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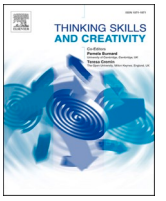

How to learn to be creative in design: Architecture students' perceptions of design, design process, design learning, and their transformations throughout their education

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ABSTRACT

The study explores students' perceptions of experiential learning, design and design process, and design education, and whether these perceptions vary according to school year students are in based on qualitative and quantitative data collected from two architectural schools. We inquire into how creativity and design could be learned through repeated design tasks without structured instructions about the creative design process. The explorative study employs surveys and semi-structured focus group interviews. The results indicate problem-solving view of design is the most common characterization, students think design is not a straightforward problem solving and is most related to art and creativity. Finally, students report school has a limited impact on how they learn designing. We conclude experiential learning in the studio create shortcomings if not accompanied with a critical and reflective stance and that undertaking design tasks one after the other without explicit reflection on these tasks is an inefficient strategy in learning about the creative design process.

1. Introduction

In this explorative study, we inquire into the perceptions of architecture students from four undergraduate levels about design, design process, and design education and how education contribute to their learning based on qualitative and quantitative data collected from two architectural schools. We inquire into how creativity and design could be learned through repeated design tasks undertaken during school years without structured instructions on the creative design process.

Design learning often follows a pedagogical paradigm, labelled as learning-by-doing (Yuan, Song, & He, 2018), according to which students are expected to implicitly learn through undertaking design tasks and its learning outcomes are evaluated based on design products without evaluating what students learn about designing (Lawson & Dorst, 2013). Schön (1984, 1987) highlighted architectural design studio as a prime location of reflective learning facilitated through learning-by-doing. The experiential learning theory of Kolb (2015) offers a close parallel to Schön's theory and it is taken by researchers as an adequate framework to understand design learning (Demirbas & Demirkan, 2007). Others have also underlined the significance of Schön's and Kolb's theories highlighting the importance of direct involvement in what is being learned (Wallace, 1996; Yuan et al., 2018) and the role of reflection in learning (Moon, 1999). Both Kolb and Schön, however, argue that experience solely is not sufficient for learning. Schön suggests that reflection needs to accompany the experience and Kolb, in reference to Kurt Lewin, extends the reflective practice stressing the cyclic nature of

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learning which involves repeated stages of concrete experience, reflective observation, abstract conceptualization, and active experimentation.

Design learning proceeds through students' attempts at dealing with design tasks given successively in the studio and these tasks are expected to help them synthesize topics covered in theoretical courses. As Van Dooren, Van Dorst, Asselbergs, Van Merrienboer, and Boshuizen (2019) state the knowledge of different domains in architecture are covered in theoretical courses. How synthesis of the knowledge from different domains could be achieved or what is exactly learned, however, remains to be a puzzling aspect of design learning since what design entails often is not directly addressed in the studio (Van Dooren et al., 2019).

Research in design learning have not taken full advantage of neither Schön's nor Kolb's theories with few exceptions (Lousberg et al., 2019; Quayle & Paterson, 1989). The ramifications of Kolb's theory is restricted to identifying learning styles in design learning and how it might relate to performance rather than the dynamics of the learning process (see Demirbas & Demirkan, 2007; Kvan & Jia, 2005; Newland, Powell, & Creed, 1987). Schön's attempts (1984; 1987), on the other hand, at explaining the dynamics of design learning are episodic in character, therefore, insufficient in demonstrating how design students learn how to design.

Kolb (2015) highlights that learning is a tripartite development involving learning about curriculum content, preferred learning styles of a discipline, and most importantly growth and creativity objectives. In this study, we specifically focus on the last two prioritizing students' impressions of how they learn to design and to be creative. We claim that design learning provides a unique opportunity in studying not only how a particular topic is learned but also investigating how they learn about the process of designing through their experience, and how above all they learn to be creative without explicit instructions. The study inquires into design learning from the perspective of beginning, sophomore, junior, and senior level students, who were from two architectural schools which follow a learning-by-doing approach of design learning without explicit instructions and courses on how to design. We expected to see differences among students from different levels because as instructors we assume that schooling has a significant impact on students. We also inquire whether there are specific designer types that students subscribe to in reference to different design models from design studies using a questionnaire and conducting focus group interviews.

1.1. Implicit learning in design studio

In the learning-by-doing paradigm, students are expected to acquire an understanding of design implicitly through designing rather than through formal methods of teaching (Kowaltowski, Bianchi, & De Paiva, 2010; Ledewitz, 1985; Van Dooren et al., 2019). Quayle and Paterson (1989) state that reflection in design studio is seldom introduced explicitly. Schön (1987), however, claimed that interactions between studio instructor and design students are rich episodes of reflection. He states that 'coaching', which designates guidance by the instructor, and 'reflective practice', which emphasizes the role of reflection in and on action, as two main devices in this type of learning. Schön (1987) states that in this type of learning students has to be active in discovering what is to be learned and concisely pinpoint the challenge the student faces in design learning, because, he is on his own in learning what is supposed to be learned 'although the right kind of telling may guide his seeing and thus help him see what he needs to see' (p. 151).

One criticism brought against Schön's view of learning is that his illustrative cases are at best examples of knowing-in-action and reflection-in-action, yet they rarely touch upon reflection-on-action and reflection on reflection-in-action (Newman, 1996, 1999). Webster (2008) criticized Schön's view arguing that it portrays the design studio as an over-idealized environment of learning. While some others, such as Christiaans and Venselaar (2005), questioned the effectiveness of project-based learning in general.

Different from the learning-by-doing paradigm, the developments of sixties and seventies in design methodology, challenged the implicit learning in studio and emphasized the formalization of design knowledge (Keller, 2006). During these years, there was a strong optimism that studies in design methods would demystify the design process (Broadbent, 1973; Jones, 1970). Design methods seemed to provide an explicit formal framework for the teaching of 'how to design' (Fowles, 1979). Schön's theory of reflective practitioner (1987) was introduced in direct opposition to the positivistic assumptions of these attempts and some tried to introduce explicit reflection on design in the studio environment in the eighties following Schön's theory (see Quayle & Paterson, 1989).

Since than there have been critiques of the design methods movement from within (see Bayazit, 2004) and from outside (Colquhoun, 1969; Hillier, Musgrove, & O'Sullivan, 1972; Ledewitz, 1985) and criticisms voiced against formalizing design education (Snodgrass & Coyne, 2006). These criticisms also led to an inadvertent acceptance and continuation of implicit learning pedagogies together with a linear approach to design learning, which is a remnant of design methods, starting with analysis and continuing with synthesis. Together with and alongside these criticisms, several proposals about how to characterize design were laid out (see Akin & Akin, 1996; Eastman, 1969; Hillier et al., 1972; Maher & Tang, 2003; March, 1976; Schön, 1987; Simon, 1973; Snodgrass & Coyne, 1992). The learning-by-doing paradigm with its implicit emphasis on informal learning, however, remained a stable pivot in architectural education regardless of the multiplicity in design characterizations.

1.2. Design characterizations and design learning

Design learning builds upon students' implicit knowledge they acquired before school, expands this knowledge by design tasks that help students implicitly build a body of procedural knowledge, and aims at converting the procedural knowledge into declarative knowledge through panel critics as suggested by Polanyi (2009). The transitions from implicit to procedural to declarative knowledge are, however, rarely reflected upon.

We maintain that the design studies literature offers a variety of design characterizations, which could be taken as a basis for reflection-on-action and reflection on reflection-in-action. One of the first models of design from design studies is the conceptualization of design as ill-defined (Eastman, 1969; Goel, 1992; Simon, 1973). Simon (1973) defines design as a problem-solving activity where

the actual 'state' is structured through 'analysis' and solved with a proposition of a preferred one by 'synthesis'. Counter to Simon, Schön (1987) saw design more like a construction, consisting of incremental steps of changes in a given design situation by 'reflection-in-action' followed by 'reflection-on-action'. Hillier et al. (1972) argued that design is 'essentially a matter of prestructuring problems either by the knowledge of solution types or by the knowledge of the latencies of the instrumental set [technological means] in relation to solution type' (p. 7). One final design model is the insight view of design according to which problems are resolved through sudden emergence of flashes of insights (Akin & Akin, 1996).

The four models above, though not a complete list, indicate distinct characterizations of design based on the temporal order in which the solution is shaped. In design-as-problem solving, the solution comes later; in design-as-construction, the solution is constructed throughout the process; in design-as-conjecture-trial, the solution is proposed early in the process, whereas in design-as-insight problem the solution appears suddenly in the process. These models also allude to different designer types, i.e., an analytical problem-solver, a world-maker who constructs a solution, a solution-first designer, and an insight problem-solver.

We use these four characterizations of design as starting points to initiate a discussion with students, to map their conceptions of design, and to determine whether there are distinct student designer types in reference to characterizations of design. We also inquired whether students' characterizations of design and their views would change with schooling or not.

2. Method

A mixed research method, consisting of a questionnaire and semi-structured focus group interviews with undergraduate architecture students from four different levels was employed in the study conducted.

2.1. The participants

The questionnaire participants (n = 364: 116 male, and 248 female; 113 first year, 87 second year, 103 third year, and 61 fourth year) were from two architecture schools (n = 158 School 1; n = 206 School 2).

For the focus group interviews (n = 30: 12 male, and 18 female; 8 first year, 7 second year, 8 third year, and 7 fourth year), we followed a purposeful sampling strategy (Creswell, 2007) to ensure multiplicity of opinions. The profiles of the interviewees varied from successful to failed students.

Focus group interviews are excellent in collecting and exploring opinions in depth (Sommer and Sommer (1997) since the interaction among members of the focus group could bring out new topics that would otherwise be not discerned (Creswell, 2007). Sommer and Sommer (1997) state that through focus groups it is possible to understand the rationale behind participants' responses to particular questions.

All interviewees volunteered to participate in the focus group. Volunteer participants are more likely to provide explanations on the reasons for their answers (Creswell, 2007). However, it is possible that some group members would be more dominant during discussions which needed to be especially taken into consideration by the moderator (Creswell, 2007).

2.2. Materials

The questionnaire was composed of 14 questions, an explanation describing the study aim, and a series of profile questions. Three questions, i.e., one rating question, one open-ended question, and one with multiple answers, were left out of the analysis since their format was different from the rest of the questions, which were all closed-ended questions (Creswell, 2012). Closed-ended questions required participants to select one possible answer that is closest to them since we investigate the participants' tendencies regarding the subject of inquiry (see Appendix A, Supplementary Material). In this self-administered questionnaire, by supplying participants a specific set of fixed responses, we wanted participants to provide substantive answers to questions (Lavrakas, 2008). Using closed-ended questions is practical in comparing participants' responses, however, they force participants to select a preset category and may leave out some of the other potential responses not included in the given categories (Creswell, 2012). We conducted focus group interviews primarily to alleviate this problem.

The questions were grouped under three topics: 'design characterizations', 'design process', and 'design education'. The first includes three questions (how design is defined; what design is most related to; and what success in design is most related to) to collect information about participants' opinions about what design is. The second section includes three questions (how one reaches a design idea; the path followed when starting to design; and which activity in design is the most important) focused on participants' experiences of their design process. The third includes five questions inquiring into how students' design process is shaped, students' ideas on design education, tutors' role in the design studio, the exchange of knowledge between students and tutors, and students' dependency on their tutors.

The first question asked students to characterize design. With this question, we limited the characterizations of design to four different definitions as explained above. The responses to this question were used to determine the designer type of student, i.e., whether a problem solver, a constructer of an idea, a solution first designer, or an insight problem-solver.

A pilot study was administered with a separate group to ensure questions were clear and unambiguous. A test-retest reliability analysis, with a two-week long break between the tests, was conducted after the pilot study with a second group of design students. The agreement rate between the tests was 70.7 per cent when Q13 (in what ways the information exchange between students and studio instructors occur) is left out of the analysis because in two-weeks period the format of interaction might have changed during the course of the semester. When Q13 is included the agreement was 65.3 per cent.

The focus group interviews investigated the same three topics in an open-ended format. A sound recorder was used to record the interviews.

2.3. Procedure

Starting the survey, the research objectives were explained to students and their verbal consent was taken. Questionnaire sessions took about 15−20 min followed by a short session determining the volunteers for the focus groups. The interviews were conducted separately with minimum three and maximum four people and each lasted between one and two hours. There were in total eight focus groups with one group from each school for every level. One of the authors moderated the discussions.

2.4. Analysis

The interview data was transcribed verbatim and was interpreted qualitatively to provide a thick description of students' opinions. A thematic analysis was conducted where each choice used in the questionnaire form in closed-ended questions were utilized as separate themes for the qualitative analysis. First, we applied structural coding to the data to make the large qualitative data set more manageable. Structural coding refers to question-based codes (Macqueen, McLellan-Lemal, Bartholow, & Milstein, 2008; Namey, Guest, Thairu, & Johnson, 2008). In further analysis, a theory-driven approach, based on the four models of design characterizations, is used. In this step, the authors coded the four design characterizations (see Table 1) together with four subthemes under design learning as exemplified in Table 1. An independent coder, given 10 per cent of the data, was asked to code these four design characterizations and four subthemes of design learning. The independent coder, an academician experienced in design education, was given a detailed description of the coding categories together with transcriptions of a focus group interview. We used the Delphi Method to determine the inter-rater agreement. In the first round of discussion, there was 68.75 per cent agreement between the authors' coding and that of the independent coder. After the second round of discussions, there was 90.62 per cent agreement.

The data from questionnaire was analyzed quantitatively. Cross tabulation was applied to summarize categorical data from the questionnaire to create contingency tables about the relationship between variables. A statistical hypothesis test was applied on the answers of the survey questions to determine the statistically significant results using Chi-Square tests or Fisher's Exact test. Statistically significant results were further analyzed using post-hoc tests comparing the standard residual values for each cell in the chi-square cross-tabulation to the critical value (-1.96 and +1.96).

2.5. Schools

The design education in the studied schools shows features of the learning-by-doing paradigm in terms of structure, content, and methods. The schools are similar in their curricula and studio pedagogy fostering a hands-on, implicit approach to design learning without any formalized model or course dedicated to the design process. Their undergraduate education consists of four years with two semesters per year and one design studio course for each semester.

Table 1
Data extract, with codes applied.

Theme	Sub-theme	Data extract
Design Characterizations	Design as problem solving	That (design) process has various components. Firstly, a problem is given when we start to design. We have a look at the project site and conduct several analyses considering the (given) problem. We both do analysis regarding the project site and about the problems regarding the project. Based on these analyses, some things start to take shape for the project which we call design.
	Design as Construction	I think, it is process where you define the problem and search for the solution by yourself.
	Design as conjecture - trial	In my opinion… I think I design by trial and error. Before coming to the design crit, I make a few different models. I work on colors, the façades, form on these models.
	Design as Insight Problem	Unfortunately, design doesn't descent as a revelation. At least not to me. That is why it does not come to me as "A-ha! Design!" But, when I have a pen and paper in front of me, when I have the program next to me, and there are examples, I doodle, I keep doodling. It comes to me as "A-ha! Design!" That is when one says "A-ha! [it] Emerged."
Design Learning	Ways of learning to design	There can be various ways of learning. Besides, after we graduate, we kind of get into similar process (where one does everything what the experienced architect told from drafting to anything in construction) But, I think school is very important. Because we start with our peers. Otherwise, if think of it like you are with very good architects and you know nothing, zero. That would have been really heavy. Following from a distance. That's why being at school, being with peers is good…
	topics during interacting with instructors	We have two types of instructors. First one, most of them, tells what is missing in our projects: 'This is not right, you have to fix this, make a research…' We make a research about it, we learn how it must be done and do it, then we get a new critic. The other type of instructor tells just the subjects that we must make a research about and gives examples of projects to look at and analyze.
	ways of interacting with instructors	We have instructors that make corrections by drawing. "Look, this is not like this, it has to be like this". I think this is really encouraging.
	frequency of interacting with instructors	We just met with the instructors at juries… I was happy with it. Actually, as you stated in the question, once in a while especially when needed would have been better. It was not allowed to ask for critic about our projects in times other than juries. I think it shouldn't have been like that. People should have been able to get something from the instructors when they needed it.

3. Qualitative analysis

The interview data revealed a wide range of opinions indicating that students were pleased to have the opportunity to talk about their learning experiences. They were able to verbalize what they know about their learning experiences. Below we summarize the interviews under the headings of design, design process, and design learning.

In total, we coded 176 comments in all the interview transcripts. On average there were 22 (SD = 4.08) coded comments per interview sessions and 16 coded comments per question themes (SD = 4.08; max = 25 for Q3: what is success in design most related with?; min = 6 for Q12: what do you talk about the most with your instructor during crits?).

3.1. What is design?

Many students mentioned that design is problem solving (59 per cent of all the related coded comments) often adding that it is an artistic problem solving effort (73.68 per cent) and few reported that it is close to engineering (10.53 per cent). The reasons why students think of design as problem solving is the importance of function in design and that it offers a solution to a problem. They also agree that it is closer to art because it is creative.

No matter how much students think of design as problem solving, creativity is often cited as the most important aspect of design (48 per cent). While some, especially those who are beginners, associate creativity with inspiration, more advanced students see creativity as related to knowledge, skill, experience, and research. Some start with the idea that design is an inspirational act enabled through the muse of inspiration. As a second-year student put it, they eventually realized that the muse never arrives without fully abandoning the hope that one day it may arrive:

> I used to think that…there is truly a muse of inspiration and that sometimes while you wait, it suddenly arrives. I thought just like they start writing poems unexpectedly, you would have a project in your mind and you would design a project… However, since the day we arrived at school the thing they explain to us is that 'no it has no connection with inspiration, no connection with skill, that it is something learnable.' However, I still think there is may be a half-half chance that there is inspiration.

Often the realization that the muse does not just drop in is accompanied with a sense of frustration and not knowing what to do. Students sometimes enjoyed commiserating about their mutual frustration. A fourth-year student expressed jokingly how instructors constantly tell them that they should not wait for the inspiration and that they rather should grab and bring it. Another one complained:

> Unfortunately, when I was in first and second year I kept waiting and waiting for the inspiration and I failed the class. The inspiration does not arrive while waiting. It is not something like that. It happens through research. By looking at magazines, at buildings around you. These are not, however, taught to us. We learned these through repeated failures, through trial-and-error, through learning-by-doing.

Or as a third-year student reported the inspiration arrives only after doing research or being concentrated on a design topic and never while waiting idly suggesting more of a constructive process through which the design idea is shaped. Another third-year student stated inspiration is only the first image in someone's mind and it all depends how one develops that through drawing implying a conjecture-trial approach to design.

While students are instructed inspiration just does not offer sudden visits they appear to learn that creativity might have something to do with research, knowledge, skill, or experience. When they were asked, what is most important for success in design, students overwhelmingly specified creativity (48 per cent) but also saw creativity as in relation to either knowledge (8 per cent), skill (12 per cent), or experience (32 per cent).

3.2. Design process

When students were asked about how they start the design process their answers indicate that one needs to either start drawing possible schemes (35.71 per cent), or try to better define the problem (28.57 per cent), or think intensely (21.43 per cent), or look for other relevant cases (14.29 per cent). A fourth-year student summarized it:

> Unfortunately, design doesn't descent as a revelation. At least not to me. That is why it does not come to me as 'A-ha! Design!' But, when I have a pen and paper in front of me, when I have the program next to me, and there are examples, I doodle, I keep doodling. Only then it comes to me as 'A-ha! Design!' That is when one says 'A-ha!' [it] Emerged.

Another fourth-year student stated in agreement that he does not believe the origin of the idea is mysterious adding that one needs to start from the givens and by looking at what others did and did not accomplish. Students from different levels mentioned that the first stage in design is identifying what the problem is, indicating that problems are seldom given in a complete form, followed by a structuring phase reminiscent of general stages of problem solving. As early as in first year some students realize that before analysis of any data one needs to notice what the problem is as a third-year student reported.

Few students mentioned that to look at examples early on might limit creativity. Some stated that they would rather concentrate on the site, the context, the user, or the problem until they formulate a generic conceptualization, which would be developed step-by-step later. It might happen that these conceptualizations are formulated through incubation as one student put it 'while watching television you stop and think. You relate what you see with the problem' or as a second-year student explained '…this semester the first two or three weeks I didn't do anything because I had nothing formulated in my mind…then suddenly I thought of a section from which a plan

emerged.' A third-year student similarly reported the importance of formulating an idea in the beginning while also highlighting that the formulation does not necessarily mean a complete solution of the problem. The student stated 'the starting point, I think is the thinking stage. Because once you have an idea, once something begins to get clarified in the mind, it seems to me that the path gets clearer, may be not quickly and easily, but steadily.' Even though the conceptual formulation is considered important, some students mentioned the difficulty in translating the concept into a design scheme, as one fourth-year student put it, 'Once these things [conceptual formulations] are formed it is time for massing, which I think is the difficult phase. Otherwise I have no difficulties with the concept.'

When students discussed what the most important activity in design is, they were divided among themselves into 'analyzers' (36.36 per cent) and 'synthesizers' (27.27 per cent), as what some students had labeled. The others mentioned incubation (9.09 per cent) and about more than a quarter stated how waiting passively for inspiration is not a reasonable alternative (27.27 per cent). Analyzers often mentioned the importance of understanding the given problem in full detail while synthesizers highlighted the significance of bringing together pieces in a meaningful way as one fourth-year student explained, 'I spend lot of time bringing together the pieces. But once I have the pieces ready in my hand it is to bring them together for me.' Some others who are synthesizers, though, seemed to suggest what is important is to formulate a general idea echoing mostly a conjecture and trial view of design. A fourth-year student stated, 'Analysis, that is to say to understand it well, is important yes but I think one has to do that anyway. I don't dwell on that too much during design. What is important to me is rather to have something different.'

Some synthesizers claimed that no matter how much preliminary analysis one puts in at the beginning of the design what matters the most is the way the project is shaped in the end. A second-year student explained:

> No matter how well it is analyzed, how well the analysis is, that is to say to have a solid foundation…if you can't bring it to a conclusion, and this happens often…It happens often that in the first weeks some start before everybody else with a big jump but later they stay behind. Or it is also possible to start slowly than proceed step-by-step to finish the project decisively. That is why the first decisions are important, yes, but to me it is more important to develop them.

Even those who claimed they are analyzers were aware of the shortcomings of relying solely on analysis. At this point some mentioned the importance of incubation as a fourth-year student explained:

> I am truly an analyzer. What could be inferred from what? I am in constant search. I work heavily on the context. However, what elevates the design to the next level is the incubation period. Because once I collect all the data, I always experience a blockage. Because my head is overloaded. I can't proceed. At some time during mid-semester, I feel truly down. I would go for horse riding, I would do anything. I would go to another city. I would go visit my family for fifteen days. During that time everything settles. I invigorate my mind.

A fourth-year student highlighted the intrinsic problem in the analysis first synthesis second view of design complaining about how school induces in them a sense that analysis is important without showing how they could go from analysis to the final product. The student said, 'They [the instructors] showed us the analysis. They told us 'you need to do analysis. Analysis is important for our school. The starting point is analysis, and the end is the final product. However, you need to shape the process between the two. There is no fixed method for this. Everybody is going to shape it according to themselves.'

3.3. Design education

This last point brings up the relevance of schooling in learning to be creative and how much the studio helps students shape their design process. When students were asked how their design process is shaped some responded by practice and trial (37.5 per cent), some with the help of their senior friends (37.5 per cent), and only a few of instructors (12.5 per cent), or that they have no set strategy they follow (12.5 per cent). As a third-year student mentioned the instructors expect students to shape their design process on their own stating, 'They [the instructors] anticipate students will improve by themselves. Because, we are not in a major where the answers are easily given. Everybody got used to finding their answers by their own methods.'

In this process of learning the instructors provide sometimes solely a judgement on the quality of the work and if the judgement is favorable the student proceeds to the next stage and if not the student starts from the beginning. At other times, the instructors provide directions, which could be understood by students as instructions to be closely followed. As one first-year student explained once the instructors' wishes are realized one can elaborate on the project. The same student thought the interaction between the instructor and the student is like a relay race and the baton is passed from the instructor to the student and the student is expected to finish the race. Another fourth-year student, though, highlighted the importance of learning from senior friends by observing and noticing how the more experienced students tackle with design problems without literally being instructed by them.

Interestingly, when students were asked where the best place is to learn how to design, the majority responded school (92.31 per cent). As one first-year student explained, students thought they are exposed to different views at school rather than one single view, as they would have been at a master architect's office working as an apprentice. However, it is also mentioned there is a similar threat in schooling as well, i.e., in being molded in one particular way. An interesting answer is provided by a second-year student who stated that it is an advantage to be in an environment where everybody is a beginner rather than starting at a place full of masters. Another reason why students thought school is a good place to learn is that they believed school provides a foundation on top of which they can improve themselves on their own. Some students thought architecture cannot be learned within four or five years or one does not become an architect upon graduation, however, one learns how to learn at school. A fourth-year student stated, 'They [the instructors] show only how we can get to the knowledge. We reach it on our own and learn it.'

When students talked about what is learned during studio crits, overall majority reported that the crits are primarily about the

design product (66.67 per cent). Some instructors, as one third-year student complained, control the process from the beginning until the end. Another third-year student reminded that students need to resist against such control. Similarly, a fourth-year student confessed that once she stopped worrying about her grades and pleasing instructors, she felt relieved:

> To be honest I became a successful student when I got rid of the stress of grades. That means once I left aside what the instructors think, I realized that I could get somewhere. Therefore, I saw that master-apprenticeship relationship did not help me much. Once I was able to approach my instructor without any worries, once I could say this is my opinion and the instructor could provide an interpretation [I was able to be successful].

When students discussed what is the best medium of interaction with their instructors, i.e., panel reviews, individual desk crits, group desk crits, or corrections, they split almost equally among themselves between those who are in favor of panel reviews (45.83 per cent) and those who are against it (37.5 per cent for one-on-one desk crits and 16.67 per cent for group desk crits). Those in favor valued the multiplicity of opinions they are exposed to during panel reviews. Those who are against often complained about the stress they are under, or sometimes even the fear they feel during panel reviews, or stated that they do not understand any of the comments, or even that sometimes it causes anger in students. As one first-year student stated some students feel tense to have to present in front of a big crowd so much so that they do not hear anything said. Another first-year student offered that during panel reviews all what is being talked is the design product and nothing else. A different first-year student expressed frustration at when a reviewer's negative comment is shared by other reviewers who actually were favorable of the project during desk crits. To a second-year student the panel review is a place where a student feels reduced to a marketer's position. Another second-year student mentioned the lack of a dialogue during reviews while another one complained about how the reviewers are preconditioned to criticize the projects. Two other second-year students evoked strong analogies, one to a battle and the other to a trial, while talking about panel reviews. The panel review becomes a battlefield when the reviewers are seen in an offensive position and the student in a defensive position. It becomes a trial when the exchange of knowledge and resolution of different opinions are not favored and only passing a judgement is enforced. In contrast, those who were in favor of reviews highlighted how important it is to hear a multiplicity of opinions after working with a single instructor. The chance to show their work to a panel is an opportunity to get various feedback and to practice to present projects. Interestingly, a second-year student stated that panel reviews are helpful for students who are in the audience rather than presenting students, who are in no position of hearing neither understanding anything said.

The last topic covered was the preferred frequency of consulting a studio instructor. All first-year students replied they would like to see their instructors almost every day. Students from other levels, however, preferred to see the instructors only when they need help (55.56 per cent). A second-year student hoped that he could see the instructor any day of the week whenever he would like to talk. A third-year student reported that a fixed schedule with instructors does not make sense because the creative production does not follow the weekly schedule of the studio and to expect it otherwise would be a useless enforcement. Finally, a fourth-year student stated that they should talk to the instructors only when it is needed.

4. Quantitative analysis

The results from the questionnaire are statistically analyzed and summarized below under the same subheadings as the qualitative analysis.

In the first round, we investigated whether class level has a significant impact on students' answers. Chi-Square test results comparing the four levels indicate that the results for five questions were significant: how students define design (Q1, χ^2 (9, N = 362) = 22.144, $p < 0.008$); what is more related to success in design (Q3, χ^2 (9, N = 357) = 18.951, $p = 0.026$, $p < 0.05$); the path followed at the beginning of design (Q7, χ^2 (9, N = 358) = 20.672, $p = 0.014$, $p < 0.05$); in what ways the information exchange between students and studio instructors occur (Q13, (N = 368) $p = 0.0005$, Fisher's exact test); and what are students' preferences for frequency of consulting their instructors (Q14, χ^2 (9, N = 357) = 56.362, $p = 0.000$, $p < 0.05$).

In the second round of analysis, we looked at the association between responses to Q1, which indicated the designer type of a respondent, and the answers to other questions. Results indicate a significant association between a small group of students who think design is an inspirational artistic activity (Q1 choice b) and what is more related to success in design (Q3, χ^2 (9, N = 355) = 23.130, p <

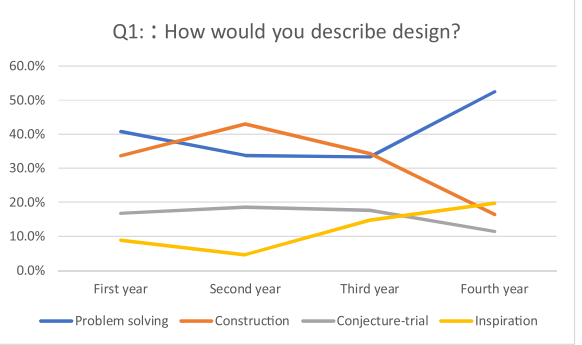

Fig. 1. The distribution of the percentages of students from each year according to how they describe design (Q1).

0.006); how a design idea is reached (Q4, χ^2 (9, N = 359) = 31.149, p < 0.000); the path followed at the beginning of design (Q7, χ^2 (9, N = 356) = 32.189, p < 0.000); and the most important activities while designing (Q9, χ^2 (9, N = 361) = 19.577, p < 0.021).

4.1. Students' conception of design

Fig. 1 shows the percentages of students' characterizations of design from each year. Students' opinions from four levels differ significantly from each other with respect to how they characterize design (χ^2 (9, N = 362) = 22.144, p = 0.008, p < 0.05). Post-hoc analysis results indicate fourth-year students are slightly more likely to characterize design as an inspirational artistic activity (std. residual = 1.94) and less likely as construction of an idea (std. residual = -2.27). The fourth year deviates significantly from the average in selecting the construction of an idea option less (only 16.4 per cent compared to the average of 33.1 per cent) and the choice of design is an inspirational activity like any other artistic activity more (19.7 per cent compared to the average of 11.3 per cent).

With Q2 we asked students what design is most related to and students overwhelmingly thought design is most related to art (80 per cent) compared to engineering, science, and craft. There were no class or designer type effect on Q2 results.

When they were asked what success in design is most related to (Q3), the overwhelming majority (62.2 per cent) from all levels stated it is related to creativity (Fig. 2). Students from different levels differ significantly in what they think is most related to success in design (χ^2 (9, N = 357) = 18.951, p = 0.026, p < 0.05). Post-hoc analysis shows first-year students are less likely to relate success to skill (std. residual = -2.17) and second-year students more likely to experience (std. residual = 2.25). When the responses were analyzed according to designer type (Q3, χ^2 (9, N = 355) = 23.130, p < 0.006), those who think design is an inspirational artistic activity (11.3 per cent of all students) are more likely to relate success in design to skill (std. residual = 3.3).

4.2. Students' conception of design process

When students were asked how they reach a design idea (Q4), the majority (57.3 per cent) picked the construction of an idea from the design inputs compared to sudden flashes of insight, from previously self-produced projects, and from others' projects. We did not see a class impact on the results. Designer type, however, has a significant impact on Q4 responses (Q4, χ^2 (9, N = 359) = 31.149, p < 0.000). Those who think design is an inspirational artistic activity are more likely to state that design idea can come suddenly at anytime and anywhere (std. residual = 4.1) and less likely to be constructed out of design inputs (std. residual = -2.8).

When students were asked what is the path they follow when they start designing (Q7), problem structuring was the foremost choice among all students and waiting for inspiration was the least chosen answer (Fig. 3). The answers differed significantly (χ^2 (9, N = 358) = 20.672, p = 0.014, p < 0.05) according to class level. First-year students were less likely to look for similar projects (std. residual = - 2.24), while third-year students were more likely to consult similar projects (std. residual = 2.04). The results indicate a significant association between designer type and the path to be followed at the beginning of design (Q7, χ^2 (9, N = 356) = 32.189, p < 0.000). Those who think design is an inspirational act were more likely to wait for inspiration (std. residual = 3.9) and less likely to read the problem description again and again to understand it better (std. residual = -2.0).

Q9 asked students what activity in design is the most important and students thought analysis (40.2 per cent) and incubation (37.2 per cent), which was defined in the questionnaire as waiting for the development and maturation of an idea, were more important compared to synthesis (17.6 per cent) and inspiration (5 per cent). There were no class or designer type effect on Q9 results.

4.3. Students' conception of design education

The results from Q6 (How did your design process shape?) indicate that little more than a third of students (34.8 per cent) think their design process is shaped from the discussions in design studio or other courses. More students think they have no specific set process and that their process change from project to project (39.8 per cent). About one fifth mentioned that it is shaped by individual efforts (21.0 per cent). No significant class nor designer type effect was found for this question.

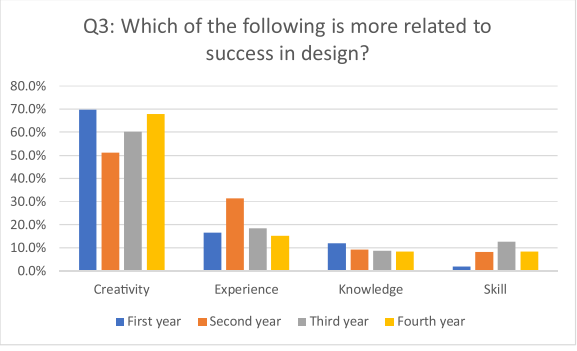

Fig. 2. The distribution of percentages regarding the selected choices by students of architecture to describe which more is related to success in design (Q3).

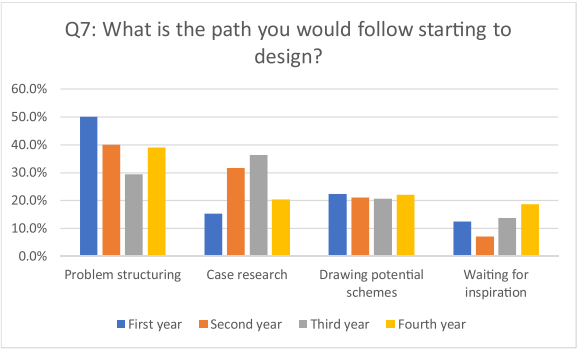

Fig. 3. The distribution of percentages of students with regard to the way they start to design (Q7).

To the question of how design would be best learned (Q11), half of the students thought design would be best learned in practice (49.3 per cent) while only a fifth thought school is the best place to learn (19.2 per cent).

Students were asked which topic is covered the most during crits (Q12). The majority (78.1 per cent) answered that they talk about their particular project and a few (4.4 per cent) answered they talk about design process.

When students were asked in what ways they interact the most with their instructors (Q13), the majority (71.8 per cent) picked one-on-one desk crits. Students' responses differed significantly ($N = 368$, $p = 0.0005$, Fisher's exact test). A post-hoc analysis indicate that first-year students state less likely one-on-one desk crits (std. residual = - 2.02), while third-year students less likely panel review crits (std. residual = - 2.62), and fourth-year students more likely panel review crits (std. residual = 2.45) and corrections from instructors (std. residual = 2.20).

When students were asked what frequency of talking to their instructors would be most helpful to them (Q14), more than half picked twice a week (Fig. 4). Their responses differed significantly (χ^2 (9, $N = 357$) = 56.362, $p = 0.000$, $p < 0.05$) with regard to class levels. A post-hoc test analysis indicate that first-year students are less likely to prefer to talk to their instructors once a week (std. residual = - 2.18) and more likely to want to meet every day of the week (std. residual = 3.64), and fourth-year students more likely to prefer once-a-week (std. residual = 3.72) and once in a while or whenever they need it (std. residual = 2.75).

5. Discussion

5.1. Students' conception of design

The problem solving characterization of design is either the most or second most view among students from all levels; and gains more prominence as students reach their fourth year, even though the percentage drops in second and third year. It seems that first year students' conception of design as problem-solving is only reinforced through their school years. Furthermore, the results indicate that fourth-year students are twice as more likely to pick design as inspiration and twice as less likely to pick design as construction of an idea.

The overall change with regards to design views from first year to fourth year is not a linear change, as one would expect intuitively. A linear change in favor of one of the views could have been attributed to a gradual shift caused by design education and would have been an indication of how students' conceptualizations were gradually shaped through experiential learning. Instead, experiential learning environment of the studio leaves it to students to configure what design is which we will summarize below.

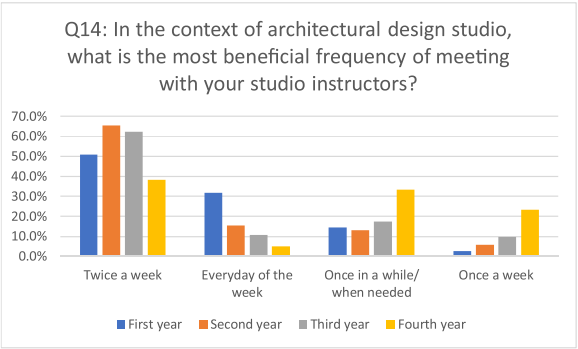

Fig. 4. The distribution of percentages of students' opinions of how often they would like to meet their tutors (Q14).

We infer from the results that design learning does not follow a linear progression towards one view of design similar to the course of development of design expertise, which does not show a linear progression either. As suggested by Lawson and Dorst (2013), the development of expertise at times surges and at times takes dips. Atman and Turns (2001), in contrast, report significant differences between first-year students and seniors in terms of their design quality scores and what they do with the time they spend during designing among engineering students. The discrepancy between Atman's studies and this study might relate to the difference between engineering design and architectural design (see Kolb, 2015), wherein creative problem solution is of utmost importance in architecture in contrast to engineering for which problems could be relatively more defined.

The dominance of the problem solving view is a robust finding. There is research that suggest that novices consider complex problems more like well-defined problems, for instance Rowland (1992). Similarly, in a study conducted among industrial design engineers, Christiaans and Dorst (1992) found that novices make less research and search for less information compared to experienced designers indicating that novices might be interpreting design more like straightforward problem solving without realizing the significance of adequate problem structuring.

Our results partially supports the findings of Rowland (1992) and Christiaans and Dorst (1992) and partially portray a more complex understanding of design. Students think design is problem solving as stated by studies above, yet they also relate it to art the most, which does not change with class level neither with designer type, and that success in design is best guaranteed with creativity suggesting a rather more complex view of design. Their conceptualizations, which show some similarity to experts' design problem solving from Rowland's study (1992), indicate a view of design, which is seen as a creative endeavor rather than a straightforward problem solving effort. We conclude that the majority of students think problem solving, art, and creativity are not exclusive to each other, and that design is closely related to all three.

It is apparent that the students recognize an association between creativity and problem solving. Newell, Shaw, and Simon (1962) suggested that "creative activity appears simply to be a special class of problem-solving activity characterized by novelty, unconventionality, persistence, and difficulty in problem formulation" (p. 66). In creative problem solving a solution to a problem may be unique or there may be several possible solutions (Halpern, 2003; Loewen, 1995). Mumford, Baughman, and Sager (2003) suggested that creative thinking is a demonstration of a type of multifaceted problem solving. Students' design characterizations are more in line with views from the literature reviewed above. However, we also conclude that how to be creative and how to learn to be creative are often left to the student as explained below.

Students may be recognizing the difficulties involved in the problem-solving view of design with its emphasis on the separation of analysis and synthesis and its shortcomings in making a transition from analysis to synthesis. This could explain the discrepancies between students' answers to different questions, which seem to suggest that students favor the problem-solving model without relinquishing the importance of art and creativity, while realizing the inherent difficulty in shifting from problem definition to problem solution.

Regardless of students' complex views of design, they still cannot fully deal with the puzzlement of creativity, i.e., how they can be creative in design, and are left on their own to figure it out as stated repeatedly in the focus group interviews. One obvious explanation to this is that explicit and reflective learning in creativity is often left out in design education (Lawson & Dorst, 2013; Ledewitz, 1985; Quayle & Paterson, 1989; van Dooren, Boshuizen, van Merriënboer, Asselbergs, & van Dorst, 2014). Another explanation might relate to expertise. Akin (1990) states that creativity in design is related to a recognition mechanism based on learning and recalling any visual representation by means of graphic chunks. Students, who are novices, may yet be forming these chunks. One piece of corroborating finding is that fourth-year students in comparison to others are more likely to think design is an inspirational artistic activity and less likely the construction of an idea. This might suggest that with expertise some students, even though very few, might be acquiring an artistic approach to design emphasizing an intuitive approach to tackle with design situations. One could interpret this change as a sign of expertise with which repeated procedures are turned into intuitions as explained by Simon (1987). Four years in design learning may not be sufficient for a qualitative change in expertise among students, yet in a small group of students, who are more likely to think that design is more inspirational in their senior year, we might think that they had acquired some expertise based on which solutions seem to be quicker and effortless.

One additional finding is the consistency of a small group of students, who think design is an inspirational artistic activity, in responding to other questions from the survey. Even though this group is the smallest group in size, the way they answer the other questions is closely associated with their designer type. We did not find a similar impact for other designer types. We do not see a consistent change in this group from first to fourth-year notwithstanding the significant difference among different class levels. Those who subscribe to this view consider skill to be more related to success when compared to other groups and they think that design ideas come as sudden flashes of light and less as constructed from inputs. This designer type seems to follow the general outlines of a romantic view of creativity according to which creativity relates most to insight or intuition (Boden, 1990).

The literature provides numerous definitions of creativity (Albert & Runco, 1999; Amabile, 1983; Boden, 1990; Csikszentmihalyi, 1996; de Bono, 1993; Gardner, 1982; Guilford, 1967; Joyce, Franklin, Neale, Kyffin, & Veronesi, 1998; Parkhurst, 1999; Sternberg & Lubart, 1999). For instance, Amabile (1983) suggests creative performance emerges from combinations of innate skills, learned abilities, and task attitudes. Rhodes (1961) suggests that definitions of creativity can be grouped under four interconnected elements, which are the creative person, the creative process, the creative product, and the creative environment. Interviewees' accounts indicate an awareness of these four elements of creativity. They commonly mention peers as creative persons who have some prominent skills. While some explain that the creative performance of these individuals is remarkable because of their innate skills, some explanations by the interviewees indicate that these individuals are somehow more experienced in dealing with such multifaceted type of problem solving.

5.2. Students' conception of design process

In accordance with results from Q1, which indicates that students are more likely to think of design as problem solving, students are more likely to do problem-structuring starting to design. First-year students are less likely to look for precedents whereas third-year students are more likely, which might indicate that expertise comes with an appreciation of the relevance of similar solution to a given problem.

More students state that they do problem-structuring starting to design, and analysis is the most important activity in design. These results suggest that the problem-solving model of design, with its emphasis on analysis-synthesis and on problem-structuring, is the most prominent view among the participants. One possible explanation could be that studio might be implicitly enforcing the analysis-synthesis model of design. As Ledewitz (1985) had indicated a while ago, even though studio instructors may not explicitly accept the analysis-synthesis model of design they employ its teaching practices implicitly. Ledewitz (1985) observed that to move from the rational analytical stage to the creative synthetic stage students must make 'a leap in the dark' (p. 4), an act of intuition and faith that is only complicated, not made easier, by the accumulation of information in the analytical stage. The reason why instructors might be implicitly adapting an analysis-synthesis model could relate to the ease of operationalizing analysis through instructions in the studio.

Another explanation could be that students might find it practical and comforting to think of design as a linear problem solving activity. Once students make 'a leap in the dark', i.e., commit to a design idea to resolve all the ambiguities in a design situation, they might feel relieved by setting a goal to be achieved. There is research that supports this explanation. Newstetter and McCracken (2001) observed that once students have an idea, they tend to stop considering alternatives, and act as though designing is a linear process. As discussed above, Rowland (1992) and Christiaans and Dorst (1992) found that novices are more likely to think of design as a linear problem solving effort.

Students' accounts indicate that while they realize that a creative product is highly valued in education, they also recognize that it is a result of a creative process. The differences lie in the activities that they perform in such a creative process. In agreement with the results from Q1, most students think analysis is the most important phase in design. However, incubation, which was described as actively waiting for a design idea to develop and mature, was a close second to analysis. The data from interviews also suggest that students do research, draw, and think during this period. The results, with the relative importance given to incubation, might also indicate that analysis by itself does not guarantee a creative solution and that design has to develop and mature, and that instructions do not help them in making the creative leap from analysis to synthesis. The work put in formulating a design idea could be interpreted as a series of design moves with which students construct a potential solution along a constructionist view of design. However, it also points out students' struggle with a simplistic analysis-synthesis model of design and the role of incubation in design. Incubation might be thought of by some students as an alternative model that enables the shift from analysis to synthesis when clear and understandable alternatives are not presented by studio instructors.

Different from incubation, inspiration suggests a sudden flash of light in the mind of the designer and is considered the least important by all students except by the inspirational artistic designer students. The inspirational designer highlights the significance sudden flashes of light in designing over problem structuring.

Regarding the rare use of similar cases in design by first-year students, we infer that they may not be able to judge their significance, since these students are not yet exposed to several examples from design domains. The relevance of cases is well documented (Oxman, 1994; Schmitt, 1993), yet case-based reasoning requires primarily a vast body of relevant cases available for multiple design situations and a rich indexing mechanism with which a designer could retrieve these relevant cases (Domeshek, Kolodner, & Zimring, 1994). A novice student lacks both of these and with expertise, some students are able to accumulate a body of cases together with an ability to recognize their relevance for specific design situations at hand. Similarly, we infer from results that student may think it is not feasible to start the design with a solution scheme, or with a conjecture, since their domain knowledge is not rich with tried out solution schemes they can adapt for new design situations.

5.3. Students' conception of design education

The minority of students mentioned some advantages of learning how to design at school. The impact of the studio seems to be limited. A third thinks the studio and the school had shaped their design process, while close to two-third reported that it is shaped either through individual efforts or that they do not have a set process. The interviews with students show a slightly different picture in that students are actually aware of the importance of schooling together with its shortcomings. Results from qualitative and quantitative analysis might indicate that students think of school, where they are surrounded with their peers and are exposed to different views, as a solid, but insufficient, foundation to start learning which continues to develop after schooling.

This brings up a valid question related to the relevance of design school in implicit learning. Atman and Turns (2001), for one, found that engineering students after their first semester show significant improvement and even reading a text book had a positive impact on them. Design learning is obviously facilitated through school, however, students may not find it sufficient especially in its emphasis on implicit experiential learning.

Another reason why students may not be rating schools highly is because almost all the time spend in studio is dedicated to design products rather than other topics that might be of importance for design learning, such as design steps, design process, or relevant issues to be researched further. As Lawson (2006) states 'one of the weaknesses of the traditional studio is that students, in paying so much attention to the end product of their labors, fail to reflect sufficiently on their process' (p.7). When studio is tailored towards producing and improving a product, students may not take full advantage of the studio environment.

Especially considering students' struggles in going through their first year and the amount of time they spend to explore design,

their learning process might remind us of the Meno paradox. In this regard, Schön (1987) states that to teach a student what design is impossible but he proposes it is possible that the student can be coached in the situated action of designing.

According to Schön the Meno paradox in design learning is resolved through convergence of meaning facilitated by instructors' and students' reciprocal reflection-in-action on knowing-in-action in an exchange through drawings and words in the context of a design problem. Leaving aside the epistemological counter arguments against Schön's account of the Meno paradox (Gilroy, 1993; Hébert, 2015; Newman, 1996, 1999), we interpret students' feedback on the desk crits and the panel reviews as not always sufficient in leading to convergence of meaning between student and instructor as illustrated in Schön's examples, which are at best episodes of knowing-in-action and reflection-in-action. Furthermore, these may also fall short of supporting a long-lasting change in the conceptualizations of students, as they may not find enough structured opportunities to reflect on their actions in addition to reflect-in-action. As it is explained by Moon (1999), in Schön's theory of learning whether there is a pause or not during action for reflection is not clear. It might be hard or even impossible to separate knowing-in-action and reflection-in-action as formulated by Schön, but reflection-on-action requires a deliberate attempt at reviewing the experience at a meta-cognitive level (see Von Wright, 1992). In the heat of finalizing a project, students might be failing to reflect on their design actions beyond the scope of individual projects not alone reflecting on their reflections on their actions. At least some students seem to be still 'leaping in the dark' even with constant coaching and seem to be more concerned about pleasing their instructors. What students in this study report to be more beneficial is rather a studio environment in which they are surrounded with other beginners involved in similar problems.

Kolb's (2015) proposes that conflicts and complexities in learning how to be creative needs to be synthesized and be dealt with directly. This might be yet another way to resolve the Meno paradox. Kolb (2015) suggests that while learning to be creative one needs to integrate all the four forms of adaptation, i.e., concrete experience abilities, reflective observation abilities, abstract conceptualization abilities, and active experimentation which together constitutes the two axis of learning consisting of grasping experience (Concrete Experience and Abstract Conceptualization) and of transforming experience (Reflective Observation and Active Experimentation). The two axis of learning are in conflict with each other in the sense they emphasize different modes of learning, yet the creative synthesis requires their mutual use. We claim that when these conflicts are not confronted and synthesized into a creative outcome they would lead to either simplistic analysis-synthesis characterization of design that do not help with the shift from analysis to synthesis or design students are left alone to 'leap in the dark' with every single design task.

Instructors play an important role in promoting cultures of creativity in studios (Rodgers & Jones, 2017). Several researchers argue that creativity can be coached using general techniques such as brainstorming, mind mapping, idea association etc. irrespective of discipline (Ivcevic, 2007; Plucker, 1998; Sternberg, 1999). Rodgers and Jones (2017) state that instructors who promote freedom of experimentation are praised by students and those who are dominant are regarded as inhibiting creativity. Nicholl and McLellan (2008) refer to these instructors as a "gatekeeper" who discourages creativity. Some focus group discussions included similar characterizations of instructors. Similarly, the results of the questionnaire indicate that students' design process is self-shaped and the interviewees repeatedly mentioned how they are told by the instructors they have to shape their design process on their own. As many aspects of design remain implicit, many aspects of creativity remain to be explored by students themselves (Rodgers & Jones, 2017). Recalling Meno's paradox again, it can be said that what students struggle with in this learning process is actually more than to learn implicitly something new through designing. More importantly, they find themselves in a struggle to understand and respond to the informal teaching methods used by the studio instructors (see Ledewitz, 1985), or to the hidden curriculum (see Dutton, 1987), or even to their personal preferences.

6. Conclusion

The focus of the study was to determine students' perceptions of design, design process, and design education in implicit learning environments and whether there are differences in these characterizations among students from first year to fourth year to investigate the role of schooling in design learning. The results indicate that design as problem-solving is the most or one of the most widely held view among students and it stays that way all through four years. Students also think that problem structuring and analysis are important phases in the design process. Regardless of some changes among students from four levels, we did not observe a linear progression in the way students' characterizations change. What needs to be underlined, however, is the view that art and creativity are closely related to the problem solving view of design suggesting that students have a more complex view of problem solving. Furthermore, the impact of school in shaping students' design process is found to be limited and students find themselves mostly alone in figuring out how to go about design. The analysis-synthesis model emphasized by the problem-solving view of design does not help students in understanding how to make a creative shift from the analytical phase to the synthesis phase. At first, most students expect for the muse of inspiration to show the way, which proves to be futile, then continue to 'leap in the dark' with the expectation that a new trial would work. The students, however, are on their own in eliminating their misconceptions about creativity.

We conclude that the learning-by-doing paradigm in the studio, when not accompanied with critical thinking along and after design episodes in the form of reflection-on-action and reflection on reflection-on-action, fosters an impoverished implicit learning environment following the traits of hidden curricula often embodied in design instructors' behaviors and preferences.

The study has some limitations especially concerning specific cultural issues that might have an impact on students' comportments towards design. In future studies, we propose that comparative studies should be conducted to see how different design pedagogies or/and different cultural preferences would have an impact on students' characterizations. We did not investigate the instructors' characterizations of design either to compare students' and their instructors' opinions. It will be informative to conduct a comparative study of students' and instructors' opinions as well (see Rodgers & Jones, 2017).

We suggest that there needs to be more opportunities in the studio for confronting and synthesizing the conflicts in the creative

process as suggested by Kolb (2015), and for reflection-on-action and reflection on reflection-in-action as introduced by Schön (1987). As suggested by Lawson (2006) it is a must to further the implicit learning during design crits and panel reviews by way of critical thinking and to make students reflect on transitions from implicit knowledge to procedural to declarative knowledge. We also propose that different models of design should be introduced and dwelled upon in the studio and students should be able to explore these strategies to see how they fit into their personal strengths.

We suggest that design studio should be structured as such that at periodic intervals students would find an opportunity to reflect on their design experiences and discuss these issues in detail. The surveys and especially the focus group interviews offered students a chance to do exactly that and we found that students were willing and excited about the chance to talk about design, design education, and their design process with their peers and with their instructors. We propose that learning in other applied domains could benefit from a similar structured learning environment.

CRediT authorship contribution statement

Batuhan Taneri: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Writing - review & editing. **Fehmi Dogan:** Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing, Supervision.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.tsc.2020.100781.

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