

Research Paper

The Relation between Design Expertise and the Quality of Design Idea

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Abstract

Designers rely much heavily on experience. Previously, it was assumed that particular developmental experiences are correlated with creativity which develops over time through experience. The aim of this study is to explore whether design expertise definitely improves the creativity of design ideas in architectural design. To test the hypothesis, several architectural designers at different levels of expertise, from novice students to expert architects, participated in a design task. The novelty and quality of the design ideas were evaluated as the signs of creativity. The results indicated that there are significant relations between design expertise with the quality, but not with the novelty of the design ideas. The expert designers preferred to find ideas that have practical solutions to the design problem, but novices looked for original ideas. In conclusion, design experience influences creative ideation but has different effects on various aspects of design creativity.

Keywords: Creativity, Novelty, Quality, Design idea, Design expertise.

1. INTRODUCTION

Design abilities are developed by expertise and education. Design education has usually relied on learning by doing. A certain level of maturity is required in different design fields, and gathering experience is significant for design (Lawson, 2004). The empirical studies demonstrated that there are some differences between the design acts and processes of experts and novice designers (Ahmed, Wallace, & Blessing, 2003; Cross & Cross, 1998; Kavakli & Gero, 2002; Lloyd & Scott, 1994), that demonstrated the importance of role of expertise in design. Researchers studied the difference between design students at different levels of expertise to investigate the effects of development of design expertise (Adams, Turns, & Atman, 2003; Atman et al., 1999; Chai et al., 2015; Christiaans & Dorst, 1992; Ozkan & Dogan, 2013). In this paper, the development of design expertise is investigated between architectural designers in relation to creative ideation.

Creativity involves the production of novel, useful products (Mumford, 2003). Common theories of creativity consider both aspects of novelty and quality of idea as signs of creativity (Dean et al., 2006; Peeters et al., 2010). Novelty is related to unusual or unexpected ideas and is a subset of divergent thinking whereas quality is related to

usefulness of ideas and is a subset of convergent thinking (Peeters et al., 2010; Shah, Smith, & Vargas-Hernandez, 2003). The developmental theory of creativity discusses that particular amount of experiences is required for someone who intends to become innovative in the field (Craft, 2006; Csikszentmihalyi, 2013; Goertzel & Goertzel, 1962). There is some empirical evidence demonstrating the positive effect of expertise on creativity in general (Ericsson, 2014; Galenson, 2011; Kaufman & Kaufman, 2007; Weisberg, 1999). It is not clear whether experience has the same positive effect in design fields and there is little evidence demonstrating the positive effects of expertise on the creativity of design ideas (Bonnardel & Marmèche, 2005; Reilly, 2008; Viswanathan & Linsey, 2011). However, some studies challenged the pre-assumed positive effect of expertise on creativity (Casakin, 2004; Cross, 2004; Cubukcu & Cetintahra, 2010).

This research explores the effect of education on the creativity of design and the question is what the difference is between the creative ideation of designers with different levels of expertise. Therefore, we studied the design ideas of architectural designers at different levels of expertise, from undergraduate first year students to expert architects. We presented them with a design task in an attempt to determine whether design expertise has a positive effect on creativity of design ideas.

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2. BACKGROUND

2.1. Design Creativity

Creativity is an interdisciplinary field to which a vast number of studies of contemporary scientists have been allocated. Creativity can refer to a person, process, product, or a place. It can be found in geniuses or in small children. Decades of research on creativity demonstrated that it is a complex phenomenon which does not have a clear and certain definition and cannot be limited into a certain type of behavior or a certain level of intelligence (Kaufman & Sternberg, 2011). But there are some definitions of creativity that often comprise something different or innovative with a high quality that is appropriate to the task at hand (Mumford, 2003).

Guilford (1967) separated divergent and convergent thinking and defined creativity based on divergent thinking which relates to the ability of creating multiple and varied ideas. The Torrance Test of Creative Thinking (TTCT) (Torrance, 1968) also considers originality, fluency and flexibility of ideas that only evaluate divergent thinking. Today, it is proved that both divergent and convergent thinking aspects are involved in the creative effort to capture original and effective ideas (Crompton, 2006). Theorists of creativity discussed that it is important to consider the suitability and appropriateness of ideas in addition to divergent aspects because creativity requires both divergent and convergent thinking aspects (Chiu, 2015; Kaufman & Sternberg, 2011; Mumford, 2003).

Evaluation of creativity requires consideration of different factors that comprise quality and novelty (Dean et al., 2006; Peeters et al., 2010). The quality of an idea means that it can give an effective and implementable solution to a problem. It has different aspects such as practicality, solving problems, ease of use, cost, and energy consumption depending on the field and nature of the design problem. Novelty comprises originality and being new, meaning that the idea is not similar to the known past. A novel idea is a rare, unusual and uncommon idea. Unique ideas have high levels of novelty whereas common ideas have low levels of novelty (Dean et al., 2006; Shah et al., 2003). The novelty of ideas includes infrequency, ingenuity, originality, and non-obviousness (Dean et al., 2006). Different factors affect an educational environment's success in the improvement of architecture student's creativity (Chulvi, Agost, Royo, & García-García, 2020). In this study, we evaluate the creativity of design ideas in both aspects of novelty and quality separately using expert judgment.

2.2. Design Expertise

Expertise develops over time; it is not simply a matter of possessing talent, but many thousands of hours of training and practicing are necessary over time as a person matures (Cross, 2004). Motivation, guidance, concentration and willingness to work hard have significant roles in improving expertise (Cross, 2004).

Design expertise is an important factor in design research. Some design theorists attempted to define design expertise. Dorst and his colleagues in a series of studies (Dorst, 2008, 2010; Dorst & Reymen, 2004; Lawson & Dorst, 2009) introduced a model of design expertise based on the Dreyfus (Dreyfus & Dreyfus, 1980) model of general skill acquisition. The Dorst model (Dorst, 2008, 2010; Dorst & Reymen, 2004; Lawson & Dorst, 2009) demonstrated how design expertise develops over time from considering objective features of situations and following the strict rules by novices to giving intuitive responses to situations, and straightforwardly selecting an appropriate action by experts. Dorst and Reymen (2004) also discussed that learning design does not only involve skill acquisition but it also involves the learning of declarative knowledge and building up of a set of experiences that can be used in new projects (Alipour, 2019).

Design researchers and specialists have mentioned that expertise in design is significantly different from that in other fields since it includes distinguishing aspects (Cross, 2004; Lawson, 2004). Some aspects of expertise in creative domains is different from other domains. For example, expert designers did not use the easiest way unexpectedly to solve the problem and treated the problem as if it were harder compared to novices' approaches to the problems (Cross & Cross, 1998). Moreover, both expert and novice designers used bottom-up problem solving strategies that did not match the expected top-down and breadth-first strategy from well-defined problem studies (Ho, 2001).

The design approaches, processes and acts are different between experts and novices. The result of a study (Ahmed et al., 2003) demonstrated that novices used the trial and error process to generate and analyze alternatives, whereas expert designers integrated design strategies. Kavakli (Kavakli & Gero, 2002) concluded that experts have control on cognitive actions and governed the cognitive process efficiently. Casakin (Casakin, 2004) discussed that expert architects added some constraints and potentials to the design problem, while novices produced more design alternatives. Novice designers have a problem-focused strategy, but experienced designers have a solution-focused strategy and attempt to acquire knowledge about solutions rather than necessarily about problems (Alipour, 2019; Lawson, 2004). Chai et al. (2015) discussed that expert designers and senior students pay more attention to the completeness of design, while novice students pay more attention to the functionality of design. Therefore, designers' performance has been changed by expertise and it can be discussed whether expertise improves creativity of design ideas.

2.3. Design, Creativity and Expertise

Expertise usually has been theorized as preceding creativity, meaning that experts in each field are more creative than novices (Csikszentmihalyi, 2013; Herzberg, 1987; Mathews & Fraser, 1999). The developmental theory of creativity that was theorized based on studying

the life of eminent creative individuals suggested that development of experience improves creativity. The theory claims that creativity develops over time by interaction between a person and environment, from potential to achievement (Kozbelt, Beghetto, & Runco, 2011). It is known that one who intends to be truly creative must be an expert in a structured and codified domain. Some discussed this phenomenon with regard to the concept of field knowledge (Csikszentmihalyi, 2013), self-confidence (Craft, 1998), and wisdom (Craft, 2006). There is empirical evidence confirming that creativity relies on expertise (Martinsen, 1995, 1993), especially on specific expert thinking skills (Reilly, 2008). Ericsson (2014) reviewed theories and findings from many different domains of expert performance and creative achievements, and discussed how experts optimize improvement in their performance and eventually attain excellence.

The relationship between expertise and creativity of design solutions has been studied across different design research fields. Diverse and often conflicting opinions have been voiced as the impact of expertise on the design creativity. Some demonstrated the positive effect of expertise on creative design (Bonnardel & Marmèche, 2005), and have proven that the level of expertise influences designers' performance and causes less fixation in design (Alipour et al., 2017; Viswanathan & Linsey, 2011). On the other hand, some others demonstrated that novice design students have better performance on some aspects of creative design compared to experienced designers (Cubukcu & Cetintahra, 2010). Some design researchers demonstrated that expert designers do not attempt to fully understand the design problem before making solutions, move rapidly to early solution conjectures and continue the process of exploring and defining problems and solutions together (Ball, Evans, & Dennis, 1994; Rowe, 1991; Ullman, Dietterich, & Stauffer, 1988). The solution-focused approach of expert designers may cause fixation on initial concepts instead of adopting a fresh alternative (Ball et al., 1994; Rowe, 1991; Ullman et al., 1988). Theorists and educationists recommend generating more alternatives, but expert designers usually do not generate a wide range of alternative ideas (Cross, 2004). Sticking to the initial solutions and not considering other alternatives and possibilities may lead to less creative design.

The concept of mental hop and mental leaps can clarify the degree of creativity which designers desire to achieve. The term mental leaps has been proposed by Holyoak and Thagard (1996) to describe that designers use a far source of analogy and connect two very different domains to achieve creative ideas. Ward (1998) described remarkable innovations as multiple small hops rather than one giant leap and defined the concept of mental hops. Mental leaps were related to extraordinary forms of creativity, whereas mental hops were found to be related to everyday types of creativity (Ward, 1998). Ozkan and Dogan (2013) found that expert architects prefer *mental hop* and answering design problems practically, whereas novice students seek *mental leaps* and attempt to find original ideas. Therefore, novice designers may look for creative ideas more than

expert designers. The present review leads us to compare the performance of different levels of architecture designers in a creative design task and investigate how design expertise affects the creativity of design ideas.

3. METHODOLOGY

This paper investigated the effect of design expertise on the creativity of design ideas empirically. Two hypotheses were tested in this research: the design expertise improves the novelty of design ideas (Hypothesis 1), and the design expertise improves the quality of design ideas (Hypothesis 2). To test the hypotheses, the relations between different levels of design expertise with the novelty and quality of design idea were examined.

3.1. Participants

A number of 140 architecture designers participated in the experiments. They belong to three groups representing different levels of professional experience. The first group was made up of 32 novice architecture students (22 female and 10 male; mean age 19.5 years), in their first or second years of undergraduate studies. The second group included 32 advanced architecture students (20 female and 12 male; mean age 22.5 years), in their fourth or fifth year of architecture education. The third group of subjects, counting 32 participants (30 female and 2 male; mean age 37 years), consisted of experienced architects that graduated from the same university. Participants were volunteers who received neither payment nor course credit in return for their participation.

3.2. Design task

The design task instruction comprised of an architectural problem that was provided in the form of an introduction page that explained the design problem (typed on an A4 sheet) - Design a roadside hotel (motel) with 15 residential rooms, reception room, dining room, kitchen, supermarket, repair shop, parking lots, and open space. Each designer had to answer the design problem through sketching which included simple presentation and were free to choose any architectural document (plans, sections and perspectives). We developed this task because, firstly, such architecture problems are not commonly taught in the students' formal education and none of the students had any previous experience about the problem; and secondly, it included many architectural aspects such as function, aesthetic, symbolism, form, structure and climate response.

3.3. Procedure

Participants were given an introduction page which explained the design problem, and a white page to sketch on. Participants had a period of one hour to come up with a design. No pre-instruction about creativity or the aim of the research was provided for the designers and they were

simply asked to create one design idea. Each of the expert architects were tested individually in his/her office. But the students were tested in their classrooms. Each classroom had groups of between 7 to 24 students. Architecture students worked individually and were instructed not to discuss any aspects of the experiment with their peers.

3.4. Metrics

The creative performance of the three groups was compared in a design task by measuring two factors of novelty and quality of design idea. The two factors of novelty and quality of design idea usually have been evaluated as the signs of design creativity (Dean et al., 2006; Peeters et al., 2010). Some researchers developed methods to assess the novelty or quality of design ideas (Jagtap, 2019; Sarkar & Chakrabarti, 2011; Shah et al., 2003). Shah and his colleagues (Shah et al., 2003) proposed a method to measure the quality of ideas that is based on the quality score of each function and weight of each function. Sarkar and Chakrabarti (2011) proposed some other parameters such as level of importance, rate of popularity of usage, frequency of usage, and duration to measure the quality factor. Measuring quality depends on the field of design problem and many of the proposed factors are not suitable in the field of architecture. In this study the quality of the design idea was evaluated qualitatively based on expert judges in reference to other scholars (Alipour, 2020; Casakin, 2005; Casakin & Goldschmidt, 1999; Cheng, Mugge, & Schoormans, 2014; Tsenn et al., 2014).

Shah et al. (Shah et al., 2003) also defined the method for measuring the novelty of ideas based on functions and stages. Sarkar and Chakrabarti (2011) developed a method to be employed to identify the degree of novelty that considered three factors of function, behavior, and structure. The novelty measuring methods have been organized to be employed in the field of industrial products and are not suitable to be used in the field of architecture. In this paper we used expert judgment to evaluate the novelty of ideas qualitatively following some other scholars (Alipour et al., 2016, 2017; Dobioli & Umbarkar, 2014).

There were two expert judges who were selected for the evaluation based on the following: 1) they were architecture design educators with more than 10 years of experience on design ideation education and 2) had an expertise in schematic architecture sketches. They evaluated novelty and quality of sketches by classifying them into five degrees, individually. Before judgment, the judges were provided with a definition of five degrees of novelty and quality. Rank 1 of novelty was allocated to common and predictable ideas while Rank 5 was allocated to unexpected and rare ideas in the field of architecture. Moreover, Rank 1 of quality meant low quality ideas that did not satisfy the design problem, while Rank 5 meant high quality ideas (the best answer to the design problem).

The judges were provided with a set of randomly ordered photocopies of the participants' Sketches. They

did not rate the novelty and quality of the idea at the same time, but at first, each judge ranked the sketches from 1 to 5 degrees of novelty. The ranking was done manually by classifying the sketches into five groups of novelty degrees. After the novelty coding, they did the same for the quality score. After individual coding, to achieve the integrity in the evaluations, they discussed the disputed cases until the consensus was achieved. For the reliability of research, after the first round of evaluation, a third expert judge that was blind to all procedures, evaluated novelty and quality of sketches. Cohen's kappa coefficient was used to test the agreement between the judges' evaluations and more than 75% inter-coder reliability was observed.

4. DESIGN EXAMPLES

In this section, 5 examples from 140 sketches designed by the participants are provided. Figure 1 demonstrates a sketch designed by a novice student. In the sketch, with very low degree of quality, the designer does not pay attention to the design problem and needs. There is no answer for the required spaces, climatic problems, entrance, and outdoor spaces. Judges ranked the novelty of this sketch low, although the form is a little more complicated than a simple cube, however, the composition of the two shapes is not suitable and the form is not novel. Another novice's sketch has been provided in Figure 2. The sketch has been evaluated as middle quality. In this example, designers paid attention to the functions, tried to establish a suitable circulation between different functions, and allocated open spaces. He designed a front door and located required windows. Because of the lack of innovation in the form and composition, judges evaluated the novelty of design as low. Figure 3 is an example of an advanced student's sketch that has been evaluated as a very novel idea. It has an unpredictable and unique form and appearance that differentiates from other ideas. Sketch in Figure 4 has been designed by another advanced student and was evaluated as middle novelty but very high quality in idea. In this sketch, the designer was aware of the problem needs, functions, climatic response, separated the public and private spaces, allocated parking lots and repair shop beside entrance, and considered interior courtyard. But the use of predictable forms and combinations led to the middle degree of novelty. Figure 5 is an example of an expert architect's sketch with middle degree of novelty and high degree of quality. The composition of this design is more complicated than the simple shapes and has a specific composition but there is no element of surprise. Therefore, the judges evaluated the sketch as a middle degree of novelty. Furthermore, this designer allocated appropriate zones for each function (supermarket, repair shop, private rooms, and restaurant) round the interior open space which is a suitable answer for both connections and climate. Therefore, the judges evaluated the design as a high-quality idea.

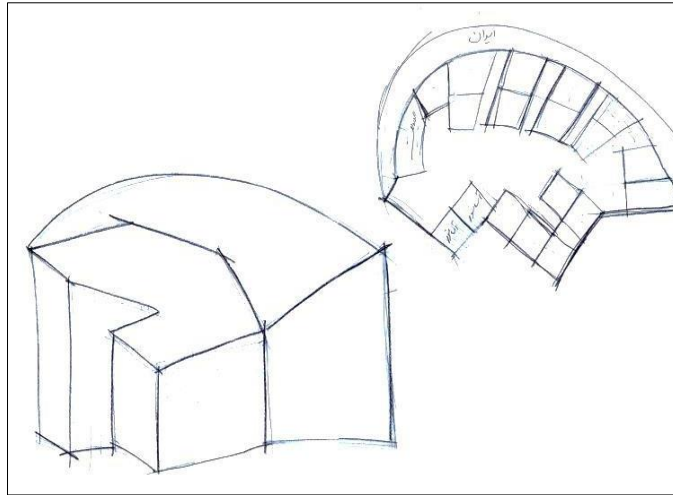


Fig 1. An example of a novice student's sketch, novelty score: 2, quality score: 1

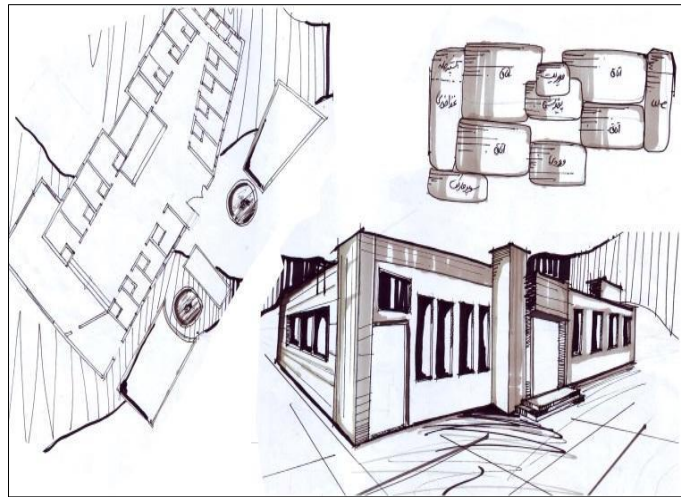


Fig 2. An example of a novice student's sketch, novelty score: 2, quality score: 3

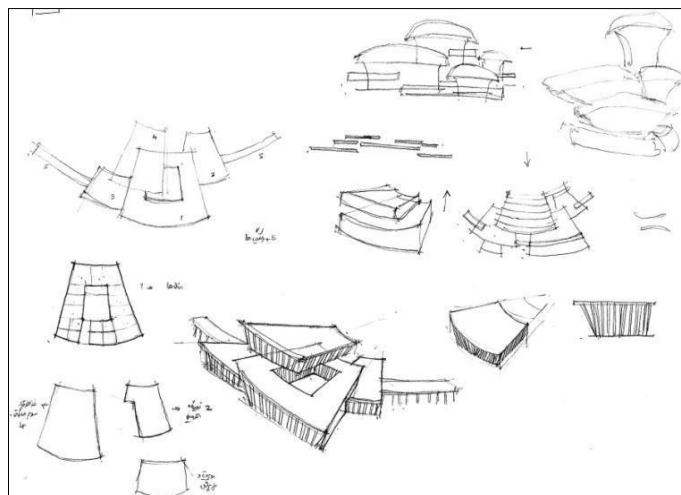


Fig 3. An example of an advanced student's sketch, novelty score: 5, quality score: 3

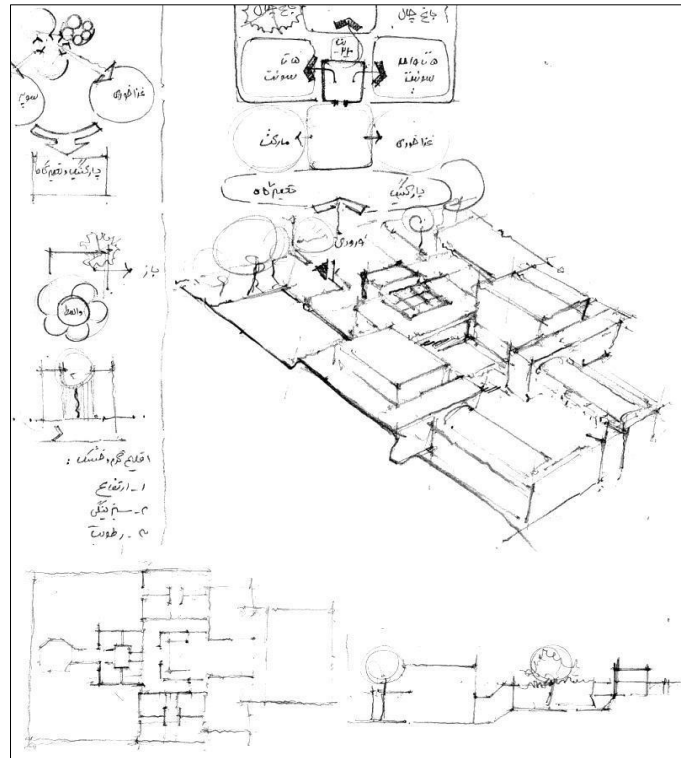


Fig 4. An example of an advanced student's sketch, novelty score: 3, quality score: 5

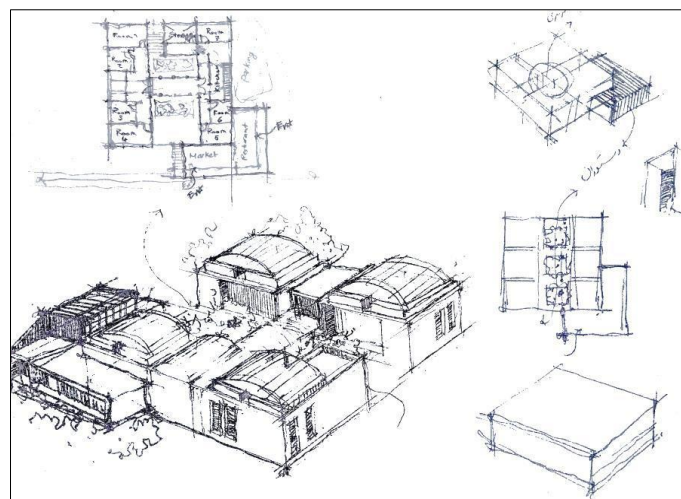


Fig 5. An example of an expert's sketch, novelty score: 3, quality score: 4

5. RESULTS

To determine whether the design expertise has a significant relation with the creativity (quality/novelty) of design idea, we conducted a multivariate analysis of variance (MANOVA) using novelty and quality scores as the dependent variables and expertise level (novice, advanced students, expert architect) as the independent variable. The results indicated a significant difference in creativity of ideas according to the expertise level (Wilks' $\lambda = .621$, $F(4, 184.000) = 12.381$, $p < 0.001$), which confirmed there is a relation between design expertise and the creativity of design ideas. A Tukey post-hoc test (Table 1) revealed that the quality of design ideas

is significantly different between novices and experts ($p < 0.001$), and advanced students and experts ($p < 0.001$) and suggested that the quality score of advanced students are more similar to novice students. But there is no statistically significant difference between groups in the novelty scores.

To test which aspects of creativity are related to the expertise level, Chi-square tests was conducted separately for novelty and quality factors. The Chi-square test was conducted to test Hypothesis 1 regarding each expertise group as an independent variable and the novelty of idea as the dependent variable. The results indicated that there is no statistically significant difference between the groups in terms of novelty of design idea:

$$\chi^2(8, N = 96) = 8.774; p = 0.362, p > 0.05$$

Another Chi-square test was conducted to test Hypothesis 2 and the results indicated that there is a significant difference between the groups in terms of quality of design idea:

$$\chi^2(8, N = 96) = 37.503; p < 0.001, p < 0.05$$

Therefore, the first hypothesis was not confirmed, but the second hypothesis was confirmed, i.e. the design expertise has significant relationship with the quality of the design ideas (Figure 7), but not with the novelty of design ideas (Figure 6). In other words, the designers in higher level of expertise created ideas that have more quality but not more novelty. The standard residual test for each cell in the Chi-square cross-tabulation with the critical values of -1.96 and 1.96 was carried out as a post-hoc test, indicating that novice students produced more

ideas with low quality (std. Residual=2.2) and less ideas with very high (std. Residual=-1.9). Expert architects produced ideas with significantly high quality (std. Residual=2.5) and very high quality (std. Residual=2.8), and produced less ideas with low quality (std. Residual=-2.6). The results for the comparison between the three expertise groups are shown in Table 2 based on the novelty of design idea and in Table 4 based on the quality of design idea. A Spearman's rank-order correlation was run to determine the relationship between novelty and quality scores. There was a weak, positive correlation between novelty and quality of design ideas, which was statistically significant ($r_s=0.225$, $n=96$, $p<0.01$). Therefore, novelty and quality of ideas are not independent of each other, and have positive relations, but this correlation is weak.

Table 1. The multiple comparison test results between different groups of design expertise.

Dependent Variable	(I) Design expertise	(J) Design expertise	Mean Difference (I-J)	Std. Error	Sig.
Novelty	novice student	advanced student	-.44	.258	.211
		expert architect	-.25	.258	.597
	advanced student	novice student	.44	.258	.211
		expert architect	.19	.258	.748
	expert architect	novice student	.25	.258	.597
		advanced student	-.19	.258	.748
Quality	novice student	advanced student	-.47	.207	.066
		expert architect	-1.47*	.207	.000
	advanced student	novice student	.47	.207	.066
		expert architect	-1.00*	.207	.000
	expert architect	novice student	1.47*	.207	.000
		advanced student	1.00*	.207	.000

Based on observed means.

The error term is Mean Square(Error) = .688.

*. The mean difference is significant at the .05 level.

Table 2. The chi-square cross-tabulation results of novelty scores of the different groups of design expertise.

		Novelty					Total	
		Very low	Low	Middle	High	Very high		
Design expertise	novice student	Count	5	10	13	2	2	32
		% within Design expertise	15.6%	31.3%	40.6%	6.3%	6.3%	100.0%
		Std. Residual	1.7	-.2	-.2	.0	-.7	
	advanced student	Count	2	8	15	2	5	32
		% within Design expertise	6.3%	25.0%	46.9%	6.3%	15.6%	100.0%
		Std. Residual	-.2	-.8	.4	.0	.9	
	expert architect	Count	0	14	13	2	3	32
		% within Design expertise	0.0%	43.8%	40.6%	6.3%	9.4%	100.0%
		Std. Residual	-1.5	1.0	-.2	.0	-.2	
Total	Count	7	32	41	6	10	96	
	% within Design expertise	7.3%	33.3%	42.7%	6.3%	10.4%	100.0%	

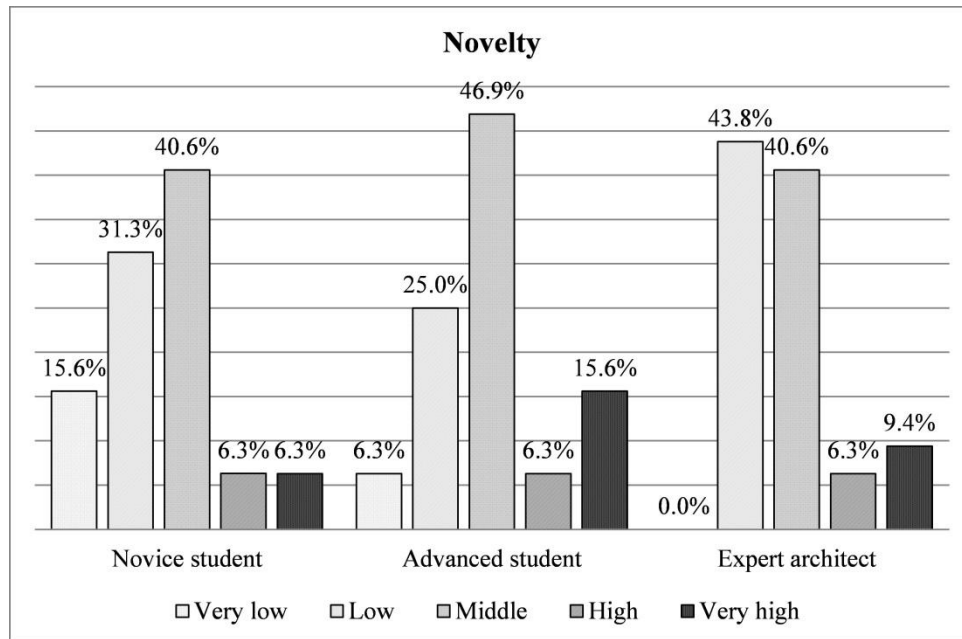


Fig 6. The degree of idea novelty with respect to the level of expertise (% within design expertise).

Table 3. The chi-square cross-tabulation results of quality scores of the different groups of design expertise.

		Quality					Total	
		Very low	Low	Middle	High	Very high		
Design expertise	novice student	Count	3	15	13	1	0	32
		% within Design expertise	9.4%	46.9%	40.6%	3.1%	0.0%	100.0%
		Std. Residual	1.4	2.2	-.2	-1.7	-1.9	
	advanced student	Count	1	10	16	3	2	32
		% within Design expertise	3.1%	31.3%	50.0%	9.4%	6.3%	100.0%
		Std. Residual	-.3	.5	.6	-.8	-.9	
	expert architect	Count	0	1	12	10	9	32
		% within Design expertise	0.0%	3.1%	37.5%	31.3%	28.1%	100.0%
		Std. Residual	-1.2	-2.6	-.5	2.5	2.8	
Total	Count	4	26	41	14	11	96	
	% within Design expertise	4.2%	27.1%	42.7%	14.6%	11.5%	100.0%	

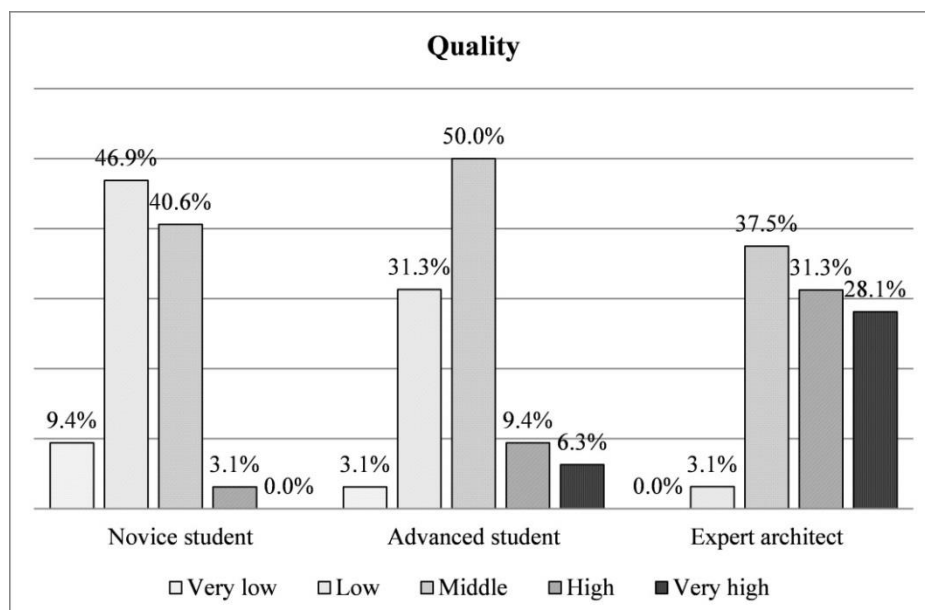


Fig 7. The degree of idea quality with respect to the level of expertise (% within design expertise).

6. DISCUSSION

In this study, we present the results of an experiment that tested the hypothesis whether design expertise improves the creativity of design ideas. There are some empirical researches that demonstrated the positive impact of expertise on creativity (Ericsson, 2014; Martinsen, 1995; y. Martinsen, 1993; Reilly, 2008). But in the design fields, there is little evidence that directly proved the positive effect of expertise on the creativity of ideas. In this research, we examined the relations between design expertise with novelty and quality of design ideas in three groups of architectural designers. Results demonstrated that there is a positive relationship between the level of design expertise and the quality of design idea, but there is no significant relation between the level of design expertise with the novelty of design idea. Some past researchers found similar evidence. Ozkan and Dogan (2013) found that expert architects consider the economy of time and practicality of design, preferred mental hops; but novices preferred mental leaps and looked for originality. Similarly, our findings demonstrated that expert designers produced ideas with more quality but not more novelty, and that confirmed experts look for practicality of ideas and not novelty. As noted before, design expertise does not simply develop over time, but guided training and practice are necessary for a person to mature. Therefore, we cannot ignore the importance of the nature of training and exercise included in their architectural education program.

7. CONCLUSION

This paper aims at exploring the difference between architectural designers' creativity levels based on their design expertise. One of the hypotheses of this study was rejected according to the results, i.e. there are no significant relation between design expertise and the novelty of design idea, but the other one was confirmed, i.e. there is a positive relation design expertise and the quality of design idea. In other words, experienced designers created ideas with better quality, but not more novelty. The reasons behind these results can be discussed with regard to expert architects who preferred mental hops, and novices who preferred mental leaps. Experts look for practicality and better answer the design problem while novices are concerned with originality. In this paper, we had doubt in the assumed positive relation between expertise and creativity and we discussed that design expertise has a complicated effect on different aspects of creativity. Further studies must be conducted to conclude how different aspects of creativity benefit from expertise.

The suggested areas for future research are a) studying the effect of expertise on the other aspects of creative ideation, b) some changes and revisions in the methodology, like as time duration and context, c) the effect of generating as many ideas as possible within given time, and d) pursuing the change in the creativity of one group of defined designers during the growth of their experience.

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