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Research Article

Integrating Computational Approach with Culture of Construction in Architectural Learning to Increase the Student's Engagement

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Abstract

This paper is built on architectural students' engagement and performance in schools of Architecture who are dealing with different cultures of construction like European and north African ones, where students need more in-class activities to deal with the target course outcomes and content. Based on several faculty discussions conducted at the French university in Egypt and INSA Strasbourg and mutual visits from the two sides it was highlighted that student engagement and the effective design of in-class activities are the key factors to get the course target outcomes. This paper presents in-class activities designed for detailed design studio course Studio D to integrate both construction cultures they are introduced to and the computational approach in architecture as a motivation for increasing the students engagements , the paper explores the planning and assessment aspects for effective and engaging in-class participation activities as well as integrating the computational approaches to enhance the student engagement experience within their course context. The paper demonstrates the activities and outcomes of the studio. It then demonstrates how concepts of computational and parametric design are incorporated to propose an activity that engages students in designing, fabricating and operating responsive systems in different phases of the detailed design process. A discussion follows regarding dynamics of detailed design studio considering the proposed class activities.

Keywords: *construction cultures, computational Architecture, students' engagements, detailed design studio.*

1. Studio D Background

Studio D Detailing design studio is a course given to Students in the fifth year of architecture at the French university in Egypt the main objective of this course is to deepen the conceptual approaches, theoretical and technical knowledge of the architectural project and to develop the ability of students to address all elements and components of an architectural project while focusing on its constructive aspect. The main scope is on the significant aspect of technical thinking over time, develop one or more projects that consider both the contextual scales and the technical resolution Thorough; 1-mastery and articulation of project parameters. 2-Transmission of experiments and decisions taken. 3-Work in the studio and on site. Directly linked to the detailing design studio is the culture of construction lectures which is gained from the French pedagogies and introduced to the Egyptian one it is considered as a catalyst part in fostering the architectural knowledge of students especially in the detailing design studio. Culture of construction aims to reintroduce knowledge of know-how into the architectural projects approach. Throughout introducing some case studies to re-understand and re reading for these case studies by doing a critical analysis of their constructive principles and the process of implementation and detailing. then, decomposition of a narrative in coherence or shift of a thought of the architectural approach. The analysis is done by a major programmatic theme evolves from year to year. This course was given for 3 years at the French university in Egypt. The work load of this studio and its learning outcomes needed an intensive preparation and enhancing the in-class students experience which required a redesigning for the course as an overall. Fig 1 shows a mind map done for the course redesign.

2. Designing Learning Objectives for Active Student Engagement and Participation

In order to design in class activities to increase the student's engagement the course must have in class learning objectives that are measurable. Using a verb table helps to avoid verbs that cannot be quantified, like: understand, learn, appreciate, or enjoy. Table 1 designing the course assessments (activities, projects, and exams) should be aligned with its lessons learning objectives. (Krathwohl, DR2002),

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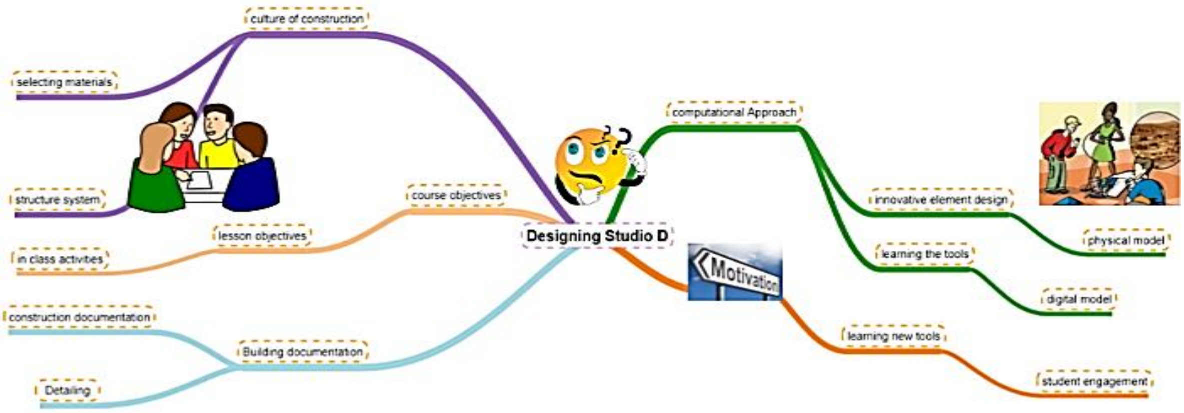

Fig.1 mind map done to redesign Studio D

Table 1 Learning objective examples with refer to bloom's taxonomy

Bloom's Level	Key Verbs (keywords)	Example Learning Objective
Create	design, formulate, build, invent, create, compose, generate, derive, modify, develop.	By the end of this class, the student will be able to design an interactive architectural element dealing with the principle of conservation of energy.
Evaluate	choose, support, relate, determine, defend, judge, grade, compare, contrast, argue, justify, support, convince, select, evaluate.	By the end of this class, the student will be able to determine whether using the kinetic facade or the static one would be more appropriate for solving their design problem.
Analyze	classify, break down, categorize, analyze, diagram, illustrate, criticize, simplify, associate.	By the end of this course stage, the student will be able to differentiate between construction material and structural systems used in the same project.
Apply	calculate, predict, apply, solve, illustrate, use, demonstrate, determine, model, perform, present.	By the end of this class, the student will be able to calculate the solar exposure of their facades using digital tools.
Understand	describe, explain, paraphrase, restate, give original examples of, summarize, contrast, interpret, discuss.	By the end of this class, the student will be able to describe the structure system of the architectural projects.
Remember	list, recite, outline, define, name, match, quote, recall, identify, label, recognize.	By the end of this lesson, the student will be able to recite the construction materials used in the project.

The course main objectives are too broad so designing in-class activities which increase the student's engagement will not be connected directly from the course objectives. Instead, lessons objectives were generated to demonstrate the mastery of course objectives. To create good course level objectives, it is a kind of bottom up process beginning by designing the in-class activities that fulfils the lesson objectives which underneath confirm that a student has mastery of the course level objectives. As shown in Fig 2

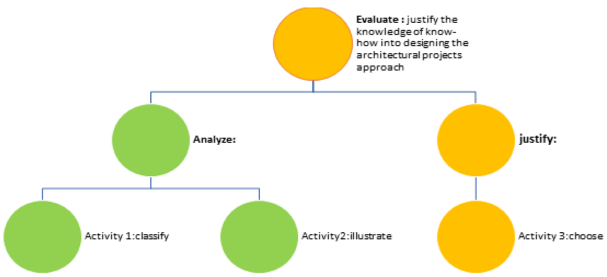

Fig.2 The breakdown of one of studio D main objectives into multiple lessons objectives provided by designing in-class activities to prove that students have mastery of the course level objective

3. Strategies for motivation, participation and engagement

The uniqueness of the course typology of Studio D wasn't easy to directly design the in-class activity that increases the student engagement. Students should be motivated to participate in the class activity to show an active engagement so an Intrinsic motivation was selected computational approach and introduced in the course where students showed their high interest in by commenting that learning the computational methods in architecture enables them to design more effectively and they feel that they need such component to be existing in their portfolios, this kind of motivation is a long-lasting and self-sustaining one but on the other hand needs efforts from the professor at promoting student learning. This makes students focus on the subject rather than rewards or punishments and increases the student confidence. It also needs lengthy preparation and requires variety of approaches to motivate different students. (Hans, MD & Fox, J 2015),

So, the course timeline Fig 3 was designed to integrate this motivation with other course objectives and if motivation was not supported by student's participation in class activity so no engagement will be obtained some activities were assigned as a group activity with a role designation and individual accountability this positively insure student's participation and increases their engagement. In order to adapt the computational approach inside the course content and merging it with the culture of construction the course timeline was divided into 3 main stages

3.1 Stage1 Project statement, materials and program design

Five weeks design studio and lectures at this stage students will be introduced to their project brief integrated by culture of construction sessions and readings assignments.

3.2 Stage 2 Creating a Responsive and Adaptive Systems

Three weeks workshop setting at this stage students will have a condensed workshop on computational approach in Architecture.

3.3 Stage 3 Detailing Documentation, Simulation and Optimization

Seven weeks design studio project and documentation development at this stage students will have a regular architecture studio to create their detailed documentation for the project including digital simulation and design optimization.

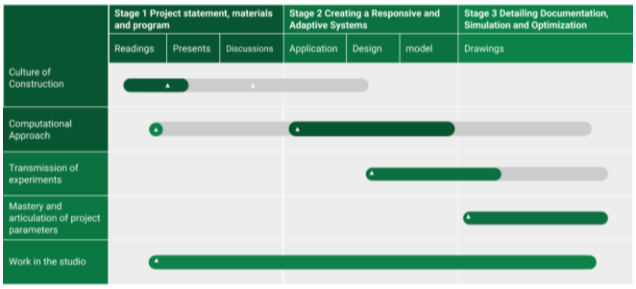

Fig.3 Studio D designed TimeLine to integrate digital approach as motivation with the course objectives.

4. Designing Studio D in class activities

The nature of studio D is that it isn't only a detailed design studio but there is a culture of construction dimension that should be received and taken into their consideration while designing the project adding the computational approach as a motivation to foster their culture of construction learning helped in designing their class activity. This is by adding a workshop setting component inside the timeline of the course. At the beginning of the semester students are introduced to their course objectives and the different stages and outcomes required from them. As mentioned previously the course was divided into three main stages.

Stage1 consists of readings and lectures related to both the culture of construction and the digital technologies and their impact on architectural practice. The activity required from them was presented on a minute paper used at the end of a class session (Brookfield, S 2015), where students are asked to take one minute and write on a separate sheet of paper: 1- the main points they're taking from the culture of construction lecture, and one question they have or issue they don't quite understand in connecting to the given readings. This in class activity allows more direct access to what students think about the material. Which opens an opportunity to take notes on recurrent themes or questions—these findings can guide the opening of the next lecture or discussion. For the students, the one-minute paper prompts them to start synthesizing the digital approach and culture of construction together and to identify their understanding related to course timeline. Increasing the students engagement is assigning a reading for each student under one topic like building information modeling where each student is going to present his reading by his own innovative way asking questions making a model or even acting a scene all of these actions and activities increases the student participation and engagement By allowing students to discuss aspects of their peers' presentations, they in turn internalize how to recognize particular reading issues like what is really meant by adopting the BIM process and methods for addressing them. These two kinds of in class activity suits the first part in the course timeline and directly connected to understand and analyze levels in bloom's taxonomy.

Stage 2 of course where students were intrinsically motivated that they will learn the computational approach and will apply this technique in their own projects here comes the workshop activity where students work in a group of four to design the project. (Hanus, MD & Fox, J 2015), This stage represents the climax of the student engagement in the course. Fig 4 Students give feedback on each other's design and sometimes propose a solution and new ideas. the most important part in this stage is helping students to understand the course expectations which is one of the most powerful ways can help them improve as architects. Just handing out models and examples of student from a previous semester will help some students produce better projects and ideas.

Stage 3 is not less important than first two stages but may be more stable and longer in time the class activity mainly concentrate on applying and generating the articulation of their project parameters where students are asked to draw the architectural documents for their projects here the articulation of construction elements and project parameters should be clear. This requires the highest level in bloom's taxonomy which is create and the nature of student engagement is one to one with the instructor.

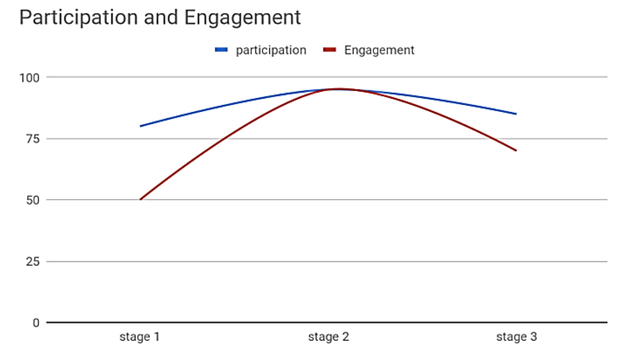

Fig.4 Studio D student participation and engagement chart along the course three main stages.

5. Computational Approach as motivation; Creating an adaptive and responsive architecture system

Described below the main outcomes and general observations in-class computational approach activities in stage 2 where students engagement was observed to reach the climax. four teams worked on their prototypes to achieve two innovative components a Sensitive environment function of new technologies and digital tools. students worked on developing digital model of their detailed project ideas as innovative prototypes representing a building technology aspect that satisfied their concept statement (including lighting elements, shading devices, awnings, system panels, openings, etc.) using digital fabrication techniques and interactive and adaptive architecture concepts. The four groups designed an interactive prototype that can interact with any stimulus the design was very flexible mechanism to give a wide range of perforations and solids with return to its original state easily without need many engines to control this mechanism digital tools used Rhino, Grasshopper ladybug and digital equipment used: Arduino Uno, light sensors and motors.

Group 1 chose to develop a ceiling structure as their responsive element. Conceptually, this structure was based on kinetic movement, where human noise underneath the structure would generate movement based on amount of sound within the environment, in addition to volumetrically altering the space underneath, therefore allowing for larger sound absorbent and diffusion to decrease the noise. In this sensing-planning-action mechanism, the environment would sense the amount of noise produced by users in space, and accordingly plan for necessary changes in folding of ceiling structure. Fig5 the students used simple laser-cut triangular paper folding connected parts to represent the ceiling structure, and motor to simulate the motion of the ceiling parts, moving up and down to change the volume of space underneath. An Arduino microcontroller was connected to the model, and four servo motors were used to pull and push the folded pattern to simulate the desired motion. Fig 6 the students used sound sensor to simulate the sensing component of the model, where the intensity of sound controlled the volumetric change underneath the roof.

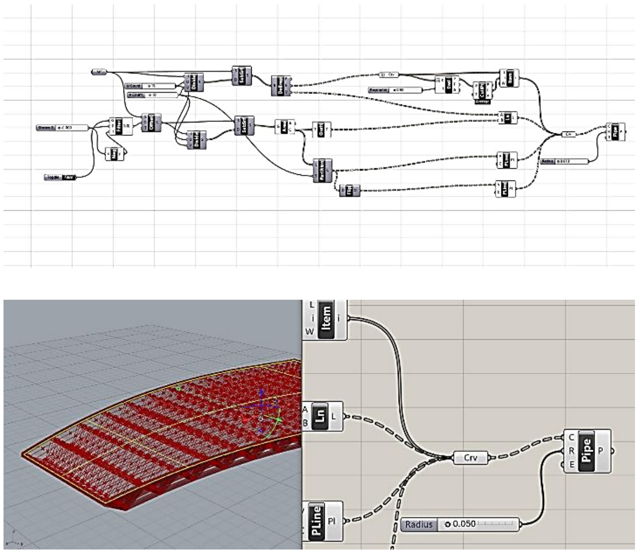

Fig.5 Group1 computational development for the celling structure

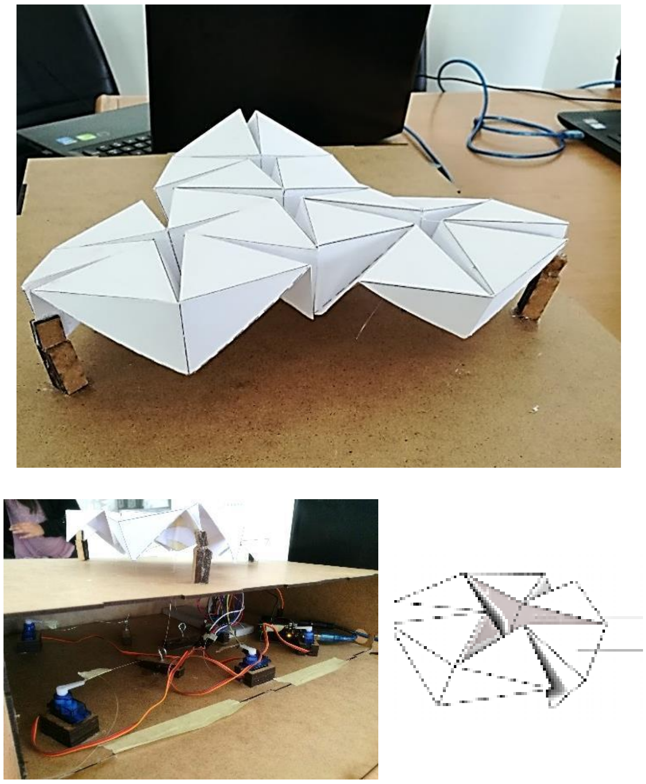

Fig.6 Group1 responsive proto type using sound sensor and four servomotors

Group 2 chose to develop a building facade screen consisting of kinetic window apertures that respond to environmental conditions. Conceptually, the element was inspired by the tensegrity concept and based on response to exterior conditions such as daylighting, where the responsive aperture within a double-skin screen would open and close to allow for different daylighting scenarios according to different times of the day. For the exercise prototype Fig7,8, the students developed a full-scale model of a 60cmX60cm screen using MDF boards. The screen was divided into four identical panels, each hosting a central motion rails working in 2 perpendicular directions to guide the kinetic movement of the modular screen units that shape the overall screen pattern. An Arduino microcontroller was connected to the model, and four servo motors were connected to each of the motion rails to achieve the desired opening and closing movement of the screen units. The students simulated the sensing activity using their cell phones, where the intensity of light controlled the angle of motion of the motors and consequently aperture sizes.

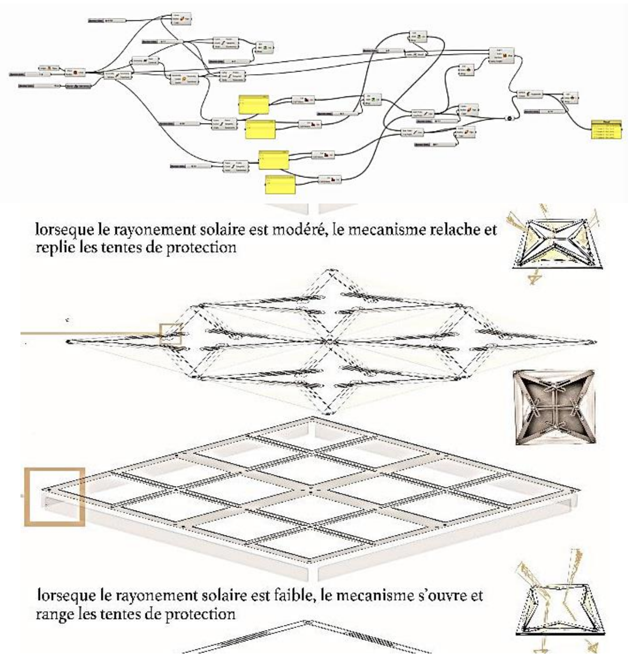

Fig.7 Group2 computational development for the building facade screen

Fig.8 Group2 responsive proto type MDF and textile.

Group 3 chose to do an "intelligent design" rather than a simple assembly of "smart components". The concept of "intelligence" associated with design of facade represents a change from a static envelope to a dynamic and reactive envelope. The thermo-physical properties and performance of advanced integrated facades depend on the application and depend on the operating conditions. They can be obtained by simulations and experimental tests. Conceptually, the element was inspired by the simple square shape that rotate around one of its edges to generate more flexible patterns. Fig9,10, the students developed a full-scale model of a 40cmX40cm screen using acrylic boards. The screen was divided into square pattern grid connected at the edges by pivot that control the motion of the grid. An Arduino microcontroller was connected to the model, and only one servo motor was connected to the whole pattern to achieve the desired opening and closing movement of the screen units. The students simulated the sensing activity using their cell phones, where the intensity of light controlled the angle of motion of the motors and consequently aperture sizes.

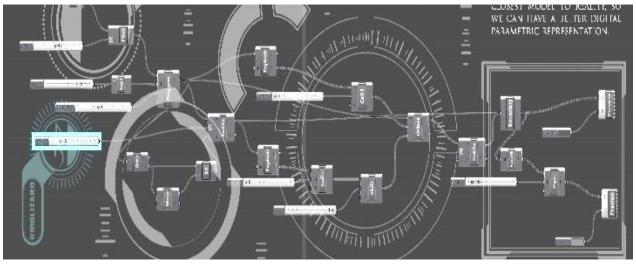

Fig.9 Group3 computational development for the intelligent facade screen

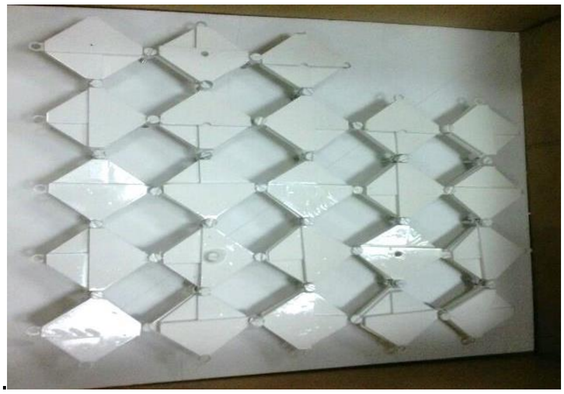

Fig.10 Group3 responsive proto type

Group 4 chose to develop kinetic louver system that responds to the sunlight exposure on building facade. Conceptually, the element was inspired by the tensegrity concept and based on response to exterior conditions such as daylighting, where the responsive louver rotate with different degree to allow for different daylighting scenarios according to different times of the day. For the exercise prototype Fig11,12, the students developed a full-scale model of a 60cmX60cm screen using MDF boards. The screen was divided into two levels, each level is controlled separately to guide the kinetic movement of the louver units that shape the overall screen pattern. An Arduino microcontroller was connected to the model, and two servo motors were connected to each of the motion rails to achieve the desired opening and closing movement of the louvers. The students simulated the sensing activity using their cell phones, where the intensity of light controlled the angle of motion of the motors and consequently aperture sizes.

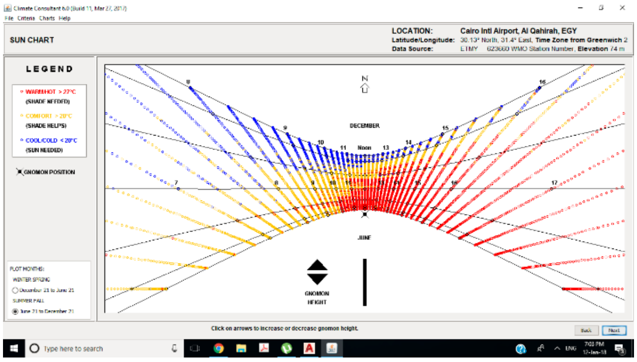

Fig.11 Group4 computational analysis for the solar exposure of the faced to design the louvers.

Fig.12 Group4 responsive louvers MDF proto type

6. Designing class participation Rubric

As observed the computational approach increased the desired class student engagement and participation but the main target here at this point was is how to assess participation? having a developed rubric can improve the instructor accountability as an assessor and provides the students with a clear sense of their instructor expectations for class discussions, in class participation and engagement. So, student should be aware that participation in the small-group environment is not an individual activity and it can be measured and evaluated. In class activity, if the student did not prepare effectively and contribute positively, other students miss out on one of those points of view, and their learning experience suffers. therefore, the evaluation of student's participation in class will be mainly based on how the student tried to improve the learning objectives of his peers by Supporting, engaging, and listening to each other making a sincere effort to respond to their comments. Playing an active role in discussions involves volunteering an opinion, asking questions, and listening carefully. The best participation are the ones that move beyond the simple commenting on each other work. Student will be rewarded for bringing up more challenging ideas and for trying to deal with them collaboratively with his peers. To do this effectively, student must have read all the assigned material carefully. Fig 13

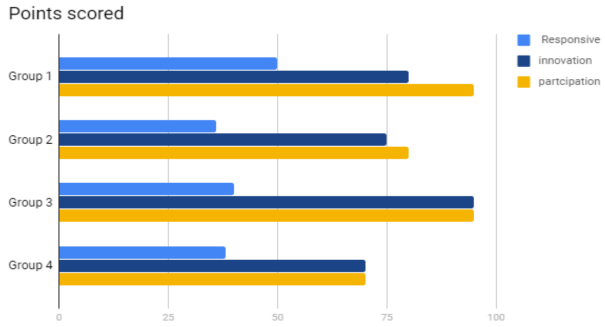

Fig.13 bar-chart showing the percentage of participation of students connected with the amount of responsiveness and innovation of designed element.

Conclusions

The benefits of addressing computational approach to design responsive systems to integrate the culture of construction and detailed design studio were twofold: (1) increase the student's engagements within the detailed process of designing, building and operating responsive systems, and (2) augmenting the basic principles of culture of construction. First, the computational tasks, and tacit knowledge required for designing responsive systems could be delivered to students of architecture in a way that fosters engagements and participations and allows for group thinking and learning. As students assume specific roles in the process or are conscious of the types of activities required to comprehensively fulfill the design and operation of a given responsive system, the tacit knowledge required is infiltrated indirectly into the general design process. Observations the student engagement and innovative elements produced showed that the more the students were participating and engaging opened the innovative responsive system to be developed and evolve more. The students realized that their participation and engagement especially when their role was defined, they were able to capture what was required of them as an integrated team in order to produce and deliver their designs.

This paper proposed the computational approach as a motivation for integrating culture of construction in detailed design studio to design a responsive system in architecture. Based on the findings of studios at The French University in Egypt, the proposed motivation engages students more in a detailed design process that utilizes the concepts of culture of construction in its phases and applications. The framework builds on introducing students to several necessary skill sets, activities and concepts in order to design, fabricate and operate responsive systems, such as facade design, fabrication and detailing, cost analysis, and sustainability analysis.

The paper demonstrates how these activities can be integrated in different phases of the course, ranging from conceptualization to implementation documents.

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