Integrating Parametricism in Creating Architecture: Insights from the Students Perceptions at the University of Bahrain

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Since the emergence of advanced technologies, architects' approaches to architecture have undergone a dramatic change. As has happened in most other disciplines, in architecture, digital technologies have had a notable impact. While it began with the technologies introduced to just draw, such as AutoCAD, today, many other digital techniques are being introduced particularly at the design studios of the schools of architecture. Parametricism is perhaps one of its latest techniques. In this context, this paper presents a study investigating the interest and willingness of the students at the University of Bahrain to engage such an approach through a new educational pedagogy. It presents the efforts made in an experimental studio on assessing the integration of "Parametricism" into the Architecture Program.

The research employed a mixed methodology of qualitative and quantitative techniques. They included a questionnaire distributed online among the students from the 4th and 5th years in the Architecture program. A sample group of the respondents to the questionnaire was subsequently interviewed individually: face to face. These enabled a comprehensive understanding of the students' willingness, to engage with parametricism, in approaching architecture: its techniques and tools.

It was revealed that around 75% of students are taking an interest into learning what parametricism. They explore a variety of platforms, encouraged by the courses offered at the University of Bahrain. The study concludes that this could be strengthened to enable such an education pedagogically. Undeniably, it will increase awareness and facilitate developing their skills before they come to the workforce.

Keywords: Parametricism, Computed programs, Pedagogy, University, Students, University of Bahrain.

Introduction

With the rise of advanced technologies, architects can now use computed programs invented in the modern times – by using machines (algorithms that generate design) – to articulate designs, with parametric techniques. Interestingly, this architectural technique has been claimed to be a sustainable approach into designing and is considered a "greener" way to design masterpieces with less waste of materials, energy and possibly less cost too. In fact, the newer technologies have an increasing impact in the work field of architecture and engineering

and thus the students at universities must be aware of them. Indeed, it is better that they get educated on these state-of-the-art technologies sooner rather than later.

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

The efforts in adoption of computational software and the integration of up-to-date technologies have always been considered and implemented at the University of Bahrain. The computer aided design (CAD) software and programs have been taught for quite some time and the students have been benefitted from the skills learnt in their design phases in 2D and 3D modelling using tools such as Autocad, Revit and Sketchup along with rendering extensions or programs such as Lumion, Enscape, and Twinmotion- starting from the second year. They are taught within the courses ARCG215 "Computer Aided Architectural Design 1" and ARCG225 "Computer Aided Architectural Design 2", as practical courses. At the same time, the students are exposed to architectural styles and techniques within the courses ARCG314 "Theory of Architecture 1", ARCG326 "Theory of Architecture 2", and ARCG414 "Contemporary Architecture" as theoretical courses. Nevertheless, not much research has been done regarding the emergence of parametricism and parametric techniques and tools that can be considered as more complex, that use advanced computational analysis and mathematical algorithms to design their projects, using variables and automation. The question thus arises as follows:

Would the students at the University of Bahrain be interested to learn and experiment with parametricism? If so, would they like for it to be offered as an integrated course in the curriculum of the Architectural Program?

This research investigates whether parametricism should be integrated in the curriculum of the Architecture Program at the University of Bahrain, and whether students are interested to learn and experiment with Parametricism and its tools. Its aim is to unearth the deep-seated students interests and experiences and to diculge them for the benefit for the program managers. Needless to say, that these can offer insights to the others who manage such programs particularly in Asia, where similar sentiments persist. Its objectives are as follows.

- To identify the need for integration of parametric design in the architecture program.
- To indicate the methods of its implementation in the curriculum.
- To recognize the patterns and influence of parametric design on students.

Theoretical background

The definitions of parametric design and parametricism are established as the use of technologies and advanced computational analysis and mathematical algorithms that are taken advantage of by the architects and designers with the use of parametric software programs to create architectural design. (Schumacher, 2017). It was Patrik Schumacher in the 1990s who articulated a theoretical relationship that discusses the emergence of parametricism. It is a term coined by Schumacher in response to a movement emerging at that time, influenced by deconstructivism. Theories suggest that parametricism has been derived from tools for and the architects who employed deconstructivism as a napproach to architecture.

Schumacher said that "they used their own design trends as a tool for a new one". The article titled "Architecture 101: What is parametricism?" mentions such characteristics as being: flexibility, and easiness of control on software rather than manual drafting. They allow the architects to explore further with less worry as changes can be made seamlessly without starting from scratch every time. This proposes a solid basis for experimentation that enables the students to try new techniques and tools freely.

In the context of architectural educational pedagogy, this also encompasses an experiential learning theory (Kolb, 1984), which focuses on a hands-on, learner-centered approach that encourages the students taking the course to construct the established knowledge through problem-solving and active engagement.

Employing these theoretical notions, the University of Bahrain integrates parametricism into the architectural design education. Kolb's experiential learning theory is aligned by encouraging an explorative learning experience and computational thinking methods, where students learn and establish their knowledge through the manipulation of parameters and techniques and tools such as Grasshopper, Rhino, Dynamo-for Revit, Generative Components by Bentley systems, Houdini, and Catia. Indeed, this helps the students to enhance analytical and computational skills while adopting creativity and adaptability in design. This also prepares the students and their advancement in skills, for the evolving demands in practice of working in the field of architecture and approach the design of spaces in architecture.

Review of Literature

Given the fact that parametricism is a relatively recent phenomenon, research that examines its multi-faceted manifestations in architectural practices or education is somewhat rare. Neverthelessl so do exist and among them, Schumacher (2017) stands out.

Schumacher (2017) argues that parametricism shall raise a comeback by a second movement, after the disruptive financial crisis, in 2008, took place in the initial stages of the rise and rapid development of parametricism's first movement, not allowing a proper bloom in style. He discusses that it is the sole style that can engage the recent advances in structural and environmental engineering capacities that have been developed through computational analytics and optimization techniques pleasingly. It is also considered the only architectural style that can entirely benefit from the use of the computational revolution that drives the contemporary civilization. Undeniably, the other architectural styles are incapable of employing adaptive structural and tectonic differentiations that arise from the new engineering intelligence in their entirety.

This argument leads to the conviction that parametricism is superior to the rest, by implying that the understanding of geometric transcoding of parameter variations into differentiated geometries inevitably lead contemporary architects into technical functionality once taken the performance conditions seriously. Yet, this perspective is not shared and agreed on around the globe. In fact, Schumacher (2017) suggests that many suspect the technical or social functionality of parametricism, not even presuming an aim at functionality. The style – as he mentions-is unfortunately misunderstood as a catch on "artistic expression" or "technophile exuberance" but can be regarded since a number of projects remain in suspect of functionality. Since the parametric design movement's discourse has not yet emphasized discussions and implications of the advantages of parametric designs, especially in the social functionality domain.

Moreover, parametricism is deemed to have a versatile formal and spatio-organizational repertory. Therefore, it is considered an adequate style that fits to address recent societal tasks that are posed by current social dynamics in architecture. Hence, major urban building tasks and infrastructure projects such as airports and train stations are now approached with parametricism as a tool in hand.

This then leads to addressing parametricism in Bahrain. The integration of parametric design into architectural education represents a critical change in how the manner and style of teaching may differ and how environmental challenges and complex spatial challenges can be addressed and engaged with by future architects that will graduate from the University of Bahrain. The creation of adaptable and performance-driven solutions in design strategies can be articulated with parametric design, in which students may learn how to manipulate architectural components through algorithms and rule-based systems.

In this connection, Jabi (2013) emphasizes that parametric design is not merely a toolset but a mode of thinking that fosters a deeper understanding of form, systems, and performance. He advocates for the incorporation of parametric methodologies into curricula to enable the students to develop conceptual and technical fluency. Integrating this knowledge and forward-thinking approaches at the University of Bahrain would align local education with international best practices and prepare the students for a competitive global market.

Hudson (2010) categorizes the teaching strategies for parametric design into 3 main categories: (1) performance-based design, (2) form-finding, and (3) rule-based systems. In fact,

almost all the computational reasoning and iterative design processes can be emphasized by these pedagogies. The exposure of the students to these pedagogical methods would help benefit them, since facing the contextual challenges of the Gulf region would require the architectural designers and engineers to think systematically and creatively, especially in applications of climate-responsive design, sustainability in construction, and rapid urban development. The parametric tools that would be taught at the University of Bahrain can thus significantly assist the development of relevant design strategies and elements such as optimized shading systems, passive cooling strategies, and facades that are responsive to the context, to name a few. Needless to say, these would have a positive impact on the designs in response to the natural context of Bahrain.

In this connection, Agirbas and Sultan (2018) propose using metaphors to teach parametric design, suggesting that metaphorical thinking aids in bridging the gap between abstract computational concepts and intuitive understanding. This strategy may prove effective for the students at the University of Bahrain, since many students may not have prior experience with algorithmic thinking or visual scripting. By grounding these concepts in culturally and contextually familiar metaphors, educators can enhance comprehension and engagement. Reis and Lopes (2023) further argue that visual programming environments, such as Grasshopper for Rhino, are ideal for teaching parametric design in the early studio courses. They show that students can develop computational literacy without compromising their creative freedom.

Given that there are efforts in increasingly emphasizing digital literacy and innovation in strategic visions, incorporating parametric tools into the curriculum would not only modernize architectural education but also stimulate student interest in interdisciplinary collaboration. This is particularly so in areas such as urban planning, environmental design, and digital fabrication. In this regard, Al Khalifa (2019) conducted a study utilizing spatial installation projects to assess students' comprehension of complex philosophical ideas related to architecture and urbanism. The findings suggest that hands-on, experiential learning can effectively convey abstract concepts inherent in parametric design.

Although parametric design and incorporation of it at the University of Bahrain, architecture program curriculum can be beneficial significantly by equipping the graduates with proficient competencies in parallel to promote knowledge-based industries thus diversifying Bahrain's economy; by contributing to innovative architectural practices, smart city development and responsive building technologies, Hudson (2010) does warn against the complete reliance on tools and technologies at the expense of conceptual clarity and understanding. Therefore, it is necessary to ensure the implementation of parametricism as a design course in Bahrain does not disrupt the students individual critical thinking and problem-solving skills. This can be achieved by carefully supporting the practical course to be implemented with strong and fundamental theoretical foundations.

These theoretical perspectives demonstrate that the understanding of pedagogical strategies and parametric design implementations can be embraced as an advancement in enhancing the quality and global relevance in the architectural design education of Bahrain. This would also foster innovation, prepare the students by equipping them with the necessary skills to overcome challenges, and a flowing digital future, empowering the students to become active contributors to contextually responsive and sustainable designs.

Research Methodology

This research employs both qualitative and quantitative methodologies to explore the practice and understanding of parametric design in architectural design studios, by the students at the university of Bahrain. It asks whether they show an interest in studying parametricism pedagogically.

The research employs a two-stage data collection process. First, it administers a questionnaire to a cohort of architecture students chosen randomly. A cross-sectional questionnaire comprised of 5-sections gathers general insights and perspectives from the students majoring in architecture at the University of Bahrain. It is followed by in-depth interviews with selected respondents.

The Questionnaire

The questionnaire has 5 sections: the sections include close-ended questions, open-ended questions, multiple choice questions, and the Likert scale (5-point) to collect both qualitative and quantitative data. It was disseminated as online google forms available at the link: https://forms.gle/1FhtNLiDBahjeaGQ9.

The questionnaire responses are then reviewed and analyzed to identify recurring themes, objective opinions, and relevant experience levels. Three respondents are selected purposefully from among them for follow-up interviews. The selection criteria include: their depth in responding to the questions to the questionnaire, their familiarity and experience with parametric design, their interest upon using and studying parametricism, and their availability to take part in the interview. The interviews are semi-structured and has 2 sections, allowing a flexible conversation, while ensuring that the key research areas are addressed.

In the section 1, the participants are asked to elaborate on their questionnaire responses to provide further clarifications and context. In the section 2, research findings and design approaches of parametricism are discussed with the participants, forming a basis for a more focused and interactive discussion, that allows the participants to reflect on, critique, and expand on the presented ideas and findings. The interviews are recorded for analysis to find the key themes, agreements, understanding and contrasting views.

This mixed-method approach allowed for a comprehensive understanding of the research topic, combining broader patterns from the questionnaire with nuanced insights from the interviews. The methodology was chosen to facilitate a dialogic and reflective investigation, enabling the research to benefit from both empirical input and interpretive depth.

Findings: Analysis and Discussion

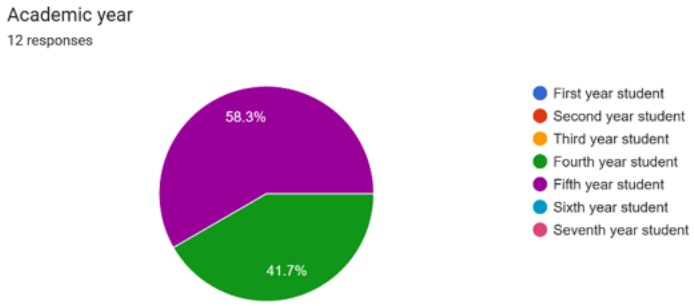


Fig. 01: Background information
Source: The questionnaire

Section 1: General Background

This section reveals the general background information of the respondents. Demographic information such as the age and contact information remains confidential. The respondents consented to share the academic year (4th and 5th academic year). 42 responses to the questionnaire were recorded. Majority of the responses are of the fifth-year architecture students with a 58.3% rate, whereas 41.7% of the respondents are fourth year students.

Section 2: Awareness & Understanding

This section consists of close-ended questions and a 5-point Likert scale. Upon being asked if they had heard of parametric design and if they had a general awareness, a large group appeared to have not even heard of it, despite being in the university. 75% of the respondents had heard of it, while 25% of the respondents have never had, demonstrating a higher rate of awareness or interest amongst the architecture students. The 75% of the respondents are then further asked where they first learnt about parametric design. The majority, with a rate of 33.3% had discovered it online, on platforms such as youtube, blogs, pinterest, etc., whereas 25% of

them had first learnt of parametricism in a university course. Interestingly, this general information, had been divulged in the ARCG414 course titled “Contemporary Architecture”, which deals with how the contemporary buildings have come into being: their characteristics and approaches behind their forms. Furthermore, 8.4% of the respondents had read about it in books, and 8.3% have had conversations with other students during which they had first learnt about parametricism by discussing it.

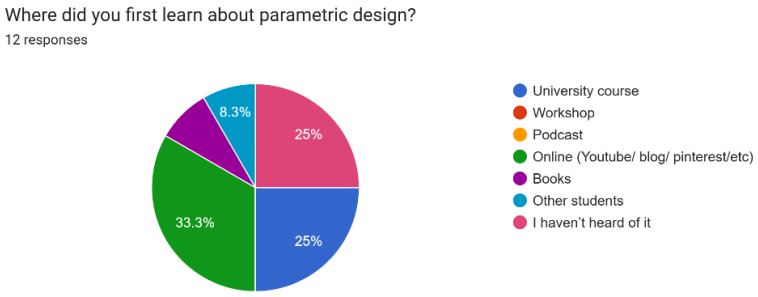


Fig. 02: the Sources of Learning Generating Interest
Source: The questionnaire

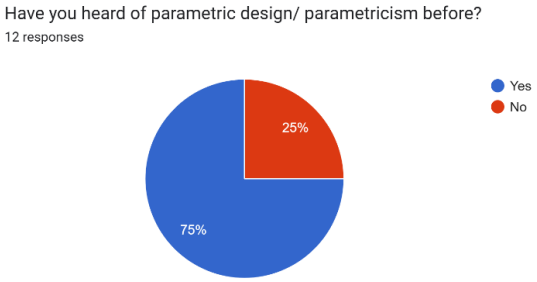


Fig. 03: Awareness of Prametricism as a Technologt
Source: The questionnaire

The students who first learnt about parametricism in a university course, were asked about the style of teaching used by their instructors during the course hours through a multiple-choice questions. The 6 choices offered were: Lecturer, Demonstrator, Hybrid, Facilitator, Delegator, and an open-ended question space (other). 72.7% of the respondents said that the teaching style was hybrid, a mix of multiple teaching styles where students and instructors are all involved within the learning process hand in hand. The 2 options, lecturer and delegator both had similar rates of response of 18.2%. However, 18.2% of the respondents also did not answer. The choices of demonstrator and facilitator were both indicated by 9.1% rate.

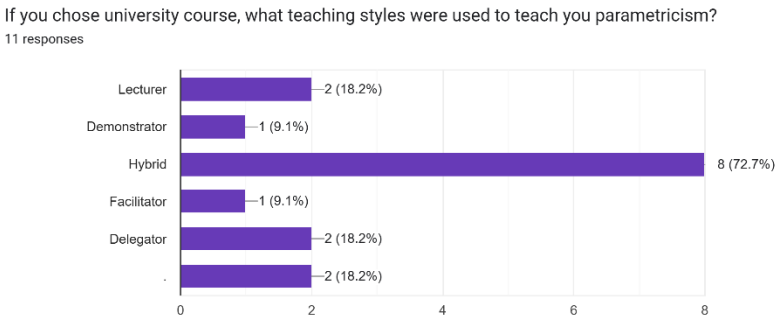


Fig 1: teaching Style

Using a Likert Scale, the respondents were then asked to rate their level of undestanding of parametric design that they have learnt about. A vast majority of 66.7% chose neutral – an understanding of parametric design that is not advanced neither not at all aware. A 16.7% rated their understanding as somewhat not understanding of parametric design . 8.3% (which is one person only) chose advanced, and another 8.7% (one person) chose that they did not understand at all. None have chosen somewhat understanding, This illustrates that students do not totally understand what was taught about parametric design in their university course or online, except for one student.

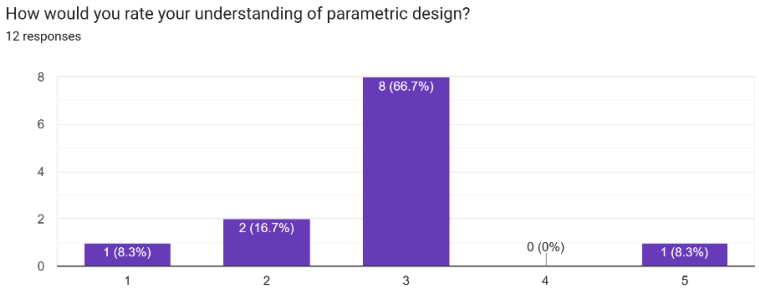


Fig. 04: Understanding Parametric Design

Section 3: Parametric Design Tools

This section consisted of close-ended questions, open-ended questions, multiple choice questions and 5-point Likert scale. In this section respondents are first asked whether they have ever used any parametric design tools like rhino, grasshopper, AutoCAD c3d or others. 58.3% responded with a yes, while 41.7% responded with no. This shows there is an equal measure of interest as well as a lack of interest.

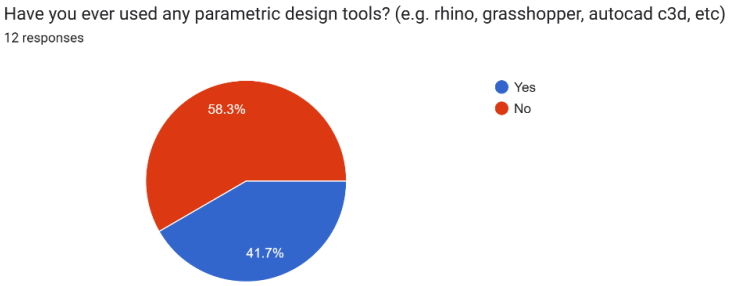


Fig. 05: Interest and Lack of Interest

The next question inquired about the tools employed for trying out the digital methods of designing. It was reported that most used tool is Auto-Cad with 80% using it, 40% use it along with Revit, and 20% used it along with Revit and Sketchup. Those are CAD tools, and they have been taught at the university of Bahrain now for quite some time. The remaining 20% use Rhino and Grasshopper, which are parametric tools, that were either self-taught or taken in an external course or workshop.

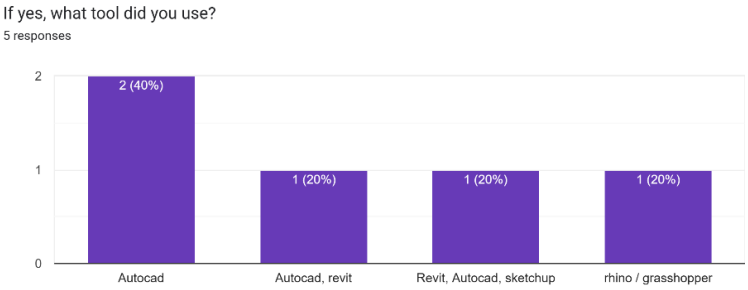
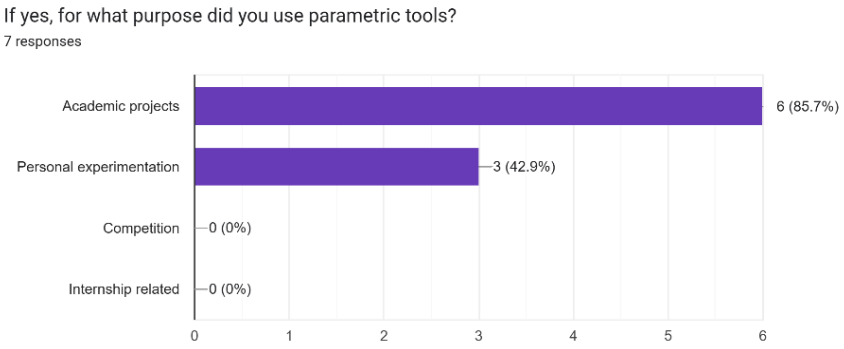


Fig. 06: The Tools Used

Interestingly, those who used these tools had not used them all for academic purposes such as design in architecture. Only 85.7% had used it for academic projects, while 42.9% had used it also for personal experimentation. Nevertheless, none had used it for competition or internship related purposes.



Since some of the respondents had tried using parametric design tools, the level of their comfort is asked with a Likert scale. The majority of respondents (37.5%) feel extremely uncomfortable using the tools, an equal rate of 25% do feel uncomfortable and comfortable, and only 12.5% feel comfortable using the tools.

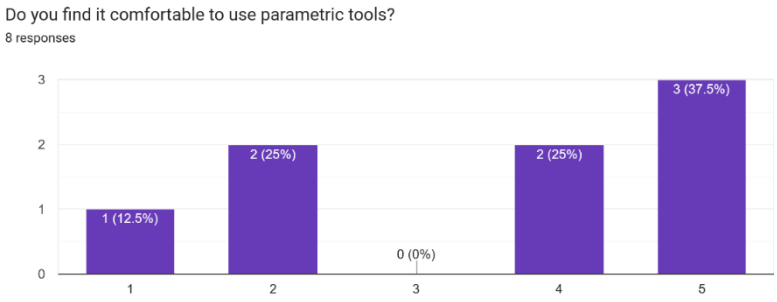


Fig. 08: Level of Comfort in Using

The reasons for feeling uncomfortable using the tools roots arose from how complex the softwares are (58.3%), the lack of guidance found (50%), the lack of resources & time constraints (33.3% each), and the occurance of many erorrs, and not feeling like a personal design (8.3%).

Yet another issue that would prevent th estudents employng parametric design is primarily a lack of interest emanating from the popular perception that the tools dictate forms. There is also apercetion that hand drawn sketches help design better. Inthis context, upon asking whether or not the respondents would be interested to use parametric design tools, 66.7% responded yes, 25% responded maybe, and only 8.3% responded no.

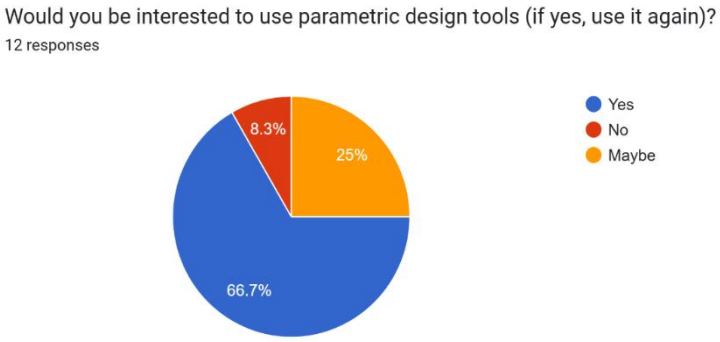


Fig.09: Interest in Parametric Design Tools

Moreover, even if one is interested in and have the tools as well as the capabilities, there may be many challenges in using these tools. Therefore, a further query was directed at revealing the challenges faced by those who are interested in using the tools. A number of aspects were revealed, which involved 'does not feel like one's own design,' 'having a lot of errors,' 'the lack of resources,' 'time consuming,' 'a lack of guidance by skilled instructors' as well as complexity of the software.' The scale of their presennce is illustrated in the Fig. 10 below.

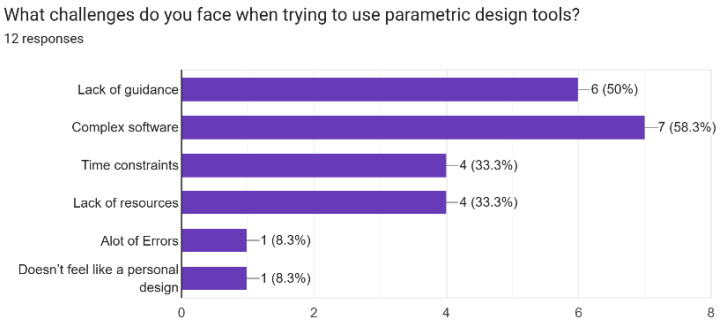


Fig.10: Challenges in using Parametric Design Tools

Section 4: Perception & Interest

This section consists of close-ended questions, open-ended questions, as well as multiple choice questions. Respondents either responded with not knowing what parametric design is, or that it is a software they can design with, or the use of calculations/ equations/geometries/ algorithms. One respondent showed interest into Schumacher's ideas on parametricism.

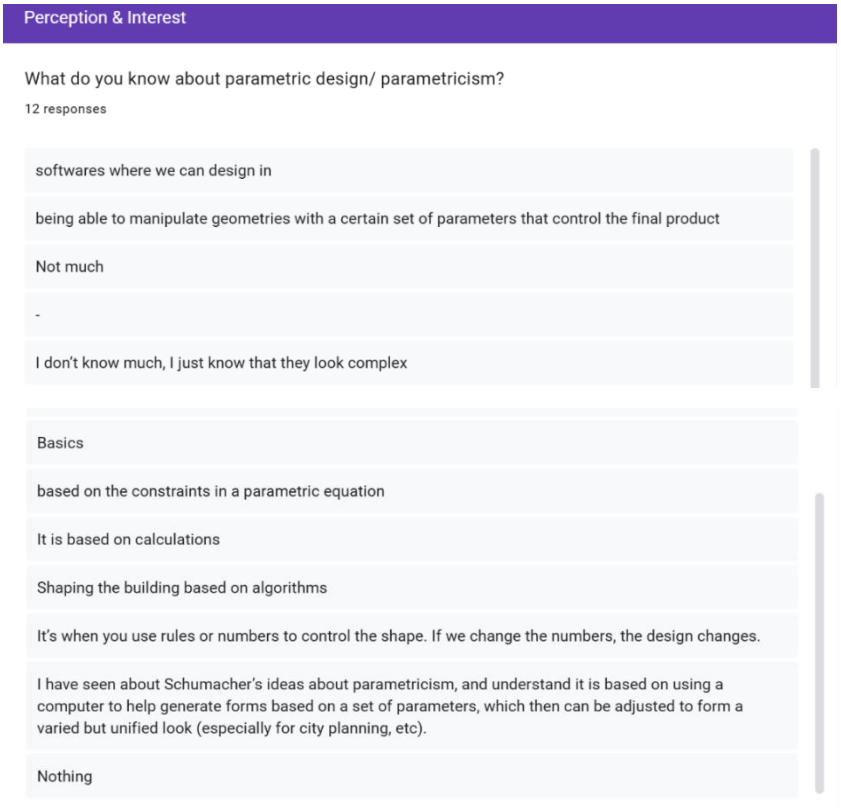


Fig. 11: Perception and Interest in Detail

These were investigated further. It was then revealed that the aspect that interests 91.7% of respondents in parametricism is form generation. This was followed by structural optimization, aesthetics, data-driven design, environmental responsiveness and iterative design problem solving, 50%, 41.7%, 33.3%, 8.3% and 8.3% respectively.

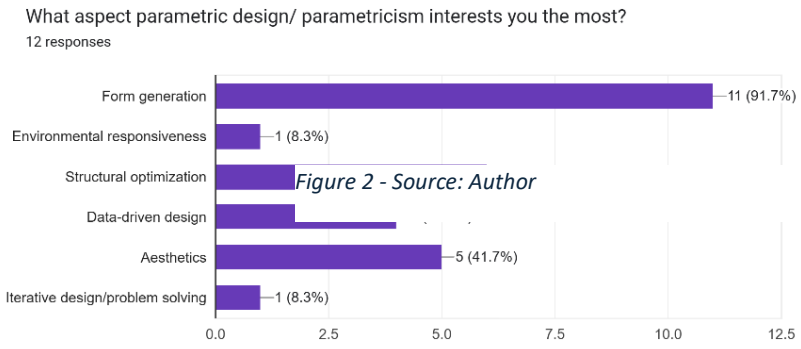


Figure 2 - Source: Author

Fig. 12: Aspects that Generate Interest in Parametricism

Despite these interestingly, only 66.7% think that parametric design is important in the future of architecture, while 25% are not sure (maybe), and 8.3% think that it is not important at all. This very low propostion of those who think that parametricism is of importance and the fact that some even think that it is not important at all is a troubling finding given the fact that the world is moving forward with the development of Artificial Inteligence and other digitally driven tools.

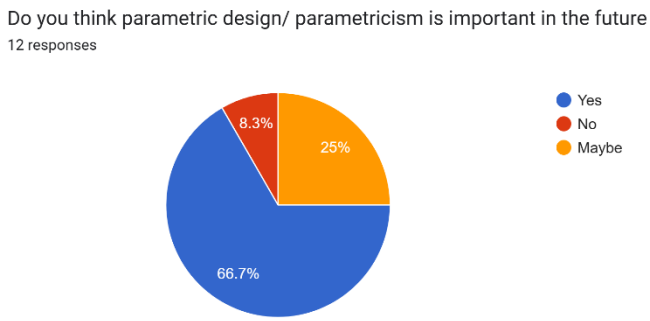


Fig. 13: Perception of the Importance of Parametricism in Future Architecture

Nevertheless, almost all the respondents believe that parametric design can improve the design process, their elaboration is as shown in the response boxes of the open-ended question space. Their detailed respponses are shown in the response boxes of the open-ended question space.

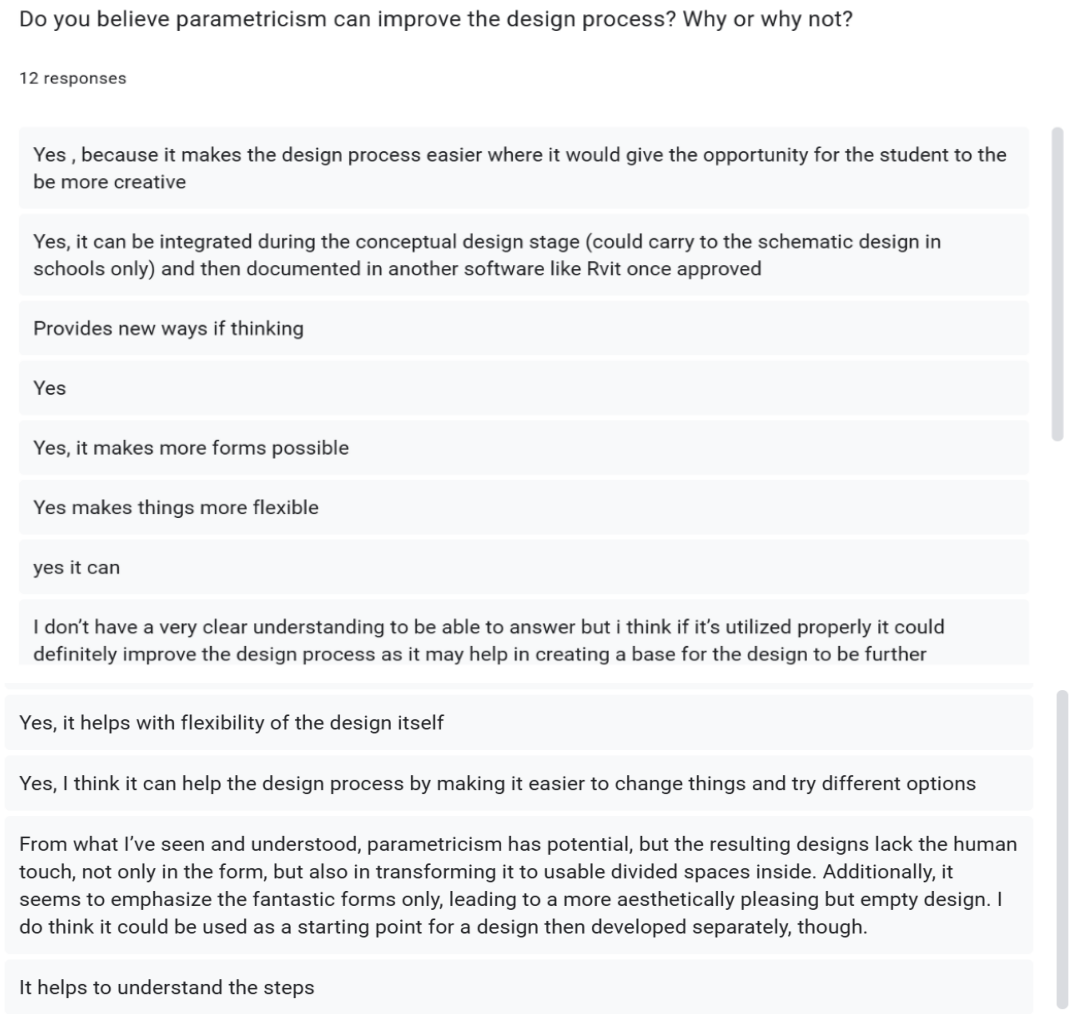


Fig. 14: The Contribution of Parametricism in Improving the Design Process

Section 5: Curriculum & Opportunities for Learning

This section consists of close-ended questions, open-ended questions and multiple-choice questions. It reveals that given the fact that some demonstrate interest, if they could or should be offered opportunities for learning. When asked, 83.3% of respondents said that they would take interest into learning more, while 8.3% said that they might be interested, and 8.3% said that they are not interested at all.

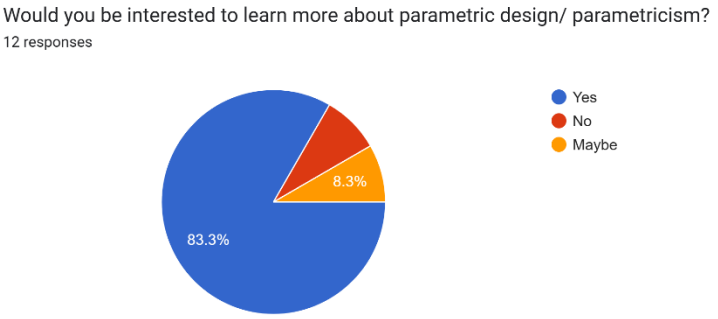


Fig. 15: Interest to Learn More about Parametricism

The next question was if the students would like the introduction to parametricism be offered as a separate course as a part of the curriculum or as an elective. The responses were that 75% would like it to be offered as a course in the architecture program curriculum, whereas 25% would not be interested for it to be offered as a course at the University of Bahrain.

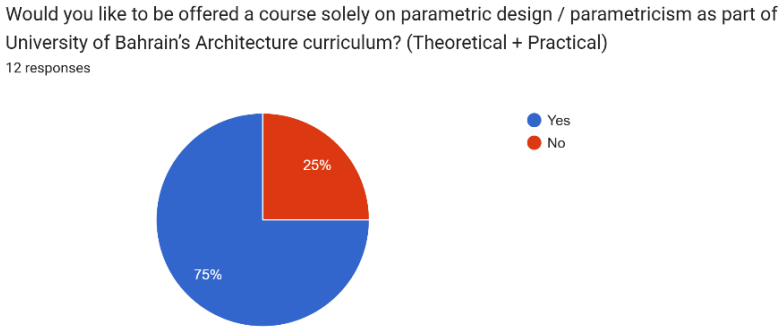


Fig. 16: To be Offred as Part of the Curriculum or Not

This aspect was further investigated in such a way that insights could be gained in terms of what format the university should introduce a course of parametricism. The research revealed the format in which the course would be delivered as follows:

- Elective course (75%),
- Workshops (58.3%),
- Semester long full course (25%),
- Online certification (25%),
- Best taught through trial-and-error process (8.3%).

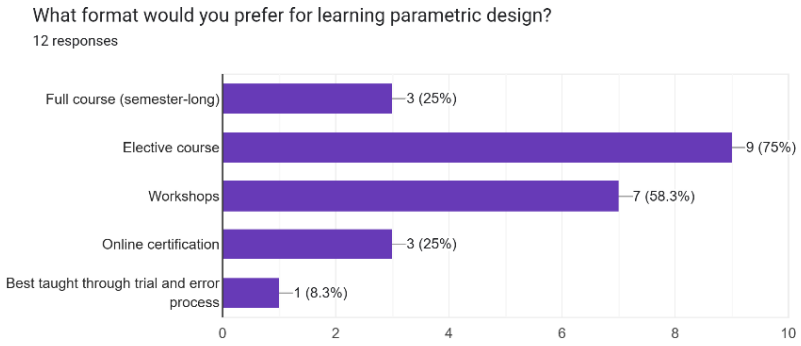


Fig. 17: The Format of Any Courses to be Offered

Finally, in terms of other views and perceptions that the respondents had, in articulating the likely introduction modes and practices of teaching of parametricism at the University of Bahrian yielded the following responses.

Any additional comments or suggestions regarding parametric design in architectural education at the University of Bahrain?

12 responses

No
teach the mentality of problem solving parametrically first before diving into the commands and so on
-
No comments
no
Good luck
Should've been taught when 3ds max course was taught
It would be interesting to actually experience creating parametric architecture; it would give me new insights about it and get me to understand how it could be added to my current design process, if at all.

Conclusions

This research carried out a comprehensive exploration of the interest and willingness of architecture students at the University of Bahrain to engage with and learn parametric design. It has been established, that there are many readily awaiting its integration within the architecture program curriculum. The study revealed a major percentage of respondents to the questionnaire, 75% of them are curious about and recognize parametric design. While generally, the students are broadly aware of parametric design, the findings show that their understanding remains superficial and are primarily limited to form generation and basic modelling tools. This gap underscores the requirement of a more structured pedagogical approach to incorporating parametricism and its tools and techniques into the curriculum, as a practical course with a theoretical foundation.

Students' interest in form generation, environmental responsiveness, and structural optimization using parametric tools reflects a readiness to embrace the evolving demands of contemporary architectural practice. Although, students expressed discomfort with advanced parametric software, citing a lack of guidance, complexity of the tools, and insufficient

resources. Despite these challenges, the vast majority believe that parametric design can significantly enhance the architectural design process, promoting innovation, efficiency, and contextually responsive solutions.

Moreover, fostering partnerships with industry professionals and software providers can offer mentorship and resources to bridge the gap between academic learning and real-world practice. By doing so, the university can prepare its graduates to become proficient, innovative architects ready to meet the demands of a dynamic, technology-driven industry. The paper suggests that similar research in other institutes could also help in establishing the need as well as the modalities in which parametricism can be introduced first in the design studios and then into the practice of architecture in the real world. There is no doubt that such an introduction could greatly advance the practice of architecture and making of wholesome built environments.

Declarations

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Statement of Conflict of Interest: The authors declare that there is no conflict of interest in carrying out this research.

Ethical Practice: This research followed accepted ethical practices. It is a synthesis of information that involved human participants, fieldwork, interviews and the collection of personal data. Nevertheless, it followed the accepted ethical standards: No person has been identified. The participants were informed of the purpose of the research. 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.

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

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