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APPROACHES IN DESIGN EDUCATION: THE ROLE OF PATTERNS AND SCENARIOS IN THE DESIGN STUDIO

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Abstract

The studio is the educational setting where architectural students dedicate a large part of their study career working individually and in groups. Supporting students with adequate methods to deal with ill-defined problems in the design studio is a major challenge for design education. Whereas different approaches such as using design patterns and developing scenarios are reported to improve the design activity, they were never investigated in the design studio. An empirical investigation was conducted in order to explore whether and how scenarios and patterns can help students in developing a useful knowledge base and enhance their abilities to solve design problems in the design studio. Students were requested to solve a series of design problems using these educational methods, while working individually and as a team. They were asked to produce as many design ideas as possible, while in the team setting were instructed to think aloud. The data assessed is gathered from surveys, problem solving sessions, and interviews. Thus, qualitative and quantitative analyses had to be done to find out about the different impact of the two methods in design. The results showed that as an educational approach, patterns aided in defining problems and analyzing idea solutions, mainly from a technical and functional perspective. Scenarios, on the other hand, were helpful to generate new ideas, and to enhance design creativity. Independently of the pedagogical method used in the design studio, working in teams showed to be central to enrich and enhance many aspects of the design activity. The findings have important implications for intervention programs in the design studio.
Key words: *design thinking, design studio, design education, educational setting, problem solving session, students teamwork.*

Introduction

This research deals with the comparison between the use of patterns and the use of scenarios as two pedagogical approaches in the design studio. The studio is the educational setting where students dedicate a large part of their academic career working individually and in groups (Batuman & Baykan 2014). Thus, in order to support the students, the use of adequate methods can be crucial for dealing with design education challenges. For example, there are pedagogical methods which are supposed to enhance creative thinking, broaden information search, or manage the design process, as well as methods supporting reflection, analysis, and evaluation of design situations (Caliksan 2012).

The main focus of the present research was to explore the role of two different methods in the early phases of the design process, also known as the conceptual phase (Cardoso & Badke-Schaub 2011). The underlying assumption hereby is that methods such as scenarios and

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patterns may support students developing a knowledge base, and enhance their abilities to deal with design problems in an effective and efficient way. Whereas the scenarios are considered to be a prescriptive tool providing guidance towards a design solution, the pattern language is an open-ended method encouraging thinking in different directions in a non-defined way (Samuels & Pattacini 1997). Whereas both methods can provide support for dealing with real life problem solving in design, this research centered on their aid in design education.

In the design studio, patterns and scenarios can contribute to not only enrich the design activity of the individual student, but also to enhance the interaction of students working in teams. By that, these methods can be used to improve the coordination processes, and the exchange of information during teamwork (Badke-Schaub & Buerschaper 2001; Casakin et al. 2015). The methods are of particular importance in situations of multifaceted design tasks (Stempfle & Badke-Schaub 2002), which demand creative skills (Casakin & Badke-Schaub 2013; Valkenburg 2000) as is the case with complex design problems. These are considered 'wicked problems' (Farrell & Hooker 2013; Rittel & Webber 1972) that require the synergistic collaboration of team members sharing a common understanding of the task.

The research reported here aims to empirically compare the use of patterns and scenarios in design tasks carried out by design students, both working individually and as a team. A particular focus was set to investigate how these methods affect the design activity, and outcome produced in a design studio session.

Scenarios in Design

Scenarios are stories made about people and their activities (Carroll 1999; Rosson & Carroll 2002a). They are characterized by: a setting, agents that have goals to achieve, actions and events carried out by the agents, and an argument describing the sequence of actions that takes place. Scenarios have been broadly investigated in different domains such as literature (Havik 2012), software engineering (Rosson & Carroll 2002; Shin et al 2005), and urbanism (Rossi 1982). A scenario is based on a number of alternative visions of a design situation (Timmeren et al. 2011). Creating scenarios is about generating fictive worlds. In the literature domain, writers construct scenarios based on selective interpretations of reality (Havik 2012). These can the motivated by the identification of sources of inspiration (Gonçalves et al. 2014; Casakin & Timmeren 2015). In design, scenarios constitute primary inspiration sources for idea exploration. According to Havik (2012) scenario is a technique that enables the development of imaginative thinking about new spatial and temporal design realities. The creation of scenarios enhances the possibility of envisioning design features from unorthodox viewpoints. Since they are a necessary simplification of reality, scenarios are not intended to deal with every unique aspect of real life problem solving. They are therefore an abstraction of reality that enable to center on selected aspects. As educational design methods, they challenge our thinking and imagination to temporarily allow the suspension of our connection to reality, and stimulate the creation of alternative realities. As a tool for discovery, scenarios make possible to explore creative ideas by combining reality with imagination.

In late 1960s avant-garde groups of architects and urbanists experimented with futuristic themes, and proposed revolutionary scenarios for urban futures. An example is the Archigram group that explored imaginative and unexpected scenarios based on new technologies to come for future living environments (Cook 1992). They made use of science fiction elements and the imagery of comic strips to characterize the city through situations related to the dynamics of movement, e.g., aerial streets and moving object-like buildings. More recently designers such as Daniel Libeskind (1999), Yona Friedman (2006), and Rem Koolhaas (1995) explored the scenario-based method as a source of inspiration for their projects. Rem Koolhaas (1994) discusses the design of fascinating places as an outcome of imaginary scenarios. He shows fictional projects for Coney Island that are based on the "technology of the fantastic", and Manhattan projects described as "archipelagos of blocks", "artificial mountains", and "cities

within cities". Descriptions about the use of scenarios are either anecdotal or historical, but no works were carried out to investigate empirically their influence in design education.

Patterns in Design

A major weakness of the approaches dealing with design problems is that they fail to tackle complexity issues (Timmeren 2013). Complexity is troublesome for designers, and even more for design students for a variety reasons. Among these are the large and diverse body of knowledge needed for an integrated design approach, and also the alignment of the numerous actors involved in the design process with different professional backgrounds, and the inability to establish predictions based on the large number of design variables, which are hard or even impossible to grasp (cf Gerrits 2011).

Pattern language offers a structure which supports efficient work on design problems, leaving at the same time enough room for the creativity of the designer. According to Salingaros (2000b) the main advantage of pattern language is the assistance for structuring problems, and producing functional coherent design solutions. Patterns are known as prescriptive ways for providing a solution to a design problem. The concept of patterns was introduced by Christopher Alexander (1977) as an approach for dealing with ill-structured problems (Casakin 2010; Simon 1984) in the urban and architectural domains (Alexander 1977; 1979). The application of patterns, however, has been extended to other fields such as computer science (Rodriguez et al. 2015; Frauenberger & Stockman 2009), where they are recognized as a powerful means for assembling computer programs. Essentially, patterns embody a recurring design problem, and the essence of a solution to that problem. A good pattern is "a true invariant, meaning that the solution summarizes a property common to all possible ways of solving the stated problem" (Alexander 1977, P. xiv).

An important advantage of using patterns is that they facilitate the communication and exchange of information related to frequently occurring situations. In this way, they contribute to enhance shared understanding among team members (Karlgren & Ramberg 2012). Another advantage is that this method allows for rapid generation of alternative design solutions, which increases the flexibility and adaptability to changing conditions (Duarte & Beirão 2011). Pattern representations also provide explanations about how they relate to other patterns, and offer solution examples through photographs, diagrams, and text information. The principles represented by the patterns can advice designers how to take appropriate decisions at different levels of scale and detail (Salingaros 1999; 2000a).

In general, patterns refer to problems related to particular situations, and inform how solutions can be applied effectively. Accordingly, a pattern can be reinterpreted in terms of other smaller patterns that can be combined in multiple ways (Alexander 1977). A weakness of this method, however, is that it may lead to repetitions and fixation of solutions (Atilola et al. 2016; Jansson & Smith 1991) with the consequence of a reduction in creativity of the design outcome. Until now the use of patterns is either anecdotal or historical, and no studies explored their influence in design education.

Patterns and Scenarios in Design Education

A main goal of the design studio is to help students developing design skills while they gain knowledge and expertise (Smith 2015). The use of patterns and scenarios in design education is considered as alternative to educational approaches that are based on the traditional model of the *Ecole de Beaux Arts*. This model, which still has a large influence in most schools of architecture and urbanism in our days (Casakin & Gigi 2016; Cuff 1992), emphasizes the traditional teaching system of transferring knowledge from tutors to students. A main characteristic is the one-to-one "desk critique", in which students meet with their instructors in individual sessions, and engage in a conversation on their projects (Oh et al 2013). An

advantage of this pedagogical method is the dialogue established between teachers and students, and the guidance received to continue developing the project. Disadvantages, however, is the dependency on the advice provided by the instructor. In this context, scenarios and patterns are helpful tools that can assist students in fostering their personal views, and can provide criteria for valuing their own experiences, which is essential to gain independence in the studio (Casakin & Kreitler 2008 Lee 2009). There are also some discussions that this kind of method leads to a simplification of the complexity that design problems have in professional practice. From a pedagogical perspective, this support can help students to progressively develop and integrate their knowledge structures as they develop domain expertise.

Another important issue that occupies design educators is how to teach students to work together as a team. According to Badke-Schaub et al. (2011), supporting teamwork entails an efficient coordination of design acts in the team. Scenarios and patterns are supposed to aid team coordination by encouraging the development of shared understanding among the members. Using scenarios and patterns can contribute to a more continuous information exchange and a common perspective of how to deal with the task in a fast and efficient way.

Although it can be assumed that the two methods are of major importance in design problem solving and design education, yet no comparative studies were carried out to test this. Moreover, no empirical investigation attempted to understand the use of these tools in the design domain from an educational viewpoint. These issues will be addressed in order to investigate how each design aid is employed in the design studio by students working independently and as a team.

Methodology of Research

Research Aim

The aim of this research was to find out how students approach scenarios compared to patterns as two pedagogical methods which are meant to support the problem solving process during the design activity. The first objective was to examine the use of scenarios and patterns with regard to critical task-related aspects. A particular focus was set on the aid provided by these methods for tackling the design task when students worked individually and as a team in the studio. Thus, the first two research questions were:

i) How and to what extent does the use of design patterns compared to scenarios help students dealing with design problem solving activities, such as definition of design problems, generation of ideas, analysis of idea solutions, clarifications and evaluations of solutions?

ii) What are the differences between the two design methods with regard to the design activities when students work individually, and as a team?

Whereas the first objective focus on the design process, the second one was to analyze the contribution of these educational methods to the creativity of the final design outcomes. Therefore the last research question was:

iii) To what extent do scenarios compared to patterns enhance different aspects of creativity such as originality, aesthetic value, functionality, elaboration, value, and overall creativity of the design outcome?

Participants and Set Up

A team composed by three Doctoral students belonging to the Faculty of Architecture and Urbanism, Department of Urbanism at TU Delft participated in the design sessions. They were informally approached in the studio, and invited to take part in the experiment. They received 15 euros as a reward for their participation. The two different design methods, patterns and scenarios were used, in which the students were requested to solve design problems. These were enacted as follows:

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Two of the authors analysed the videos and the transcripts, focusing on the relationship between the use of patterns and scenarios, and their effect on the design activity. Based on the categorization system proposed by Badke-Schaub et al (2011), the researchers discussed and arrived at a common agreement upon the key episodes illustrating the use of these methods through the different stages of the design process.

Patterns and Scenarios

Students first worked independently, and thereafter as a group. They were given a task sheet containing general instructions, a design problem, a map and photographs of the site. In addition, they were provided with a set of four patterns, and were told that they have to use them to deal with the problem at hand. Students were supplied with a set of A3 numbered sheets of paper, and were requested to produce as many creative conceptual design solutions as possible.

In the scenario setting the students also started working individually and then in the team. They were provided with the same design problem and instructions as in the other method. However, in order to avoid fixation of previous solutions, map and photographs corresponded to a slightly different site. They were explained the main characteristics of a scenario method, and were asked to use it to solve the problem.

Design Task, Procedure, and Instruments

The team was asked to design a square in order to revitalize an awkward area. Furthermore, they were requested to propose design ideas about different activities and spaces that could make the plaza a more enjoyable place. The problem requirements included the design of small human scale spaces with different levels of privacy, as well as a clear circulation path connecting these spaces. Whereas in the pattern method the plaza was located at the entrance of Amsterdam Schiphol Airport, in the scenario method the plaza was situated near the Faculty of Architecture and Urbanism at TU Delft. The design was to be developed at a schematic level. Students were well acquainted with the physical, cultural, and social aspects of the problem.

The four sessions (two per method) lasted around 2hs, and another 30 minutes were added at the end for a debriefing session. Each lasted about one hour, including 20-25 minutes for the individual and team sessions. Ten additional minutes were added at the end of each session for filling in questionnaires about the design activity of the last 2 hours (See Table 1). In the team sessions 7-10 minutes were assigned to produce a final solution to the design problem, including a brief description of how the solution works. Students were told to think aloud as the team sessions were videotaped.

Based on the categorization system proposed by Badke-Schaub et al. (2011), and Casakin & Badke-Schaub (2015), in each design session an individual questionnaire was administered to the students when they worked alone, another one when they worked in the team. These represented their viewpoints, assessments and evaluations about the contribution of the scenarios and patterns in the design process, and in the outcomes. The questionnaires included 5 items dealing with the aid provided by the design patterns and another two the scenarios (e.g., "The design patterns helped me to think about new ideas", "The scenarios helped me to make clarifications about the problem?") (See Table 2). Another questionnaire containing 6 variables about the creativity of the final design outcome was delivered to the students when they worked in the team (e.g., "How novel or innovative is the design solution?", "To what extent the design works". (See Table 3). These items have been used and validated in previous studies on creativity in architectural designs (Casakin & Kreitler 2005a, 2005b). Participants responded on a scale of five points, from 1 ("Not at all") to 5 ("Quite a lot").

Table 1. Experimental design.

Patterns				Scenario			
Part I		Part II		Part I		Part II	
Individual session	Self report	Team session	Self report	Individual session	Self re-port	Team session	Self report

Data Analysis

The data analysis focused on the way communication among team members developed during the design activity, and how the design process was affected while using pattern and scenario tools. The theoretical assumption was that design activities can be described as problem solving process - dealing with design (e.g., content) and procedures (e.g., planning). To this end, following the standard procedure of analyzing verbal data, the video recordings were transcribed, segmented, and analyzed based on the categorization system which had been developed and applied in former studies (Badke-Schaub et al., 2011; Casakin & Badke-Schaub 2015).This included: problem definition, generation of ideas, analysis and evaluation of solutions, and clarification of design situations.

Results of Research

Use of Patterns and Scenarios

Given that the use of patterns and scenarios have not been investigated in a team context, this section offers a qualitative analysis of key episodes in which idea solutions are explored using the two educational methods.

Patterns

At the beginning of the team session, the three students start analyzing the physical context, whereas one of them focused on the circulation problem (See Figure 1):

0:24 Charles: there are a few bus stops here …and there are free entrances, but … the stops and the entrances are not well linked, that's problem one, and … it's a big one because this square is one empty space…"

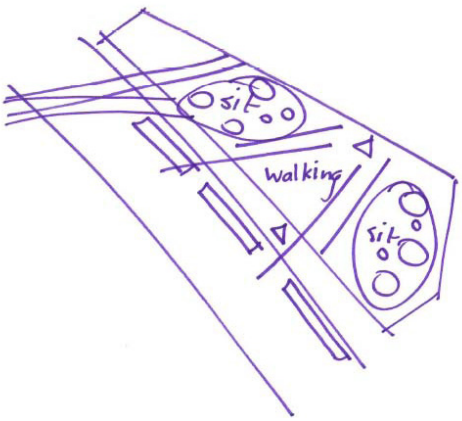

Figure 1: Sketch depicting an analysis of the circulation problem in the pattern session.

As the design process progressed, students moved from the analysis of the problem to the generation and analysis of design solutions, and produced a few sketches. However, establishing relations between the patterns and the design problem was not so straightforward. Extract 2 illustrates a conflict that emerged between an idea related to the circulation system pattern and a proposed solution:

4:16	Bryan:" … buses produce quite a lot of noise … so maybe we can make a sort of screen here… so probably we can enclose the whole square…"
5:08	Charles: "…but there might be a conflict with the fact that this is the main entrance [of the airport] … this [the panel] is a really large thing …and everybody who is arriving by bus… is in a hurry to get as fast as possible the plane…"
5:30	Albert: "…and also they need a visual confirmation about where they are going…"

At no stage of the design process, idea solutions were retrieved from information external to the design problem (between-domain knowledge), which is known to encourage the exploration of creative and unexpected solutions. On the contrary, students mainly focused on specific aspects of the problem related to functional and technical issues:

In the subsequent stages of the process, the team members continued analyzing different aspects of the problem, and proposed idea solutions based on the patterns available. Remarkably, students did not fixate or reproduce any of the examples provided. In contrast, they managed to make abstractions and retrieve relevant information from the patterns, and transfer them to the design solution. Extract 4 illustrates an analysis of ideas that centered on the pattern 'size of spaces', which was used to subdivide the square into hierarchical spaces:

10:58	Charles: "…there is a back side... where we have different zones and different…large and small elements…".
11:15	Albert: "…well in that case I think we have to try to subdivide…and design this space as something that has both large scale and small scale spaces…"

At the end of the process, students produce a sketch for the definitive solution. Remarkably, the solution was not based on a unique concept, but was rather the integration of different idea solutions. Each dealt with a partial aspect of the design problem related to a pattern (See Figure 2). The main characteristics of the final design were: a circulation system connecting bus stops with airport entrances, clear borders delimiting the square and protecting it from external noise, a hierarchical division of zones, and the creation of spaces with different scales. Except for the design of urban furniture, the ideas embedded in the final solution were the direct outcome of the use of the available patterns.

The following key aspects were observed from the pattern method:

- In contrast to what could be expected, the use of patterns did not lead to design fixation. Students managed to switch between abstraction and generalization from the information in the examples provided, and applied this information to the design problem.
- Design solutions explored during the session were based on within-domain information, and no ideas from domains remote to the design problem were generated.
- Patterns contributed to tackle the problem in a concrete and practical way.
- These tools supported communication and sharedness of within-domain knowledge: (i) at a social level, they encouraged interaction and dialogue among team members; and (ii) at a cognitive level, they enabled to communicate and exchange technical and functional information, and arrive at a shared understanding of the team.

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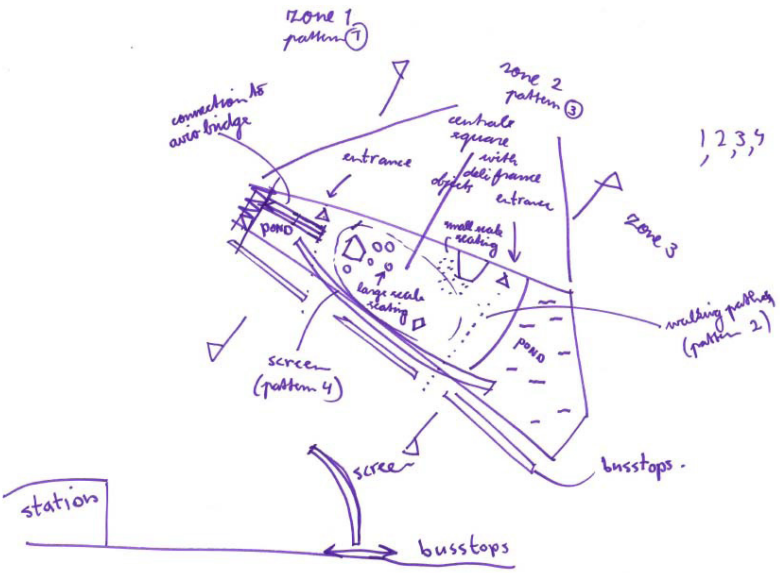

Figure 2: Example of a sketch produced in the pattern session as a combination of different idea solutions.

However, there were also disadvantages:

- The strong connection established between patterns and the design problem did not help to put reality in suspense, and relax design constraints.
- Thus, design solutions were analyzed and evaluated mainly by considering initial design constraints concerned with technical and functional issues.
- The use of patterns did not contribute to reinterpret and restructure design situations.
- Therefore, unexpected design solutions were not explored, and consequently the creativity of the final solution was reduced.

Scenarios

The team activity started with the three students communicating to each other thoughts related to the scenario produced during their individual sessions. The construction of scenario was based on different films used as inspiration sources for idea exploration and discovery, and were characterized by: plots, actors, and actions that occurred in a physical space under a specific ambience. Students produced a series of sketches that served to represent and communicate different ideas related to the scenarios (See Figure 3). Extract 5 illustrates an exploration of one scenario containing a potential idea solution:

01:59	Albert: "…that was one of my best [*ideas*] I thought about… "Una Giornata Particolare" where the two protagonists walk on the roof of the apartment building through the laundry."
02:23	Brian: "… and she tries to kiss him..."
02:23	Albert: " yes, she tries to kiss him… there is a meeting, and a discussion… there is intimacy … and so I thought we can hang the laundry up there… so people can walk around."

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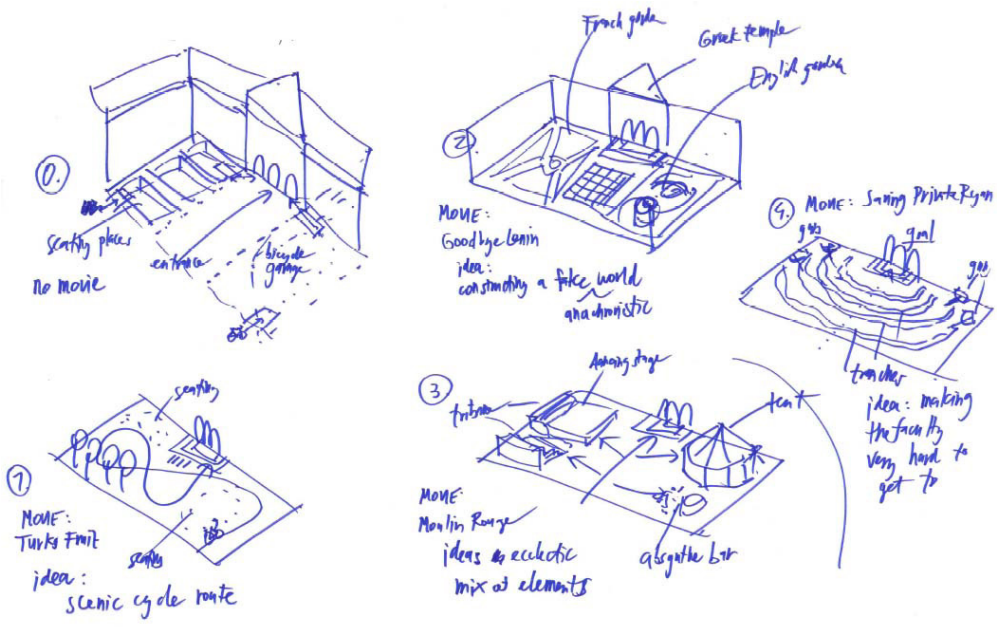

Figure 3: Examples of sketches produced in the scenario session depicting different idea solutions.

As scenario continued to be explored, students began to discuss their idea solutions. However, establishing relationships between the scenarios and the problem was not an easy task. Applying diverging thinking was useful to deal with this situation, and to explore ideas belonging to remote domains not directly associated with the design. Relaxing the problem constraints enabled to identify different type of ideas from the scenario, although at a superficial level (See Figure 6):

03:54 Charles: "For me this was a very hard assignment… to connect design problems with these movies… the connection is not evident… so in the end, I came up with a… typical war movie… actually it is not very important which movie is…maybe a First World War movie…but I thought about trenches… and lots of guns …".

04:38 Charles: "… So maybe we can introduce those trenches underneath there…"

While the team members increased their understanding of the task, they intensified their interactions and exchanges of ideas. Sharing information during the team session contributed to find similarities with scenarios developed during the individual sessions. In so doing, students synthesized and combined different ideas so as to narrow down the number of potential solutions. This is illustrated in extract 7.

10:40 Albert: "… my last film is an opera …It is about "Nixon in China"…[*in which*] there was a Boeing 747 coming from this side…this is the head of the airplane …and a staircase … coming down from where Nixon entered the square… [*the concept*] has to do with … monumentality."

11:30 Bryan: "Nice, I suggest to combine this" [*idea*] " with …Waterloo" [*film*] " which was one of my ideas too…so we can make a water square, and put the airplane into the water…"

11:40 Charles: "… well… we can think about a floating platform…"

11:48 Albert: "Ok, so for me is about monumentality and also about… authority."

11:50 Bryan: "… yeah for me was the same… playing with water… like a walking route through the water…"

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12:25 Albert: "…like …The Gardener…the movie with Peter Sellers…he is walking on water…over stepping stones that are just one centimeter underneath the water."

After exploring different alternative solutions, the students took a decision and produce a final solution that combined different scenarios that were adapted to the square problem.

The following key issues were identified from the analysis of the scenario method:

- The movies were good inspiration sources to explore creative design ideas based on scenarios. Ideas that emerged did not exactly resemble the original scene in the film, but were rough abstractions reflecting the representational skills of the designer.
- Interpretation of movies and construction of scenario showed to be related to the beliefs and motivations of the designer.
- Scenarios enabled to explore and discover many creative design ideas, most of which were fanciful, unexpected, and belonged to a domain that was remote to the problem.
- Scenarios provided a suitable framework where to look at reality from unusual viewpoints, and this encouraged the generation of creative ideas.
- Scenarios showed to be a flexible method to support the combination of different idea solutions.
- The lack of apparent connection between scenarios and the design problem helped designers to temporarily put in suspense reality, and explore creative ideas.
- Consequently, design solutions were not analyzed and evaluated in terms of original problem constraints, but mainly in regard to the imagined scenarios.
- The use of scenarios contributed to restructure design situations, and consider new problem constraints.
- Scenario supported communication and sharedness of between-domain knowledge: (i) at a social level, promoted interaction and dialogue among team members; (ii) at a cognitive level, enabled the discovery and common understanding of unexpected information.
- However, observed disadvantages were:
- The transfer and application of between-domain knowledge was difficult due to the remote distance between the scenarios and the design problem.
- Making abstractions of scenarios demanded a level of expertise that not all the students had.
- Scenario were unsuitable to deal with technical issues of the design.
- Design ideas were not easy to represent graphically due to their spatial complexity. As a result, most design solutions were produced at a schematic level.

Debriefing

At the end of the experiment, a debriefing session was carried out with the students. They were requested to express their views about the aid provided by the patterns and scenarios tools during the problem solving tasks. Advantages and challenges of using the methods were discussed and compared. In general, patterns were seen as more practical, easier to apply to the design problem, and effective to use under time pressure. The drawbacks were: they were perceived as less inspiring sources, limit the fun of designing, and they led to less creative outcomes.

In contrast, scenarios were perceived as inspiring tools for a vast number of creative and surprising outcomes. They helped to create distance with the problem, and to make personal interpretations from unusual perspectives. They also aided to exploring design ideas in terms of time and space. However, since scenarios belong to a domain different to the problem, the process of making abstractions and establishing structural relationships with the design was not always smooth.

In sum, patterns aided to retrieve familiar and practical information, whereas critical drawbacks were their inability to inspire designers to challenge known solutions, and the production of more predictable outcomes. In contrast, scenario were inspiring and motivating tools that enhanced unorthodox thinking. They also promoted the sharedness and exchange of information among team members, and the exploration of creative ideas. However, accessing and abstracting information was challenging and demanded establishing unfamiliar associations with remote sources.

Survey

In this section, a comparative investigation is carried out to analyze major differences between the design pattern and scenario methods. Although the small number of participants do not justify a quantitative analysis, some descriptive results are shown: mean scores and standard deviations.

The Use of Patterns and Scenarios in Individual and Design Team Activity

Table 2 depicts the mean scores obtained for the aid provided by patterns and scenarios in the different design activities. Observing both the individual and team sessions, it was found that the help for the team equipped with patterns was highest in design clarifications, and lowest in idea generation. In contrast, the aid supplied by scenario was highest in idea generation, and lowest in problem definition.

Table 2. Mean scores for the method provided by patterns and scenario in individual and team sessions.

	Patterns				Scenarios			
	Single session		Team session		Single session		Team session	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Problem definition	3	1.0	3.66	0.6	1.66	0.6	3.33	0.6
Idea generation	2.66	0.6	3	0	3.66	1.2	4.66	0.6
Analysis	3.33	0.6	3.33	1.2	2.33	0.6	3.33	0.6
Clarification	3.33	0.6	3.66	0.6	2.33	0.6	3.66	1.2
Evaluation	3	0	3.33	0.6	2.66	1.2	3.33	0.6

In the pattern method, an emphasis on problem definition and evaluation was higher in the team session higher in the individual one. Low differences between individual and team sessions were found for clarifications and idea generation and no differences were found for analysis of solutions. In the scenario method, all five design activities scored higher in the team session.

In the individual session, the use of patterns was higher in the amount of clarifications and frequency of analysis, whereas students employing scenarios explored more ideas. In the team sessions, students largely used patterns in problem definition and clarifications, and scenarios in the exploration of ideas.

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Table 3 shows the mean scores for the quality of the design outcomes produced by the students when using patterns and scenarios methods. It was found that whereas the use of patterns scored higher for functionality of the design, the aid of scenarios excelled in a wide spectrum of creativity measures such as originality, aesthetic value, elaboration, and overall creativity.

Table 3. Mean scores for creativity aspects of the final design outcomes when using patterns and scenarios during the team session.

	Patterns		Scenarios	
	Mean	SD	Mean	SD
Originality	2.33	1.2	4	0
Functionality	3.33	0.6	2.33	0.6
Aesthetic value	3	1.0	3.66	0.6
Elaboration	2.66	0.6	3.33	0.6
Overall value	3	0	2.66	0.6
Overall creativity	3	0	4	0

Discussion

In line with Salingaros (2000b) design patterns were found to provide functionally and structurally coherence within-domain knowledge. Thus, they played a critical role in clarifying design problems, and analyzing design solutions. One disadvantage, however, was that due to the well-defined knowledge structures afforded by this method (Alexander 1979), students had problems to generate innovative ideas. Contrary to this, the major aid afforded by the scenarios was in idea generation. As suggested by Havik (2012), results showed that scenarios helped to 'think-out-of-the box'. Their unstructured between-domain knowledge contributed to enlarge the solution space to a farther limit. Consequently, these tools demonstrated to be good inspiration sources for exploring creative ideas (Perttula & Sipila 2007).

A further distinction was concerned with the dissimilar aid provided by patterns and scenarios when working individually and in teams. With the exception of problem definition, almost no differences were observed for the use of patterns in all the design activities. This finding may suggest that students were more familiar with the patterns, and thus they benefited from them as individual designers. However, this may be also a reason since this method did not contribute further when they interacted as a team. In contrast, the aid provided by the scenarios was largely more relevant when students worked in the team, and all five design activities were considerably enhanced. The results suggest that the use of scenarios played a critical role in enhancing the exchange of communications among the members, which as noted by Stempfle & Badke-Schaub (2002) contributes to improve design quality. Scenarios are characterized by providing between-domain knowledge, and therefore establishing associations with the design problem demands vast imagination (Casakin 2010), and larger cognitive resources. It is possible that students had difficulties to make the cognitive effort needed to think 'out-of-the-box' (Petre 2004) when working individually. Nevertheless, this limitation was overcome when they interacted in the group. It can be inferred that in order to optimize the employment of the two methods, students should combine their activity working as individual designers at some stages of the process, and as a team at others.

Independently of the tool used or the session type under consideration, it was observed that the dominant activity was idea generation, followed by design clarifications. Intervention programs in the design studio should take into account that novice designers dedicate large efforts to understand the problem at hand when searching for ideas. Thus a major challenge for design educators is to realize how patterns and scenarios can best support a process in which idea solutions co-evolve or develop iteratively with design problems (Witsching et al. 2013). Moreover, in the scenario method, idea generation was higher in both individual and team sessions. It is suggested that design teachers should encourage in their intervention programs the use of between-domain sources such as scenarios. As argued by Cardoso & Badke-Schaub (2011) between-domain-thinking is critical for enhancing design activities related to conceptual thinking. Problem definition and problem clarification were the prevailing activities supported by the use of patterns. Due to their organizational and descriptive power, and in line with Dorst & Cross (2001), the use of these within-domain sources was shown to be helpful in framing and structuring problems in a coherent way. Another finding common for both methods was that most design activities increased in the second part of the meeting, that is when the students worked in groups. Design teachers should be aware that team interaction has much to contribute to enhance problem solving activities, independently of the design tool used.

Finally, comparing the relevance of the different criteria of creativity, the factor functionality was the most domain dependent one. It is interesting that design patterns were most effective when students dealt with the technical issues of the design, which was reflected in the overall value of the outcome. This may suggest that students perceive functionality as the important component of the design value. The finding is supported by Salingaros (2000b), who claims that a major feature of design patterns is to help produce functionally and structurally coherent solutions. Scenarios, on the other hand, contributed to enhance nearly all creativity aspects of the final design. It is suggested that educational programs aiming to promote creativity in the design studio should encourage scenario use for envisioning design solutions from a variety of novel perspectives (Carroll 1999).

Conclusions

This research dealt with the use of patterns and scenarios as two educational methods in the design studio. Both qualitative and qualitative analyses of the data provided insights into the benefits and challenges of employing these tools when working individually and as a team. Moreover, it was possible to unveil how design students think and interact when exposed to within-domain and between-domain knowledge.

Generally speaking, patterns helped students to gain a basic understanding of the design activity from a technical and functional perspective. Scenarios, on the other hand, were fundamental to think out-of-the-box, to generate a large number of creative ideas, and in consequence to enhance design creativity. Both methods allowed to gain a quick understanding of critical aspects of the problem at hand, and to explore solution ideas in a short time. These aspects are of fundamental importance for the education of design students.

The research is a first attempt to explore empirically the process and performance of using design education methods in the studio. Design studio teachers interested in developing intervention programs aimed at supporting students in the different phases of the design process may benefit from these findings. A major challenge for the implementation of educational programs, however, will be to realize how to integrate the use of scenarios and patterns in an optimal way during the different phases of the design process. For example, whereas scenarios relate to between-domain and unstructured knowledge sources, they can be employed to stimulate divergent thinking. The application of this tool can play a significant role during the conceptual phases of the design process, where idea generation is the most dominant activity. In contrast, patterns represent within-domain and coherent knowledge sources that can support convergent thinking, and the testing of design conjectures against real constraints in later phases

of the process. From an educational perspective, the combined use of both methods can enable to put reality in suspense for exploring innovative ideas, and on the other hand to produce suitable design solutions in response to technical and more concrete demands. Moreover, the two methods can encourage interaction among team, and can aid to coordinate design actions along the process. Patterns, in particular, can be considerably helpful in developing a common language among team members with different knowledge and expertise.

One limitation of this research is the small sample; thus the results are not intended to generalize beyond the design meetings we analyzed. On the other hand, an aim was to explore the contribution of the two methods in the daily education of the design studio. Consequently, the problems were simplified and adapted for a conceptual stage of the design process. Despite these limitations, there were some remarkable findings reflecting how each educational method can be best applied when dealing with design problems.

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