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RE-THINKING BLOOM'S TAXONOMY BY INTEGRATING DIGITAL SIMULATION IN

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Abstract

Despite the significant developments in adapting Bloom's taxonomy in architectural design studio in the last few years, in addition to the advancements in applying digital media in the education process, there is still no integrated framework that combines all threads together. The learning objectives of advanced design studio include pragmatic thinking through testing new hypotheses, evaluating and applying different parameters, and identifying appropriate decisions. These are only achieved once barriers between design studio and building sciences considerations are overcome by addressing the process of simulation across the domains and levels of the revised Bloom's taxonomy. The Design Studio and building sciences have traditionally been viewed as independent disciplines due to the lack of an integrated framework to connect them. This formulates a sound basis on which to explore the utilization of revised Bloom's taxonomy levels, adapted through the use of the process of digital simulation in design studio as a decision-supporting tool. This paper aims to design a path for the integrating building performance simulation through upgrading the framework of Bloom's taxonomy. To achieve this, the paper adopts qualitative exploratory approach of integrating building simulation software and its application in an Environmental design studio. The importance of the proposed framework is determined through measuring the attainment attributes. The results show that using this methodology in the design studio highlights the gaps in the learning process that students are facing in conventional architectural education.

Keywords

Architectural Education, Design Studio, Building Performance Simulation, Revised Bloom's Taxonomy

RE-THINKING BLOOM'S TAXONOMY BY INTEGRATING DIGITAL SIMULATION IN PRAGMATIC ARCHITECTURAL EDUCATION

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ABSTRACT

Despite the significant developments in adapting Bloom's taxonomy in architectural design studio in the last few years, in addition to the advancements in applying digital media in the education process, there is still no integrated framework that combines all threads together. The learning objectives of advanced design studio include pragmatic thinking through testing new hypotheses, evaluating and applying different parameters, and identifying appropriate decisions. These are only achieved once barriers between design studio and building sciences considerations are overcome by addressing the process of simulation across the domains and levels of the revised Bloom's taxonomy.

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1. INTRODUCTION

This paper proposes establishing the environmental design thinking in a learner-centered pedagogical framework by integrating the usage of BPS and re-thinking revised Bloom's taxonomy to ensure an ideal learning process for architecture students. In recent years, scientist and naturalists have expressed great concern about the alarming rate at which climate change and environmental corruptions is being accelerated. As a result, the profession of architecture has been preparing for the environmental alerts and changes reported in the Paris Climate Conference

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(COP21st) ("Our Common Future under Climate Change," n.d.). The American Institute of Architects, the first adopters of 2030 challenge which provides a framework to evaluate the impact design decisions have on project's energy performance, continues to prove the importance of using energy modeling from a project's inception that allows the design team to keep working on energy reduction through twists and turns with the aid of several software packages ("2030 Commitment - The American Institute of Architects," n.d.). Considering the importance of receiving awareness and willingness to change, this paper suggests that fostering critical thinking is attained by the integration of building performance simulation through the design process that must start through the levels of undegraduate architectural education.

Establishing a link between BPS and design process is only the first step in understanding why students find it hard to develope a moral reasoning and understanding of environmental conducive learning in the design studio. Although the use of BPS tools by design professionals became a fundamental way to support design decisions for energy efficient buildings, its breadth challenges students to fully appreciate and apply theories and concepts in the Design Studio. Furthermore, technology based learning environments activate students to become active learners functioning in various capacities (Vosniadou, De Corte, & Mandl, 2012). The motivation to engage digital simulation leads inexorably to cultivating the learner-centered environment. However, how can the student implement effectively the usage of BPS in student-centered paradigm?

The key to this approach is through designing an attributes framework that support the student (learner) and instructors in recognizing the learning outcomes and objectives. This point is driven from the model of revised Bloom's taxonomy and the progressive work of educational psychologists that stem from it. Consequently, its re-thinking through integrating building performance simulation in the design process is essential for the sake of enhancing student performance and learning process in the Design Studio. This paper reviews a cross section of bloom's taxonomy in terms of Architectural Education, limitations of BPS in conventional design process, and the integration of Building Performance Simulation. Limitations and future directions are also described in order to improve this prototype for better application in architectural design education.

1.1 The Need to re-think the learning Taxonomy model

Bloom's Taxonomy is distinguished as a classification system evolved by Benjamin Bloom, a leading American psychologist, to categorize intellectual skills and behavior important to learning (Bloom, College, & Examiners, 1956). The origin of Bloom's taxonomy is traced back to 1948 were Benjamin Bloom and several colleagues performed a wide series of discussions and case studies. For decades, it has been widely accepted as a useful framework for identifying and classifying educational goals. The initial intent of Bloom is to concentrate on three major domains. These domains are cognitive (thinking), affective (emotion/feeling), and psychomotor (physical/kinesthetic). Despite Bloom's intent to speak about all three domains, the handbook focuses only on intellectual skill development.

Bloom further categorized these domains into simple and complex classifications. The cognitive learning domain focuses on mental skills and intellectual abilities that help the learner to know, comprehend, apply what he/she learned to a new situation, analyze synthesize/construct and evaluate the value of ideas and materials. The objectives of the affective domain described "changes in interest, attitudes, and values, and the development of appreciations and adequate adjustment." And at last, the psychomotor domain pertained to "the manipulative or motor-skill area" (Kurt, 2012).

The first popular re-thinking of Bloom's Taxonomy is done by Lorin Anderson (a former student of Bloom) who updated the taxonomy with a new group of cognitive psychologists to be pertinent to 21st century work. The major differences between Bloom's original and revised editions revolve around the hierarchal stepped pyramid of cognitive domain, substitution of the upper two levels, and replacing verbs instead of nouns related to each level (Anderson, Krathwohl, & Bloom, 2001). Despite its stressing on higher level thinking, this approach didn't realize the whole Bloom framework. Listing critics on the detailed level of the hierarchy of cognitive level is out of place here since this paper deals with re referring to the original goal of Bloom, the original three domains.

1.2 Bloom's Taxonomy in terms of Architecture:

Bloom expressed that the original taxonomy was never intended to be definitive so that each field would have its own taxonomy written in the language of its discipline. Obviously, his work continues to be used to provide inspiration and tracking tool to achieve new researches and strategic goals.". Adopted after that by the American Institute of Architects and many art related educational institutions, the revised Bloom's taxonomy had proven its adaptability with art and architectural related education. Basically, most of the focus was only on the cognitive domain (Munzenmaier & Rubin, 2013).

In the field of architectural education, cognitive domain has been widely accepted as tool for defining learning outcomes but excluded the affective and psychomotor. According to (Savic & Kashef, 2013), the necessity of adding the other two domains is crucial in order to attain the learning outcome in a student centered learning approach. These evidences compose a strong platform to take the action of re balancing the dimensions between the three domains. This approach can be adapted to designing a framework because design students construct the knowledge of design by the help of their own observations which facilitate developing an understanding about design. They learn by experiencing the design procedure and reflecting on the process. This means that their cognitive talents; emotional expressions and psychomotor skills are developed during the learning procedure (Kurt, 2012).

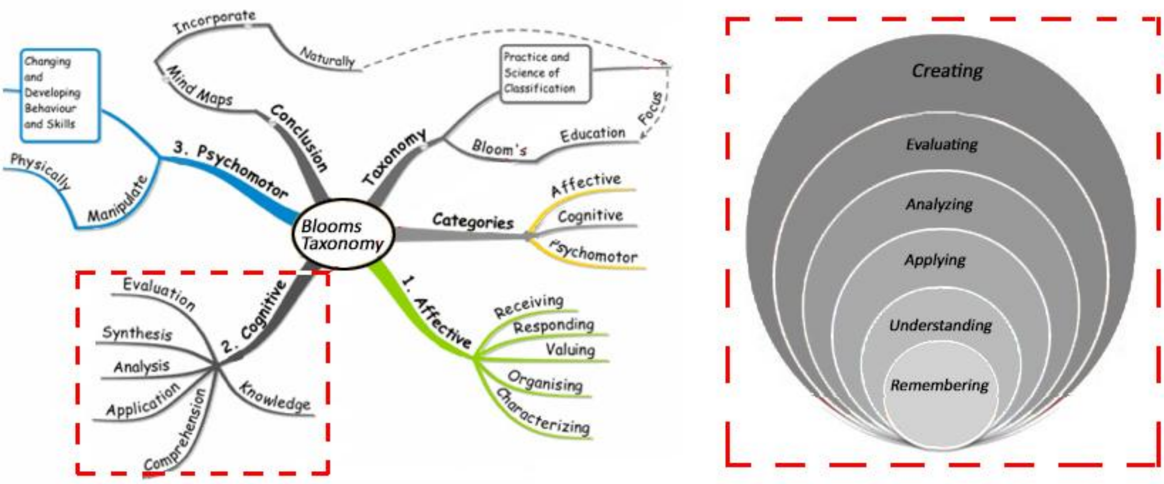


Fig. 1 Diagrams showing at the left Bloom's Taxonomy of Learning Domains according to the American Institute of Architects and excluding the affective and psychomotor as shown in the right diagram.

Reference: ("Study Skills and Bloom's Taxonomy," n.d.), ("Bloom's Taxonomy of Learning Domains - The American Institute of Architects," n.d.)

2. CHALLENGES OF SIMULATION IN ARCHITECTURAL DESIGN STUDIO

The conventional placement of environmental design in the Design Studio represents a departure from integrating simulation. The paradigm of design in many studios is still strongly predicated upon visual reasoning solely (Oxman, 2009). Simulation is the essence of the design process, so much so that there is no way to over emphasize its crucial role by referring to the very beginning of Western ideas. Plato warned of the deceptive nature of copies of reality, while Aristotle valued the cathartic experience of viewing simulations of real life. It is characterized by the generation of data, in a propositional form, that can be returned to the real-world context for its benefit. A more standard use for simulation is that it can yield information about dangerous conditions without placing people in harm's way (Groat & Wang, 2002). Simulation is useful when dealing with questions of scale and complexity.

Despite the importance of simulation, not every student understands its nature and function. The old ways of delivering digital techniques emphasize the representation aspects of Computer Aided Design (CAD) (Basa & Şenyapılı, 2005), but lack exposure to its simulation and analytical capabilities for assisting design generation. For example, many students consider it as a highly technical and deactivate creativity; environmental and technological courses are taught apart from the practical part were student inhibit repeating the learning experience; environmental analysis is basically concentrated on rules-of thumb; and finally the mission of convincing others with design solutions lacks consistent reliability and force students to apply re-design assessments and consequently lose time and hard work instead of achieving the ultimate objectives of the exercise.

3. RESEARCH METHODOLOGY

This study presents an explorative qualitative approach through investigating rethinking the revised Blooms taxonomy in the presence of BPS for achieving an integrated model of attributes framework. It is applied through "Arch339 Environmental Design Studio" a mandatory course included in the curriculum for level III students at the faculty of Architectural Engineering - Beirut Arab University, Debbieh Campus. Students were assigned a design project as a group work of 4 to 6 students during the spring semester 2014-2015. The project is an adaptive reuse building with the scope of achieving an eco-friendly approach and creative solutions. The selected software is Design Builder which is easy to learn and considered as a standalone software that can integrate CFD and radiance daylighting simulation.

3.1 Revising Bloom's taxonomy for Implementing BPS in Critical Design Approach

Critical thinking is not only important in Design Studio but also in every field of study. It is the role of higher learning institutes to prepare students to be critical towards whatever things they learn (Postman & Weingartner, 1973) and (Letiche, 1988) suggests the significance of every student to acquire the skill of 'learning to learn'.

Part of achieving this aim is to be able to think pragmatically by understanding the usage of technical and scientific knowledge of environmental concerns and software. In line with the traditional architectural sciences, BPS is necessary for constructing the design proposal in the real world for assessing a series of performance parameters to justify its validity and respect in the architectural decisions (figure 2).

The intersection of creative and critical thinking with the pragmatic thinking enable architecture students to achieve holistic design solutions. However, a simulation is considered ineffective as a learning tool if it doesn't adequately represent important elements of the environment under study. Therefore, the point of the present discussion is to investigate Bloom's taxonomy after the integration of BPS in design process in the pursuit of critical(pragmatic) thinking in order to build in the following section a revised Bloom's Framework:

- BPS in Cognitive Domain: The cyclic model adopted by the AIA fits the objectives of the integrated design process rather than hierarchal. Because we aim to transform student for manual BPS user into a master one who know the causes of what is produced. So BPS is not a mere experience but a selective one orbiting consciously to gain and create wiser knowledge examined by the students ability to teach. (ex, atrium design to improve thermal and daylighting performance).

- BPS in Affective Domain: Usage of BPS is concerned to produce a positive effect for building human intuition and appreciations. Certainly, studio learning environment is the initial incubator and specifically group work. Responding to the situation by running the appropriate treatment and simulation demonstrates the increase of positive attitude of student.

- BPS in Psychomotor Domain: Convincing others such as students and instructors deserves careful consideration, then it is crucial to prepare student to support his points adequately. This domain is concerned with behavioral skills so it is the main vehicle for strengthening for strengthening knowledge structures. Following the exploration of simulation environment and designing the strategy to conduct, student utilizes BPS for his specific target and rotate consistently in the loop of decision- making. This is managed by the students performance in testing, reading and analyzing empirical results and translating it into architectural language. Thus, BPS will definitely support the student's decisions and at the same time tests his/her ability for coordination between empirical data and design in the lens of his perceived problem.

Finally, the integration of BPS in design process ties within Bloom's taxonomy to enhance student's performance and learning process.

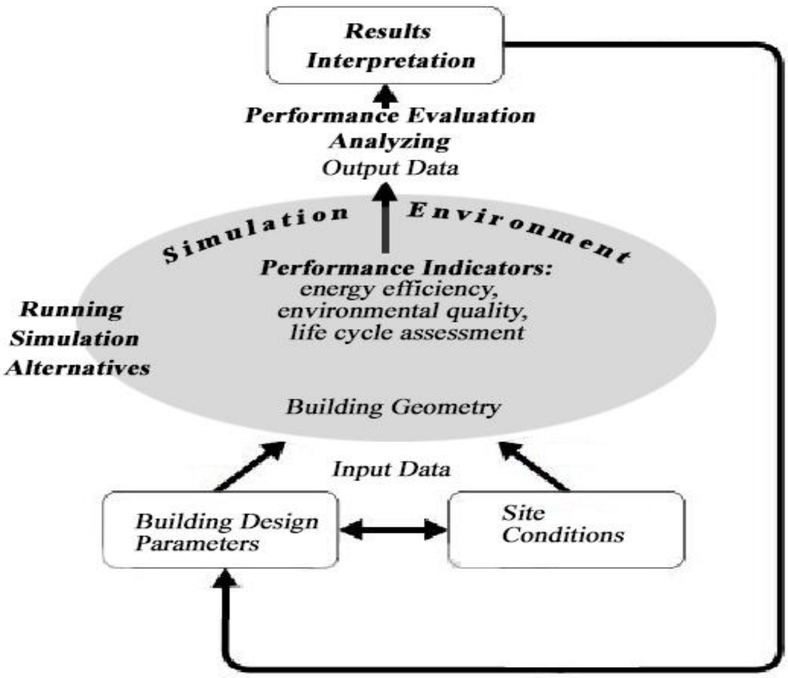


Fig. 2 Flow Diagram showing the design process within a simulation environment
Reference: The authors

3.2 General and Specific Learning Outcomes

Bloom's taxonomy is perceived as a convincing approach to re-think in the context of integrating BPS. This study continues to list the General Intended Learning Outcomes and specific objectives since it is an essential prerequisite to building the revised bloom's framework.

General Intended Learning Outcomes:

- To understand and apply the environmental principles into an architectural design solution by integrating digital simulation
- To identify key design parameters in order to achieve energy performance objectives underlying scientific principles
- To involve the student with iterative processes by establishing clear goals, modeling, simulating and critically thinking to achieve design decisions by exploring alternatives
- To develop Whole Building Energy Performance model for the purposes of predictive and evaluative analysis

- To generate a comprehensive technical and performance data to achieve an optimum solution to complex design problems.
- To create and reflect innovations in the field of BPS technology and sustainability on the student's design output.

Specific Objectives:

- **Building Input Data**
  - To identify building geometry, zoning, thermal properties, building fabric, cooling and heating systems, operational schedules.
- **Calibrating the simulation model**
  - To correlate measured building energy data for similar project typology and location with that predicted by software to accurately represent the real energy use
- **Interpretation of Simulation Output**
  - To create an understanding of the impact of building features on energy consumption
  - To analyze and interpret performance indicators resulted from running the simulation
  - To identify energy problems from the output results and propose energy savings strategies to recover defects
  - To sensitize the numerical value of savings of different alternatives
  - To optimize the design solution to Improve Energy Performance
- **Applicable Standards and Codes or compare to target performance**
  - To comply with energy related legislative requirements
  - To measure design solution against the target criteria
- **Disciplinary and interdisciplinary studies on a specific subject**
  - To apply system thinking within a team work to develop the project design and plan collaboratively
  - To demonstrate the ability to collaborate within other disciplines in order to bring about a successful outcome.

3.3 Building of revised Bloom's Framework (Integration of Building Performance Simulation)

The conclusion derived from the previous discussion proposes the following revision of Bloom's Framework (as indicated in Table 1). The aim of the study is building an attributes framework(qualitative evaluation) that will provide a valuable guide for the student in Design Studio. This study hypothesize that this integrated model leads students to determining their performance and learning process.

Table 1. An Integrated Model including the Design Context and Simulation Context of Learning Process.

Reference: The Authors

		Integrated Model	
Revised Bloom's Domains	**Criteria**	**Design Context (Physical Environment)** — Data Produced → / ← Data Extracted	**Simulation Context (Virtual Environment)**
Cognitive Domain	Remembering (Can The student recall the elements and principles)	- To identify the key parameters derived from both the site and its setting - To effectively identify large amounts of project-related information and recall input data base	- To identify the methodology (choosing the simulation tool) - To recognize modeling and simulation process
	Understanding(Understanding theories and explain ideas)	- To represent intuitively the principle of architectural programming integration of building elements and relevant context factor - To map design strategies giving the	- To extrapolate different design alternatives

		best combination of environmental and comfort performance	
	Applying (Using what they learnt in a new way)	- To apply the design process to complex, interdisciplinary design problems - To implement suitable methodology for the design problem	- To use and further develop a detailed digital model of the building using a BPS application for the purposes of predictive analysis and information production
	Analyzing(criticizing and distinguishing between parts)	- To integrate design elements - To integrate energy performance strategies for the building at macro and micro levels to achieve targeted performance objectives.	- To distinguish between different spaces relationship (identifying thermal zones)
	Evaluating(Taking decisions and justifying those decisions)	- To critique, test, revise and improve the quality of design	- To test a wide range of design objectives and constraints from different key performance indicators covering energy efficiency, environmental quality, life cycle assessment
	Creating (It is where majority of thinking)	- To articulate the iterative processes required to bring about successful outcome of an architectural design project - To produce design solutions which address underlying scientific principles, energy performance criteria	- To generate a comprehensive technical information package using digital simulation
Affection Domain	Receiving and responding	- Responding to the environmental psychology of users. - Responding to the physical characteristics of site and context (soil, water, air) - Responding acquiescently to specialized factors of site and building contact.(ex, if the project is floating on water or embedded underground)	Receiving awareness of building performance Simulation in relation to: -type and density of users occupying a space. - physical characteristics of site and context
		Alertness for some specialized cases - Take particular notice to extension of ancient buildings	Willingness to respond to particular cases(retrofit buildings) by voluntarily testing (mobile tools) - Getting realistic and observed input data of existing building to be added as input for BPS
		Responding to a design problem - Giving controlled or selected attention for some specialized modules. (ex, classroom/school; patient bed unit/ hospital)	- Valuing simulation as a clinical diagnostic tool in the design process
	Actions on Decisions	- Taking decisions toward major indicators that affect the satisfaction of design process - Taking decisions toward design alternatives	- Organizing the hierarchal importance of performing indicators and their priorities in relevance for every project
	Optimizing	- Organization of tools of BPS into level of complexity in relevance to building systems - Valuing the preference of BPS for a diversity of scales and complexities of design projects - Organizing the priority of evidences in relevance to available time - Organization of BPS into a value system with other concepts	- Characterization of the complexity of building system to be tested - Preference for certain performance indicators over others (ex, test daylighting factor in a school project) - Readiness of student to examine other new evidences of the impact of many indicators upon progress in design process - Being able to perceive the impact of

			BPS on form, facades, material selection, building character and human dimension
	Operating values/Intuition	- Building human intention with a developed philosophy of design interests and attitudes integrated with BPS to form a total adjustment of simulation thinking perspective	- Outlining design intentions achieved - Transferring and coexisting of this experience to future courses
Psychomotor Domain	Exploring		*1. Exploring of simulation environment (virtual laboratory)* *- Decision making: to design a strategy that illustrates mutual relationships between environmental concerns and BPS*
	Integrating problem solving Decision-making loop on the basis of: - Characters/users - Setting: - Place(context, site, building type) - Time (weather, climate) - Period (length of time of occupying the tested space) - Performance indicators (which are selected according to preference-discussed previously in affective domain)	- Decision-making(for integrated solutions)	- Problem-solving: integrating the BPS analysis with design guidelines -Experimenting: testing a hypothesis. (ex, testing the thermal performance of using double skin facade; or using conical form as shelter)
		- Investigate: collecting further data based on the results of experimented results	- Reading and identifying errors to re-adjust the input data. (ex, wrong weather file will definitely distort the tested hypothesis)
		- adapt architectural form in relevance to validated results - refer to perception psychology theories that overlap with the adjusted form based on empirical results	- Validation of results - Validate the concluded results by matching relationships between causes and effects
		- Transform the empirical comparative data into architectural(form,..) decisions	- Prediction of future system behavior - Illustrating a comparison of building performance between different realistic weather conditions
		- Strengthening concept structure through accumulated experience. - Decision-making built on a series previous temporary decisions - Integration between the environmental considerations and other guidelines by an invented formula by the learner for re-addressing/designing the problem	- list alternatives with a value system to recognize the percentage of BPS influence on design
	Building Communication Skills	- Generalizing the individual experience into team-work by understanding a common representation languages(empirical, drawings, diagrams, graphs) - Designing within a teamwork	- Learn how to teach the viewer of the causes, effects, mechanisms and methods selection of BPS indicator/s rather than other to support the total design quality
		- Increase self-esteem and pleasure based on the support of empirical data analysis - Intrinsic feedback on student experience (ex, -embedding part of the volume/building according to tested evidence;	- orienting building in east -west according to comparison - the building on this site took an extensive linearity based on empirical proof)
		- Prepare the student to cooperate with others(students, institutions, student) of other disciplines - Ignited motivation leads to digesting technical benefits and minimize the pressure of navigating through environmental realm	- Multi-disciplinary integration

After re-thinking the revised Bloom's taxonomy in the context of BPS and design process, we utilized it as an attributes framework (qualitative evaluation) so that each student can realize his/her performance in the learning process.

Knowing that this model is qualitative, this study proposes also an assessment sheet by adding the three main phases of Design Process: conceptual phase, schematic design phase, and detailed design phase.

This sheet provides a basis for further developed quantitative assessment sheet and become dependent on numbers or scale assigned by the instructor or maybe future research.

Table 2. Assessment Sheet (for the instructor) to match with integrated Model refer to Table 1

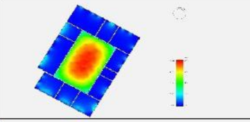
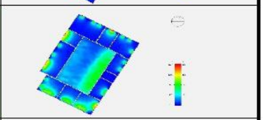
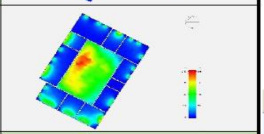
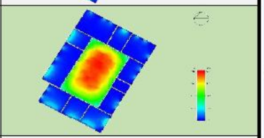
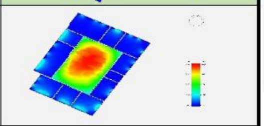
Reference: The Authors

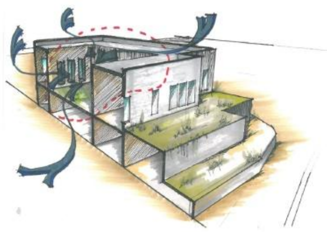
Domains	Design Process	Conceptualization Phase				Schematic Design Phase				Detailed Design Phase			
		Gathering Information	Define the design Problem	Setting Performance Goal	Design Criteria	Modeling through BPS	Active and Passive Systems	Running Simulation	Data Produced Analysis	Scenarios Evaluation	Design Development	Optimizing Performance	Detailed Design
Cognitive Domain	Remember												
	Understand												
	Apply												
	Analyze												
	Evaluate												
	Create												
Affective domain	Receiving and responding												
	Actions on Decisions												
	Optimizing												
	Operating												
Psychomotor Domain	Exploring												
	Integrating problem solving												
	Communication Skills												

3.4 Live Study

In order to address the students' performance of learning process, the attributes framework (evaluation framework) is used for ensuring the proper usage of BPS. Achieving the aim of the studio necessitates selecting buildings of manageable scale to explore the building performance and the solution founded by students.

The first team project to highlight by (Hadi Hamzeh, Hiba Itani, Housam Baradieh, Layal Zaatri, Sahar Mohti and Zahra Saab), who developed their site configurations based on prevailing wind pattern and solar exposures. The team proposed to develop an abandoned traditional Lebanese house into a cultural center. For the cognitive domain, the team identified key parameters based on site analysis checklist and explored relationships among architectural value, landscape, biological and human dimension; studied the concept of cross ventilation and daylighting for the element of court in this building. In terms of BPS, they identified the relevance of both daylight factor and cooling load, started modeling the base case scenario and specify the geographic coordinates of building (in remembering). The team also refined the building program based on research of site, users occupation and changes in function; and gain a thorough knowledge of the interactive relationship between spatial design and energy performance for achieving the building program. In terms of BPS, the refined function of the court lead to thinking about different treatments of atrium and the team decided to conduct experiments on skylight alternatives with respect to the previously selected indicators (in understanding). For the psychomotor domain, after validating the results of the rule of thumb concerning the appropriateness of the courtyard space, students improved their knowledge by understanding the empirical data of cooling loads and daylight factor. The idea was to change the open courtyard space into covered for blocking unfavorable wind in winter. The team performed five experiments normal skylight, different materials, different materials with voids, concrete pergola and glazing and finally wooden pergola and glazing. Knowing that the performance in psychomotor is interactive with cognitive domain, the interpretation of the simulation results lead the team to conclude that the lower cooling load is when the courtyard is opened space or when it is covered with different materials of skylight while for daylighting it is when covered with wooden pergola and also when it is uncovered. This means that the difficulty in interlining the cognitive and psychomotor prohibited the team from focusing on understanding the causes of alternatives (2) rather than the other 4 alternatives. For the affective domains, the team found a difficulty in treating the geometrical form of the proposed cover so that they depended on changing materials only excluding the importance of molding it in various geometries so that relation between form and simulation did not exceed material selection.

Alternative	Cooling design load (KW)	Daylight
1- Normal skylight	366.58	
2- Different materials	327.78	
3- Different Materials and voids	331.43	
4- Concrete pergola and glazing	345.01	
5- Wooden Pergola and Glazing	341.06	



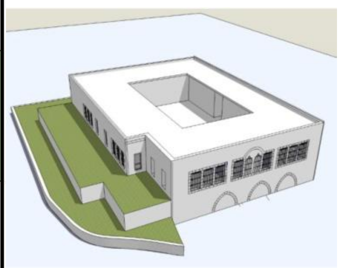
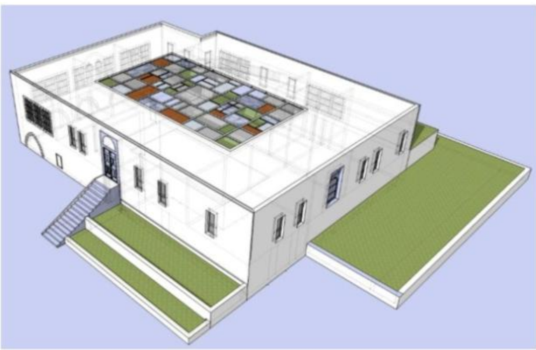


Fig. 3 Skylight alternatives assessed in terms of cooling and daylighting
Reference: Produced by Team 1



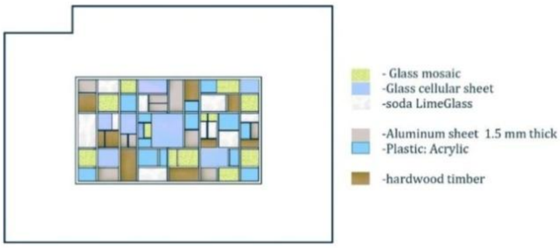


Fig. 4 Exploring different material patterns for the skylight
Reference: Produced by Team 2

Another project done by (Nemer Nabbouh, Norma Azzam, Ahmad Bushnaq, Dana Lamaa and Alaa Saad) also initiated an integrated design process in order to test how several design options for building envelope can affect the project performance. They started by assessing the current building situation and added shading devices in order to optimize the location of fenestration, type of glazing and shading devices in order to provide visual comfortable and reducing energy consumption. These passive strategies were effective especially on the southern facade and minimized 25% of the cooling load. Students were keen to complete such analysis and move to synthesis in order to achieve the generation of the optimum design. These design activities executed iteratively from the early stages of design and through the design development are reflected in Table 1.

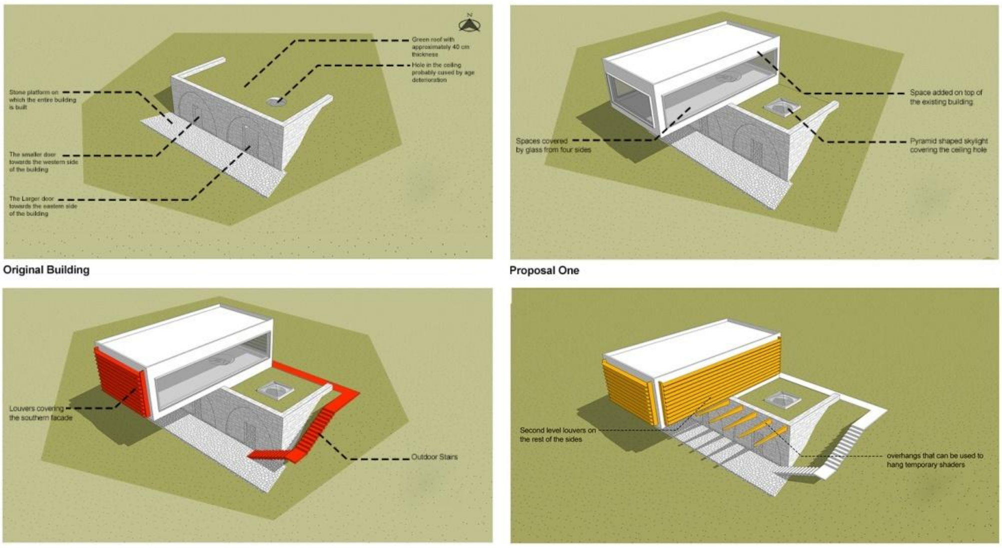


Fig. 5Testing four design options
Reference: Produced by Team 2

4. DISCUSSION

With the usage of the attributes framework (qualitative evaluation), students are able to recognize that they experienced a preliminary performance and learning process because of the gaps in psychomotor domain which deactivated consequently the flow of knowledge in the cognitive and affective domains. This was very effective in order to focus on improving learning process from the different domains which can integrate and allow students to approach the holistic design. Furthermore, students are considered as beginners in integrating this tool in their design process which did not allow them to perform elaborated simulation and lost the balance between the detailed modeling and approaching realistic output data consequently and its reflection appeared in the inability to validate accuracy of results needed to support design decisions. Students realized the efficiency of BPS infusion within the design process in producing effectively their decisions despite the limitation of time. Once referring to the attributes framework, students become more aware to the deficiencies and strengths of their performance in the learning domains and helped them to go beyond and pay attention for developing their potentials.

5. CONCLUSION

Finally, the following conclusions may be derived from the research:

a. The feedback students provided about using BPS in their design process through the end of course evaluation is valuable in helping the instructor to identify weakness especially being their first exposure to this approach.
b. Students' assessment highlighted on several advantages for BPS integration including improving environmental performance of the project and developing communication within teamwork, facilitating the exploration of 'what if scenarios', predicting performance, and responding pragmatically to the design problem.
c. The attained learning outcomes cover the three domains indentified in the integrated Model particularly the Affective and Psychomotor domains which were neglected in the conventional design studio.

d. Enhancing creativity depends on how skilled is the use in modeling in order to implement more innovative techniques.
e. Strengthening the pragmatic thinking developed also the creativity by accelerating the speed of mutual relationship between decision making and evaluation to generate consistent design solutions.

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