Different Visual Cognitive Styles, Different Problem-Solving Styles?

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Abstract: Individual differences in spatial problem-solving have been of central concern for both design research and education. While individual differences in spatial problem-solving have been well established in literature, there has been comparatively little attention paid to individual differences in visual cognitive styles and thereby its relationship to spatial problem-solving. By using a case of a design studio, we examine the relationship between individual differences in problem-solving and visual cognitive styles in the context of design education. This study will have implications to established theories on spatial problem-solving and studio-based instruction.

Key words: design problem-solving, cognitive style, spatial visualization, architecture, interior design, design education

1. Introduction

Individual differences in learning and problem-solving have been studied from a variety of perspectives in many disciplines, including education and psychology. Yet, it is difficult to apply the knowledge obtained from the previous research to such unique learning environments as design studios. Design studios are the core of architectural and interior design instruction and learning. Schön [26] identifies the so-called "reflection–in-action" process in design studio as what distinguishes the learning from other settings. Students' problem-solving processes in a design studio are constantly interactive and iterative, which involves brainstorming, peer-to-peer and instructor-to-student critiques. The unique design studio setting offers students a more constructive and rich learning environment that facilitates creative design problem-solving.

The current study focuses on how students approach design problem-solving in their preferred modes of visual cognitive processing, so-called "visual cognitive style." The goal of this study is to understand the role of students' visual cognitive styles for their design problem-solving in an early architectural/interior design studio. Design studio problems are unconventional and often very ambiguous, thus, they require unique and creative problem-solving by individual students. Specifically, beginning studio problems are more abstract and even less structured, leading to solutions that are very diversified and distinctive from student to student. For effective design pedagogy, it is essential for instructors to prepare students for multi-faceted design professions by acknowledging individual differences relevant to their problem-solving.

Traditionally, individual difference research in cognitive psychology had the dichotomy of verbalizer vs. visualizer [15, 24], assuming unitary visual ability either bad-good imagers; however, recently researchers proposed two imagery subsystems: object and spatial imagery [17, 4]. In this paper, the Object-Spatial Imagery Questionnaire (OSIQ) was utilized to identified students with different visual cognitive styles between object visualizers and spatial visualizers [17] —a new distinction for mental imagery derived from cognitive psychology. Object and spatial imagery subsystems are known to process visual information differently: object imagery refers to “literal appearance of individual objects,” and spatial imagery refers to “abstract representations of the spatial relations amongst objects” [4].

We explore students’ cognitive styles in response to their approaches to problem-solving in the following four sections: (1) theoretical overviews of the construct of learning styles and visual cognitive styles in design context, (2) a case study - analytical observation of different problem-solving and review criteria based on individual visual cognitive styles and (3) discussion of study findings and implications.

2. Theoretical Background

2.1 Overview of Visual Cognitive Style Research

Cognitive style is one of the individual characteristics that affect any kind of information processing necessary for problem-solving. It is a psychological dimension that represents consistencies in how an individual acquires and processes information [1, 19]. Visual cognitive style is related to an individual’s preferred approach of processing visual information.

Among various cognitive style dimensions proposed and studied by researchers, one of the dimensions continuously draw attention for research is how individuals process visual information using different strategies. The classic visualizer-verbalizer categorization, based on visual information processing, has been widely studied since its introduction [2, 23]. According to this distinction, individuals can be classified as either verbalizers or visualizers, depending on their preferred modes of information processing, i.e., cognitive styles. Until recently, before neuroimaging technologies were developed, research on individual difference in visualization processing styles and preferences has been based mostly on the theory that imagery is a single dimension and therefore individuals may be classified as good or bad visualizers [25, 24].

While the visualizer and verbalizer concepts were considered to be opposite ends of a single continuum [22], recent empirical studies in neuroimaging and neuro-psychology suggest that there are two areas in the brain that are functionally distinct for perceptual processing of object properties and spatial relations [20, 10]. Kozhevnikov et al. [17] found that visualizers fell into two contrasting groups for either low or high spatial ability. A newer approach to characterizing individual differences in cognitive styles is based on the evidence in neuro-psychological studies proving that higher level visual areas of the brain are divided into two functionally distinct subsystems: the object and the spatial relations subsystems [14, 27]. Similarly, in neuroimaging studies, spatial and object imagery tasks led to very different patterns of brain activity [16]. Particularly relevant to the current study is the well-established distinction between the ventral visual system functions (mainly for processing shapes and other properties of objects such as color and texture) and the dorsal visual system for processing spatial relations.

Object Visualizers versus Spatial Visualizers

Blajenkova et al. have defined object visualization as “representations of the literal appearances of individual objects in terms of their precise form, size, shape, color and brightness” [4], and spatial visualization as “relatively abstract representations of the spatial relations among objects, parts of objects, locations of objects in space, movements of objects and object to parts and other complex spatial transformation” (p.236). Recently, Chabris et al. [5] have established the validity of the dissociation between object and spatial visual cognitive styles with 3,800 participants. Using the Object-Spatial Imagery Questionnaire (OSIQ) self-report inventory, they found that object and spatial processing preferences were uncorrelated. In addition, women, humanities majors and people with visual arts experience preferred object visualizations, where as men, science majors and people with videogame experience preferred spatial visualization. It was also found that object visualizers performed better on a difficult test of picture recognition, whereas spatial visualizers performed better on tests of mental rotation and virtual maze navigation. The distinction between spatial-object cognitive styles is recent and gaining more convincing evidence from animal studies [27].

2.2 Design Problem-solving

Defining Problem-solving in Context

Problem-solving has been a long-standing topic in many fields including cognitive psychology, computer science and education. Problem-solving can be generally understood as the process involved in seeking solutions to problems. Among many variations of its definition with labels of involving processes, Newell and Simon [22] stressed individual characteristics for problem-solving behaviors. They also noted that problem-solving consists of iterative processes of selecting a goal, selecting a method, evaluating the results, selecting another goal and so forth.

Design problems in a studio setting are non-routine and often ambiguous; thus, the solution-seeking needs to be creative and varied according to individuals. In such context, there seems to be much overlap between definitions of creativity and problem-solving. MacKinnon [18] viewed creativity as a process characterized by a novel response to a problem and defined creative process as problem-solving process. On the other hand, Gelfand [12] noted that creativity is a special form of problem-solving thinking needed for an unusual or unique situation. Especially for design problems, creativity and problem-solving are seamlessly intertwined concepts.

In this study, design problem-solving is the solution-seeking, creative process that contains the individual’s unique interpretation of design problem, execution of the design solution, and the activities in-between.

Factors to Consider

In a design studio, the instructor is responsible to facilitate creative problem-solving, but it is typically the individual student who chooses to employ internal or external resources, to determine goals and to make decisions toward the goals. External resources available to students can include tools and materials to execute the design work, and internal resources are individual traits and abilities that each student possesses: different skills, intelligence, prior experience, cognitive styles etc.

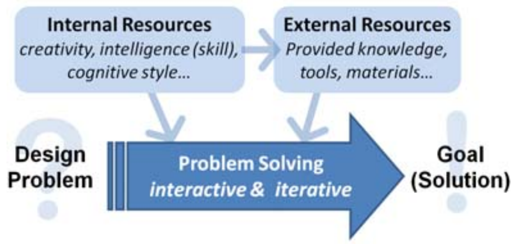


Figure 1. Design problem-solving

Approach to problem-solving depends on how individuals use internal resources. Internal resources also influence the preference of external resources for problem-solving in case they are not predetermined by the instructor. Previous research has addressed different intelligences and skills as representative internal and personal resources that affect problem-solving and performance in various contexts.

According to Gardner's well-known theory of "multiple intelligence" [11], every person possesses eight types of intelligences that can be developed at different levels of proficiency. As shown in Table 1, in his theory, intelligence is viewed as a construct to process information for problem-solving. D'Souza [9] has extended Gardner's multiple intelligence approach for architectural design education and claimed that Gardner's theory can help explain how designers arrive at their solutions differently. In his study, D'Souza found three most relevant intelligences for architects–spatial, intrapersonal and interpersonal intelligence–and suggested that the use of these intelligences by designers in the design process leads to better understanding of creativity.

Table 1. Multiple intelligence theory: types and characteristics

Gardner's eight intelligence types	Characteristics and associated personalities [11]
Linguistic intelligence	Sensitivity to meaning and order of words. Journalists and poets
Logical-mathematical intelligence	Ability to handle chains of reasoning and recognizing patterns, numbering and order. Computer programmers and mathematicians
Spatial intelligence	Ability to perceive, transform and modify spatial information easily. Artists, painters and sailors
Bodily-kinesthetic intelligence	Ability to use body, to control over motor actions and manipulate external objects. Dancers, gymnasts and rock-climbers
Musical intelligence	Sensitivity to pitch, melody, rhythm and tone. Composers and musicians
Interpersonal intelligence	Ability to recognize others' feelings, beliefs and intentions and understand people and relationships. Counselors, human resource personnel and teachers
Intrapersonal intelligence	Ability to recognize personal feelings and emotions. Writers and thinkers
Naturalist intelligence	Ability to connect with the intricacies and subtleties of nature. Botanists and archeologists

2.3 Assessment of Design Problem-solving

Assessing the Creative Process

For successful instruction, assessment should be a vehicle for understanding student learning. Critical assessment for problem-solving in the design domain is more qualitative in nature than quantitative; thus, instructor grading for design solutions is typically based on the form of criteria specified for the individual project. Educational assessment of creativity has been in a long-standing crux. While the focus of the assessment in general is on the end product, researchers in the field claim that the processes of creative thinking, design conceptualization and development should also be taken into consideration as an important part of design instruction and assessment.

Specifically, assessments on aesthetic value and creativity can be subjective, ambiguous and complex. While assessment criteria can be developed by the assessor and can be operationalized using systematic scales, it is fair to say that the assessment reflects the reviewer's own interpretation of the student work. Because certain phases of problem-solving in design are intangible in nature, it becomes almost impossible to develop quantifiable parameters to assess the entire problem-solving process.

For example, among four stages of the creative process, i.e., preparation, incubation, illumination and verification proposed by Wallas (1926), incubation and illumination stages are most internalized processes and are harder to assess, whereas verification is relatively less complicated to operationalize with quantifiable parameters for assessment (Table 2).

1. Preparation	Analysis and formulation of the problem and related issues
2. Incubation	A period of time away from the problem to allow relevant processing to occur below the conscious level
3. Illumination	Effortless (or sudden) or inspirational illumination with a solution
4. Verification	Critical self evaluation of the idea (solution)

Table 2. Wallas' four stages of the creative problem-solving process

Guilford [13] has addressed four factors to assess creativity: originality (or innovation), elaboration, fluency and flexibility. In searching for correlation between creativity and design problem-solving, Casakin [5] found the significance of originality among multiple creativity factors and concluded that design creativity can be enhanced when a redefinition of the design problem and a search for alternative solutions interact with each other.

Letting the Work Speak for Itself

While instructors may be able to evaluate that the design problem-solving was original and innovative, it is rarely possible to closely observe the entire design processes of every student in a studio unless they are articulated and documented in a communicative form. Students, as well as design practitioners, tend to work off of free improvisation. In design studio, problems are often intended to immerse students in the act, focusing not on reading or writings, but on doing. For these reasons, articulating conceptual ideas and schematic rationales for design process are extra and unfamiliar tasks. Generally, students in early studio sequence are less fluent in communicating their ideas and problem-solving processes, either verbally or visually. Therefore, the culture of "letting the design work speak for itself" in design is well adopted based on the assumption that the end product can demonstrate the design problem-solving to an acceptable degree.

Specialized accrediting agencies for professional architecture and interior design programs such as NAAB (National Architectural Accrediting Board) [21] and CIDA (Council of Interior Design Accreditation) [8] provide criteria to examine curricular goals and student performance as learning outcomes substantially based on "completed" student work. As accrediting agencies require sample student work that demonstrates student learning expectations, studio projects are designed to meet the professional criteria. Beginning studio project requirements include demonstration of creative thinking, visual/verbal communication skills and fundamental design skills in the completed work. In summary, while the thinking process categorized as incubation and illumination [28] may not be fully communicated, the creative problem-solving and solution can be generally gathered in students' final presentations and critiques.

3. Case Study

In this study, we examined 33 sophomore students enrolled in beginning studio with approximately equal number of pre-architecture and interior design majors at a Mid-west university in the U.S. Their solutions for two design projects were examined by design critics. About four weeks were given to each design problem, which contained a series of assignments leading to the final design outcome. At the end of the four-week period, students were required to document and present their problem-solving processes, in addition to presenting their design boards at the final critiques.

In order to investigate individual students' visual cognitive styles, student responses to Object-Spatial Imagery Questionnaire (OSIQ) items were collected and analyzed using SPSS statistical software.

3.1. Design Problems

In architectural/interior design studios, design problems for the beginning studios are abstract and cover a wide variety of topics focusing more on the fundamentals of design through creative, aesthetic solutions with competent concept development and effective communication [8]. Students are expected to learn and exhibit their understanding of a foundation in fundamentals of design including design elements (for example, line, space, mass, shape), principles (for example, balance, scale, proportion, harmony, variety, rhythm, emphasis) and principles of color/light and design composition.

Students were asked to solve two design problems as outlined below.

Problem 1: Three-Dimensional Interpretation of Cubist Painting

Students were asked to choose one painting by a cubist artist, such as Picasso, Braque, or Gris; create a 3D sculpture and turn it into a 3D meditation space. This problem was designed to encourage students' spatial thinking and facilitate effective use of design principles for creative design solution. Additionally, students are expected to become more familiar with how to start and finish creative problem-solving from a unique context. Over the course of four weeks, four assignments were given: create 3D model of a cubist painting, explore lighting alternatives, convert an abstract space into a realistic design space and explore color schemes. The 3D models were approximately 12”×18” using museum boards. Google “Sketchup” software was used to render the architectural space.

Problem 2: Musical Passageway

Students were asked to design an underground, musical passageway inspired by a music piece of their choice. The passage is 36ft-wide, 160ft-long and maximum 25ft high. In addition to the passageway, students were required to add a small seating area of about 300 square foot. First, students selected a music piece and recorded their inspiration from it using sketches. Next, students explored various lighting effects with 8inches×8inches×8inches lighting study boxes with multiple layers, different color/temperature and shapes (point/line/area lights). Then, students incorporated what they learned in the physical model of the passageway. During the final week, students developed their design in floor plan, elevation, section and selected materials using computer rendering.

3.2. Different Visual Cognitive Styles: OSIQ Results

The total number of participating students was 33, comprised of 27 females and 6 males from Design Studio I. Both pre-architecture (n=16) and interior design majors (n=17) are enrolled in the Design Studio I evenly split. To understand visual cognitive styles, a self-report test using Object-Spatial Imagery Questionnaire (OSPIQ) [4] was administered. The OSIQ instrument includes 30 total items on a 7-point Likert scale—15 items from the object visualization factor and 15 items from the spatial visualization factor. The SPSS statistical package was used to analyze the data.

After a series of data reduction and scale reliability tests of the original OSIQ items, twelve items –six items for each visualization scale- that were most representative of the two visualization measures were retained (Table 4). For each student, the six items from each scale were averaged to create object and spatial scale scores.

Table 4. OSIQ items included in the study

Object visualization items	Spatial visualization items
• I can close my eyes and easily picture a scene that I have experienced. • My mental images of different objects very much resemble the size, shape and color of actual objects that I have seen. • My visual images are in my head all the time. They are just right there. • Sometimes my images are so vivid and persistent that it is difficult to ignore them. • When reading fiction, I usually form a clear and detailed mental picture of a scene or room that has been described. • My images are very vivid and photographic.	• I have excellent abilities in technical graphics. • If I were asked to choose between engineering professions and visual arts, I would prefer engineering. • I can easily sketch a blueprint for a building that I am familiar with. • I am good in playing spatial games involving constructing from blocks and paper (e.g., Lego, Tetris and Origami). • I can easily imagine and mentally rotate three-dimensional geometric figures. • If I were asked to choose between studying architecture or visual arts, I would choose visual arts. (reverse coding)

Statistical analysis demonstrated that there was no correlation within the two scales of object visualization and spatial visualization among designers (r =.10, p=.57). However, this finding is a variation from previous findings that show that the two scales were not only uncorrelated but also negatively correlated [5, 17]. This result could be partly attributed to the homogenous sample of students of spatial design majors who participated in this project.

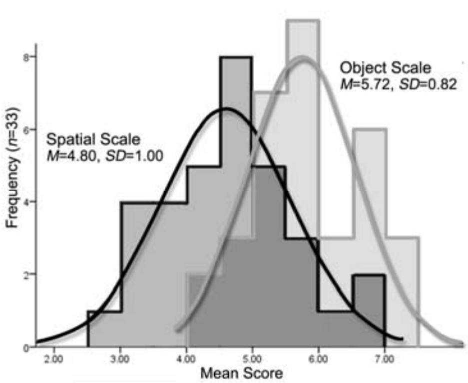


Figure 2. Histogram: object-spatial visualization scales

Moreover, as shown in figure 3, in the aggregate students scored higher in object visualization (M = 5.73, SD = 0.82, minimum = 4, and maximum = 7) as compared to spatial visualization (M = 4.80, SD = 1.00, minimum = 2.67, and maximum = 6.67). For the object scale, Cronbach's α = 0.83, and for the spatial scale, Cronbach's α = 0.81, both of which are above recommended coefficients.

While the current study is the first visual cognitive style study with a design student sample group consisting architecture and interior design majors, the OSIQ results in large follows the patterns consistent with previous studies.

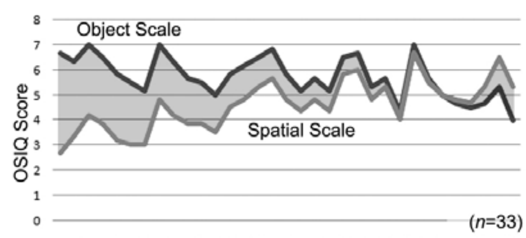


Figure 3. Score gaps between object and spatial scale (M=1.13, SD=1.23)

Coherent with previous findings [7], the mean scores were higher on the object scale than the spatial scale (Figure 2), and significantly more object visualizers were observed than spatial visualizers. As demonstrated in Figure 3, the score differences between object and spatial scales determines object or spatial visualizers and noticeably more students exhibited higher object visualization scale scores than spatial scores ($M_{object\text{-}spatial}$ = 1.13, SD=1.23).

In Blajenkova et al.'s [4] study with three professionals–visual artists, scientists and humanities professionals—the findings display that visual artists and humanities professionals scored higher on the object scale, while scientists scored higher on spatial score. Similarly, Casey et al. [6] demonstrated that engineers, physicists and mathematicians scored higher on spatial ability tests, whereas visual artists scored higher on visual memory tests. Kozhevnikov et al. [17] also found that visual artists scored higher on object imagery test, but scientists and engineers scored higher on spatial imagery tests.

Previous studies [3, 4, 17] found differences in visual cognitive styles among professionals in different fields. Since the sample consisted of both architecture and interior design majors, we assumed that there could be significant differences between the visual cognitive styles of these two groups. To test the assumption, an independent-sample t-test was conducted. While no significant difference in object scores was found between two major groups, we found that architecture students scored higher (M=5.07, SD=0.81) on the spatial visualization scale than interior design students (M = 4.25, SD = 1.04), t(31) = -2.52, $p < .05$. (Table 6)

Table 6. T-test result: visualization scores for architecture vs. interior design students

	Major : *M(SD)*			
	Architecture	Interior Design	*T*	*df*
Object V. Score	5.60(.88)	5.81(.79)	7.20	31
Spatial V. Score	5.07(.81)	4.25(1.04)	-2.52***	31

Note. * = $p < .05$, *** = $p < .01$. Standard Deviations appear in parentheses below means.

The OSIQ has been validated as an instrument assessing object and spatial imagery by demonstrating that professionals known to use a different visual processing mode in their work or training score differently on the scales. In our study, it is important to note that participants determined their majors but have not started professional training. As an OSIQ item indicates, architects are considered spatial visualizers, and visual artists are considered object visualizers. This result is consistent with mainstream design thinking where architects are considered stronger in spatial visualization. Our finding suggests that students choose their major between interior design and architecture according to their visual information processing styles and the characteristics of the profession.

3.3. Design Assessment Results

Based on the score differences between the two visualization scales as outlined in the previous section, we identified the following three groups.

- Object visualizers: students scored high on object scores and low on spatial scale
- Spatial visualizers: students scored high on spatial scale and low on object scale
- Unclassified: students scored similarly in the two scales

As shown in Figure 3, among the students in this study, object visualizers significantly outnumbered spatial visualizers. For the current study, we wanted to explore the characteristics of design problem solving by the two visualizer groups–i.e., object visualizers and spatial visualizers– specifically based on critical assessments.

Two design professionals reviewed the student work based on evaluation criteria described in the problem description; design concept, design exploration and development, element and principles in design outcomes, and communication. Evidence of each criterion was required for the final critique. The evaluation criteria were further developed for critical assessment by the critics. Table 3 shows the assessment categories and descriptions.

Table 3. Assessment criteria

Main category	Descriptions	Sources
Design concept	Understanding of the nature of the project Originality and creativity of the idea	Written concepts
Design development	Ability to work with plan, section and elevation simultaneously in 3D (spatial ability)	Study models, sketches
Design principles and elements	Aesthetic quality of the completed work with successful use of lighting, color and other design principles	Completed work
Visual presentation	Effective visual communication skills shown in craftsmanship, computer/manual rendering, visual organization of required contents and board layout	Renderings, models, presentation boards

With the criteria providing a broad framework, the assessments we present are based on the critic's interpretation of design criteria based on the student's presentation boards demonstrating the required materials including design concept, design development, and solution. As shown in examples of student work from the two design problems (Table 5), whether there is a relation between the critics' assessments and the characteristics of visual-cognitive styles was further explored.

After reviewing each project based on design criteria, written evaluations were analyzed to capture general characteristics in the two groups' problem-solving style. Table 5 demonstrates different styles in problem-solving for studio problems by two students: Olivia (object visualizer) and Sara (spatial visualizer).

Problem 1: Three-Dimensional Interpretation of Cubist Painting

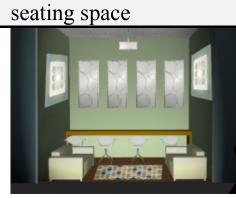
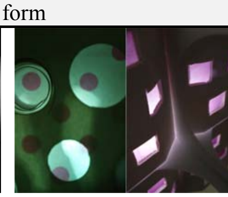
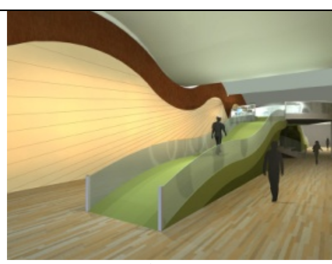
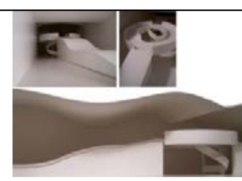
> Object visualizers tend to simplify the original paintings, whereas spatial visualizers incorporate more layers for 3D interpretation assignments. Object visualizers focus more on individual elements (e.g., trees, faces, etc.), and spatial visualizers demonstrate spatial harmony among the individual elements more successfully. The 3D models by object visualizers are primarily worked out in plan, while spatial visualizers display more sectional thinking in the solutions.
>
> In creating the 3D meditative space, object visualizers tend to emphasize realistic details more than spatial visualizers. Therefore, there seems to be more information in object visualizers' designs than spatial visualizers'. Spatial visualizers tend to use figure-ground principle (negative space as important as positive space) more effectively. Spaces designed by spatial visualizers were more abstract.

Problem 2: Musical Passageway

> For object visualizers, inspirations mostly came from the lyrics or mood, while spatial visualizers used instruments or melodies for inspiration. More regimented use of form and color is observed in object visualizers' solutions. Object visualizers tend to use design elements to create two-dimensional visual interests, i.e., pattern, on walls, floor and ceiling; spatial visualizers tend to develop musical experience with the entire form or three-dimensional addition to the space. Overall, object visualizers are likely to have more emphasis in two-dimensional elements, while spatial visualizers are better at spatial thinking, such as treating the space as sculpture.

Table 5. Sample student works: object vs. spatial oriented problem-solving

Problem1	Select a Cubist painting	Construct 3D interpretation	Explore lighting alternatives	Develop a meditative space from a chosen area
Object visualizer	 *Still life before an open window* by Juan Gris			  Design concept The simplicity of the form with the curvilinear details was used to create a sculpture inducing reflection and relaxation. Olivia
Spatial visualizer	 *Girl before a mirror* by Pablo Picasso			  Design concept The sculpture was created to emphasize the contrast between the curves, which define the woman and her reflection. Sara

Problem2	Design a pedestrian passageway Inspired by music	Create a Develop seating space	Develop study model for lighting and form
Object visualizer	 *Swing* by Jacks Mannequin	 Design concept Circle shapes were used to convey symbolic message of life and the movement of music	  Olivia
Spatial visualizer	 *Leaving Istanbul* by Rosette Guitar Duo	 Design concept Peaceful transition inspired by the delicate melodies of the instrumental guitar piece, a peaceful transition was designed with the form of the curved silhouette of guitars.	  Sara

These characteristics are confirmatory of previous studies. Blajenkova et al. [4] reported that object visualizers tend to construct colorful, pictorial and high-resolution images of individual objects, while spatial visualizers tend to use imagery to schematically represent spatial relations among objects and to perform complex spatial transformations. Kozhevnikov et al. [17] added that object visualizers encode and process images holistically, as a single perceptual unit, and visual artists tended to be object visualizers; spatial visualizers generate and process images analytically, part by part. The finding in this study also demonstrated that object visualizers and spatial visualizers approach design problem differently in studio design problem-solving context.

4. Conclusion

Visual cognitive styles are understood as individuals' preferred modes of encoding or decoding visual information. This study is an attempt to investigate how individual students approach creative design problem-solving by exploring different visual cognitive styles when working on studio problems. Design problems in an early studio within an architecture-interior design curriculum are unique in the sense that they are more driven by aesthetics than functionality, focusing more on the fundamentals of design. In addition, novice design students in professional design programs are accustomed neither to creative problem-solving nor to articulating their ideas and thought processes. Thus, it is important for instructors to grasp how and why students arrive at design solutions. Understanding individual traits in visual cognitive process allows the instructor to be more effective in facilitating students' design problem-solving with more balanced and constructive feedback.

In this study, critics' qualitative reviews on student projects were analyzed with the students' preferred visual information processing styles acquired by the OSIQ self-report instrument. Several comparable characteristics in problem-solving by the two groups, object visualizers and spatial visualizers, were observed. Object visualizer students displayed their tendency to work with 2-D details and to choose more familiar objects as design motives, creating simpler 3-D structures and emphasizing materials. On the other hand, spatial visualizer students tended to perform better at incorporating 3-D elements in design via spatial thinking with less emphasis on materials. In the studio of our case study, between two major groups - architecture and interior design - it was also found that architecture students scored significantly higher in spatial visualization. Our findings also suggest that students choose their majors based on their perception of architecture and interior design majors as well as their visual cognitive styles. Architecture students had higher spatial visualization style scores compared to interior design students. While our findings are generally in agreement with previous characterizations for the two visualizers, we did not clearly observe the holistic image processing for object visualizers and analytical, part-by-part processing for spatial visualizers.

As the assessment of creativity, aesthetics and design problem-solving is still a critical issue in the literature, one limitation of this study stems from the absence of quantifiable assessment data for critics' evaluations. For more generalizable implications, future study may explore quantitative assessments by more reviewers to statistically analyze the various dimensions of creative problem-solving in response to student cognitive styles. Based on this study's framework and findings, additional work will lead to a more rigorous investigation between the relationship of visual cognitive styles and design problem solving. This will have practical implications for teaching and learning by more effectively accommodating individual differences in design instruction.

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