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IMPACT OF FULL-SCALE MODELS ON STUDENTS' CREATIVITY IN BASIC DESIGN COURSE

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Abstract. Designing and implementing full-scale models by architecture students is one of the most difficult and uncommon experiences in design education. The study evaluates the impact of this experience on the development of creative design skills among first-year students. This is achieved by applying a methodology that combines quantitative analysis of learning outcomes, especially those associated with the skills of Basic Design courses, with qualitative analysis of sketches, scaled and full models, and video recordings of students during design and implementation stages. This study provides experimental support for the use of full-scale models in design education to develop students' creative skills, in addition to discussing opportunities and challenges to help faculty and researchers in the field of design education.

Keywords: basic design, creativity, design education, design process, full-scale model, teamwork.

Introduction

Innovation in engineering disciplines, particularly those related to art and utility product design, is closely related to cognitive structure, personality traits, tools and thinking styles; architectural and urban design, and automotive design fall as examples. Therefore, the Basic Design course is considered an exploration, sorting, and mentoring for talents. Teaching this course largely depends on teaching preliminary drawing skills and learning about design principles that are a constant element that does not change with changing design methods and tools. Despite such principles are fixed, the ways of thinking through them have been completely altered by the tools of modern architectural design, which require radical changes in the methods of teaching drawing and design skills to become a real preparation for students.

The radical and accelerating changes occurring to various engineering disciplines continuously require the development of teaching the basics of design and creativity methods in general and for first-year students in particular due to the importance of the beginnings

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of their intellectual and cognitive formation. The matter at hand is figuring out the ways to prepare the students of the basics of architectural design course to deal with those requirements and variables in order to not only improve their orientation to the next stages but also increase their creativity skills.

Three major variables are involved in this proposed study which seeks to explore the links between them and identify the literature findings. These concepts are summarized in: (1) the components and requirements of the creative process in engineering disciplines, especially architecture, (2) building full-scale models in architectural design education, and (3) methods of teaching the basics of architectural design. The results of the examination of the literature regarding the components of the creative process have shown deep richness in all engineering majors, including architecture. As for the second variable, building models on a scale of 1:1 is a recent approach that advanced as a testing tool for digital applications for the design and implementation of the architectural product. The leading attempts for this approach emerged as separate master's programs from architectural education programs, for example, the Emergent Technologies and Design Graduate Program, the Design Research Laboratory in Architectural Association School of Architecture, Integrative Technologies and Architectural Design Research Program. These programs are based on digital design tools where design is based on a multidisciplinary approach (biology – science – physics – computer science). Studies interested in teaching the basics of design are very few owing to the knowledge building they require, and the cooperation of more than one discipline. As for the third variable, which is teaching the basics of architectural design, the study finds a neglection to the impact of design methods of creating an architectural full-scale model product and its effect on enhancing the students' creativity.

Therefore, the study assumes that building a full-scale model in a systematic context of Basic Design courses contributes to developing the students' creative skills, and to address the problems associated with their knowledge structure of Basic Design courses. The study aims to simulate and confirm the concepts of architectural thinking and design through applying the methods of manual drawing and two-dimensional and three-dimensional engineering projection ending with the implementation of a 1:1 model as a tool to increase students' creative skills with the Basic Design courses.

1. Literature review

Design and implementation have become complementary in the creative process, as the implementation stages enable students to validate design hypotheses and develop it to solve the emerging problems (Chamel, 2016). The contact of engineering students in design studios 1 and 2 with the implementation stages of the model is an important tool through which students are integrated into real-life problems and applications of creative ideas. In this context, Charyton et al. (2011), and Brown (2007), discuss the importance of changing stereotypes of teaching that separate students from reality. Mustar (2009), also confirms that introducing students to practical aspects, entrepreneurship, and engineering outside the classroom connects students to practical realities after they graduate.

The design-build phenomena has become widespread in architectural education curricula. Building and designing are essential to each other, as knowledge of one strengthens and supports the other (Stonorov, 2018). Therefore, the practical applications of building full-scale models within the design courses for first-year students will positively contribute acquiring knowledge that is the essence of the creative process.

Chamel (2016), argues that a constant reliance on graphics in architecture has led to a continuous separation between the design process and the product industry, as well as repetition, lack of innovation, and the inventiveness of products. Teaching pedagogy based on physical experiences can transmit positive energy in all courses regardless of course content (Chamel, 2016). Also, Danaci (2015), said that the most serious problem with architectural design learning is that students are unable to transfer theoretical knowledge into actual practice.

According to the design strategies proposed by Kruger and Cross (2006), first-year students are not suited to either strategy knowledge-based design or information-based due to the necessity of having previous knowledge, as well as multiple experiences in information-gathering methods.

The importance of increasing the quality of architectural design education is essential to keep pace with rapid changes in technology, research, and innovation (Doheim & Yusof, 2020).

Present strategies, which are based on dealing with problems and finding solutions, require the student's awareness about recognition principles during the product's creative design stages. In this sense, the design ending with the implementation contributes to building the feedback for students and providing them with knowledge-based design skills and collecting information methods through experimental documentation of both the design and implementation stages.

There are many reasons to study implementation-completed design considering its effect on creativity skills for first Basic Design studio's students. Schmucker (1998), said that many of them find it difficult to imagine the structure of graphics. As stated by Lemons et al. (2010), building a true stereoscope contributes to a better understanding of the differences between a real stereoscope and the initial concepts of designs for students who encounter problems with the cognitive processes referred to.

There are also several studies that poll students' feedback on the effectiveness of the implementation of the models, whose results indicated positive interactions with these strategies (Helbling & Traub, 2008; O'Neill et al., 2007; Schmucker, 1998).

The architect, Kengo Kuma, highlighted how most of the world depended on fabrication and dealing with real materials using hands, before industrialization. Although he was referring to architectural practice, the same idea could be applied in design education (Winterbottom, 2020). The question is, for contemporary design and manufacturing tools, which are used in architectural practice and education, will Kuma's idea be acceptable? The authors believe that we need to use our hands again, along with understanding of modern manufacturing tools, to support innovation and creativity. The use of hands, in the early stages of design education to simulate contemporary design and construction tools, will be useful for the students' innovation and creativity by deepening their understanding of how these manufacturing tools work.

From hereafter, the study seeks to develop the methods of teaching the basics of design courses in the first year for engineering students. The aim is to achieve the requirements of creative thinking from a complex knowledge structure during the first year which greatly relies on the adaptation of students to comprehend the creative process in an integrative manner and in all its stages. Such stages start from the design idea and end with the real product "model" while measuring the impact of this on increasing the students' creative aspects. The implementation of tangible figures helps increase the students' understanding, their respect for the physical world, and their ability to assess working with materials (Chamel, 2016, p. 54). Additionally, one of its benefits is to create a sense of responsibility and originality in their products, whether the final results of their works are successful or not (Chamel, 2016, p. 54).

Engineering creativity is defined as the creativity that has a specific level of novelty and originality and is characterised by its modern ideas. Not to mention the importance that creative ideas have functional benefits and are applicable in reality (Charyton et al., 2008, 2011; Charyton & Merrill, 2009). Hasirci and Demirkan (2003), argue that the most important elements of creativity are (person – process – product) and the results of this study indicated that each element has an independent significance in the creative process. Consequently, Demirkan and Hasirci (2009), analysed the interactions between creativity elements within the design field, and the results of this study indicated that the product component is the most powerful element in determining the amount of creativity in the design process, with a value of 49.89%, while the person component is 19.54% and the process component is 14.46% (Demirkan & Hasirci, 2009). Due to the increasing need for creativity in engineering tracks, many tools have been developed to support it in various disciplines and to support engineers and designers in the creative design process (Shneiderman, 2007). These developments have deeply affected the methods of teaching creativity engineering disciplines (Taurasi, 2007; Charyton et al., 2011).

Meanwhile, according to the dialectic between knowledge and creativity and the effect of increasing knowledge on the creative limits of products and designs, Ayyıldız Potur and Barkul (2006), discuss a number of contradictory findings of knowledge building and its impact on creative freedom among first-year students against the final years' students. The results show that first-year students in architectural design have more innovative products due to the lack of cognitive restrictions. In contrast, final and advanced years can be more strict on the professional and intellectual side (Ayyıldız Potur & Barkul, 2006).

In this context, Doheim and Yusof (2020) discuss that the interpretation of creativity varies from one level of design education to another and the more constraints and limitations on design, the higher the expectations of the creativity availability in the product. However, constraints and limitations of the design must be interpreted according to the way the students dealt with it, and the creativity can be assessed through the model of the creative process referred to by Hasirci and Demirkan (2003). The main objective of Basic Design courses is to support and encourage students to increase their creativity (Ramaraj & Nagammal, 2017), that could be applied easily before the advanced stages of design education, as the design restrictions and limitations increases.

However, it is important to note that a product that does not contain an authentic and robust cognitive structure cannot be called a useful, innovative product in engineering tracks, so knowledge building is the essence of the creative product. Therefore, the goal of the product ending with full-scale model implementation is to approximate distances to cooperate with theoretical sciences to create a knowledge structure that maximizes creativity among students.

The development of creative skills in engineering disciplines depends mainly on the ability of students to perceive, build, and analyse accumulated knowledge through training and practical practice. Through his study which included the analysis of 70 studies, Scott et al. (2004), confirmed that successful training courses indicate the importance and effectiveness of information related to knowledge in developing creative skills. Demirkan and Afacan (2012), said that the designer builds his ideas into the design process through knowledge, previous experience, and information stored in his memory. Concerning first-year students in the Basic Design studio, this knowledge and experience can differ, because they are in the beginnings of building experiences and knowledge. From this standpoint, students' knowledge of the possibility of implementing their ideas in real size can be a motivation to develop their creativity skills.

Building full-scale models of design projects in architectural education are not new. It belongs to the Bauhaus School (1919–1933), Germany, and modern technology has strengthened the extension of this approach (Symeonidou, 2014). There are many studies that discuss building models by using digital design tools in architectural education (Nováková et al., 2010; Loh, 2015; Symeonidou, 2014).

The design-build projects using full-scale models became one of the most attractive ways in architectural design education programs (learning through experience), as they are characterized by different methods, scopes and outcomes in light of the expansion and variety of design concepts using digital media (Folić et al., 2016). Construction of full-scale models have become a systematic alternative to the theoretical method, where students participate in the construction and design process with different educational settings (Elaby et al., 2022). This motivates students to increase their skill and establish strong links between design, construction, and materials through experimentation (Canizaro, 2012).

The study tries to provide a construction approach for a scale of 1:1 within the architectural design basics course, as a tool to interact with modern design methods through the design stages to enhance students' creative capabilities.

2. Methodology

This study aims to evaluate the effect of full-scale model design and implementation on the development of creative design skills for first-year students in the engineering track. Therefore, a mixed methodology was applied that combined quantitative analyses of learning outcomes, especially those related to creative design skills in the curricula of Basic Design studios 1 and 2. In addition to the qualitative analyses of students' sketches, scaled models, full-scale models, and video recordings for students during the design and implementation stages.

The study was applied using the creativity assessment tool (CAT) to assess the learning outcomes related to students' creativity in terms of quantitative analyses. This was reached by a study to explore creativity in design education and identify indicators to its evaluation in the design studio for the first year. The measuring tool was divided into three main factors: design elements, design principles, and artifact creativity (Demirkan & Afacan, 2012). The aforementioned study separated each factor and went deeper by analysing the interactions between these factors, which resulted in 41 criteria in total.

This study has been applied in two phases as follows.

The first phase was in the academic year 2017–2018: it analysed the creative design skills for 308 students according to their learning outcomes in the course of Basic Design studio 1 at the end of the first semester. In this phase, 70 students were chosen as a selected sample of students with high creative design skills. In the second semester, they were divided into two groups in the course of Basic Design studio 2 where each group consisted of 35 students. Thus, one of the two groups worked on a design that suffices with scaled models, while the other group works on designs that end with implementing one of them in full-scale and then re-evaluate the level of creativity of both groups.

The second phase in the academic year 2018–2019: it analysed the creative skills in design for 385 students according to their learning outcomes in the Basic Design studio 1 course at the end of the first semester. In this phase, 100 students were chosen as a selected sample of students with creative design skills that vary between high, medium, and weak. Then, they were divided into two groups in the Basic Design studio 2 course in the second semester where each group consisted of 50 students with varying levels as well so that the students' level stability in both groups is guaranteed in a different way. Like the first phase, one of the two groups had a design that is sufficient for the scaled models, while the other group worked on designs that end with the implementation of one of them in full-scale, to verify the results of the first phase of the study, if applied to students with different levels of creativity.

3. Data collection and analysis

The two phases were performed during the Basic Design studio 1 and 2 courses in the College of Architecture and Planning (CAP) and the College of Engineering (CE) at Imam Abdulrahman Bin Faisal University (IAU, formerly University of Dammam), Dammam, Saudi Arabia. The research study was based on the students' design projects during the second semester and was divided into five consecutive stages which affected the students' creative process. In the first stage, the students created an initial sketch of the project concept. The second stage was the development of the design concept. Followed by the third stage, the students studied and carried out their study models. During the fourth stage, the students chose the features and materials from a selected list that they used to build their projects. Lastly, the fifth stage is for students of groups whose projects end with the implementation and building of the full-scale model only (Figure 1).

Students have worked on a range of issues and settings, including determining the space for building a 3.5 x 6.0 x 3.5 m. model. They used and applied design elements and principles in the proposed models to achieve a better and more creative solution by developing a set of alternatives and concepts for models based on the above limitations. They accomplished this through the following five stages.

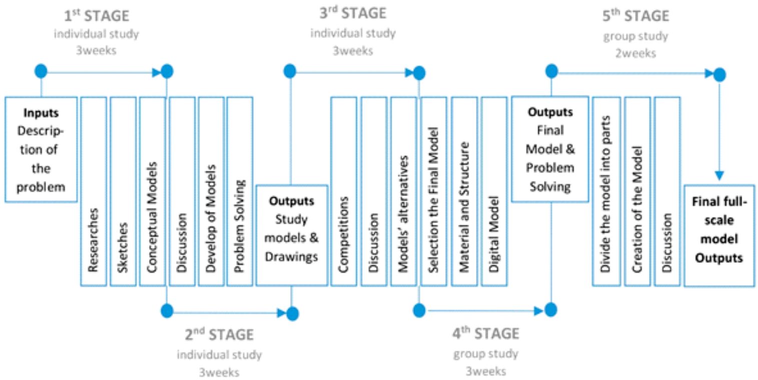

Figure 1. The diagram showing the different stages of the research study to design and implement the full-scale model (source: created by authors)

3.1. Stages toward a full-scale model

First stage: Working with students through sketching different ideas on paper for three weeks, according to previous standards and principles. This is followed by correcting and discussing their ideas with staff members in order to solve any problems that occurred (Figures 2–3).

Figure 2. The students during lectures and the initial stages of sketching and modelling alternatives (second group in first phase) (source: created by authors)

Figure 3. The students during the workshops and the initial stages of creating their computerised models (second group in second phase) (source: created by authors)

Second stage: Observing and following-up the students' design alternatives and discussions to develop them to choose the best alternative for each individual student. This is done by recording videos and photos that show a lot of data and information that was directly analysed and displayed how students solved problems. The problem-solving skills to deal with these models are one of the important points in the elements of creativity, as it results in innovative solutions for the prototypes.

Third stage: Students are required to develop individual proposals for a competition, which are later reviewed by both the staff and students to choose the best form and design. For some students, it was a one-stage procedure, for others, it was a multi-stage plan, where winning model proposals are redesigned. Those winning models have then judged competitively again but in terms of their enforceability and several proposals are chosen for the models (Figure 4).

Figure 4. The staff's follow-ups and discussions with the students to develop their proposed alternatives (second group in first phase) (source: created by authors)

Fourth stage: One proposal is chosen from all of the students' proposals which have met a set of criteria. The most important one of which was that it had to be a creative model with an innovative idea that could be implemented in real life. On the other hand, some simple problems that could be solved later were overlooked. One of the most important benefits of this stage is that the final selection is agreed upon by all of the students and each student contributed to the final proposal. This stage focuses on assessing, developing, and improving students' critical and self-assessment capabilities, and helped them make the right decision (Figures 5–6).

Figure 5. The final discussions and the staff's follow-ups with the students to settle on the chosen proposal for implementation (second group in first phase) (source: created by authors)

Figure 6. The students during the fabrication process in the laser-cutting laboratory and the beginning of the actual implementation (second group in first phase) (source: created by authors)

Fifth stage: Finally implementing one of the models of the group of students in full-scale model. It is immediately preceded by a series of tests for the bearing force of the proposed materials at the CE laboratories. Students and a group of specialized technicians then discuss the suggested thickness of the implementation material was an important point of this research. Cardboard was tested to determine its durability, as well as give the students practical experience in selecting and using various devices to test the building material. These tests confirmed that the material could bear and fit the actual implementation of a full-scale model (Figures 7–8).

The model was divided into parts so that each group of students could implement it under the supervision and observation of staff until the construction was completed (Figures 9–10). The aforementioned stages were arranged over three weeks' steps, two of which were in the studio, to address implementation, assembly, and installation problems for the individual parts of each group. Then, in week 3, the entire parts were combined outside the studio based on the vision and overall orientation of the team.

Figure 7. The students during the bearing loads tests for implementation materials which were made of cardboard cylinders (second group in second phase) (source: created by authors)

Figure 8. The students during making the model through gatherable parts (second group in second phase) (source: created by authors)

Figure 9. The students during the installation of the final full-scale model (second group in first phase) (source: created by authors)

In the first year (2017–2018), students' skills in manufacturing and building digital models and codes were developed. While, in the second year (2018–2019), the main idea was to choose recyclable materials after the model was completed (Figures 11–12). It was therefore installed in a commercial community awareness complex and focused on the interaction between the idea of recycling materials and its importance to the environment.

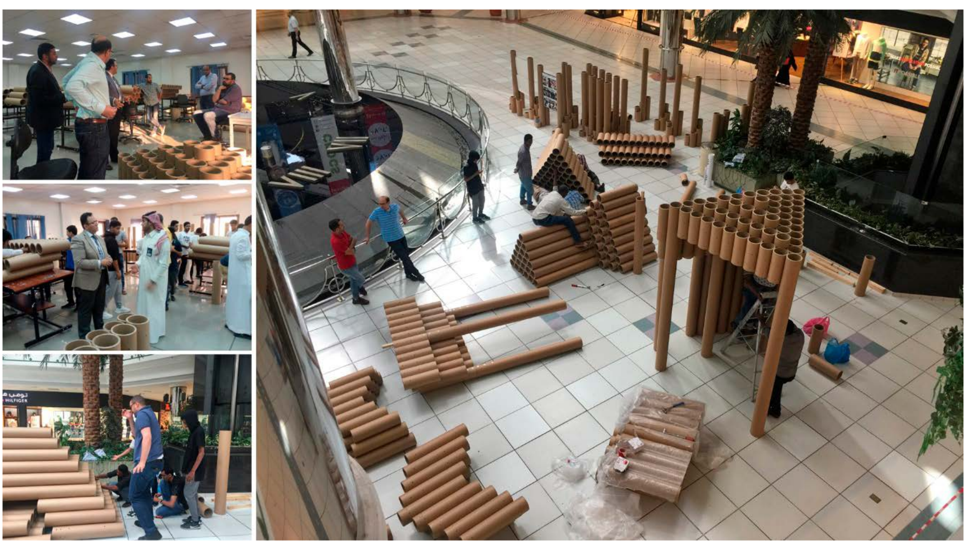

Figure 10. The stages of gathering the model's parts in the mall (second group in second phase) (source: created by authors)

Figure 11. The final implementation stage of the full-scale model (second group in first phase) (source: created by authors)

Figure 12. The final implementation stage of the full-scale model and the community's interaction with it (second group in second phase) (source: created by authors)

3.2. Quantitative data

Quantitative data consists of a set of assessments of students' work during the second semester of the Basic Design course for the first academic year, where the study was sorted in two phases. The first of which was during the academic year 2017–2018 and the second during the following academic year 2018–2019, where the quantitative data consisted of data for two groups of students in each of these two phases. One of the two groups made designs for their projects without implementing the full-scale model and was called in for the first phase (first group in first phase (group I-1)), while the second group made designs for the same project in addition to the implementation of one of those designs in a full-scale model and they were called second group in first phase (group II-1), and similarly, the other two groups were named in the second phase, first group in second phase (group I-2) and second group in second phase (group II-2), respectively.

A quantitative assessment of the creativity of students was carried out by applying the CAT, which was concluded by a study of Demirkan and Afacan (2012), through three main factors. The first one is the design elements which contains 7 criteria, the second is design principles which, also, contains 7 criteria and finally the artifact creativity that contains 27 criteria, and therefore all students' work has been evaluated through a sum of 41 criteria.

The work of each group under study was evaluated in the first semester, through a checklist that contained a relative weight for each of these criteria according to the degree of its correlation ratio to the creativity process inferred from the research referred to. This is to be compared to their work in the second semester, to obtain results indicating the percentage change in their creativity. Figure 13 shows the criteria used and their relative weights.

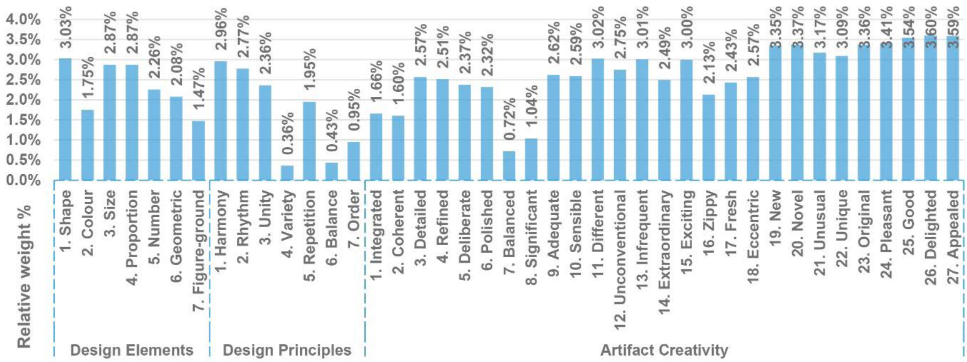

Figure 13. The relative weight of every criterion used in the quantitative assessment for the four studied groups (source: created by authors)

3.3. Qualitative data

The qualitative data consisted of pictures and videos of student interaction with the in-studio staff members over the past two years. Additionally, it included faculty discussions and meetings with students in their studio. One way to develop creative options for traditional teaching methods that support analysis and assessment research – is by using the "Dead Head Deadline" strategy, where relevant phenomena are carefully monitored, and observations are recorded. More than 200 hours of recorded videos and photos were gathered of phase one of the academic year 2017–2018, where the creative skills of 308 students were assessed. While in phase two of the academic year 2018–2019, a number of 385 students were assessed. The evaluation was according to the outcomes of the Basic Design studio curriculum where one of the groups worked on a design that ended with study models while the other worked on a design that ended with a full-scale model. However, there was only a small part was chosen to represent the best assessment principles for measuring the creative aspects of teaching and learning for this discussion (Figures 14–15).

A qualitative assessment has been made of the three elements of creativity (student, process, and product) referred to earlier in the research literature. The Likert scale is one of the most common and reliable methods for measuring a person's attitudes and behaviour. The Likert scale measures attitudes and behaviours using varying response options from least likely to most likely, thus allowing the detection of ideas. That is why this measurement can be particularly useful for sensitive or difficult topics. In addition to the five-point Likert scale assessment questionnaire, the resultant data of the two groups, the students with and without deep faculty interaction, are displayed for comparison.

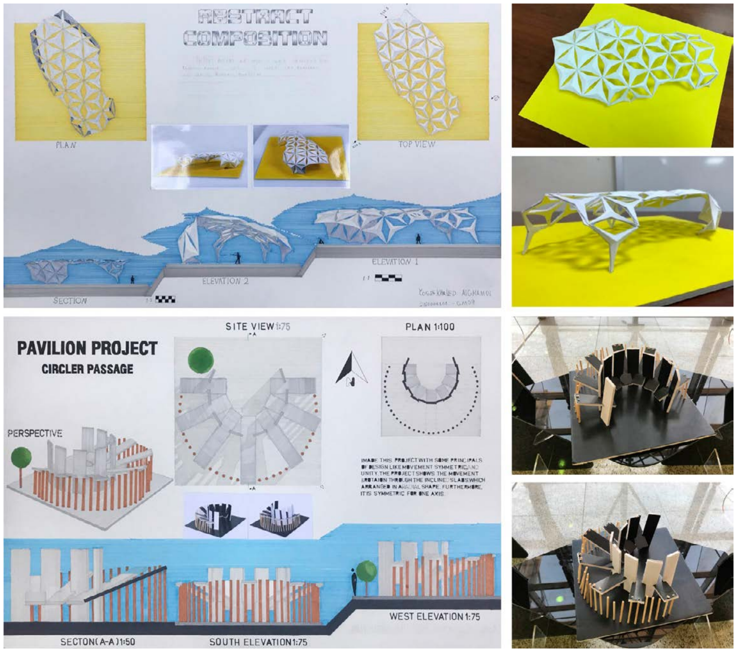

Figure 14. The students' projects and models of the group that ended with making study models (first group in first phase) (source: created by authors)

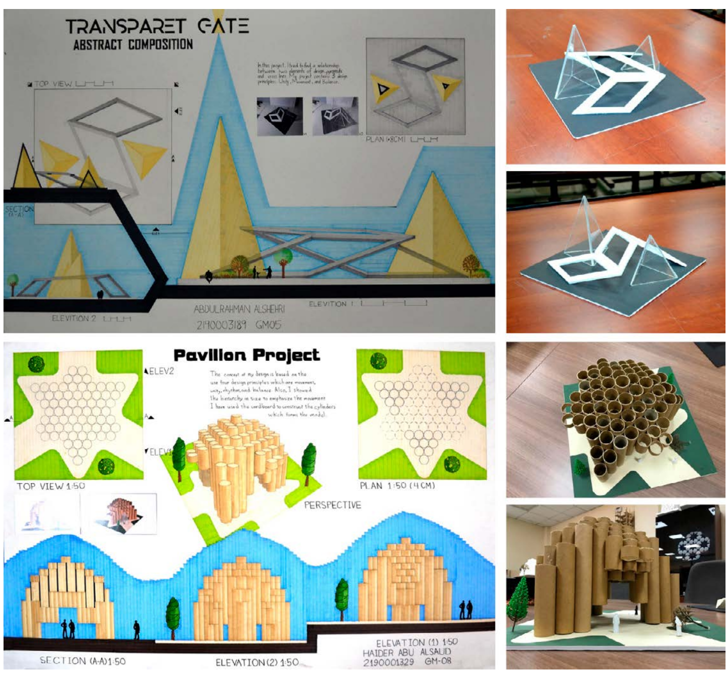

Figure 15. The students' projects and models of the group that ended with implementing a full-scale model (second group in second phase) (source: created by authors)

4. Results

The results showed a significant change in the level of creativity of students participating in the experiment, based on both quantitative and qualitative analysis of their work over two consecutive academic years representing the experiment period. As the quantitative analyses showed, there was an increase of 8.9% in the first phase of the study and 14.4% in the second phase, in terms of creative design thinking levels among students participating in designs that end with the implementation of one of them as a full-scale model. Likewise, the qualitative analyses showed an increase of 12.7% in the first phase and 18.6% in the second phase, and the following are results for the two phases (first and second) of the study in detail.

4.1. First phase: quantitative analysis

The results of group I-1 show increasing of creativity in the second semester compared to the first semester for 16 students, which equals to 45.71% of the sample. While the creativity decreased for 18 students, which equals to 51.42% of the sample, and no change was noticed for 1 student as shown in Figure 16. The results also show that the average of students' creativity in the second semester was decreased by 1.6% compared to the first semester in this sample.

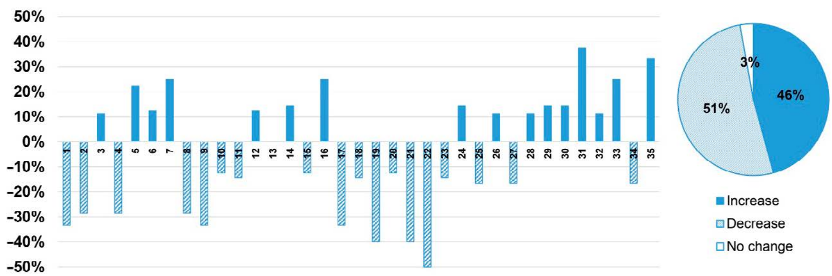

Figure 16. Average of changed percentages in the students' creativity (first group in first phase) (source: created by authors)

Group II-1 results showed an increase in creativity in the second semester compared to the first semester for 17 students, which equals to 48.57% of the sample. While there was a decrease in creativity for 7 students which equals to 20% of the sample, and for 11 students the creativity ratio did not change, which equals to 31.42% of the sample, as shown in Figure 17. The results also indicate that the average student's creativity in the second semester has increased by 7.3% compared to the first semester in that sample.

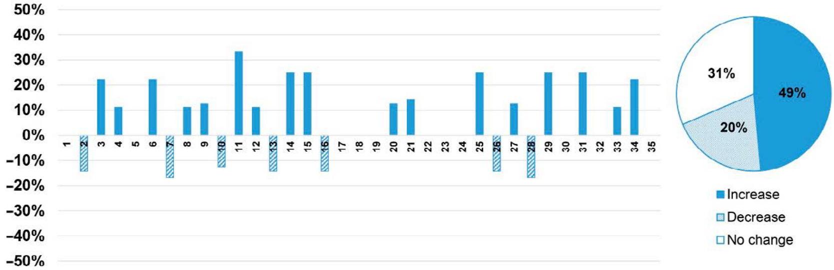

Figure 17. Average of changed percentages in the students' creativity (second group in first phase) (source: created by authors)

By comparing the results of the previous two groups, the number of students who were more creative in the group I-1 is 16, while the number of students whose creativity has increased in the group II-1 is 17 students, *i.e.* the second group overcomes the first by one student or 2.86% of the sample.

Since the average student's creativity in the second semester for the group I-1 was 1.6% lower than the first semester in that sample, while it grew by 7.3% in the group II-1, the second group has surpassed the first group by 8.9% in the average students' creativity. This means that the full-scale model contributed to an 8.9% increase in students' creativity in that academic year.

The results of the analysis of the creativity criteria that were used in the evaluation of students' work in the first stage indicate that the largest number of students of the group II-1 had achieved most of these standards, as the number of students in this group increased in 31 criteria by (75.6 %) of the total number of criteria. While their numbers decreased in 8 standards by (19.5%), and the numbers of students in the two groups were equal in only two standards, as shown in Figure 18.

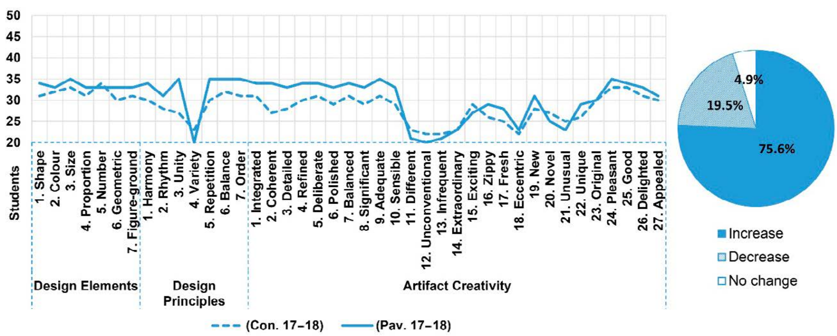

Figure 18. Rate of change in creativity criteria for the students of both groups (first and second groups in first phase) (source: created by authors)

4.2. Second phase: quantitative analysis

The results of group I-2 showed an increase in creativity in the second semester compared to the first semester for 19 students, which equals to 38% of the sample. However, the creativity decreased for 22 students, which equals to 44% of the sample, and no change in creativity ratio for 9 students, which equals 18% of the sample. As shown in Figure 19, the results also indicate that the average students' creativity in the second semester has increased by 0.9% compared to the first semester in that sample.

The results of the group II-2 showed an increase in creativity in the second semester compared to the first semester for 26 students, which equals to 52% of the sample. While it decreased for 11 students which equals to 22% of the sample, and no change in creativity ratio for 13 students which equals to 26% of the sample, as shown in Figure 20. The results also indicate that the average of students' creativity in the second semester has increased by 15.3% compared to the first semester in that sample.

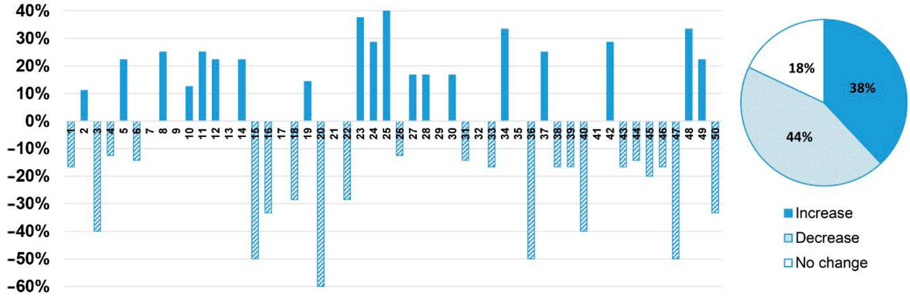

Figure 19. Average of changed percentages in the students' creativity (first group in second phase) (source: created by authors)

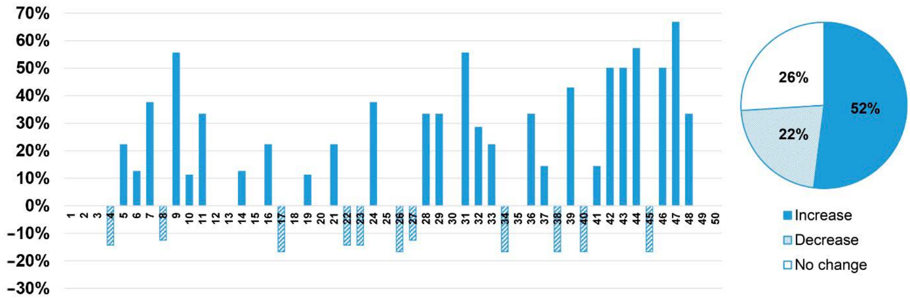

Figure 20. Average of changed percentages in the students' creativity (second group in second phase) (source: created by authors)

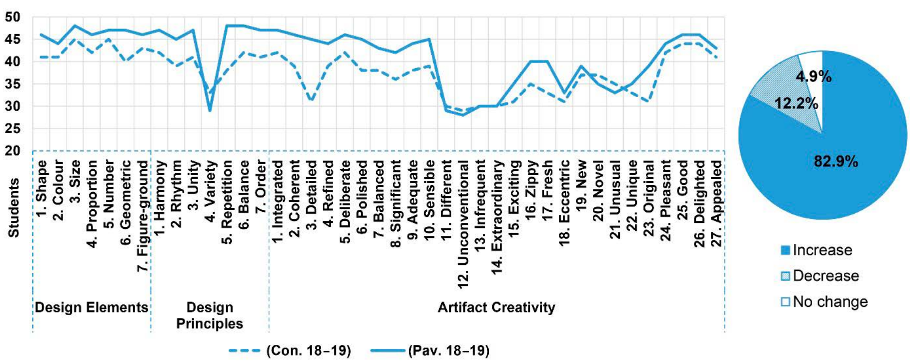

Figure 21. Rate of change in creativity criteria for the students of both groups (first and second groups in second phase) (source: created by authors)

By comparing the results of the previous two groups, the study found that the number of students whose creativity ratio increased in the group I-2 was 19 students, while the number of students whose creativity ratio increased in the group II-2 was 26 students. Therefore, the second group overcomes the first group in the number of creative students by seven students, which equals 14% of the sample.

Since the average of students' creativity in the second semester of group I-2 has increased by 0.9% compared to the first semester in that sample, while it increased by 15.3% in group

II-2, then the second group has surpassed the first group by 14.4% in the average of students' creativity. This means that the full-scale model enhanced the students' creativity by 14.4% in that academic year.

The results of the analysis of the creativity criteria used in the evaluation of students' work in the first stage of the study show that the largest number of students of the group II-2 had achieved most of these standards. The number of students in this group increased in 34 criteria by (82.9 %) of the total number of criteria, while their numbers decreased in 5 standards by (12.2%), and the numbers of students in the two groups were equal in only two standards, as shown in Figure 21.

4.3. First phase: qualitative analysis

The previously mentioned factors and elements of the creative process were used to make a qualitative evaluation of the two groups of students, group I-1 and group II-1, through a criteria list that contains a relative weight of each of the elements. The study used the Likert scale to analyses students' attitudes and behaviours as well as their activities and interactions in dealing with problems within the studio, by observing and monitoring videos and images for each of the studied groups.

Such discussions allowed uncovering ideas through different options and responses from least likely to most likely. According to the degree of relevance of each group to the creative process, a qualitative assessment tool (QAT) was designed to evaluate the creativity. That tool contains three main factors (student – process – product), and each factor contains a set of elements that make up 13 elements for evaluation.

The results of the assessments of the two groups, group I-1 and group II-1, using the Likert scale in the first phase of the experiment for the academic year 2017–2018, show the superiority of the group II-1 in most of the elements of the QAT. While the average evaluation of that group increased in 10 of the 13 elements, or 76.9% of the total number of elements,

Elements of creativity	Flexibility and clarity of concepts	Fluency, responses and interactions	Thinking skill and innovation	Problem-solving skill	Building knowledge and making sketches	Developing ideas according to design principles	Alternatives and model making	Study models making	Problem-solving & final model selection	Final drawings stage	Material selection stage	Stage of materials Loading tests	Stage of implementation & the model's problem solving
(Pav. 17-18)	4.6	3.3	4.4	4.2	3.8	4.6	4.2	4.7	4.7	4.6	4.4	4.1	4.1
(Con. 17-18)	4.5	3.3	4.2	4.1	3.6	4.3	4.3	4.7	4.6	4.5	4.5	1	1
Factors of Creativity	Student				Process					Product			

Likert scale: 1 = Not interactive, 2 = Slightly interactive, 3 = Moderate interactive, 4 = Interactive, 5 = Very interactive.

Figure 22. Average creativity percentage of both groups (first and second groups in first phase) using the Likert scale in the first phase of the experiment for the academic year 2017–2018 (source: created by authors)

and its average evaluation decreased in one element (alternatives and model making), and the two groups were equal in the average evaluation of two elements (fluency, responses and interactions (study models making)).

Comparing the average change in the creativity of the two groups, group I-1 and group II-1, using the QAT with respect to the Likert scale, the average evaluation of the two groups were 3.74 and 4.28, respectively, meaning that the group II-1 has out-performed the other group by almost 12.6%, as in Figure 22.

4.4. Second phase: qualitative analysis

The same process mentioned earlier was repeated in the academic year 2018–2019, to measure the percentage of change in the creativity of students of both groups, group I-2 and group II-2. The results of the assessments of the two groups showed the superiority of the group II-2 in all elements of the QAT, as the evaluations of that group increased in 13 elements of creativity, *i.e.* 100% of the total number of elements, as in Figure 23.

Elements of creativity	Flexibility and clarity of concepts	Fluency, responses and interactions	Thinking skill and innovation	Problem-solving skill	Building knowledge and making sketches	Developing ideas according to design principles	Alternatives and model making	Study models making	Problem-solving & final model selection	Final drawings stage	Material selection stage	Stage of materials Loading tests	Stage of implementation & the model's problem solving
(Pav. 18-19)	4.5	3.3	4.5	4.1	3.7	4.4	4.2	4.6	4.6	4.5	4.4	4.1	4.1
(Con. 18-19)	4.1	3.2	4	3.8	3.3	3.9	4.1	4.1	4.2	4.2	3.9	1	1
Factors of Creativity	Student				Process					Product			

Likert scale: 1= Not interactive, 2= Slightly interactive, 3= Moderate interactive, 4= Interactive, 5= Very interactive.

Figure 23. Average creativity percentage of both groups (first and second groups in second phase) using the Likert scale in the second phase of the experiment for the academic year 2018–2019 (source: created by authors)

Comparing the percentage change in the creativity of the two groups, group I-2 and group II-2, using QAT with respect to the Likert scale, the average ratings of the two groups were 3.45 and 4.23, respectively, meaning that the group II-1 has out-performed the other group by almost 18.43%.

Discussion

Through previous studies, it was noted that it is very important to plan for the first design decisions in which new architectural students made their first experiences (Ozorhon' et al., 2016). Not to mention that the study by Sidawi (2013), which was conducted in the period from 2010–2013 to students of the CAP, had indicated that the design studio environment is slowly improving, while it must be radically strengthened to help students produce creative projects. This prompted researchers to develop the teaching approach to Basic Design courses 1 and 2, and that is over more than a year to reach the best practices that support the design process and creativity for new students.

Frederick (2007) in his book *101 Things I Learned in Architecture School* points out the importance of teaching new students design through models as an essential skill (Kesseiba, 2017). Kesseiba (2017) also stated that it is very important to link the educational process with the life and educational experiences that architecture students will need to face after completing their architectural education. From hereafter, the idea of the research emerged to determine the effectiveness of not only the work of students of small-sized models but of full-scale of 1:1 model.

Researchers preferred that the function of the model to be built is simple, commensurate with the amount of information and experiences of first-year students so that it does not become an obstacle to students' creativity in design. This agreed with what was indicated by a previous study that students who focused on the design of the models and its structure did not reach satisfactory results about its function, due to the lack of their knowledge and experience (Ozorhon' et al., 2016). The researchers believed that the participation of a group of students in a full-scale model by 1:1 contributes significantly to the development of many students' skills as well as creativity in design. This is based on the study that stated that implementation enabled students to have stronger perceptions and skills to express in the three-dimensional forms. Furthermore, it enhanced their ability to face implementation problems in terms of the relationship between the implementation material and the design aspect, while developing themselves in terms of active participation in teamwork (Ozorhon' et al., 2016).

Indeed, the quantitative results of the research indicate the noticeable increase in the level of creativity of the two groups of students involved in building the full-scale model 1:1 rather than the other two groups made the individual small models. However, it was noted that the increase of creativity level in the first stage of the experiment in the academic year 2017–2018 was less than the second stage in the academic year 2018–2019, where the rates of increase in students' creativity were 8.9% and 14.4%, respectively. The researchers believe that this noticeable difference, estimated at 5.5% between the two stages of the experiment, is attributed to the group of students who were chosen in the first stage of the experiment who were highly creative in design, and therefore did not show significant development in their level of creativity. Whereas the group of students who were chosen in the second stage of the experiment were with varying levels of creativity in design, and therefore the results showed significant development in the level of creativity they have. Conclusively, students with medium and low levels of creativity were the most benefit from participation in building a full-scale model. The qualitative results of the research also showed an increase in the level of creativity among students participating in building the full-scale model in the first and second stages by 12.7% and 18.6%, respectively, which strengthens that conclusion.

Conclusions

The study aims to assess the impact of full-scale model design and implementation on the development of creative design skills of first-year students in the engineering track. The results of the study showed a marked increase in the level of creativity among students whose designs ended up implementing a full-scale model compared to their peers whose designs ended up with only scaled models, especially those associated with thinking, innovation and problem-solving skills. The results also indicated that the implementation of the full-scale models played an effective role in the development of students' creative skills during the stages of building knowledge and sketching, where this acts as a catalyst and motivation for students to exert more effort during that stage. It is important to point out the high level of creativity among students during the stages of the selection and testing of materials and solving the problems associated with implementation once they implement a full-scale model.

Since this study was limited to male students from one university, the global value of this experiment has not yet been proven. However, the researchers believe that the experience of first-year students building full-scale models has an effective impact on the development of their creative abilities. It is also unlike the prevalent trend in linking these experiences to advanced and postgraduate students, which opens the way for further advanced studies in this subject. In general, the researchers consider that the use of this methodology in teaching Basic Design courses will enhance students' creativity.

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