Solution Generation Design Profiles: Reflection on "Reflection in Action"

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Abstract

Solution-generation design behavior in general, and "reflection-in-action" in particular, can serve to differentiate designers, recognizing their personal reflecting when designing. In psychology, reflection is found a more robust tool to enhance task performance after feedback from a personal "device" that generates the process itself while interacting with visual representation. Differences among students' interior design processes appear in their solution-generation design behavior. A “think aloud” experiment identified solution-generation behavior profiles. Qualitative and quantitative methodologies showed how design characteristics unite, forming patterns of design behavior. A comprehensive picture of designers’ differences emerged.
The research aimed:

- to identify individual design students’ solution-generation profiles based on design characteristics.
- to show how reflection-in-action appearing in the profiles can serve to predict how novice designers learn and act when solving a design problem.
- to enhance the uniqueness of reflection-in-action for designers as distinct from reflection in other fields.

Four distinct solution-generation profiles emerged, each showing a different type of reflective acts. Identifying reflection-in-action type can robustly predict how designers develop design solutions and help develop pedagogical concepts, strategies and tools.

Keywords: reflection in action, design behavior, solution generation, individual difference, design characteristics, design process

The research that forms the foundation for this paper is based on two main principles. The first is that acquiring a personal process of design, i.e., a way of thinking about making a design, is a central objective of the design process; and the second is that understanding the differences among designers is key to optimizing the design process of each designer, by allowing each of them to trust their process and share it with others. The design process can be analyzed according to two main phases of problem formulation and solution generation. In this paper, we choose to relate only to the phase pf solution generation.

We address two issues: Design Behavior Profile, and Reflection in Action. The Design Behavior Profile is shaped by a combination of design characteristics, which generate the individual's innate way of designing. We define a design characteristic as a single aspect of behavior in the context of designing, which demonstrates the individual’s habitual mode of solving design problems. A combination of design characteristics that is shared by a group of designers in the

way they design can be defined as a Design Behavior Profile. Such profiles represent various approaches to formulating design problems and developing solutions.
While analyzing the various profiles, we found that the design characteristic of "reflection in action" or self-assessment is key to differentiating designers. Looking at the model of solution generation profile, one can predict the characteristics of reflection/assessment by other characteristics such as framing (or main preference), solution type and the resources used while designing. The main goals of this paper are:

- To identify individual solution generation profiles of design students on the basis of design characteristics.
- To show how reflection in action is manifested within the various profiles and can be a used as predictive tool for the way novice designers learn and act when solving a design problem.
- To enhance the uniqueness of the notion of reflection in action for designers as opposed to the use of reflection in other fields, such as psychology.
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In this research, exploratory qualitative methods were implemented to infer various designing characteristics. Then quantitative research methods were used to determine how these characteristics act in unison and form comprehensive patterns of design behavior. Conducting the research using a relatively large sample population of designers allowed for a detailed quantitative analysis that produced a wider range of results.

By analyzing the combinations of the design characteristics of solution generation phases, we identified various design behavior profiles: Realization Oriented Profile; Learning Oriented Profile; Designer Oriented Profile; and Assessment Oriented Profile. Each design behavior profile is shaped by a combination of designing characteristics that generate the individual's innate manner of designing. The findings demonstrate that design behavior profiles guide various approaches to solution: focusing on the designer, focusing on the given problem and focusing on the end solution.

Design behavior and individual differences

One of the challenges of design research is to capture the design process as a complex entity. Some researchers have mainly aimed at capturing an objective representation of the design process (Gero and McNeil, 1998; Purcell et al., 1996; Suwa et al., 1998); others have attempted to understand designers' behavioral patterns, concentrating on specific aspects of design behavior (Akin and Lin, 1995; Cross, 2001; Goel, 1995; Goldschmidt, 2001; Schön and Wiggins, 1992). Within their frameworks, the researchers performed in-depth investigations and arrived at a profound and detailed understanding of how design behavior is expressed throughout the actual process of designing. Due to this in-depth approach, most of the studies were conducted on relatively small samples, therefore placed little emphasis on distinguishing differences among designers.

Identifying individual differences in designing in reference to various design behavior characteristics presents a great challenge. The importance of understanding the differences among designers stems from our wish to optimize design education, in the sense that helping each student find his/her appropriate process is an important goal. In the words of Ochsner (2000): "Not the problems themselves or the solutions alone are the aim of design education.

Rather, the aim is learning a personal process of design – a way of thinking about making architecture" (p. 195).

Schön (1998) notes the “oblique” way in which studio instructors challenge students to enter into the design process. He describes an experiment whereby he tried to learn more about the knowledge and reasoning of practiced designers. He observed that different designers construed the task they were asked to perform in very different ways. Their different interpretations of the task led them to wholly different global patterns of designing because they used different design rules. One of the main questions refers to the different judgments designers make when designing.

When referring to design education, in many cases design instructors will judge their students as "not progressing" or "not successful" because the instructors were unable to address their pedagogical approach and their ways of instructing according to their students' way of thinking and doing design.

Reflection in action

All across different psychological domains there is a great deal of research on the notion of reflection. Studies refer to systematic reflection, which serves as a key tool in learning from experience. Ellis, Carette, Anseel and Lievens showed that through systematic reflection people can learn from both their successes and their failures (2005, 2014).

Reflection in action can be seen as a unique demonstration of reflection that is inherent to the design process and problem solving. Donald Schön, with his notion of the design process as "reflection in action," introduced a critical modification in the way design teaching and learning is viewed. His concepts, which were presented in his best-known books *The Reflective Practitioner* (1983) and *Educating the Reflective Practitioner* (1987), have been seminal in research into design activity for the past 30 years.

In his attempt to understand the central educational features in design and the notion of the design process, Schön analyzed audio-taped protocols from student-teacher sessions in the design studio. Schön's main claim was that design is a "reflective conversation with the situation"—namely during the design process the designer enters into a "frame experiment," a "dialogue" with the materials of the situation. In the process, the designer makes tentative operational moves while the materials "talk back" to the designer, constraining and shaping subsequent moves.

In an interview with John Bennett, Schön discusses the activity of design and speaks about three kinds of reflection: reflection in action, reflection on action and reflection on practice. He says: "Reflection in action is closely related to the experience of surprise. Sometimes, we think about what we are doing in the midst of performing an act. In architectural design the ‘performer’ frequently conducts an experiment in the form of series of drawings combined with talking” (Bennett, 1996, 172). Bar-Eli's (2010) analysis of sketches and their role in differentiating designers defined three distinct sketching profiles, which characterize designers' use of sketches as a tool for thinking and communicating ideas. Particularly today, when digital tools offer

endless possibilities for representation, designers may benefit from using sketches in order to clarify and communicate their design ideas and choose the precise tool for developing them into solutions.

In the second type of reflection "the designer exhibits a reflection on action, pausing to think back over what she has done in a project, exploring the understanding that she has brought to the handling of the task. She may, for example, construct a new theory of the case, reframing the problematic design situation in such a way as to redefine, interactively, both means and ends" (Bennett, 1996,172).

In the third kind of reflection, reflection on practice, the designer may surface and criticize tacit understandings that have grown around repetitive experiences of designing. For example, he may become aware of having fallen into an unfortunate pattern of design behavior, such as "falling in love with an initial design idea," or "trying to build a diagram" (Bennett, 1996, 172).
The notion of “reflection on action” and “reflection on practice,” although present throughout the design process, can be closely related to systematic reflection because it is used as a post-action tool, in order to "draw lessons from prior experiences and eventually to behavioral change (behavioral effect)” (Ellis, Carette, Anseel and Lievens, 2014; 68). In analyzing systematic reflection, Ellis and Davidi assert that it serves three functions: self- explanation, data verification and feedback (2005), and that all three must be combined in order to become an effective learning tool. The three functions are seen as an integrative system, but there isn’t any reference to the weight of each in differentiating people.

Schön's work had a great influence on research of design, enabling the researcher to place an emphasis and observe the designer's "conversation with the situation" more closely, as he asks new questions about the content, structure and the design process, and develops a new taxonomy of design problems and frames.

The notion of reflection in action is closely related to the characteristics of assessment and evaluation. In many cases it can be used interchangeably. Lloyd and Scott (1995) state that "evaluation is the process of guiding and controlling design by making subjective decisions about problem, solution or process. It is similar in some respects to Schön's idea of 'reflection in action'" (p. 385). Jonassen (1997) describes this process as monitoring the problem’s space and solution options, and agrees with Lloyd and Scott that it occurs throughout the entire process, as a reflective procedure in which the designer "must have some epistemic knowledge about an alternative solution, and then develop a strategy for framing the problem, and selecting and synthesizing a unique solution" (p. 82).

The act of iteration or redesign, which Blessing treats as process backtracking (1992), was discussed in depth by Adams et al. (2003). These researchers describe the act of iteration as including "self-monitoring, clarifying and examining activities. These observations of self-monitoring activities include reviewing and evaluating progress, self-monitoring understanding and searching for or being open to finding potential solution failures" (p. 286). Frequently these monitoring and assessment activities result in returning to the problem requirements, redefining the problem, and revising the solution elements. The individual differences in the assessment and

evaluation processes, and how they influence each individual designer's subjective choices, will play an important part in the analysis of the student-designers' design behavior and processes.

Method

This research implements mixed methods: qualitative research methods are implemented to infer the various designing characteristics; then quantitative research methods are implemented to determine how these characteristics act in unison and form comprehensive patterns of design behavior.

The population of this research was 50 interior design students on different levels of study in an interior design department. The participants took part in a "think-aloud" design problem-solving experiment involving two design problems, and were allocated up to 30 minutes to complete the task. The entire process was videotaped, and the materials (including their verbalization) were used to create protocols, which were then analyzed using a coding scheme pertaining to designing characteristics.

Qualitative content analysis was performed on the first twelve protocols in order to identify differences and similarities between subjects. We began by using a large number of characteristics for the first twelve participants. The analysis allowed us to determine which characteristics would later be used in the quantitative phase of the research (design behavior profile identification).

The quantitative analysis was performed on the entire experiment population. In this article, we focus on the solution generation phase and the specific characteristic of reflection in action—or assessment and evaluation.

Results

Solution Generation Profiles

From analysis of the variables relating to solution generation, we identified four design behavior profiles: **Realization Oriented Profile, Learning Oriented Profile, Designer Oriented Profile** and **Assessment Oriented Profile.** We used AMOS (Analysis of Moment Structures) to perform a Confirmatory Factor Analysis. The factor loading of the solution generation phase is presented in Table 1.

Table 1: Factor Loading – Solution Generation Profiles

Designing characteristics	**Profile S-1 Realization**	**Profile S-2 Learning**	**Profile S-3 Designer**	**Profile S-4 Assessment**
Solution type				
General	-0.456	0.004	0.196	-0.003
Detailed	0.707	0.002	-0.005	0.131
Thinking type				
Abstract	-0.119	-0.393	0.746	0.0007
Concrete	0.726	0.146	-0.283	0.251
Main Preference				
Functional issues and rules	0.185	0.755	-0.151	-0.005
Spatial issues and rules	0.136	0.740	0.105	0.007
Strategic issues and rules	-0.007	0.104	0.754	0.106
The use of examples				
Personal	-0.328	0.0002	0.418	-0.286
Design world	0.632	0.156	0.142	-0.302
Reality	-0.147	0.777	-0.0006	-0.248
Assessment				
Testing design steps	0.106	0.594	0.192	0.378
Testing the ideas in reality	0.709	0.118	-0.103	0.193
End solution according to initial idea	0.003	0.003	-0.005	0.827
Personal awareness	-0.144	0.183	0.748	0.009
Solution according to problem requirements	0.222	-0.008	0.228	0.586
Cronbach's Alpha	0.68	0.70	0.64	0.46

The CFA (Confirmatory Factor Analysis) results are presented in Figure 1. The four profiles were built from the solution generation characteristics with the highest factor loading, and then analyzed to check their inner paths[1], i.e., the way the solution generation characteristics are related in a specific factor.

[1] Since we found complex relations here among characteristics, we used Structural Equation Modeling (SEM via AMOS) in order to find the different paths among characteristics. SEM allows us to introduce multicollinearity into the models and to model mediating variables, rather than be limited to an additive model, as in OLS regression.

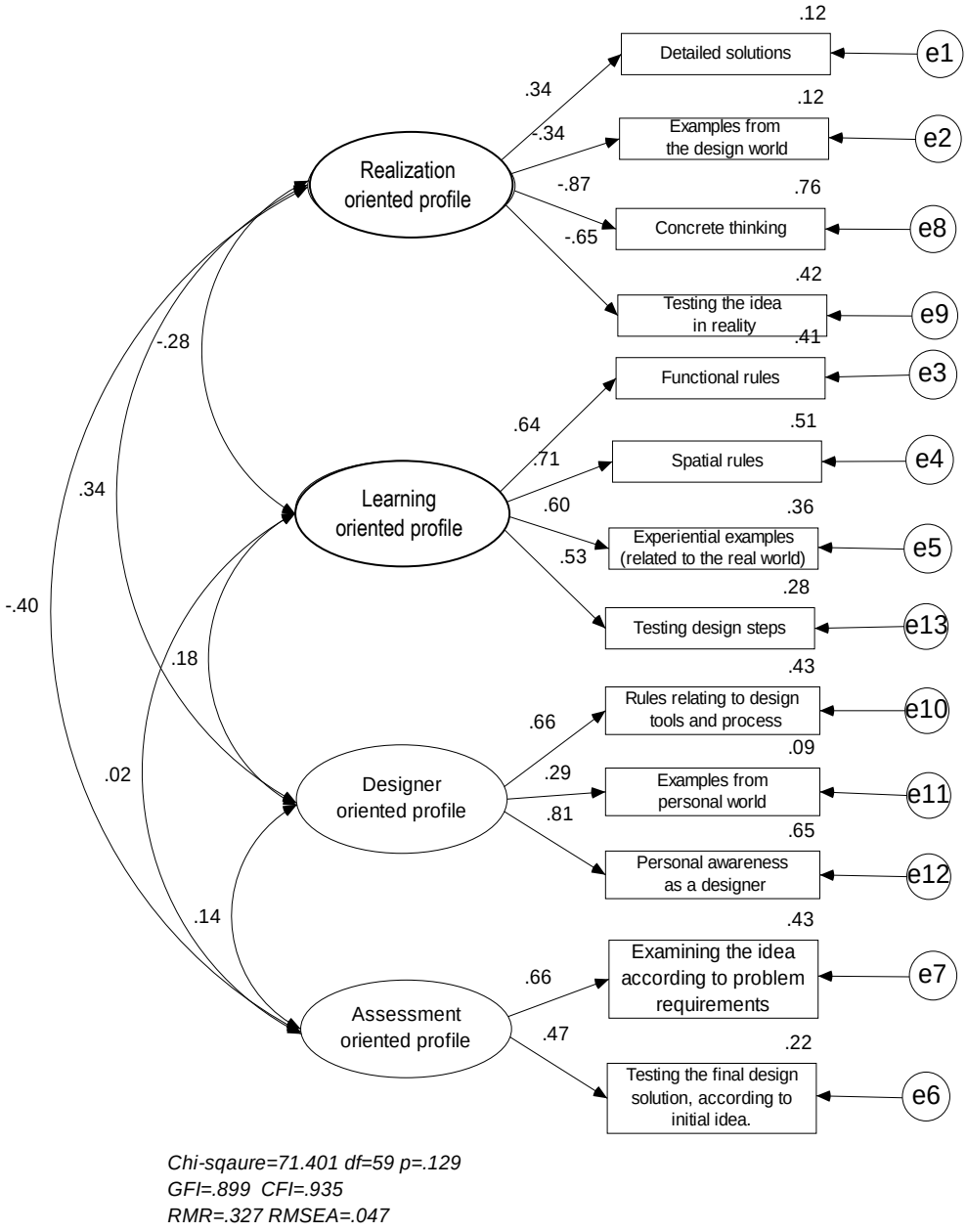

Figure 1: Confirmatory Factor Results – Solution Generation Characteristics

Solution Generation Profiles Mapping

a) Realization Oriented Profile (Profile S-1)

The profile displays a significant positive correlation among the designing characteristics. When examining the complete profile, all the designing characteristics of detailed solution—the use of examples from the design world and thinking in a concrete manner—explain the characteristic of

testing the design idea in reality. In other words, the above characteristics influence and predict the nature of dealing with design ideas and solutions in the practice of design (Figure 2)

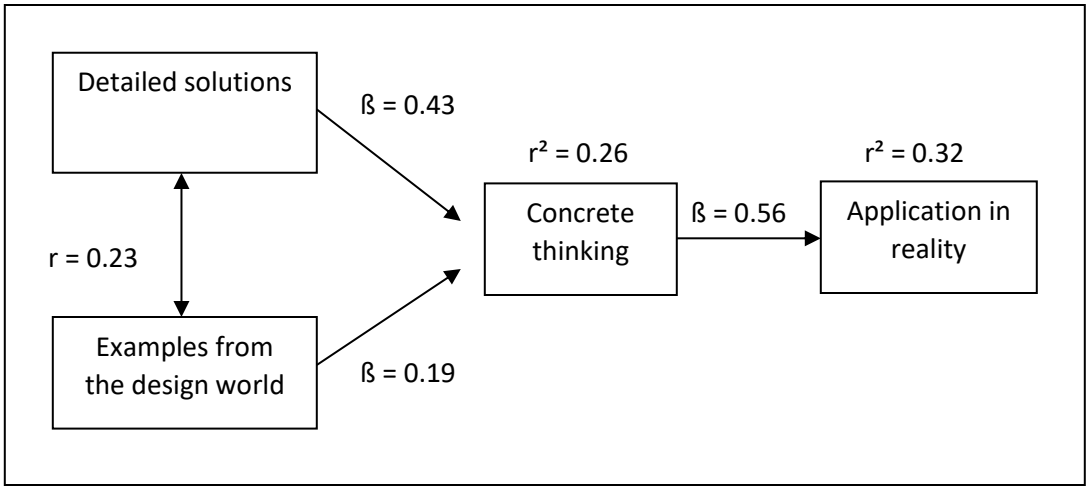

Figure 2: Solution Generation Profile S-1 – Realization Oriented Profile

The profile model was accepted as having a good model fit,[2] i.e., the overall model fits not only the sample data but also the population data.
The profile displays a significant positive correlation between the characteristics of detailed solution and the use of examples from the design world. That is, students who tend to use examples from the design world also tend to detail their design solutions during the process of solution generation. The profile path includes these designing characteristics as positively affecting concrete thinking (they vary in the extent of their effect; detailed solution has the greatest effect on concrete thinking).

The concrete thinking characteristic affects the assessment characteristic of testing the design idea in reality; the complete path model explains 32% of the assessment characteristic variance.

[2] *Chi Square goodness of fit* test was not significant (p=0.104). A significant chi square indicates lack of satisfactory model fit.

b) Learning Oriented Profile (Profile S-2)

When the complete profile is examined, all the designing characteristics—emphasizing functional issues and rules, use of examples from reality (experiential examples) and use of spatial issues and rules—explain the characteristic of testing the design steps during the solution generation process. In other words, the above characteristics influence and predict the testing the design steps characteristic (Figure 3).

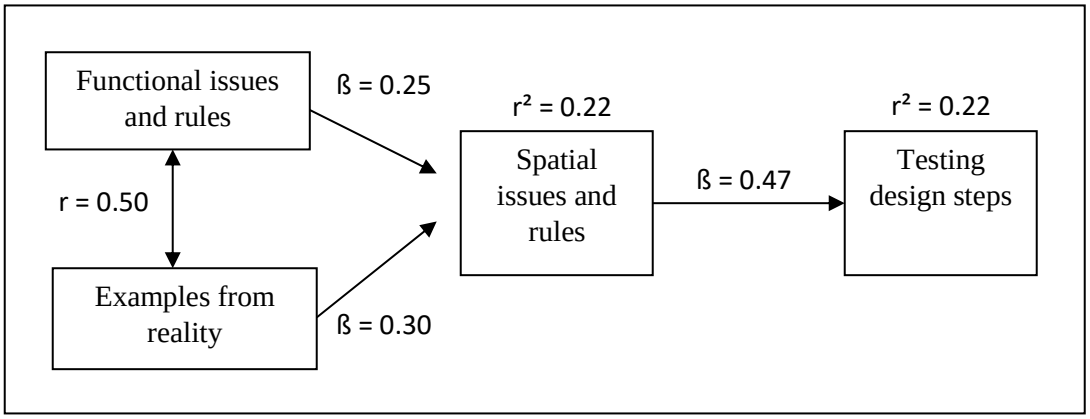

Figure 3: Solution Generation Profile S-2 – Learning Oriented Profile

The profile model was accepted as having a good model fit.[3] The profile shows a significant positive correlation between the characteristic of use of functional issues and rules and use of examples relating to the real world—that is, students who tend to use examples from reality also tend to use functional issues and rules in their solution generation process.
The profile path includes these designing characteristics as positively affecting the use of spatial issues and rules, which affect the assessment characteristic of testing the design steps; therefore, the complete path model explained 22% of the assessment characteristic variance.

c) Designer Oriented Profile (Profile S-3)

The complete path displays the designing characteristics: using abstract thinking, using examples from one's personal world and emphasis on strategic issues and rules that are uncorrelated, as explaining the characteristic of designer's personal awareness. In other words, students who display this profile tend to use abstract thinking, which leads them to use either one or both examples from their personal world and to emphasize strategic issues and rules (relating to design tools and processes). This affects their behavior of being aware of their design processes during the solution generation phase. The extent of the effect of emphasizing strategic issues and

[3] *Chi Square godness of fit* test was not significant (p=0.540).

rules is greater than the use of examples from one's personal world. The complete model explains 32% of the variance of the assessment characteristic (Figure 4).

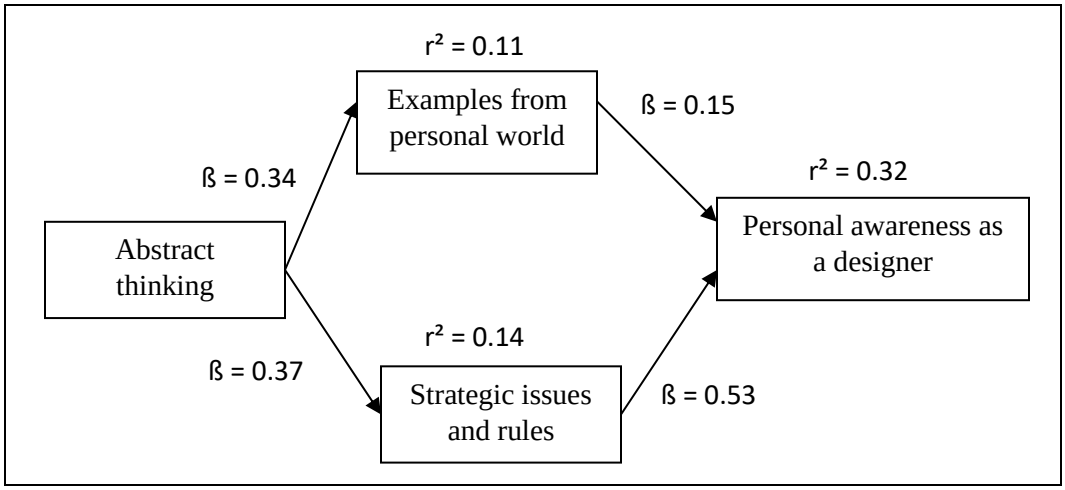

Figure 4: Solution Generation Profile S-3 – Designer Oriented Profile

d) Assessment Oriented Profile (Profile No. 7)

The profile includes a significant positive correlation between the designing characteristics: examining the design idea according to problem requirements and testing the final design solution according to the initial idea; that is, students who tend to examine their design ideas with the problem requirements in mind also tend to test their final design solutions according to their initial ideas or concepts (Figure 5).

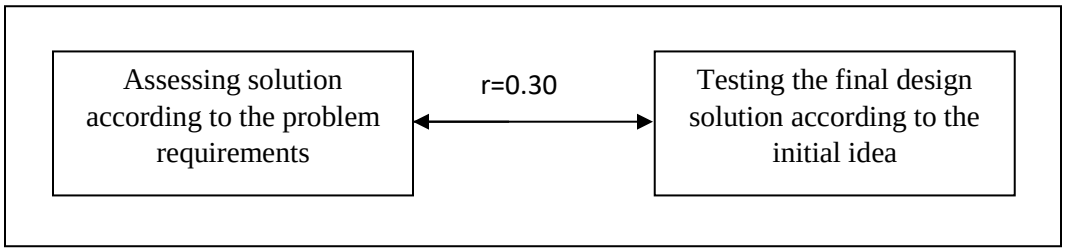

Figure 5: Solution Generation Profile S-4 – Assessment Oriented Profile

Discussion

We identified differences between students' design behavior based on combinations of design charactertics that generated the individual's innate manner of designing. The four profiles distinguished in the solution generation phase proved significant; they were displayed by 80% of the participants who developed design solutions.

In analyzing the four solution generation profiles, we see that they may be divided into three approaches to design: (1) the personal approach, which focuses on the designer, and his individual process of idea generation focuses on the personal design process and on theorizing design ideas (S-3 – Designer Oriented Profile); (2) the information driven approach, which focuses on the given assigned design problem and focuses on solution generation as a learning experience (S-2 – Learning Oriented Profile); (3) the realistic approach, which focuses on the end solution and its implementation in reality (S-1 –Realization Oriented Profile and S-4 – Assessment Oriented Profile directed at the end solution and its assessment).

The solution generation profiles model (Figure 6) includes four components: (1) main preference and/or solution type; (2) use of resources; (3) assessment type. Observing the model, we see that the resources used by student-designers and the manner in which they assess their process and solutions are consistent in all profiles. The direction of the arrows that represent the relationships between the components all affect the way student-designers reflect and assess their processes and solutions. This discussion analyzes in depth the profiles, with emphasis on the type of reflection in action and assessment. We also address the differences and similarities between reflection in action as manifested in the profiles and the notion of systematic reflection in psychology.

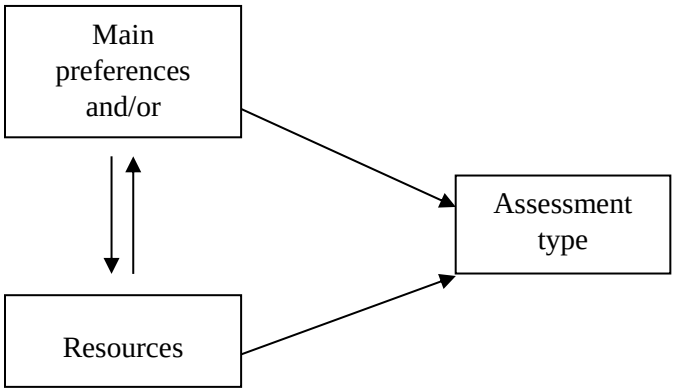

Figure 6: Model of Solution Generation Profiles

Realization Oriented Profile (S-1)

The Realization Oriented Profile (S-1) was identified in student-designers who sought solutions that could be tested in reality and implemented in the practical realm. To reach a solution that could be tested based on practical criteria, these student-designers believed that solutions had to be detailed and clearly explained. Throughout the entire process they tended to use within-domain knowledge resources—from the design world and from the profession, which suited the type of solution they chose to develop. These resources resemble the "objective intention" of designers, as expressed by Downing (2000, 100). She found that some designers, when describing places, were less concerned with their personal experience and feelings than with an analytical and objective description.

The use of resources helped student-designers to detail their solutions by repeatedly referring to examples as they developed their design. Moreover, it affected the way they assessed their progress by continually asking themselves whether the solution could be implemented in reality, and whether it could actually be built. They expressed the focus of their solution in statements, for example: "*I will design it in a precise and professional manner so I can see if the ideas can withstand the test of reality*"; "*only someone who stands here can see what happens on the highest shelf* "; "*I need to relate to the different hours of the day and how people enter the space*."

Relating this type of reflection to the issue of systematic reflection, we can say that the students placed greater emphasis on feedback due to their primary focus on the end result: if their design could actually be implemented in reality.

Awareness of this type of design behavior can be applied to learning in design education by showing students precedents and demonstrating their contribution to both design development and the application of their solution in practice.

Learning Oriented Profile (S-2)

The Learning Oriented Profile (S-2) was displayed by student-designers who remained within the parameters of the given problem and regarded the assignment as a learning experience. They were not interested in reaching a detailed end solution, but in presenting the best linkage between function and space. Throughout the entire process they developed their solutions based on the relationship between functional and spatial aspects, using rules and themes associated with functionality and spatial language. To acquire better understanding of this relationship, student-designers used experiential resources.

This profile can be seen as a combination of both the designers' "objective intentions" (Downing, 2000, 100) and "experiential intentions" (Downing, 2000, 97). Objective intentions are represented by the continuous analysis and description of the spatial attributes and the functional rules. Experiential intentions are represented in reference to the designers' experience in situations evoking the desired atmosphere within the current designed space.

The focus placed on the relationship between function and space, and the use of experiential examples, affect the manner in which the assessment is performed—in this case, repeat testing of design steps throughout the solution generation phase. Testing plays several roles, including keeping track of the design moves; checking the spatial aspects of the design; inspecting its uniformity, as manifested in the relationship among the functional, spatial and experiential aspects of the design. Testing often sets the pace for the progress of the solution generation process. This type of reflection is represented by phrases like: *"I'm looking at plans, trying to figure out what else I have in this space" (looking at the given data of the design problem) ..." I think I made a good decision to lower the ceiling because it's not comfortable to be in such a narrow and tall space" ....." I have to look back at all my ideas and to see if they really work within the space I designed. Does the movement in space, actually work?... I have to emphasize the main element under the window, so people will have something to look at..."*

When relating this type of reflection to the issue of systematic reflection, we can say that there is greater emphasis on data verification due to the student-designers' main focus on the process as a learning experience, and being involved in checking the data given in the design task and if it is used properly in the process of developing the design solution.

These findings can be applied to learning and design education by encouraging students to use experiential resources, and thus contribute to better use of functional and spatial issues and rules in the generation of solutions.

Designer Oriented Profile (S-3)

Student-designers who displayed the Designer Oriented Profile (S-3) were mostly preoccupied with their own personal design process. Their objective was to develop a general solution that was personal, and that could serve as a basis for future development based on their design ideas, processes and tools. These student-designers, as opposed to student-designers acting upon all the other design profiles, were not interested in arriving at a detailed solution; nor were they interested in relating to the specific data of the given space. Throughout the process, they used a rich vocabulary of personal resources in the form of abstract visual images and analogies. These resources helped them enrich their design ideas and produce a formal design language. These participants also relied on procedural knowledge, referring to the design tools and processes that they used in the process.

It is interesting to note that reliance on procedural knowledge in the use of design tools was evident during the assessment, when the student-designers reflected on the actions forming the design process. Reflection on the process is expressed in statements such as: "*I do things without thinking, and even if the sketch doesn't look right to me I continue to develop it so it will look nice*"; "*My purpose is to arrive at a general language that will dictate the type of conceptual model and sketches that will follow*"; *"What I'm doing here is actually making a conceptual model and the building in the end will look entirely different."*

This profile may reinforce the observation of Murty /CHECK SPELLING IN REFS/ and Purcell (2007) with regard to experienced architects who were identified as process orientated designers. In this research, we showed that this orientation is also displayed by students, and not only experienced designers, as observed by Murty and Purcell.

When relating this type of reflection to the issue of systematic reflection, we can say that there is greater emphasis on self-explanation due to the student-designers' constant involvement in discovering their actions while designing.

Assessment Oriented Profile (S-4)

This fourth solution generation profile consists of two design characteristics: evaluating solutions according to the initial proposed idea, and doing so according to the design problem requirements. At times, designing on the basis of this profile occurs in conjunction with designing according to other profiles. In other words, participants who display this profile in combination with other profiles tend to reinforce the act of assessing their results, in addition to following their progress throughout the solution generation phase.

Nevertheless, students who designed on the basis of this profile were constantly preoccupied with evaluating their solutions, to verify that they were succeeding in implementing their own design decisions and fulfilling other requirements (in this case the problem requirements). Often, the evaluation was performed by describing the final result, and commenting with phrases such as "*This is like the idea I wanted to develop*"; "*My initial idea was… so I would like to keep it like that*"; " *I like it this way*."

Although this profile is relatively narrow due to its sole focus on evaluation, it can be easily detected by design teachers and used to encourage students to evaluate their final design with regard to both their ideas and their teachers' requirements. We observed that many of the student-designers, when developing their solutions, designed on the basis of this profile in combination with other profiles. This finding underscores the role of reflection and assessment in the design process and reinforces the need for greater awareness of this profile's design characteristics. It would be interesting in future research to study the effect of extensive use of assessment and evaluation on the student-designers' results in terms of quality and originality.

Studies relating to systematic reflection have further shown that its effectiveness depends on situational (e.g., reflection focus) and person-based (e.g., conscientiousness) factors (Ellis et al., 2014, 70). We believe that understanding the various types of reflection in action and assessment of designers can be used for further research in systematic reflection during people's activities. This affirms Ellis's view: "Given today's unrelenting pace and the abundance of activities in which people are involved, future researchers may want to investigate how to effectively integrate systematic reflection within the busy daily environment of the learner."

Conclusion

Creating awareness in both design instructors and students of differences in design behavior may add another, beneficial, dimension to design teaching and learning. Design education may be optimized if we use the knowledge acquired about design behavior to help students find the approaches and processes that are most suitable for each.
The notion of reflection in action and reflection in general must be firmly related to individual differences and can serve as a tool to perceive and predict learners' behavior. Distiguishing various ways reflection may encourage choosing the right way of teaching and learning for the particular learner and help him, through reflection, to improve his abilities.
Teachers/instructors will be able to make decisions regarding the way they give their students guidance. They could raise their students' awareness of their strengths and of the possibilities offered by other approaches.
We believe that teachers will be able to develop a specific design pedagogy addressing their students' problem-solution orientation tendencies, and increase their awareness of the design phases and their contribution to the overall design process.

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