information activities (Frequency) |
|---|---|---|
| 1 | POLIPD | 204 |
| 2 | PMM | 188 |
| | Total | 392 |
| | Mean | 6.53 |
| 1 | PUO | 80 |
| 2 | POLISAS | 98 |
| | Total | 178 |
| | Mean | 2.97 |

Research outcomes shows that the total number of student searches in treatment group is 392 (M=6.53) and total searches in control group is 178 (M=2.97). This outcome clearly shows that student searching activities increased with web site integration related to real case based on mobile technology.

**Comparing the product of analysis activity**

This outcome comparing the quality of designs' information being created from analysis activity consists of two methods which are design information created through conventional method and design information created through integrated method. Research outcome shows in the Table 3.

Table 3 Finding on comparing design information produced in analysis activity

| t-test | n | mean | s.d | t | p |
|---|---|---|---|---|---|
| Analysis Activity | | | | | |
| Treatment | 60 | 81.2 | 5.13 | 18.369 | 0.000 |
| Control | 60 | 65.5 | 4.19 | | |

In analysis stage, inferential data shows that there is a significant difference between the mobile technology integrated data (M=81.2) and conventional method (M=65.5), t (118) = 18.369, significant. The significant different on the product being produced in analysis activity proves that the integration of web site based on mobile technology helps the students to produce quality design informations in analysis activity.

**Creating new ideas in synthesis activity**

In determining student skills at synthesis stage in design process with CAD integration, research has been made to decide whether students using CAD technology integration in synthesis stage has made more idea changes from two dimensional to three dimensional compared to students using conventional method in synthesis stage. The research outcomes of the synthesis activity in the design process show in Table 4.

Table 4 Finding on ideas produced in synthesis activity

| No | Name of polytechnic | Conceptual diagram | Early ideas | 2D to 3D |
|---|---|---|---|---|
| 1 | POLIPD | 110 | 132 | 126 |
| 2 | PMM | 119 | 111 | 109 |
| | Total | 229 | 243 | 235 |
| | Mean | 3.82 | 4.05 | 3.92 |
| 1 | PUO | 69 | 70 | 61 |
| 2 | POLISAS | 81 | 80 | 66 |
| | Total | 150 | 150 | 127 |
| | Mean | 2.50 | 2.50 | 2.12 |

Research outcomes show that conceptual diagram produced for treatment group is 229 (M=3.82) while conceptual diagram produced by control group is 150 (M=2.50). Research outcomes also show that sketching changes from 2D to 3D for treatment group is 235 (M=3.92) while total number of sketching changes from 2D to 3D for control group is 127 (M=2.12). It shows that treatment group is actively involved in synthesis activity compared to control group.

**Comparing the product of synthesis activity**

The inferential finding data for synthesis activity are shown in Table 5. This inferential data will determine whether there is a significant different between the product being produced by treatment group at the synthesis stage compare to the product being produced by control group at the synthesis stage.

Table 5 T-test finding to compare mean between treatment group and control group product for synthesis activity in design process

| t-test | n | mean | s.d | t | p |
|---|---|---|---|---|---|
| Synthesis Activity | | | | | |
| Treatment | 60 | 80.6 | 3.72 | 17.184 | 0.000 |
| Control | 60 | 67.1 | 4.80 | | |

Inferential data shows significant difference between initial idea created in synthesis activity using CAD technology integration (M=80.6) compared to initial idea created in synthesis activity using conventional method (M=67.1), t (118) = 17.184, significant. This proves that the initial ideas being produced from integrated method better than the initial ideas being produced from conventional method.

**Comparing the product of simulation activity**

The inferential finding data for simulation activity are shown in Table 6. This inferential data will determine whether there is a significant different between the product being produced by treatment group at the simulation stage compare to the product being produced by control group at the simulation stage. The creative and quality product being produced at the simulation stage helps the students to produce a quality final design product.

Table 6 T-test finding to compare mean between treatment group and control group product for simulation activity in design process

| t-test | n | mean | s.d | t | p |
|---|---|---|---|---|---|
| Simulation Activity | | | | | |
| Treatment | 60 | 80.5 | 5.46 | 12.267 | 0.000 |
| Control | 60 | 66.9 | 6.68 | | |

Inferential data shows there is a significant difference between final design idea produced in simulation activity using CAD technology integration (M=80.5) compared to final design idea produced in simulation activity using conventional method (M=66.9), t (118) = 12.267, significant. This proves that the design idea that being produced from integrated method is better than the design idea being produced from conventional method.

**Comparing the final product**

In this research the creativity of the design product being determined based on CPAM model which are unique, practicality and detail. This inferential data will determine whether there is a significant different between the final product being produced by treatment group in the design process compare to the final product being produced by control group in the design process. The inferential finding data for comparing design product between treatment group and control group are shown in Table 7. This finding can prove positive effects on the integration of mobile and CAD technology in the design process for producing creative product.

Table 7 T-test finding to compare mean between treatment group product and control group product based on CPAM model

| t-test | n | mean | s.d | t | p |
|---|---|---|---|---|---|
| Unique Aspect | | | | | |
| Treatment | 60 | 78.0 | 7.07 | 7.134 | 0.000 |
| Control | 60 | 68.5 | 7.63 | | |
| Practical Aspect | | | | | |
| Treatment | 60 | 78.0 | 4.69 | 6.901 | 0.000 |
| Control | 60 | 73.1 | 5.97 | | |
| Detailing Aspect | | | | | |
| Treatment | 60 | 81.5 | 4.57 | 11.076 | 0.000 |
| Control | 60 | 71.9 | 4.85 | | |
| Overall Creative Aspect | | | | | |
| Treatment | 60 | 79.1 | 4.27 | 10.610 | 0.000 |
| Control | 60 | 70.5 | 4.61 | | |

Inferential data shows that there is a significant difference between design process integrated with mobile and CAD technology (M=78.0) compared to conventional method (M=68.5) in producing unique design product, t (118) = 7.134 significant. Inferential data also shows that there is a significant difference between design process integrated with mobile and CAD technology (M=78.0) compared to conventional design process (M=73.1) in producing a practical design product, t (118) = 6.901 significant. Inferential data also shows that there is a significant difference between design process integrated with mobile and CAD technology (M=81.5) compared to conventional design process (M=71.9) in producing high details architectural product, t (118) = 11.076, significant.

As a conclusion, final product comparison from creativity aspect between treatment and control group show significant differences. Research outcomes also show that there is a significant difference between final product produced through the design process that being integrated with mobile and CAD technology (M=79.1) compared to final product produced using conventional method (M=70.5) from creativity aspect, t (118) = 10.610 significant. Overall, inferential outcomes show that there is a concrete effect on mobile and CAD technology integration in producing a creative architectural design.

This research shows on how the integration of web site being built using the real case approach based on the mobile device help the students to get more design information at anytime and any place. The integration of mobile technology in the design process generates students' interests to be more active in searching design information during the design process. More design informations being gathered by the students makes it easy to produce creative products. The integration of CAD technology makes it easy for the students to change their designs' ideas from two dimensional to three dimensional. Three dimensional models in the form of digital model make it easy for the students to get the overall view of the building they want to design at the early stage of the design process. CAD technology also allows the students simulate the real situation in their design

process. This simulation activity makes it easy for the students to generate ideas in creating their final design products to solve the problem being given to them.

**THE PRODUCTS**

From this research, the integration of mobile technology and CAD technology help the students to produce quality product of architectural works. The final students' products from the treatment groups had its own identities. The products from the treatment group also show qualities of creatives products based on CPAM model. Some samples from the students' products are shown in the figures below.


Figure 1: Product 1

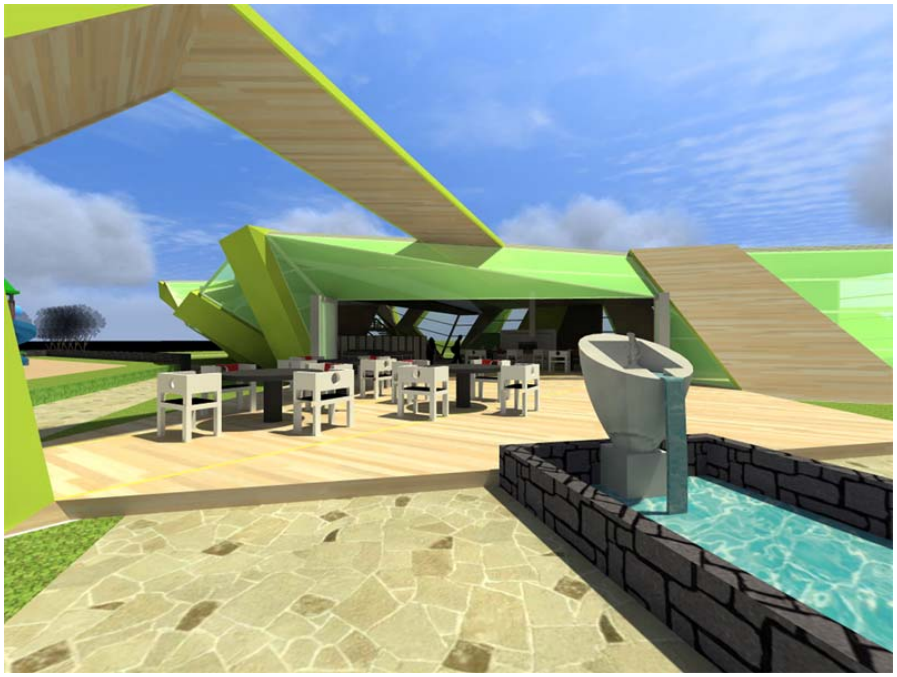

Figure 2: Product 2

Figure 3: Product 3

**CONCLUSION AND DISCUSSION**

In this research, positive research results for mobile technology based website shows that learning approach using mobile technology can be a good replacement for computer based learning approach. Students and lecturer can gain benefits from easier and faster access of information sources. When it is easier for the students to get the design informations it will create interest to them to involve actively in the searching designs' informations activity. Web site being built by a real case approach also will make the students activity to search for design information become focus and easier. As a conclusion the integration of web site built on a real case based on mobile device will make the searching information activity in the design process become focus and occur at anytime and any place. Rapid development in mobile technology has contribute in growth of faster and higher memory mobile equipment, so that these mobile equipments can be used to download data faster than before and it can also save a lot of informations in the memory. Mobile technology offers a practical educational approach in providing a unique learning community based on technology for the betterment of future polytechnic. Still, there has to be a lot more qualitative and quantitative research to obtain suitable guidance for mobile technology integration in learning process. In the future, graphic resolution and screen size for mobile equipment is expected to be better build. Furthermore, if internet surfing cost can be cut to a lower price, this mobile technology will definitely be useful for higher education students or out-campus students. From CAD technology design aspects, it is proven that CAD technology are able to give comfort for student to produce three dimensional digital model and also increases students understanding of space through good visual effect. This is because CAD technology enhances student creativity and it also encourages student to appreciate interior space when student are doing simulation using different details and lighting in the same space. Students also get excited with produced space via simulation increment with different details and lighting towards their three dimensional digital models. Students understanding toward space are increased with the ability to run a simple simulation into their designed interior spaces. With the animation, student can look at the space from a different perspective. Students give good response towards three dimensional digital model usage to produce good quality interior space designs. Overall, CAD technology via three dimensional digital models helps students to produce a creative final product design. Three dimensional digital model effects based on the finding from this research can be strengthen with the research done towards NBBJ firm by Mark Von Wodtke (2000) which shows that three dimensional digital model can give good design idea and it also helps designer to validate the space, building shape and details of designed buildings. This research outcomes is also strengthen by Lawson (2007) research outcomes which states that architect Ian Ritchie has produced a creative gallery space in London Museum with the help of CAD technology integrated design. Lawson (2007) also says that the kindergarten design produced by kindergarten teachers with the help of CAD technology has higher esthetic value than the one produced by an architect using conventional method. From this research, it is concluded that CAD technology are able to help architectural students to produce much more creative product design. CAD technology, specifically via three dimensional

digital models can boost students' understandings towards space while they are in designing process through the use of good visual impact.

Overall, mobile and CAD technology integration in design process proved to have increased the quality of the final product designed by architectural students which has been achieved in the learning process via architectural design module. As a conclusion this research contributes to the use of real case approach in the development of architectural information sources, in the use of mobile technology as media information sources, the use of CAD technology in synthesis and simulation activity in the architectural design process and in the development of instrument based on CPAM model to evaluate creative architectural design products.

**REFERENCES**


Anna Trifonova and Marco Ronchetti., 2003. Where is Mobile Learning Going? Dipartimento di Informatica e Telecomunicazioni, Universita degli Studi di Trento Italy.*E-Learn 2003*

Besemer, S.P., & Treffingger, D. 1981. Analysis of creative products: Review and synthesis. *Journal of creative behavior, 15*, 158-178.

Betz J.A. 1996. *Computer simulation: An Integrated Tool.* Paper presented at the SAGE 6th Canadian Symposium, The University of Calgary.

Bottentuitista Junior, Joao Batists dan Coutinho Clara. 2007. Virtual Laboratories and MLearning: learning with mobile devices. *Proceedings of International MultiConference on Society, Cybernetics and Informatics*. p 275-278, Orlando, EUA.Julho.

Brown, A., & Campione, J. (1996). *Psychological theory and design of innovative learning environments: On procedures, principles, and systems*. In L. Schauble & R. Glaser (Eds.), Innovations in Learning: New Environments for Education. P 289-325. Mahwah, N.J.: Erlbaum.

Catangay, M. 2009. Use of mobile phones for quality education. *Philippine Daily Inquirer*.4th April.

Chen J. & Kinshuk.2005. Mobile Technology in Educational Services. Journal of Educational Multimedia and Hypermedia, 14 (1), 91-109.

Ching, Francis.D.K. 1979. Architecture: Form, Space and Order. New York : Van Norstrand. Inc

Demirkan, H. 1998. Integration of Reasoning Systems In Architectural Modeling Activities. *Automation in Construction.* 7. 229-236

Dong, W & Gibson, K. 1998. *Computer Visualization: An Integrated Approach for Interior Design & Architecture*, 1 St. Ed, USA: McgrawHill.

French, H. 1998. Architecture : A Crash Course. New York. Watson Guptill Pub.

Gokhale, A.A. 1996. Effectiveness of computer simulation for enhancing higher orderthinking. *Journal of Industrial Teacher Education, 33* (4), 36-46.

Harkow, R.M. 1996. *Increasing creative thinking skills in second and third grade gifted students using imagery, computers and creative problem solving*. Unpublished master's thesis. NOVA Southeastern University.

Hamdan, A. 2005. Laporan Panel Penilai Hari Produk JKA 2005. *Unit Senibina*. 29 Nov – 01 Dis 2005

Husain Jahit, 2007. Penghasilan produk lebih mantap. Harian Metro. 25 Julai 2007.

Jianying, Jin. 2003. Computer 3d visualization technology – A Dynamic Design Representation Tool In Solving Design and Communication Problems In The Early Phases of Architectural Design Process. Mississippi State, Mississippi.

Kearsley, G. 1994. Minimalism (J. M. Carroll). (Online). http://www.gwu.edu/~tip/carroll.html (19 April 2008)

Koberg, D & Bagnall, J. 1981. Universal Traveler : A Soft Systems Guide to : Creativity, Problem Solving and The Process of Reaching Goals. California: William Kaufmann Inc.

Koutamanis, A. 2003. CAAD's Seven Arguable Virtues, International Journal of Architectural Computing, 2 (1) pp.51-65.

Laseau, Paul, 2001. *Graphic Thinking For Architects and Designers*. 3rd Ed. McGraw Hill.

Lawson, Brian. 2007. CAD and Creativity: Does the Computer Really Help? *ISAST,* Vol. 35, No. 3, pp. 327–331.

Lehner, F. and Nosekabel, H. 2002. The Role of Mobile Devices in E-learning First Experience with a E-learning Environment. In M. Milrad, H. U. Hoppe and Kinshuk (Eds.), *IEEE International Workshop on Wireless and Mobile Technologies in Education* (pp.103-106). Los Alamitos, USA: IEEE Computer Society.

Mark Von Wodtke. 2000. *Design with Digital Tools – Using New Media Creatively.*

McGraw-Hill.

McBride, Jacquelin. S. 1984. Case Study as a Teaching Tool Intergrating Design, Energy and Economic Analysis, M.Arch. Thesis, MIT, Jun. p10

Menn, D. 1993. Multimedia in education. *PC World*, M52-M60. Oktober

Michael, Kurt Y. 2000. A Comparison of Students' Product Creativity Using Computer Simulation Activity Versus A Handson Activity In Technology Education. Virginia Polytechnic Institute. Doctorate Dissertation. p 14 – 15.

Mills, C. B. 2005. *Designing with models : A studio guide to making and using architectural design models*. 2nd Ed. USA. John Wiley and Sons Inc.

Oren, Tim. 1990. Cognitive Load in Hypermedia : Design for the Exploratory Learner. Learning with Interactive Multimedia. Ed. Redmond, WA : Microsoft Press. p127.

Salman H.S., 2004. CAAD Impact on the Early Stages of the Architectural Design Process.Thesis (MSc). University of Wolverhampton.

Sanders, K. 1996. The digital architect : a common sense ; guide to using computer technology in design practice. 1st ed. New York : John Wiley & Sons. Inc

Vavoula, G. N. and Sharples, M. (2002). KleOS: A personal, mobile, Knowledge and Learning Organization System. In M. Milrad, H. U. Hoppe and Kinshuk (Eds.),

*IEEE International Workshop on Wireless and Mobile Technologies in Education*. August 29 - 30, (pp. 152). Washington, DC, USA: IEEE Computer Society.

Vijayalakshmi Koti. 1997. Hypermedia in Architectural Education : The World Wide Web as a Learning Tool. University of Washington. Jun 9.

Watanabe, S .1994. Knowledge Intergration for Architectural Design. Automation In Construction. 3. 149-156

Wei Dong & Kathleen Gibson, "Computer Visualization – An Integrated Approach for Interior Design & Architecture", McGraw-Hill, 1998

Yunus Baharom, Harris Zamzairie & Hafiz Noh. 2006. *Laporan Penilaian Projek Semester Enam Sesi Jun 2006*. Unit Senibina. 30 November 2006.