Promoting Parametric Design Thinking in Architectural Design: Insights from an Experiment in an Architecture Studio in India

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Abstract

It is now well known that the practices of design in the fields of architecture, interior and landscape architecture are undergoing dramatic change. With the emergence of digital technologies and Artificial Intelligence (AI), both the students and the practitioners are inclined to use these for the benefit of design. Given this situation, while architects' offices have to adapt, the curriculum of architectural studios also needs to incorporate the demands of the present professional world. In fact, it is hard to deny that the advanced design thinking approaches like parametricism help tackle various complexities of the design process. Most academics also believe that this is the need of the hour. In this context, this research reviews insights from the incorporation of problem-based learning (PBL) for parametric design thinking in an architectural studio in a school of architecture in India. It examines the students' learning experiences through a hands-on problem.

Problem-Based Learning (PBL) is a student-centered approach in which the students learn about a subject by working in groups to solve an open-ended problem that tackles the complexity of parametric design thinking. Various challenges have also been observed with the integration of parametric design thinking in traditional architectural studios which follow a linear design process. This problem is what drives the motivation and involvement of the students in the course.

This issue was explored through an experimental design studio in which an assignment was given to the students to ascertain how parametric modeling tools may be applied to think about construction detailing as well as form generation. Tutorials were conducted to expose the fundamentals of Rhino + Grasshopper workspace and establish the logic of algorithms, definitions, and how to build and manage parametric data structures. After working on a few exercises on the logic and the principles of this designing medium, participants applied the learned techniques in a design exercise of modeling various objects in the Rhino workspace. Findings conclude that the problem-based learning added depth to the designs developed using parametric design thinking.

Key Words: Problem Based Learning**,** Architecture, Design, Parametricism, Pedagogy.

Introduction

Since the arrival of digital technologies, designers' approaches to design have undergone dramatic changes in many fields such as architecture, interior design and landscape architecture. Undeniably, they have had a notable impact. At the beginning, some computer programs such as AutoCAD helped the task of drawing affecting draughtsmanship, but today, many other digital techniques have come to influence even the main task of design. Parametricism is one of the latest techniques that is gaining attention. In fact, these newer technologies have an increasing impact in the field of architecture and engineering and thus the students at universities must be aware of them. It is now accepted that it is better that they get educated on these technologies sooner rather than later.

This is because the integration of parametricism and its tools in the architecture programs at the universities can help prepare the students for the workforce and their future careers. However, unfortunately, efforts to do so is still at infancy and more needs to be done. although there are some exceptions.

In this context, an experimental studio was offered recently at the Bharati Vidyapeeth College of Architecture, Navi Mumbai, India. It was aimed at ascertaining the ways in which parametricism can be introduced into design studios. Its aim was to make both the faculty as well as the students become aware of the emerging technologies and particularly parametricism. Its objectives are as follows.

1. To introduce the complex techniques of parametricism to students of architecture.
2. To ascertain the ways in which parametricism can be employed in the design tasks.
3. To identify the potentials of employing parametricism to conceptualize forms.
4. To identify the challenges and obstacles in introducing parametricism to architecture students to use it in design.

Introducing Parametric Design Thinking in Architecture Studios

The curricula of architectural schools universally consist of various types of teaching such as design and supporting subjects which introduce contextually relevant subjects such as technology in design studio teaching. In the design professions, processes are rapidly evolving, and the way design is being approached is a subject of discussion. The challenges for the designers are ever increasing due to an increase in the desire for creative forms, inventive design tactics, environmental considerations, and technical as well as structural innovations.

Simultaneously, the advances in technology are also facilitating methods like digital fabrication and advanced construction techniques in architecture. This in turn is causing a paradigm shift in the role of an architect. In modern practices, it is crucial to comprehend the ramifications of designs, including their production and construction. Given this, it has become vital that architects also tackle non-conventional techniques and incorporate this line of thinking into architectural pedagogy. Parametric thinking is one such design paradigm that incorporates complexity, variety and open-endedness. These tools of design thinking can also drastically reduce the time one needs to invest in the exploration of alternatives in the designs that they create and provide much more visual clarity in different aspects of a design.

Challenges

Digital design technologies are commonly used as shallow form-finding tools in the area of architecture, and their use is regularly subjected to superficial scrutiny. Experimenting with non-conventional forms without the appropriate tools yields improper results. For example, a student exploring non-conventional forms for their designs through physical model making limits their possibilities and in turn increase the time needed to create more options as shown in the Figure 2. This example shows that there is room for experimentation if the same thought process is dealt with advanced parametric tools**.**

According to Woodbury (2010), the parametric design process is characterized by three principles as follows: designers develop rules and define their logical relationships while creating 3D visualization models; designers can modify their models at any time; and design alternatives can be developed in parallel at any stage of the process.

Problem-Based Learning Approach to Incorporate Parametric Design Thinking

Generally, in architecture studios, the students study the main design concepts and the paths to construct a building. They do so by breaking down a large project into smaller manageable design tasks. Problem-based learning is a practice-oriented pedagogical model, in which the students develop their expertise on the content area under study by working with cases and problems that represent real-life situations. Parametricism as a part of a design studio must deal with the complexities between elements by assigning values to organize the constraints and they bear a relationship to the real-world circumstances. The most relevant pedagogical positioning for a parametric plug-in in an architectural design studio is the incorporation of parametric modeling in the project which has been broken down into identifiable and understandable subsystems with simple interactions which are then modeled using patterns.

Algorithms developed in parametric design thinking as a solution to a design problem can often be open-ended. Without these parametric tools, it is difficult to achieve dynamic design solutions, open-ended and complex. Problem-based learning therefore is an apt methodology to achieve these desired outcomes.

The Investigation

An experimental course involving students was conducted using parametric modeling tools to ascertain the relevance and usefulness of parametricism in design. However, the tools were used for more than just form development; indeed, they were also used to think about engineering and construction specifics. The main goal of the course was to investigate the architectural studio from a fresh perspective to question the conventional notions of how to teach parametric design thinking.

In broader terms, teaching refers to a process of transmitting knowledge by a teacher. Learning refers to the process of acquiring knowledge by doing. Altet defines pedagogy as the articulation between teaching and learning processes, involving knowledge and aims (Altet,2006). In fact, Oxman has developed the definition by stating that;

> "any new framework for design pedagogy must be responsive to conditions in which digital concepts are integrated as a unique body of knowledge consisting of the relationship between digital architectural design and digital design skills"
>
> Oxman,2008:106

De Boissieu (2013) highlights that in order to define the most relevant pedagogical positioning for parametric modeling in architectural design, several skills need to be developed including theoretical knowhow and soft skills. Through learning, these two kinds of knowledge shall be acquired: one fundamental and stable, and the other evolving rapidly according to the development of the tools necessary for numerical parametric modeling.

From this understanding, a problem assignment can be designed to plug in this pedagogical position about the idea of parametric design thinking in an architectural studio. The problem is to simply design an installation and then fabricate it for the site specified. The challenge for this particular exercise was that the installation has to be based on the concept of 'disruption'. The methodology should progress with the experimentation of concepts, then methods and forms leading up to the materiality of the installation.

The main idea behind this methodology was that even a simple installation process based on a certain type of concept would be a test bed of form generation working hand in hand with material practices and would allow the participants to orient their thinking in a paradigm that includes complexity, variety, and open-endedness. As the brief of the studio instructed the participants to do form-finding exercises on the given concept. Participants individually tackled the concept of disruption with various visual narratives of the three-dimensional form that could represent the idea.

Research Methodology

The assignment for this studio was designed to see how parametric modeling tools may be applied to think about engineering and construction detailing as well as for form generation. The methodology applied in the course undertaken are as follows:

First, various suggestions of waves, ripples, and splashes brought the students to look at water as an inspiration and go about designing around it. Whilst working on a narrative for the concept evolution, the participants also had to think about design with its surrounding context. A part of the problem also elaborated on the site that was selected for the installation. The design problem for the particular studio was conceived to test the parametric modeling tools for facilitating form generation, fabrication as well as construction detailing as opposed to just form generation. Following process facilitated the desired results for the studio problem:

a. Encoding of a computational geometrical and functional representation of the design in a virtual form. In order to build a virtual prototype with an associative parametric definition, Grasshopper plugin for Rhino was used.
b. Fo the fabrication as a part of Parametricism in the design, students were also to investigate various digital fabrication methods, test them and then generate physical prototyping. This was critical in their understanding of correlation between the virtual and physical environments.
c. Students were also introduced to the identified site, which was within the campus. The identified location for the installation was the porch of the college and the design expected to be ceiling-hung. The main constraint for the participants here was to address in their design, the notion of public and design gathering spaces with the installation adding value in terms of micro-ambiances.

Participants and the Environment

Workshop environments are based on overarching knowledge structures that are necessary for a shift in participant involvement and learning. We adopted a participatory problem-based learning approach and designed a workshop methodology based on the main tenets and tools of parametric design thinking. We tested this methodology to initiate the incorporation of parametricism in an architectural studio to allow the students to explore more non-conventional designs.

None of the studio participants had any previous experience in Rhino + Grasshopper or parametric design techniques, as detailed in the Table 1. Studio methodology was structured to teach the participants not only the use of computational tools (grasshopper) as a generative tool but also how to integrate them to solve the design problems. The studio was initiated with the participants learning the fundamentals of working with the Rhino & Grasshopper interface and establishing the logic of definitions, building, and eventually managing parametric data structures. After equipping themselves with the necessary parametric tools, they moved on to the architectural installation design work which was in a problem-based learning format. The studio was concluded by executing the design solution on-site on a 1:1 scale, learning the digital fabrication techniques in the process. The outcome of the studio reflects the concept of disruption between the form and patterns and represents the participant's aesthetic sensibility.

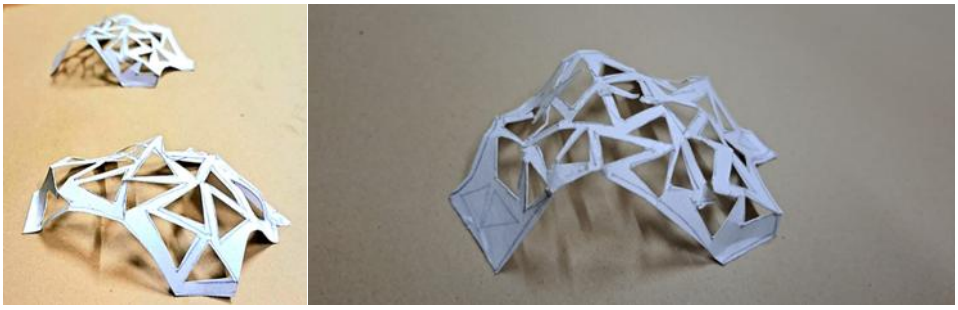


Fig. 1: Exploration of non-conventional forms through physical model making without using advanced tools. Source: Author

Table 1: Detailed teaching program and the activity plan of the course.
Source: Author

Session No.	Main Topic	Description	Independent Learning	Teaching Methodology
1	Introduction to parametric design	• Defining parametric design. • Basic understanding of parametric thinking. • Developing parametric thinking through design parameters and development process. • Building material and construction techniques.	Built example of parametrically designed buildings	Blended learning
2	Introduction to parametric modeling software & basic modeling skill	• Bridging parametric thinking and parametric modeling software logic: • Basic interface of digital modeling software of Rhino and Grasshopper • Developing modeling skill based on attractor point case	Basic command in Grasshopper	Flipped classroom
3	Rhino Modeling & Workspace understanding	• Surface manipulative commands • Attractor point algorithms • Parametric Skyscraper Algorithm	Basic command in Grasshopper	Flipped classroom
4	Grasshopper Basics & algorithms	• Interface |Material & Command Library • Basic Components • Developing one's own algorithms • Introduction to brief of the problem	Skill development through model exploration	Tutorials & Problem Based Learning
5	Digital Fabrication Techniques	• Introduction to various fabrication Techniques • Additive Fabrication • Subtractive Fabrication	Experimenting with various techniques	Direct Instruction
6	Integrated parametric design thinking - 1	• Developing creative design proposal supported with advanced modeling skill	Skill exploration on surface and BREP component	Blended learning
7	Integrated parametric design thinking - 2	• Preparing design proposal for fabrication process	Exploration of fabrication techniques	Participatory Learning
8	Final Assessment	• Assessment conducted on completed creative design proposal: • Poster explaining design concept, goal, etc. • Physical model Digital modeling file • Complete documentation on fabrication process	-	Assessment Jury
9	Building the installation	• The selection of appropriate digital fabrication techniques and the development of architectural detailing.	Experimenting with construction details	Participatory Learning

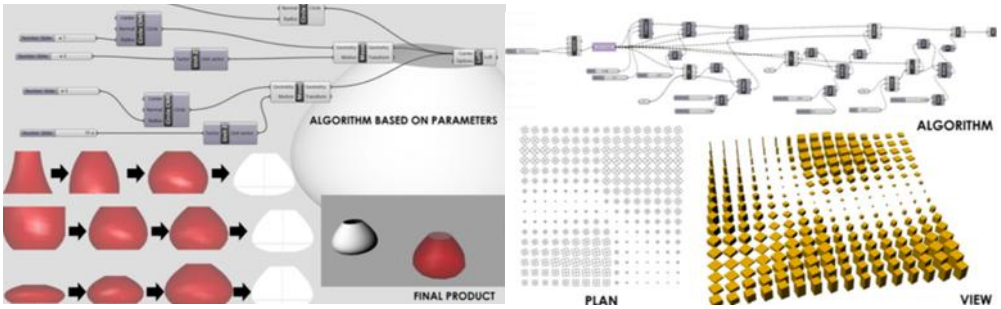


Fig. 2: Algorithms created to explore forms.
Source: Author

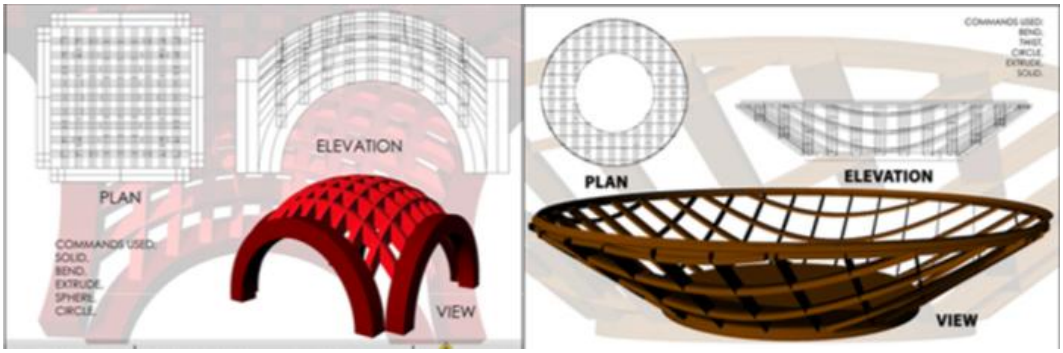


Fig. 3: Form exploration keeping the fundamentals of geometry and form development through a parametric model. The design here is not just limited to form but is also mindful of engineering and construction specifics.
Source: Author

Identifying an algorithmic approach to solve the problem:

As a part of the initial phase of the course, the students theorized an algorithm identifying the constraints of the problem and lectures were conducted to bring awareness about the principles of parametric design thinking and its applications in problem-solving through case studies and a literature review. Tutorials were conducted to introduce the fundamentals of Rhino + Grasshopper workspace and establish the logic of algorithms, definitions, and build and manage parametric data structures. After working on a few exercises on the logic and the principles of this designing medium, participants applied the learned techniques in a design exercise of modeling various objects in the Rhino Workspace (Figure 3).

Participants analyzed the algorithms created and developed parametric data structures and explored form finding by developing three-dimensional models. This exploratory feedback process breaks away from the traditional linear design methodology and arrives at a more bottom-up-oriented approach to generate possible forms and spatial patterns. For the development of conceptual models, students formed groups of four, through parametric design thinking, mapped the data gathered, and generated an algorithm through visual scripting with Grasshopper to form various iterations of the basic form (Figure 4).

The selection of an appropriate material for the construction of the prototype was critical and the groups explored various applications of the materials. Students engaged with the properties of these materials with the purpose of selecting a material to investigate how design can be influenced by the qualities of the material. This study is crucial for its application to the development of geometry & the construction of the parametric form that correlates with the selected material.

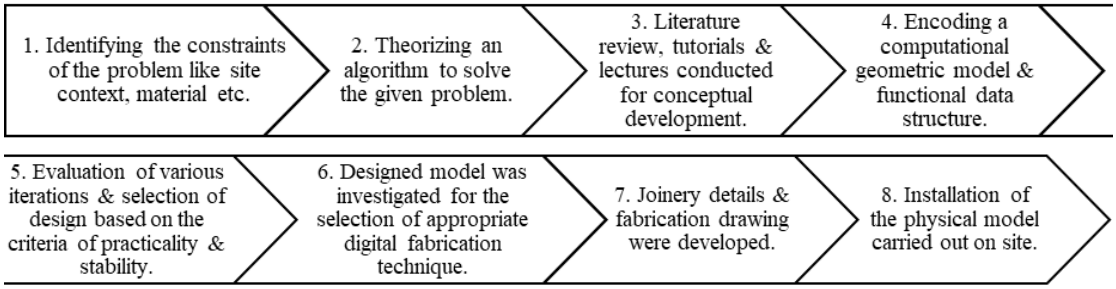


Fig. 4: Methodology used for the course.
Source: Author

Table 2: Detailed marking sheet of the group-wise assessment conducted.
Source: Author

Assessment Parameters	Conceptual Study Model	Parameter Defination	Algorithm Development	Application of Parametric Tools	Problem Solving Capabilities	Design Geometry	Finalization of Model	Fabrication & Detailing	Total
Max. Marks	10	10	10	10	20	10	10	20	100
Group1	7	7	8	6	10	5	5	10	58
Group2	8	7	6	7	13	7	7	13	68
Group3	8	6	6	7	11	6	7	11	62
Group4	5	5	5	6	10	6	6	10	53

After the model development, the course instructors organized an evaluation and a discussion to select one design (Table 2) for the installation to be detailed and worked upon in the installation stage. The main criteria for the selection during the evaluation are discussed in the Table 2: Design, Problem-Solving skills, etc. which focuses on the stability of the prototype as well as the practicality of the fabrication process.

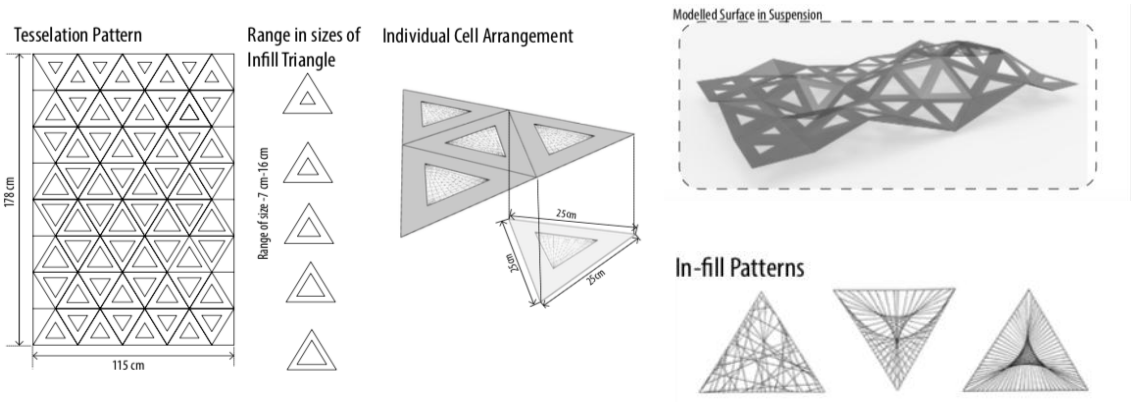


Fig. 5: Final concept selected for installation.
Source: Author

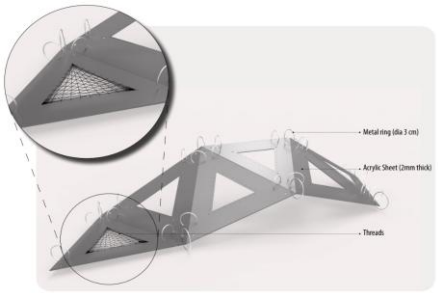


Fig. 6: Triangular components of acrylic sheets joined by metal rings to create the form
Source: Author

In this, triangular components of acrylic sheets are joined by metal rings to create a hinged joint to make the surface flowy to adapt to any freeform shape. Different colored threads are used to create a weaving pattern as a way of incorporating fabrication and construction detailing in parametric modeling.

Fabrication process selected for the construction of the installation

The latter half of the design studio was focused on the materialization of the selected design. The design was further developed by the selection of appropriate digital fabrication techniques and the development of architectural detailing like the creation of hinge joints etc.

The Figure 7 depicts the design of the on-site installation and a visualization of the design after the selection of the right material. Sectioning & triangulation techniques were used to draft digital fabrication drawings for the fabrication of the installation. Figure 5 depicts the conceptual model selected during the evaluation, which was to be fabricated as a conclusion of the course by applying the triangulation system. Moreover, the participants engaged with the design of the installation by designing appropriate joints and connections to allow for the fabric -like behavior. The selection of construction material, the dimensions and the thickness in which it is available, decides the structural stability that could be achieved through the design of the joinery details and support the anchor points to afford easy assembly, strength and rigidity. The design developed for the installation by the participants was worked upon initially in the development of the fabrication drawing and digital fabrication model to the available market size of the sheets of acrylic which fits on the bed of the laser cutter (70x100 cm). Anchor points for support and flexible joinery details were further developed.

Appropriate fabrication drawings were developed to facilitate laser cutting and reduce the waste of material. Triangular components of acrylic sheets are joined by metal rings creating a hinged joint to make the surface flowy to adapt to any freeform shape. Different colored threads were woven through the triangular elements of the model to add depth and complexity. Further, the anchor points were marked on the site and the installation of the model was carried out.

After the conclusion of the course, and after the installation of the model on the site, the students were finally able to physically interact with the model. The effect of crease behaviour, drape, and formability allowed the fabric-like behavior of the final surfaces due to the flexible joinery design for the installation allowed the final form to be determined with the help of gravity as shown in the Figure 8.

Most notably, the participants of the course appreciated the experience of constructing and installing a life-scale model, the efforts taken to combine the following two aspects of the course.

1. Engaging with the digital model.
2. The possibility of fabricating and assembling it as a whole.

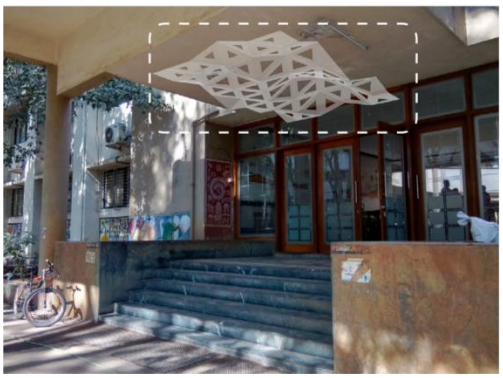


Fig. 7: Proposed Design intervention
Source: Author



Fig. 8: Final Design intervention after installation.
Source: Author



Fig. 9: Participants preparing the model for installing it on site.
Source: Author

The Participant Survey

A survey was designed to assess the learned capabilities of the participants based on the 'classification of learning' by Robert Gagne, broadly consisting of intellectual skills, cognitive strategies, verbal information, and attitudes (Gagne' et al. 1972). The survey consisted of 8 parameters, covering four out of the five learning domains proposed by Gagne (Gagne' et al. 1972), viz., Intellectual skills, cognitive strategies, verbal information and attitude, which were deemed to be relevant to the study. Participants' feedback was obtained using a 5- point agreement scale. A total of 40 students participated in the survey.

Graph 1 summarizes the feedback offered by the participants about their experience throughout the course and the learned skills. The outcome demonstrates that the participants gave the majority of the parameter's positive ratings. This shows that the problem-solving approach to teaching has been effective in bridging the gap in conventional instructions and achieving the desired learning objectives. The statement inquiring the participants if they preferred parametric design thinking to traditional design was an outlier in the results because it was predicted that the students would generally use conventional approaches given their familiarity with them.

The score of general problem-solving abilities and usability, which was approximately 73% & 80% agreed with the propositions, is another finding worth noticing. It's also interesting to note how prior experience with CAD software like AutoCAD affects the acceptability of the use of parametric design.

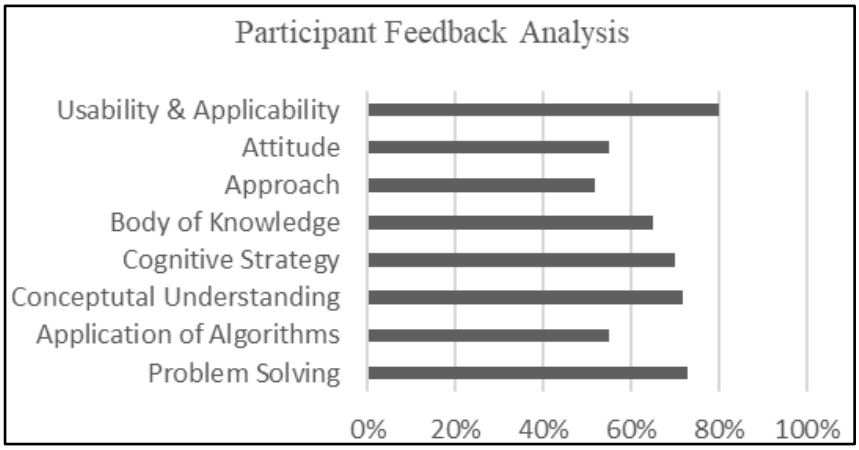


Fig 10: Participant feedback analysis.
Source: Author

Discussion

This research aims to convey and discuss the experience that the authors' teaching method has offered the students in an experimental design studio, particularly regarding the students' engagement in the learning process, especially when dealing with parametricism to encourage non-conventional designs in an architectural studio. By delivering answers to the technical problems individually but still in coordination, the integration of technology in the design studio offers a chance to support the design process and reduce some of the workload related to the design project. According to the participants, thinking parametrically had been beneficial when looking for appropriate design solutions for the identified problem.

According to the survey, they had discovered that this thinking approach is consistent with the iterative design process in architecture, which is a very self-evolving and cyclic approach to arrive at a solution through numerous revisions. At the same time, working with participants throughout the studio course, and utilizing the problem-based learning approach allowed the authors to imbibe in the participants the skill of analytical thinking required to handle challenges in real life as well, with an apt use of parametric tools and interactions with construction materials and digital fabrication techniques. Unarguably, these skills will support the practice of architecture eventually as professionals.

Conclusion

This research examined the ways in which parametricism can be introduced into design studios. Its aim was to make both the faculty as well as the students become aware of the emerging technologies and particularly parametricism. An experimental studio was offered to introduce the complex techniques of this digital medium to students of architecture, to ascertain the ways in which parametricism can be employed in the design tasks and to identify the potentials of employing it to conceptualize forms. It also expected to identify the challenges and obstacles in introducing it to architecture students to use it in design.

After concluding the studio course, it was observed that the approach adopted here: 'problem-based learning' added depth to the design developed using parametric design thinking. Creating a parametric data structure involved the programming of the digital algorithmic model that allowed the participants to interact with the various iterations of a singular model.

It was also discovered by conducting this experimental studio course, that parametric design tools enabled the students to be efficient by reducing the time required to explore the digital model which allows variety in design. As it is known, the variety in design options helps create and provides freedom to explore unconventional forms. Depending on how the project is developed, parametric tools not only offer freedom and variety in the form-finding stage, but also in how the project is fabricated. It also ensures that the participants did not just use their learning to explore forms but acquire an integrated approach including the fabrication of the model.

It is thus concluded that it is possible to introduce the complex techniques of this digital medium to students of architecture, and that there are numerous ways in which parametricism can be employed in the design tasks. The research identifies the potentials of employing parametricism to conceptualize innovative architectural forms. It also identifies the challenges and obstacles in introducing it to architecture students and to use it in design. Further experiments and cautiously conceptualized academic courses need to be offered so that the schools of architecture produce potential professionals who will eventually lead the field of architecture and introduce innovative new ways of conceptualizing architecture. Without doubt, the students are willing to take up the challenge if only the instructors are prepared to offer the leadership and the guidance needed, as demonstrated in this paper.

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Statement of Conflict of Interest: The authors declare that there is no conflict of interest in carrying out this research. It was in the interest of academic education that this research was conducted and the findings benefit the university in conceptualizing future programs.

Ethical Practice: This research followed accepted ethical practices. It involved human participants, hands-on design work, interviews and collection of personal opinions. Nevertheless, no person has been identified. The participants were informed of the purpose of the research. They were informed that participation or non-participation did not affect the grades. They participated willingly and had the option either to join or not join the group of respondents. They also had the option to stop participating in the research, in which case an al alternative studio would have been offered.

Availability of Data: This study does report some original primary data. These data is available for scrutiny if officially requested.

References

Abdullah, F. (2006) An Evaluation of Problem-Based Learning in Architectural Education,University of Strathclyde,Glasgow, U.K: Unpublished PhD thesis.

Altet, M. (2006) Les pédagogies de l'apprentissage, 2e édition, Paris: Presses Universitaires de France.

De Boissieu, A. (2013) Modélisation paramétrique en conception architecturale, ENSA Paris la Villette: Unpublished PhD Thesis.

Delgado, F. (2005) Designing a Problem-Based Learning Course for Mathematics in Architecture, in *Nexus Network Journal,* 7(1), 42-47.

De Graaff, E. & Cowdroy R. (1997) Theory and Practice of Educational Innovation; Introduction of Problem-Based Learning in Architecture, in *International Journal of Engineering Education,* 13(3),166-174.

Essa, H. (2017) Developing a proposal for a Non- Traditional Pedagogical approach to Architectural Design Education, Yakın Doğu Bulvarı Lefkoşa: Near East University library.

Gagné, R. & Briggs, L.J. (1974) Principles of Instructional Design, New York: Holton, Rinehart & Winston.

Goldman, G. & Zdepski, S. (1987) Form, Color and Movement, Integrating Computers into the Architectural Curriculum, in *ACADIA Conference Proceedings,* Raleigh, North Carolina, USA,39-50.

Oxman R. (2008) Digital architecture as a challenge for design pedagogy theory, knowledge, models and medium, in *Design Studies,* 29(2), 99-10.

Woodbury, R. (2010) Elements of parametric design, New York: Routledge.

Vrouwe, I., Dissaux, T., Jancart, S. & Stalls, A. (2020) Concept Learning Through Parametric Design; A Learning Situation Design for Parametric Design in Architectural Studio Education, in *Education and research in Computer Aided Architectural Design in Europe eCAADe20,* Proceedings of the 38th eCAADe Conference, 2,135-144.