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INTEGRATING COMPUTATIONAL ANALYSIS TECHNIQUES IN EGYPTIAN ACADEMIC ARCHITECTURE CURRICULA

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Abstract

Educational environments must support real life needs, and serve industry demands on both local and worldwide levels. Computer technology can enhance architecture in so many ways. Data Collection, conceptual design, computer aided design, digital model, physical model, virtual reality, simulation, and remote collaboration are different fields that support architecture technically, not to mention the advantages in construction industry. That is why it must be integrated in architecture education, but with care so as not burden creativity. It was found that 75% of the computer modules in architecture departments in Egyptian universities and institutes do not fully integrate with other modules. As an output, two major problems resulted. The first problem is that the design final project comes out either weak or supported by professional paid eligible aid. Secondly, and more important is the need for external software courses to support design projects and not just on the drafting level. Teaching techniques must bear in mind how to integrate modules and courses that aim at enhancing final outputs. As an example is one of the most important courses in the field, which is the computer course taken mostly in early years. Despite the overloaded architecture curricula, because of its multiple identity academia or practice; techniques or aesthetics; science or humanities (Kocaturk, T. and Kiviniemi, A, 2013) how and when to integrate these aspects is crucial. The focus of this paper is to test the importance of integrating computational analysis tools into architecture education (specifically in design). It also aims at emphasizing on the importance of integrating all modules to achieve a qualified output. In order to achieve the fore mentioned goal, a survey on graduates' educational conditions is first conducted. This is followed by a critical review of some of the existing educational approaches. This paper explores introducing three different computational analysis tools, addressing three different parameters, to evaluate a sample of architecture design projects at a schematic stage. The chosen parameters had a strong impact effect on the design project. Evaluation in a quantitative manner was the third aim of the paper. Quantitative approach was compared to traditional evaluation measures. The focus of this approach indicates a strong necessity to use computer analysis tools during the schematic phase, and recommends suitable building forms and orientations.

Keywords

Integrated Design, Architecture Teaching Methods, Architecture Curriculum, Computer Tools, Simulation

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Abstract

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Despite the overloaded architecture curricula, because of its multiple identity academia or practice; techniques or aesthetics; science or humanities (Kocaturk, T. and Kiviniemi, A, 2013) how and when to integrate these aspects is crucial. The focus of this paper is to test the importance of integrating computational analysis tools into architecture education (specifically in design). It also aims at emphasizing on the importance of integrating all modules to achieve a qualified output. In order to achieve the fore mentioned goal, a survey on graduates' educational conditions is first conducted. This is followed by a critical review of some of the existing educational approaches. This paper explores introducing three different computational analysis tools, addressing three different parameters, to evaluate a sample of architecture design projects at a schematic stage. The chosen parameters had a strong impact effect on the design project. Evaluation in a quantitative manner was the third aim of the paper. Quantitative approach was compared to traditional evaluation measures. The focus of this approach indicates a strong necessity to use computer analysis tools during the schematic phase, and recommends suitable building forms and orientations.

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INTRODUCTION

Architecture education has always been integrated with other disciplines: structural, mechanical, electronic, social, legislative, management & economic. Recently, updating collaborate current university curriculums throughout universities and institutes, to meet the ever growing dynamic contemporary computational techniques, (interface graphics, simulation tools & visualization tools) is quite a challenging issue. Most of the accreditation programs such as UIA, RIBA, ABET, NAAB, NARS or others do not include computational tools, nor do they identify any graphic requirements for architecture curriculum programs whether for universities or institutes. Recently RIBA'S Plan of Work (launched in May 2013) has required embedding BIM (Building Information Modeling) into the process, as a new guidance, for generating a bespoke practice (Allen, S., 2012). Graduates rush to take simulation courses everywhere. Competence in using computational techniques is not a part of certain learning objectives although an obligatory necessity for practice and for industry.

Computational techniques has tremendously reduced the risks, cost and time associated with building & testing a physical model. Simulations can define a building's structure, thermal flow, lighting, acoustics and the behavior of its inhabitants in terms of energy consumption. One of the most beneficial use of simulations is to analyze the best location and size of windows for reducing a building's energy consumption, as well as optimal form maximizing lighting levels (Kyu, Y., 2013). Analyzing the performance of buildings is important for utility bills & comfort. Recently simulation tools have undertaken major development in energy, lighting and airflow domains. Such domains should be tested and measured separately for design and performance evaluation of buildings.

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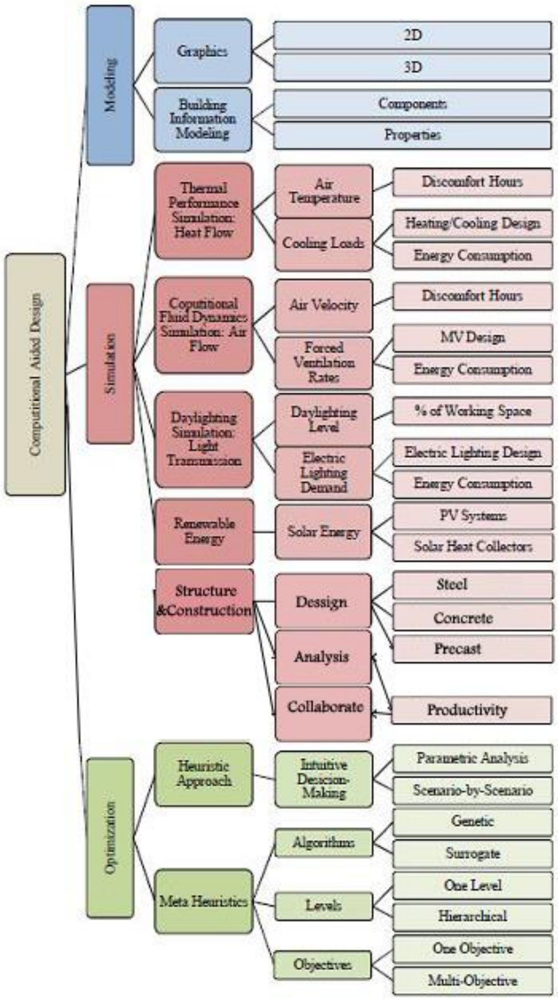

Figure 1: Development of Computational Tools (Adapted from Source: Samaan, M. et al, 2013)

Many countries have set out ambitious plans to fully collaborate simulation techniques such as BIM with all projects in terms of asset information, documents and data (Kocturk, T. and Kiviniemi, A, 2013). Although each region has different standards and different work habits, currently architecture in Egypt is faced with two types of industry commands. These techniques include local construction methods, and the global process demands. Architecture education must focus on both theoretical modules as well as operative and technical modules. Slow adoption of computational techniques, including BIM, has set a draw back in architecture education. The enormous technological and institutional transformation in the industry has bought up forthcoming challenges. Globalization, digital technology, environmental change and increasing market-driven education economy are already reshaping academia (Ockman, J. and Williamson, R., 2012).

LITERATURE REVIEW

There have been several experiments and research discussing advantages and fields of impact of computational techniques. From the study made by Saman, M., et al, discussing the use of BPS (Building Performance Simulation) tools as an approach for greening buildings listing of the development of computational aided tools can be shown in Figure 1.

Environmental Tools

Pedrini et al. recommended that students should be introduced to scientific and technical foundations for the use of BPS tools, during their education, to learn how to integrate them in their own practice (Pedrini, A. and Szokolay, S., 2005).

In a university in Brazil, a paper addressed the problems of a Brazilian university (UNICAMP) and its architectural program which lacked a bioclimatic studio. They started by a brief coverage of using simulation tools in Brazilian universities and went on through a traditional research phase before beginning the design phase. During the design phase, they referred to a simulation expert, and modified their initial design based on the results. The results of this experiment showed that students preferred to simulate day lighting, as opposed to thermal effects (Delbin, S., Da Silva, V., and Kowaltowski, D., 2007).

Several studies have been conducted to survey which analytical tools are commonly used in firms, and for which environmental parameter. In conclusion, it is always important to have up to date feedback from stakeholders and firms to find preferred software to be taught in schools. Many other studies have been concerned on when to encourage incorporation of BPS tools in the design process. Despite numerous researches, some suggesting in the schematic level, still questions are raised for more research on the topic. A study made by Palme (Palme, M., 2011) found that students were far more interested in learning building physics concepts through practical experience, as opposed to traditional learning.

Several studies have been made on the teaching approaches, including building simulation tools into design. The majority indicated that students preferred a game-based approach covering the key concepts relevant to building energy dynamics in opposition to other approaches (DeBaillie, L. and Reinhart, C., 2012). Tarabeih et al. conducted a study using a learning-by-doing approach allowing students to individually interact with simulation tools on their own design projects. Tarabeih's study focused on the relationship between form and energy consumption, aiming at enhancing students' learning skills with building simulation tools, as well as acquire feedbacks from students' experiment for future coursework. On questioning students on preferred method of teaching simulation tools, it was found that the majority preferred direct hands-on experimental approach with specific-tasks relevant to the project design development to gamed-based approach and traditional lecture lab assignments (Tarabeih et al., 2013).

Building Structure Load Tools

There is several, in fact numerous structure analysis software tools. Structure and construction software can design, analyze, and collaborate more accurately. Some of these softwares support in the early structural design and analysis, in the detailed phase. It supports structural design whether in steel, concrete, precast or more important the digital (virtual) architecture even in the detailing stage. Project insight is gained greater with visualization and simulation tools, by using structural software design and analysis and create more accurate documentation. In general structural design and analysis software tools can increase productivity, perform accurate simulation, and collaborate more effectively. Research on its integration in academia is minimal.

Landscape Tools

Developing and producing is among the primary advantages of landscape software programs (selfgrowth.com, 2015). It isn't any more necessary to be on-site to build landscape layouts. A significant advantage is having the chance to try out theoretical landscape designs that can be used in upcoming landscape assignments. Landscape software can save time and effort in putting a plan into action.

Using landscape softwares can easily allow a landscape designer to figure out potential problems that might encounter before actually beginning to work. It gives a chance to get approvals and make adjustments in project proposals.

CASE STUDY

Currently higher education, an ever growing sector is undertaking a very mobile turn. Every year new universities whether governmental or private, and new institutes whether governmental or private are established all seeking accreditation. A survey was designed for all educational bodies that address architecture in Egypt. Currently, Egypt has 33 governmental universities, 19 private universities, 2 governmental institutes and 26 private institutes that teach architecture programs (www.egy-mhe.gov.eg). The study was designed to survey as many universities/institutes that had an architecture department as possible so as to be of substantial results. Only feedbacks from 20 universities and institutes, distributed evenly nationwide, (Ain Shams University, Alexandria University, Assiut University, Al-Azhar University, Cairo University, Egypt-Japan University of Science and Technology, Kafrelsheikh University, Mansoura University, Tanta University, American University in Cairo, Arab Academy for Science and Technology and Maritime Transport, Canadian International College, British University in Egypt, El Shorouk Academy, Future University in Egypt, German University in Cairo, Misr International University, Misr University for Science and Technology, Nile University, October 6 University and Pharos University in Alexandria) were obtained.

In an iterative and collaborate process, surveys were designed for graduates and instructors in all of the twenty educational bodies. First, surveys were targeted to collect information about when and what was taught in terms of computer technology techniques. The data collected was done in the form of questionnaires, and not by reviewing the course contents and specifications. Although both specifications and contents of a course matter, but different instructors at different universities and from year to year changed to some extent, in the way they taught their modules. For this reason, graduates questioned had to be of different graduation years but within the last 5 years. Simultaneously, students were questioned about how these tools can affect their designs, and the degree of impact. The second task was to test a sample of 6 proposed schematic design projects, on second level in one of the average Egyptian governmental universities, on three different computer tools. The first tool compared was to test the vegetation/landscape elements impact, on the wind speed levels of the outdoor spaces, of the selected projects by using ENVI-met. Wind speed is one of major indicators of human comfort. The second tool compared different proposals in terms of bending moment on SAP2000. The third tool was to compare different forms to light intensity on Design Builder. Multiple rating systems are then compared to final design project submission grades, without using computer tools.

COMPUTATIONAL TOOLS IN ARCHITECTURE EDUCATION IN EGYPT

Practical Computer Technology Tools Used in Egyptian Architecture Academic Bodies.

The first inquiry was about percentages of usage of the different computer tools in architecture education in Egyptian universities and institutes. At what level was also questioned. It was important to collect information on current status, and inquire on what is taken, especially practically in order to evaluate current conditions.
Results, as can be shown in Figure 2, indicate that almost all of the universities and institutes that taught architecture do not use computer technology methodologies practically. Beginning from second level students significantly started to use AutoCAD. Revit was then significantly used in third level and onwards. Photoshop was used significantly only on fourth level. To conclude, the variety of computer tools used in Egyptian architecture academia was minimal.

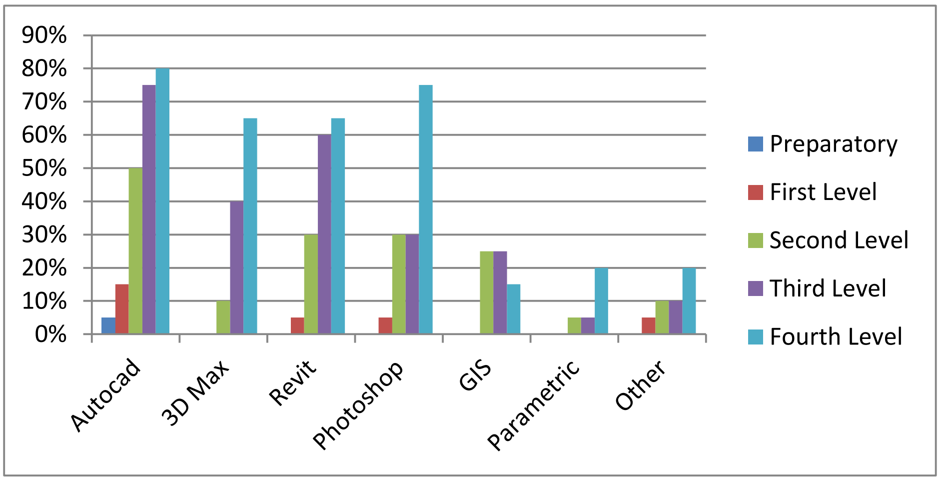

Figure 2: Percentages of Universities & Institutes Using Computer Technology Practically in their Architectural Programs. (Source: Author)

Computer Tools Applied in Different Architecture Modules at Egyptian Universities and Institutes.

The second inquiry was to record percentages of architecture departments in Egyptian universities and institutes that apply computer tools. Again, it is important to collect information on current status in order to improve current conditions.
From reviewing Figure 3, it can be shown that computer tools were significantly used starting from third level. The usage of tools gradually increased in fourth level. Exceptionally Construction, Specifications and Project Management modules rarely used computational tools despite their importance in professional field work. As for the Environmental Control module, although computer tools were used in second level, its usage decreased in

fourth level despite its importance. It is important to note, that the results are related to the level the main course is taught.

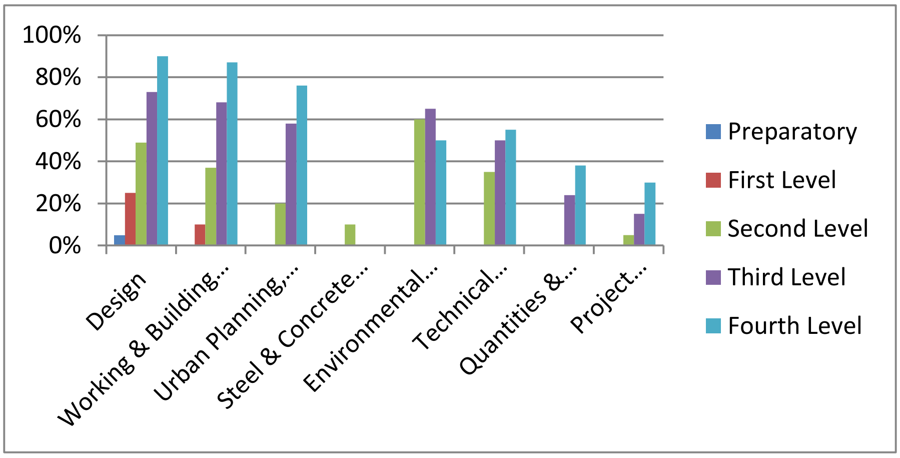

Figure 3: Percentages of Universities & Institutes Applying Computer Tools in Different Architecture Modules (Source: Author).

Number of Egyptian Universities and Institutes that Taught Architecture Which Actually Integrate Computer Tools in the Design Module.

The third inquiry was to estimate the number of Egyptian universities and institutes that taught architecture, which actually integrates computer tools in the design module. Again, it is important to collect information on current status in order to enhance current conditions.

From Figure 4, it can be shown that 37% of the sample of the Egyptian architecture departments in universities and institutes integrate computer tools totally in the final design module. 58% integrate the tools partially, and 5% do not integrate the tools at all.

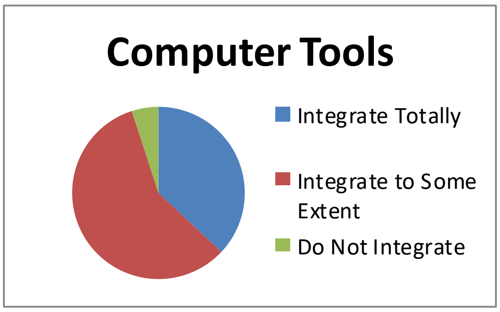

Figure 4: Percentage of Universities & Institutes That Integrate Simulation Tools from Different Modules in the Design Course (Source: Author).

Average Area of Impact the Computer Tools Have on the Design Module

A.Introduction

The fourth task was to conduct a matrix that could indicate the area of impact, of the computer tools, on the design module in the Egyptian architecture departments in universities and institutes. Such a questionnaire can give a visionary look on how scholars feel towards the importance of such computer tools. The scholars interviewed, in this questionnaire, were of a variety of graduates and instructors from the same schools of architecture mentioned before. Scholars were questioned on the area of impact the computer tools in the different modules had on the final design module.

B.Results

Table 1 can show that computer tools can strongly impact the design module in many ways such as in conceptual design, computer aided design, digital and physical model as well as virtual reality from almost all modules tested.

Area of Impact in the Design Module	Data Collection	Conceptual Design	Computer-Aided Design	Digital Model & Physical Model	Virtual Reality
Working & Building Construction					
Urban Planning, Conservation, & Legislation					
Steel & Concrete					
Perspective, Shadow & Visual Studies					
Environmental Control					

Table 1: Average Areas of Computer Tools Impact from the Different Modules on the Design Course (Source: Author).

Extent of Impact of the Different Supporting Computer Tools on the Final Design Output

A.Introduction

The last questionnaire conducted was made by a bipolar ruler, from 1 to 7 to indicate the degree of impact of the different supporting computer tools, on the final design output. Such a questionnaire can give a visionary look on how scholars feel towards the importance of such computer tools. Again, scholars of graduates and instructors from the same schools of architecture were investigated on the degree of impact of the different areas of computer tools in the final design module.

B.Results

Table 2 displays the survey done on the sample of the Egyptian architecture department in university and institutes. Results from a bipolar ruler of seven showed that scholars thought that computer data collection tools had a medium impact on the final design output. It had a third degree of seven when questioned on the strength of impact of the conceptual design tools. Computer aided design tools had stronger effect on the design output according to scholars questioned where they choose two out of seven. Both virtual reality and simulation tools had medium results.

Data Collection								
Strongly								No Impact
Conceptual Design								
Strongly								No Impact
Computer Aided Design								
Strongly								No Impact
Digital Model & Physical Model								
Strongly								No Impact
Virtual Reality								
Strongly								No Impact
Simulation and Remote Controlling								
Strongly								No Impact

Table 2: Average Areas of Impact in the Final Design Output (Source: Author).

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DISCUSSION

Softwares mentioned in Table 2 of the study were mostly mentioned in computer modules, but they were minimally taught practically. Even when the softwares were mentioned students were not taught when and how to use them. The type and quality of softwares used was minimal to what is available in real life work. Softwares are numerous, but when and how to be used is another matter. Despite the usage of most well-known local computer softwares in market in the different modules, they were not necessarily the best nor were they the most suitable. They were simply the ones available to be taught in market and not by scholars. Some of the scholars themselves did not know how to use the tools and took external classes as well. It is clear from Figure 3, Table 1 and Table 2 that integration of computer softwares is important, and all the scholars questioned were aware of the computer tools' impact on the output of their work, as well as the importance of integrating the modules taken.

COMPUTATIONAL TOOLS IN EVALUTION OF ARCHITECTURE DESIGN PROJECTS

Introduction

Design projects have always been evaluated qualitatively by so many different types of benchmarks. Some evaluate design by the degree of form, context, function, meaning, construction and will. Others have different benchmarks weighing the benchmarks differently. There are so many ways of evaluating design studio projects at different stages of the design. How to formulate a quantitative way to enhance design outputs has been the focus of researchers for the past 30 years, but only few use quantitative methods in academic evaluation of design studio tasks. The use of software to evaluate design studio projects can help in enhancing design projects evaluation in future design studio classes. There are numerous trials in that field, but again most of the trials focus on how to enhance projects in field work and few in education. Despite efforts, it is important to note that there some design matters that cannot be measured quantitatively such as aesthetics, humanities and physiological matters.

Methods & Materials

In a design studio for second level architecture department, in one of the average Egyptian governmental universities, random samples of 6 schematic design projects were evaluated qualitatively. The design sample of the project requested as can be shown in Figure 5 was of an elementary school. Grades of the sample evaluated at the schematic stage can be shown in Table 3. The projects in schematic phase were compared by quantitative evaluation tools on three different important parameters, which were related to the design project, by using three different computer tools.

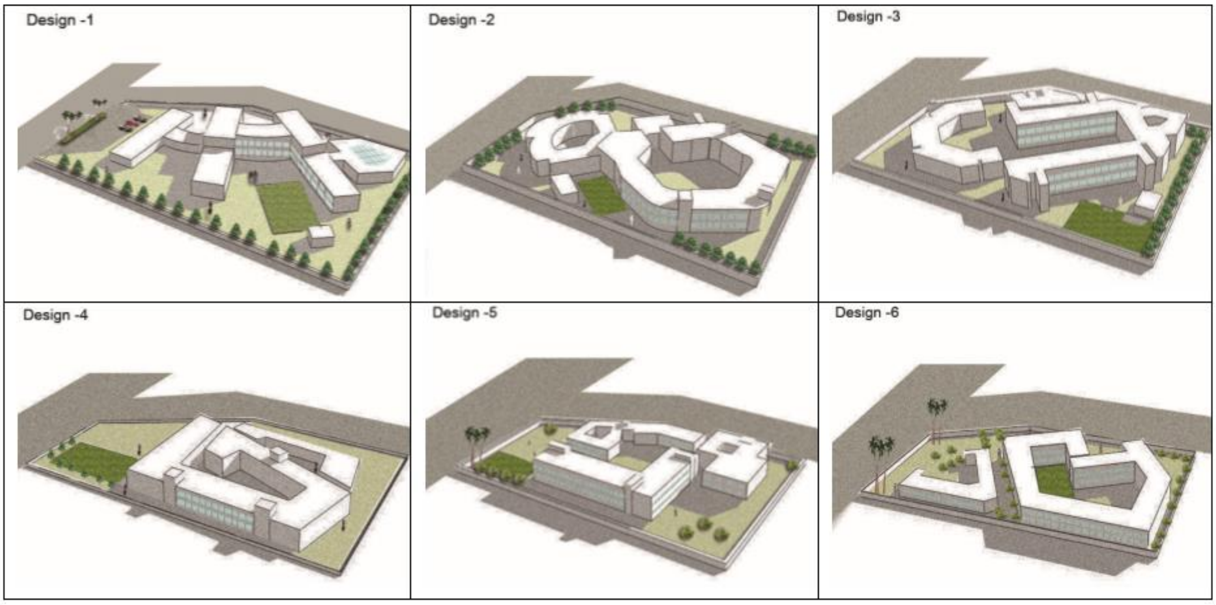

Figure 5: Six Sample Designs of an Elementary School Project Were Used in the Experiment. (Source: Author)

The first tool was used to compare different forms to light intensity on Design Builder. Design Builder provides a modeling that enables to develop comfortable and energy-efficient building designs from concept through to completion. Light intensity was chosen as a research category in this study due to its importance to educational environments.

The second tool used was SAP2000, which is an intuitive interface that allows creating structural models intuitively without long learning curve delays. This software can automatically generate wind, wave, bridge, and seismic loads with comprehensive automatic steel and concrete designs. SAP2000 can be used to calculate straining actions such as bending moments, normal forces and shearing forces in both directions as well as the corresponding deformations.

Design Number	1	2	3	4	5	6
Grades of Schematic Design	72	75	68	69	70	64

Table 3: Grades of the Sample Evaluated at the Schematic Stage.
(Source: Author)

The third tool used was to compare the effect of vegetation/landscape elements on the wind speed of the outdoor spaces of the selected projects by using ENVI-met. ENVI-met is a powerful three-dimensional microclimate tool designed to simulate the landscape interactions in urban environment. Wind speed which is one of the parameters that ENVI-met can measure is used in this experiment because of its importance on human comfort specifically in the outdoor spaces of schools.

Results & Discussion

Results from the Design Builder simulation, of the 6 proposed designs showing light intensity, can be seen in Figure 6. For educational buildings, it is recommended to have light intensity of 500 lux in school buildings. As can be seen in Figure 7, light intensity in Design 2, Design 4 & Design 5 is most suitable. Light intensity in Design 2 & Design 4 are acceptable, and Design 1 is the least suitable.

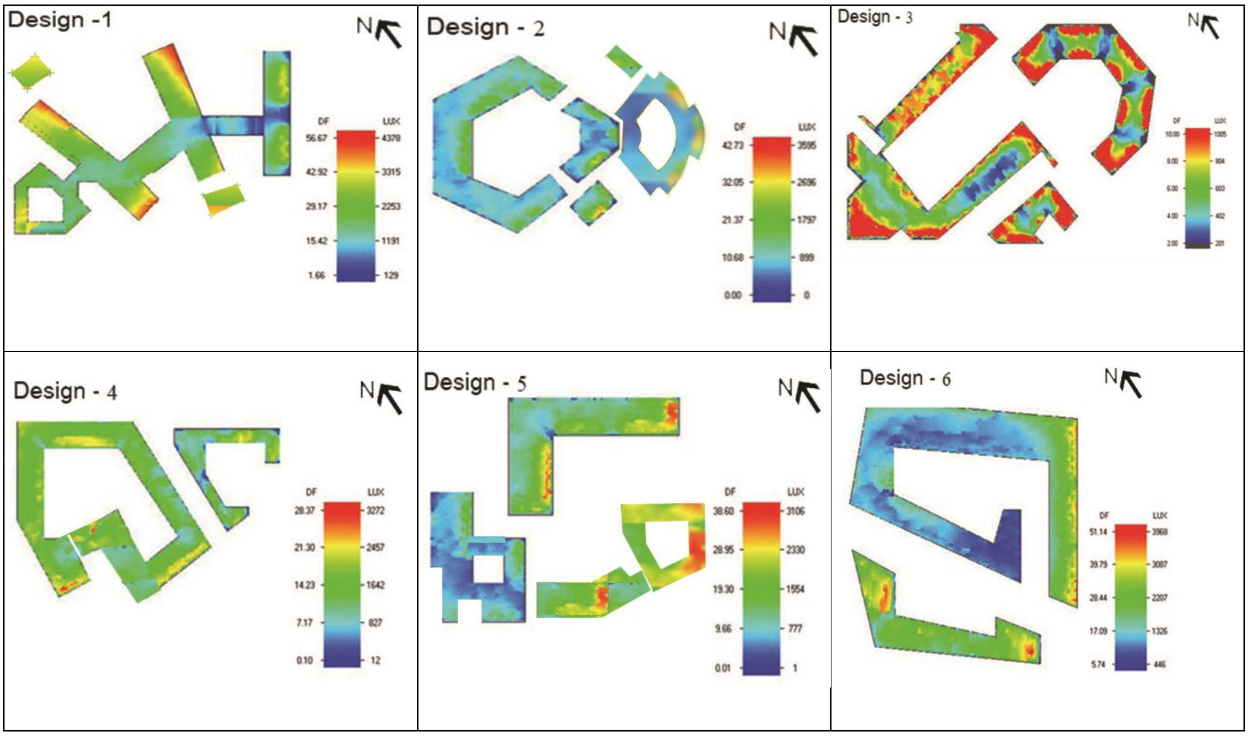

Figure 6: The Six Designs of an Elementary School Projects Testing Light Intensity on Design Builder.
(Source: Author)

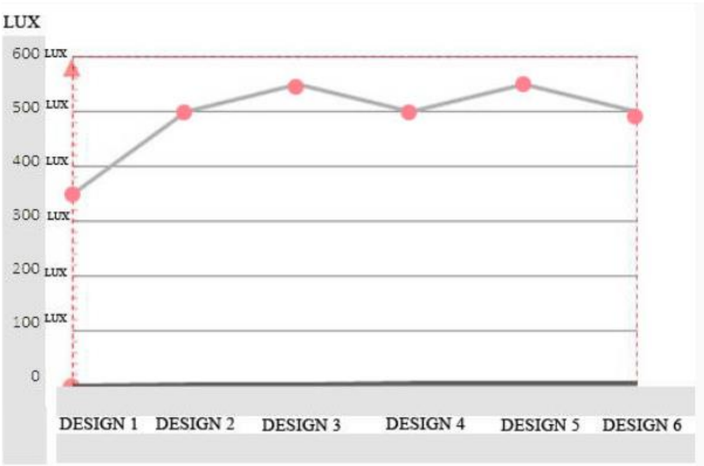

Figure 7: Comparative Results of Light Intensity of the Six Designs Based on Design Builder Testing. (Source: Author)

SAP2000 results of the bending moment of the six design samples were different, yet their structure system was similar because of strict school legislations in terms of area, openings and height. Structure systems were almost the same. There were no comparison measures in terms of area, and hence in term of cost. Bending moment results can be shown in Figure 8 which displays the bending moment of the 6 proposed projects.

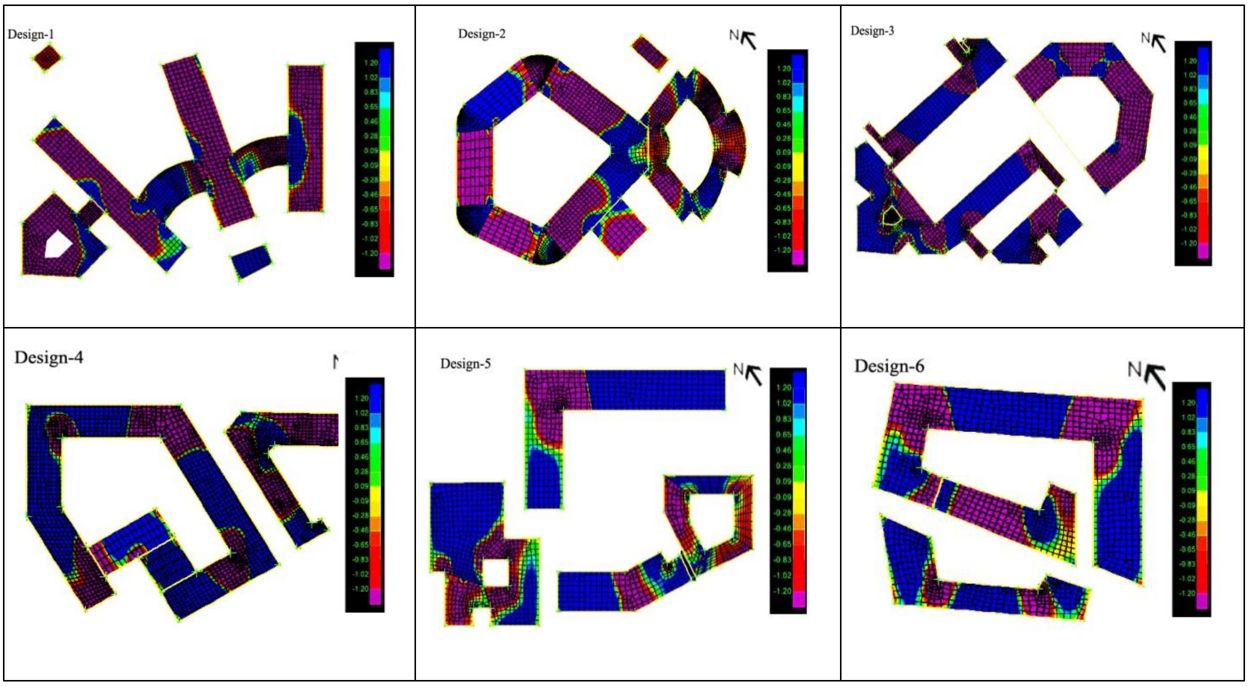

Figure 8: Bending Moment Results of The Six Design Samples of the Elementary School Project on SAP2000. (Source: Author)

ENVI-met results of wind speed of the 6 proposed samples of design can be seen in Figure 9. Wind speed change can contribute on air movement, which in term affects thermal comfort and thus participates in human comfort. A breeze of around 50 cm per second provides an equivalent temperature reduction of around 3°C. The reduction in velocity near the surface is a function of surface roughness, so wind velocity profiles are quite different for different terrain types. From Figure 10, it can be shown that Design 4 was the most preferred, followed by Design 6, then Design 3. Design 5, followed by Design 1 in order, and the least preferred was Design 2.

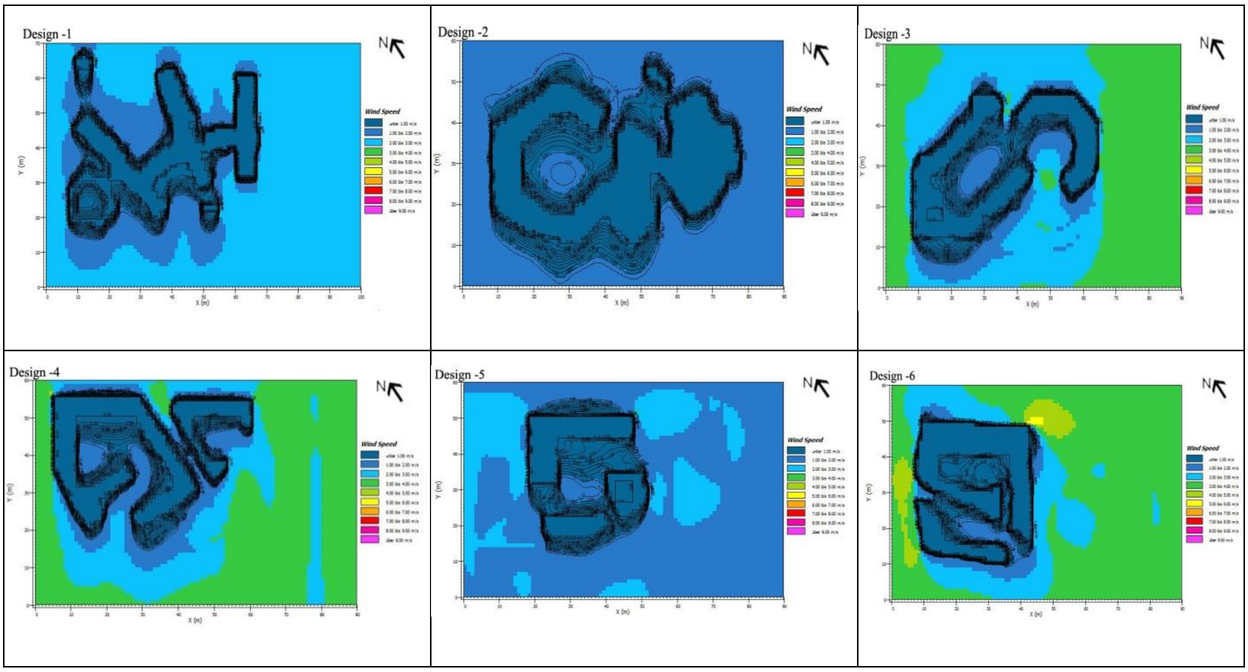

Figure 9: The Six Designs of an Elementary School Projects tested Wind Speed on ENVI-met. (Source: Author)

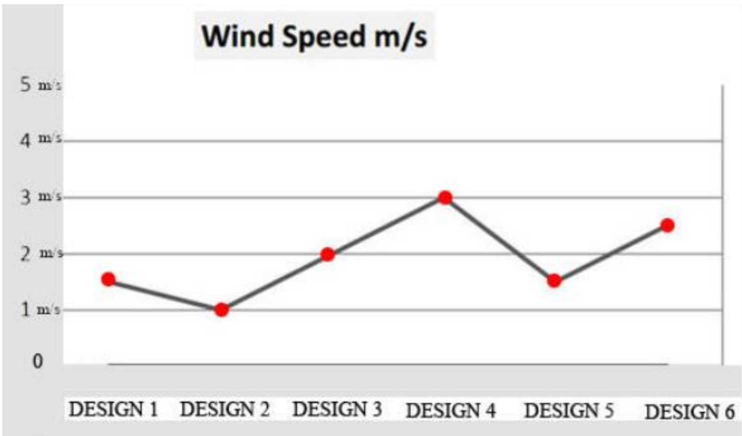

Figure 10: Comparative Results of Wind Speed of the Six Designs Based on ENVI-met Testing. (Source: Author)

Design Number	1	2	3	4	5	6
Grades of Schematic Design	2	1	5	4	3	6
ENVI-met	4	5	3	1	4	2
SAP 2000	-	-	-	-	-	-
Design Builder	4	1	2	1	2	1
AVERAGE ORDER	5	4	3	1	4	2

Table 4: Comparative Evaluation Results of the Six Designs Proposed Designs. (Source: Author)

GENERAL DISCUSSION

The study highlights on the importance of computational tools in enhancing designs in the schematic stage. Design, previously rated and evaluated by: Form, Context, Function, Meaning, Construction and Will qualitatively, must now be done partially quantitatively. As can be seen from Table 4, displaying a comparative evaluation of the six proposed design in a qualitative evaluation, Design 2 comes first but for a functional building like a school Design 4 comes first when evaluated quantitatively.

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From the result's outcome, it can be seen that integrating technological computer tools does help in enhancing designs. Using those tools is a necessity at an intermediate stage that is in addition to the importance on integrating courses and modules technically, in order to produce a good design project.

Tools for individual and distributed competencies must meet pedagogical demands and intended learning outcomes. Despite debates, on whether computer analytical techniques enhance the creative process of graphic design, using such tools and methods are necessary to better understand and represent the behavior of buildings in a quantitative way. Whether modeling, monitoring or parametric, they all have become a fundamental aspect of contemporary scientific knowledge. Such a level of sophistication does not stifle creativity but it rather introduces a new aesthetics vocabulary.

CONCLUSIONS

The purpose of this paper has been to present a general overview of a new framework for integrating computational analysis tools into architecture education (specifically in design), and in order to examine the close relationship between computational tools and academic architecture curricula. In addition, it was an attempt to review the possibility of integrating technical parameters that had strong impact effect on design. The contents have covered a sample technological enhancement tools that have strong impact on academic design outputs through simulation procedures.

This research has addressed a limited scope within the quest of viable strategies to achieve the broader architectural educational goals. This is a dynamic domain, one that continually engenders new ideas and involves new roles on the part of different academic institutions. It is believed that new technologies and approaches will emerge as the educational environments and circumstances change. The role of academic tutor will thus acquire further significance in the field.

RECOMMENDATIONS

As a broad perspective, it could be summarized that the principle of integrating computational analytical techniques that affects architecture education is a vital one, and needs to be considered/addressed through a number of recommendations, guidelines and special measures. The following is a focused set of recommendations based on the above-presented study:

- Necessity of an exclusive computer laboratory, environment laboratory and modeling Laboratory to support architecture academic curricula even if self-funded.
- Maintain creativity and manual artistic sketching in early years.
- Enhancing instructors' capabilities and human resources development by obligatory training.
- Update academic curricula more frequently to meet technological development requirements.
- Consider quantitative tools in evaluation in addition to qualitative ones.
- Architecture should be 5 years in order to be able to insert all integrated domains.
- A lot of the softwares in market despite publicity need to be tested on ground readings.
- Market and industry requirements must be always surveyed in order to produce efficient architecture outputs.
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