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The Relationship Between Cognitive Style and Visual Spatial Intelligence Of First Year Architectural Students

İlk Yıl Mimarlık Öğrencilerinin Bilişsel Stilleri İle Görsel Uzamsal Zekaları Arasındaki İlişki

Yasemin ERKAN YAZICI
İstanbul Kültür Üniversitesi, Mimarlık Fakültesi, Mimarlık Bölümü, İstanbul, Türkiye

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Abstract

This paper investigates the relationship between the cognitive styles and visual spatial intelligence of freshman students of architecture. Cognitive styles of the students were determined using the "levels" dimension of the Thinking Styles Inventory. The assessment of the 2D and 3D perception skills of the students was based on their performance in answering a series of questions on 3D projections and perspective drawings. The performance of students at answering the questions was found to be significantly related to their cognitive styles. The students with local cognitive style were found to have more advanced spatial perception skills in comparison to the students with global cognitive style.

Keywords: *Architectural Design Education, Cognitive Style, First Year Architecture Education, Thinking Styles Inventory, Visual Spatial Intelligence.*

Özet

Bu çalışmada, ilk yıl mimarlık öğrencilerinin bilişsel stilleri ile görsel uzamsal zekâları arasındaki ilişki incelenmektedir. Öğrencilerin bilişsel stilleri, Düşünme Stilleri Envanteri'nin "seviyeler" boyutu kullanılarak tespit edilmiştir. Öğrencilerin 2 ve 3 boyutlu algı becerileri, 3 boyutlu objelerin izdüşüm ve perspektif çizimleri ile ilgili bir dizi soruyu yanıtlamada gösterdikleri performanslarına bağlı olarak belirlenmiştir. Öğrencilerin soruları yanıtlamadaki performansları ile bilişsel stilleri arasında önemli ölçüde bağlantı olduğu görülmüştür. Ayrıntıcı bilişsel stile sahip öğrencilerin uzamsal algı becerilerinin bütüncü bilişsel stile sahip olanlara göre daha gelişmiş olduğu tespit edilmiştir.

Anahtar Kelimeler: *Mimari Tasarım Eğitimi, Bilişsel Stil, İlk Yıl Mimarlık Eğitimi, Düşünme Stilleri Envanteri, Görsel Uzamsal Zeka*

1. Introduction

Architects use two dimensional drawings such as floor plans and sections and three dimensional models to communicate and evaluate design ideas. Spatial ability of architects is generally assumed to be vital for visualizing three-dimensional information from two-dimensional drawings and in expressing three dimensional information using two dimensional drawings. According to Cho (2012), "understanding the relationship between spatial ability and architectural design studio performance" and "the development of domain-specific tools that measure spatial ability" are among the major research areas related to spatial ability in the domain of architectural education.

Understanding the cognitive processes behind the development and improvement of spatial ability are active areas of research for all STEM (Science-Technology-Engineering-Mathematics) educators, due to its significant effect on the academic performance of students (Ramful and Lowrie, 2015) (Wai et al., 2009).

Individuals develop their own personalized methods for solving problems, achieving objectives and interacting with the environment throughout their lives. These methods are generally shaped by personal decision making processes which are significantly influenced by the cognitive style of the individual or the ways a particular individual prefers to collect, classify, process and interpret information (Erkan Yazıcı, 2013).

This study investigates the impact of cognitive styles on the spatial ability of architecture students. The paper begins with a brief treatment of the theoretical fundamentals related to "cognitive styles" and "visual spatial intelligence". This is followed by the description of the experimental study conducted with freshman architecture students to measure their perception levels in two and three dimensions. Implications of the results of the experimental study are discussed in the conclusion.

1.1. Cognitive Styles

Sternberg (1997) defines cognitive style as the "preferred ways of using the ability one has when thinking or doing something". Some individuals adopt a local or global cognitive style while others adopt a mixture of local and global cognitive styles (Sternberg 1997). When Sternberg's definition of cognitive style is considered in the context of architectural design, it may be remarked that the differences in the cognitive styles of students will have an influence on their preferred ways of solving a design problem which will in turn reflect on their final design products (Erkan Yazici 2010).

Cognitive styles of individuals cannot be simply classified as good or bad and are most definitely not indicators of talent. Rather, the cognitive styles refer to the tendencies of how individuals use their personal talents and abilities. This is an important distinction. Talent refers to how well an individual can carry out a particular task whereas cognitive style refers to an individual's preferred way of carrying out a task (Sternberg and Wagner, 1992).

Riding and Cheema (1991) states that majority of the cognitive style research can be classified under two time periods - from 1960s to the late 1970s and from 1980s to the present. Key studies on cognitive styles during the 1960s and 1970s include Witkin's (1962) field-dependent/field-independent cognitive styles; Kagan's (1965) impulsivity/reflectivity cognitive styles; Pask's (1972) holist/serialist cognitive styles; and Hudson's (1966) divergent/convergent cognitive styles. There are three key studies during the period between 1980s and the present: Lynn Curry's (1983) the three-layer onion model, Riding and Cheema's (1991) two-dimensional cognitive style model, and Sternberg's (1988) mental self-government model.

Sternberg and Wagner (1992) developed Thinking Styles Inventory (TSI) to measure cognitive styles by using Sternberg's Mental Self-Government Theory, which is based on the idea that there are similarities between the ways people make decisions or take action and the ways a society may be governed. According to theory of mental self-government there are thirteen cognitive styles under the five dimensions of mental self-government which are functions, forms, levels, scopes and leanings (Table 1).

Zhang (2002), classifies the cognitive styles into two groups, namely, Type 1 (e.g. legislative, judicial, hierarchic, global) and Type 2 (e.g. executive, local, monarchic, and conservative). According to Zhang, Type 1 cognitive styles are complex in terms of information processing and students with Type 1 cognitive styles and take a deeper approach to learning in comparison with the students with Type 2 cognitive styles. Individuals with global cognitive style are comfortable working on abstract ideas and pay less attention to details whereas individuals with local cognitive styles are more comfortable when working on problems with concrete details (Zhang, 2002).

Table 1. Cognitive styles described by Sternberg's theory of mental self government (Sternberg and Wagner,1992)

Dimensions of Mental Self Government	Cognitive Styles
Functions	Legislative Executive Judicial
Forms	Hierarchic Oligarchic Monarchic Anarchic
Levels	Global Local
Scopes	Internal External
Leanings	Liberal Conservative

Thinking Styles Inventory (TSI) was used to assess the cognitive styles of the students participating in the study as it is a widely-accepted tool in the literature. A number of studies on the validation and reliability of the Thinking Styles Inventory has been conducted by Zhang (1999), Dai and Feldhusen (1999), Zhang (2002) and Zhang (2005). Recently, the Thinking Styles Inventory has been adapted to Turkish language by Buluş (2005) and reliability and validation study of the Turkish adaptation has been conducted by Fer (2005).

1.2. Visual-Spatial Intelligence

Howard Gardner (2011) suggests that each individual has a different intelligence profile and developed the Theory of Multiple Intelligences as explained in his book, *Frames of Mind: The theory of multiple intelligences* (1983), highlighting the skills, learning styles and tendencies of individuals. Gardner proposed eight aspects of intelligence instead of two and identified such eight intelligences as verbal–linguistic, logical–mathematical, visual–spatial, bodily–kinesthetic, musical–rhythmic, interpersonal-intrapersonal, individual/existential, and naturalistic. Visual-spatial intelligence encapsulates the ability of individuals to objectively observe, perceive and evaluate their environment. Individuals with strong visual/spatial intelligence learn better by studying with pictures, lines and colors. Professions requiring maximum level of visual/spatial intelligence are architects, pilots, mariners, artists, sculptors, scouts, hunters, designers and decorators (Gardner 2011).

The language of visual/spatial intelligence uses visual symbols like colors, textures, shapes, pictures, and images. As a basic characteristic, individuals with this type of intelligence think through pictures, images and shapes and love designing, drawing, creating graphics, imagining, visual presentations and artistic activities. They are skilled in making origami and models, finding directions, understanding the perspectives of object from different angles, and transforming their knowledge into visual presentations (Lazear 2000).

Spatial visualization is essential for communicating and understanding ideas in architectural design and other STEM (Science-Technology-Engineering-Mathematics) fields. Strong and Smith (2002) define spatial visualization as the ability to visualize the changes in position of objects or their rotation at different angles in space. According to Clements (1998), the spatial visualization is the ability of understanding, and visualizing the movements of two or three dimensional objects. In the studies conducted after 1930s, spatial skill was understood to have two main components, namely, spatial visualization and mental rotation (Clements 1998). Spatial visualization refers to the ability to imagine the resulting new shapes after moving two or three-dimensional composite objects or their components in space (folding, spreading, or assembling parts of an object) (Burnet and Lane 1980). Mental rotation skill is ability to understand the relationships between objects as well as understanding new arrangements when these relationships change (Clements 1998).

2. Experimental Study

The experimental study was conducted with 84 first year students of the Department of Architecture at Istanbul Kultur University who were registered to the Expression Techniques course which is quite similar to engineering graphics courses in engineering programs during the 2013-2014 Fall Semester. Participation to this study was voluntary and the participants were informed about the study and its purpose.

The study consisted of two stages. In the first stage, the cognitive style scale of the Thinking Styles Inventory featuring 16 questions developed by Sternberg and Wagner (1992) was used to determine cognitive styles of students. The average score for the first 8 questions was associated with global cognitive style and the average score for the remaining 8 questions was associated with local cognitive style. The answers provided by the students were evaluated against assessment tables to determine their cognitive styles (Sternberg 1997).

According to the levels dimension of the mental self government theory, individuals can have a global, local, or a mixed cognitive style involving the characteristics of both. The key attribute of individuals with a global cognitive style, is that they deal with the whole, the general environment and abstract ideas. Individuals with local cognitive style are mainly known for their ability to analyze the whole, to identify the pieces composing the whole and to deal with concrete thoughts and details. Individuals with mixed cognitive style have both cognitive styles, demonstrating the characteristics of both groups.

In the second stage, a set of questions developed by the researcher was used to evaluate the two and three dimensional perception skills of students. The study was conducted at a workshop setting during the Expression Techniques course which aims to teach the fundamental rules of technical drawing to the freshman students of architecture.

The fundamentals of technical drawing were delivered in the first 11 weeks of the course and exercises on visualizing 3D objects from orthogonal projections and drawing their perspectives were conducted on the weeks 12 and 13. This study was conducted on the 14th week (the final week of the course) so that the students were had enough time absorb the fundamental knowledge required for drawing perspectives and had two weeks to practice on perspective drawing exercises.

In order to form a balanced population, the participants were selected among the students who took the Expression Techniques course for the first time.

During the study, students were given a questionnaire consisting of 1 example and 3 questions. The example, which provided a brief explanation of the study, showed the top, front and side views of an inclined-surface object with no hidden gaps (Fig. 1).

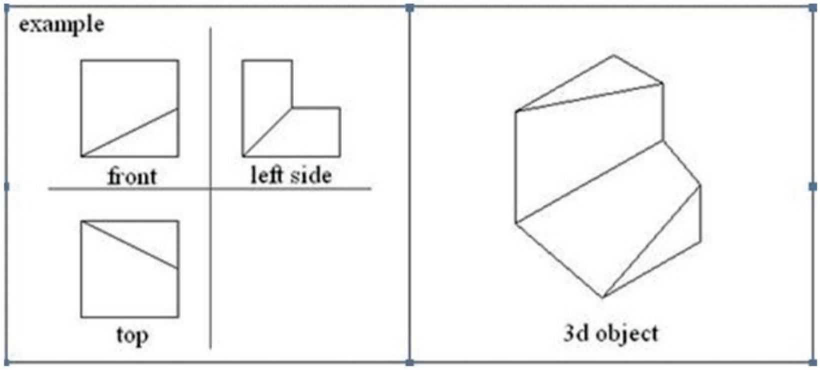

Figure 1. An example for which perspective projections and the perspective drawing were given

The students were asked to answer the questions using the example provided. Three types of questions with different difficulty levels were developed to reduce the impact of the question type on the results and for an objective assessment. The first question included top, front and left side views of an upright-surface object with no hidden gaps; while the second and third questions provided the same for an upright-surface object with hidden gaps (hidden gaps are indicated with dashed in the views) and for an inclined-surface with no hidden gaps, respectively. The students were expected to perform a perspective drawing of objects by using the two-dimensional views given (Fig. 2). Line thickness (shading) used to indicate front-behind or far-near on the views given was not provided in order to measure the third dimension perception of students without providing clues.

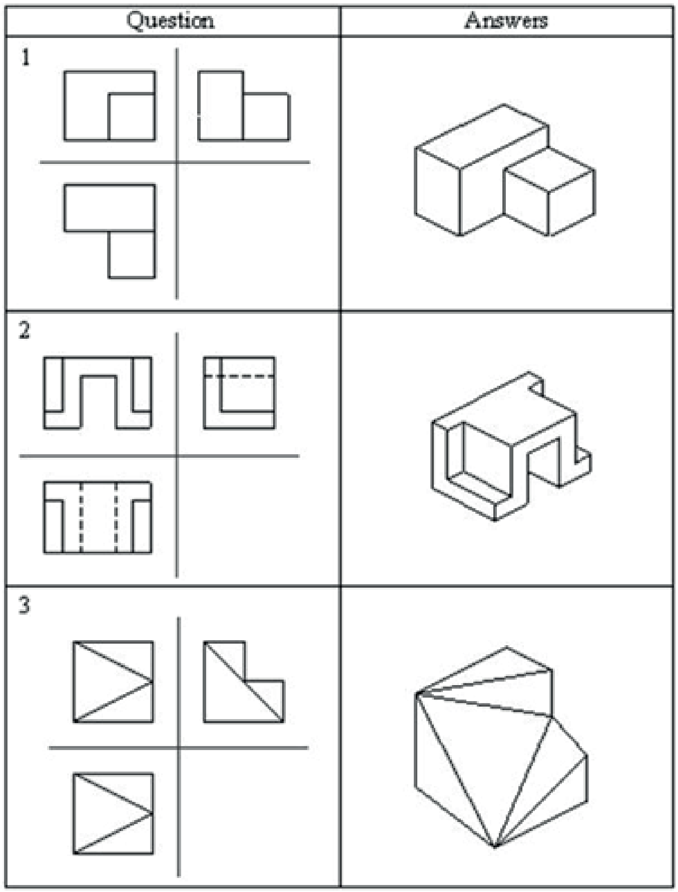

Figure 2. Provided example for two dimensional perspective projections and expected perspective drawings

The students were instructed to draw manually without using a ruler for a direct reflection of their thoughts and were given 15 minutes to complete the exercise. The purpose was to observe the impact of the cognitive style of the students on the three-dimensional perception of two-dimensional views in a limited timeframe. Since architects have to work with two and three dimensional objects throughout the course of their professional practice, being able to visualize a 3D model from 2D drawings is an important skill for architectural students to develop during their undergraduate education. Each question was ranked separately in the evaluation by the researcher. Good, average and below average ratings were based on the criteria for drawing perspectives presented in the course which are identifying the appropriate viewpoint, paying attention to figure proportions and using the appropriate visualization techniques. The perspective drawings which complied with all of these criteria received a "good" rating. The perspective drawings which approximately resembled the correct visualization but had problems with using the appropriate proportions and the correct viewpoint received an "average" rating. "Below average" ratings were given to perspective drawings which did not satisfy the criteria for "good" and "average" ratings. Blank answers or severely incomplete perspective drawings which could not be graded received an "N/A" rating.

3. Results and Discussion

The results of the Cognitive Style Inventory questionnaire conducted during the first stage of the study showed that out of 84 students, 20 (24%) have local; 32 (38%) have global; and 32 (38%) have mixed cognitive styles.

At the end of the study, perspective drawings prepared by the students for each question were evaluated and rated as "good", "average", and "below average". Examples for the "good", "average" and "below average" answers are provided in Figs. 3-4-5.

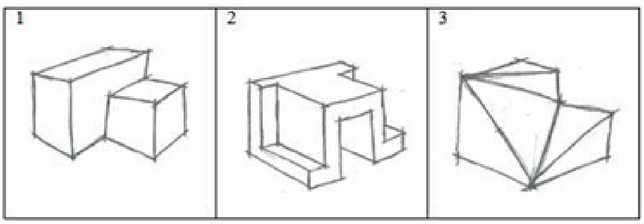

Figure 3. Student drawings rated as "good"

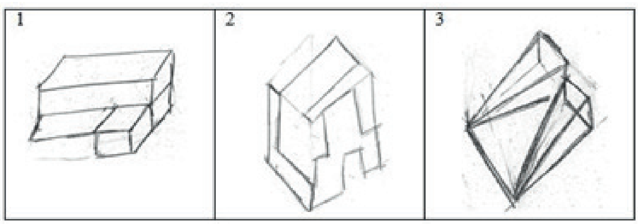

Figure 4. Student drawings rated as "average"

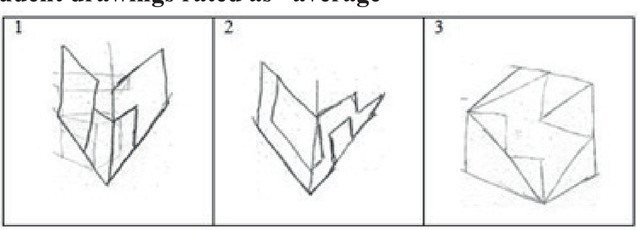

Figure 5. Student drawings rated as "below average"

Bar charts in Fig. 6-7-8 provide a comparison of the performance of students at answering the given questions with respect to their cognitive styles.

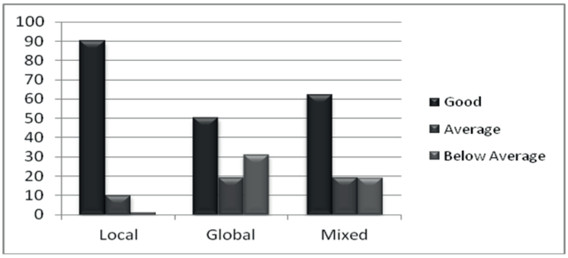

Figure 6. Overview of the performance of students for question 1 with respect to their cognitive styles

As seen in Fig. 6, answers of students with local cognitive style to the 1st question are 90% good, 10% average and 0% below average while the answers of students with global cognitive style are 50% good, 19% average and 31% below average. Finally, the answers of students with a mixed cognitive style are 62% good, 19% average and 19% below average. Overall, out of 84 students, 64% scored good, 17% scored average and 19% scored below average. The most successful students in answering the 1st question were the ones with local cognitive style followed by mixed cognitive style and global cognitive styles.

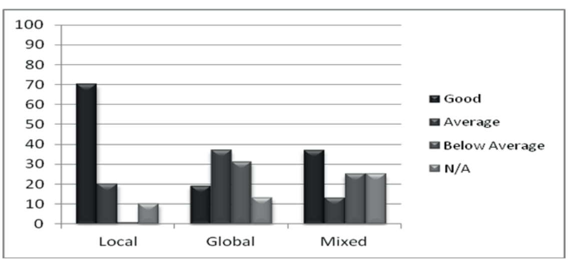

Figure 7. Overview of the performance of students for question 2 with respect to their cognitive styles

As seen in Fig. 7, answers of students with local cognitive style to the 2nd question are 70% good, 20% average and 0% below average with a 10% unanswered. The results for students with global cognitive style are 19% good, 37% average, and 31% below average with a 13% unanswered. Finally, the answers of students with a mixed cognitive style are 37% good, 13% average, and 25% below average with a 25% unanswered. Overall, out of 84 students, 38% scored good, 24% scored average, and 21% scored below average with a 17% unanswered. The most successful students in answering the 2nd question were the ones with local cognitive style followed by mixed cognitive style, and lastly the global cognitive style.

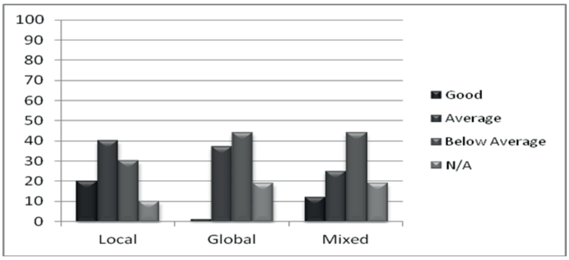

Figure 8. Overview of the performance of students for question 3 with respect to their cognitive styles

As seen in Fig. 8, answers of students with local cognitive style to the 3rd question are 20% good, 40% average, and 30% below average with a 10% unanswered. The results for students with global cognitive style are 0% good, 37% average, and 44% below average with a 19% unanswered. The results for students with mixed cognitive style are 12% good, 25% average, and 44% below average with a 19% unanswered. Overall, out of 84 students, 10% scored good, 33% scored average, and 40% scored below average with a 17% unanswered. The most successful students in answering the 3rd question were the ones with local cognitive style followed by mixed cognitive style, and lastly the global cognitive style.

Each student demonstrated different performances in answering questions with varying difficulty levels. The relationship between the performance and the cognitive style were evaluated using the pie charts shown in Figs. 9-14.

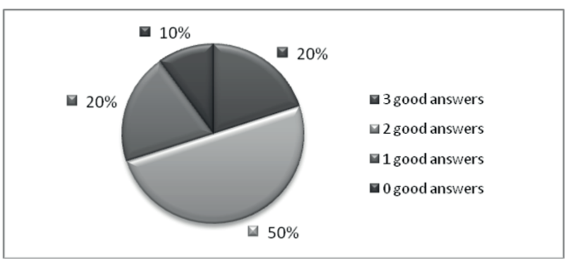

Figure 9. "Good" level assessments of students with local cognitive style for 3 questions

As seen in Fig. 9, 20% of the students with local cognitive style managed to provide good answers to all 3 questions, 50% managed to provide 2 good answers and 20% managed to provide 1 good answer. Only10% of the students with local cognitive style did not provide any good answers.

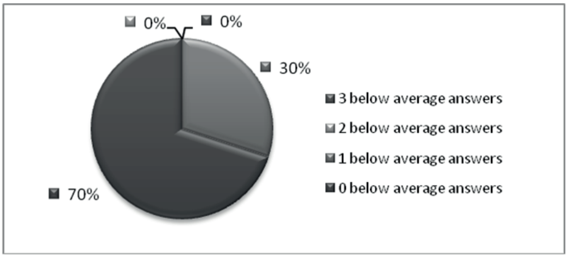

Figure 10. "Below average" level assessments of students with local cognitive style for 3 questions

As seen in Fig. 10, 30% of the students with local cognitive style provided below average answers to 1 question and 70% provided no below average answer. None of the students with local cognitive style provided more than 1 below average answer to all 3 questions.

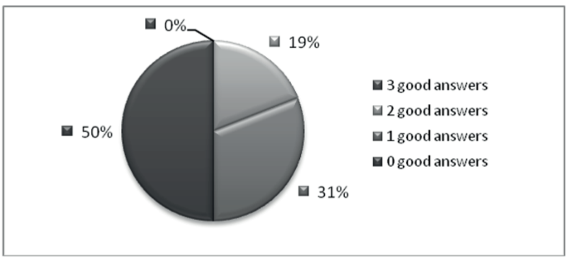

Figure 11. "Good" level assessments of students with global cognitive style for 3 questions

As seen in Fig. 11, none of the students with global cognitive style managed to provide good answers to all 3 questions, 19% managed to provide 2 good answers, 31% managed to provide 1 good answer and 50% of the students with local cognitive style did not provide any good answers.

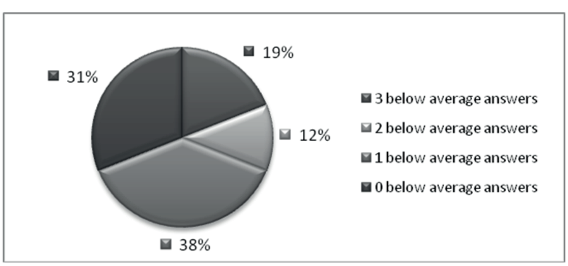

Figure 12. "Below average" level assessments of students with global cognitive style for all 3 questions

As seen in Fig. 12, 19% of the students with global cognitive style provided below average answers to all 3 questions, 12% provide 2 below average answers, 38% provided 1 below average answer and 31% of the students with global cognitive style did not provide any below average answers.

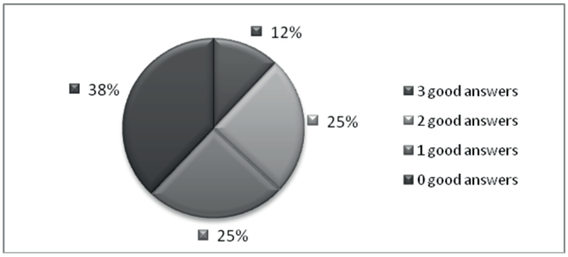

Figure 13. "Good" level assessments of students with mixed cognitive style for all 3 questions

As seen in Fig. 13, 12% of the students with mixed cognitive style managed to provide good answers to all 3 questions, 25% managed to provide 2 good answers, 25% managed to provide 1 good answer and 38% of the students with mixed cognitive style did not provide any good answers.

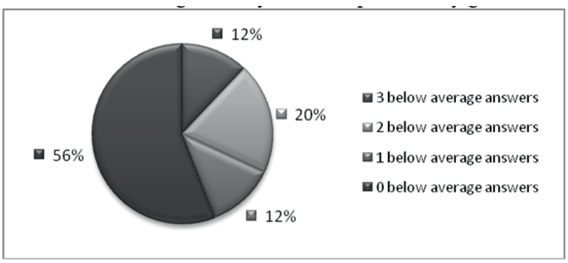

Figure 14. "Below average" level assessments of students with mixed cognitive style for all 3 questions

As seen in Fig. 14, 12% of the students with mixed cognitive style provided below average answers to all 3 questions, 20% provide 2 below average answers, 12% provided 1 below average answer and 56% of the students with global cognitive style did not provide any below average answers.

The object in the first question was a three dimensional solid with no hidden gaps; while the objects in the second and third questions were a solid with a hidden gap and an inclined-surface solid with no hidden gaps, respectively. Questions were arranged based on difficulty levels with Question 1 being the easiest and Question 3 the hardest. General results for the perspectives drawn were 64% good, 17% average, and 19% below average for Question 1; 38% good, 24% average, 21% below average, and

17% unanswered for Question 2; and 10% good, 33% average, 40% below average, and 17% unanswered for Question 3. These results confirm the difficulty level of the questions. The relationship between the questions and given answers shows that the list of questions developed by the researcher can be used as a tool for evaluating three dimensional perception skills.

An overview of the performance at answering questions, shows that 20% of the students with local cognitive style, 0% of students with global cognitive style, and 12% of students with mixed cognitive style managed to provide a good answer to question 3, the most challenging question in the exercise, whereas 10% of the students with local cognitive style, 50% of students with global cognitive style, and 38% of students with mixed cognitive style failed to give good answers to any question. These results suggest that the majority of freshman architecture students with local cognitive style who participated at this study managed to draw correct perspective drawings based on the plans and views of a given object and performed significantly better than the students with global cognitive style.

Evaluation of the answers to Questions 1, 2, and 3 with respect to cognitive styles show that the most successful students were the ones with local cognitive style followed by students with mixed and global cognitive styles. Students with mixed cognitive style exhibit a mixture of the characteristics of local and global cognitive styles. Relatively better performance of students with mixed cognitive styles in comparison with the students with global cognitive styles could be attributed to their tendency towards analytical thinking.

Overall performance of the students at answering the questions indicates that a significant portion experienced difficulties in perceiving and working with three-dimensional geometrical objects. It was observed that some student had problems with depth perception and struggled with assigning a third dimension to planar figures. The magnitude of these difficulties varied in accordance with the cognitive styles of the students.

4. Conclusions

An architecture student with a high level of visual-spatial intelligence should be able to successfully carry out tasks which require three dimensional perception since they are skilled at three dimensional visualization and mental rotation according to Gardner's definition of visual-spatial intelligence. A review of the performances of the students along with their cognitive styles suggests that the overall visual-spatial intelligence of students with local cognitive styles were more advanced than those with the global cognitive style.

The better performance of students with local cognitive styles could be attributed to the nature of the drawing perspectives. Drawing perspectives is a concrete problem which relies on following rules and paying attention to details and the relatively poor performance of students which are the strong points of individuals with local cognitive styles.

This study investigated the relationship between cognitive style and visual-spatial intelligence of freshman students with little or no experience in technical drawing. It is entirely possible for inexperienced students to be able to visualize a 3D object but not be fully capable to transfer it on paper. Further research could be conducted to study the implications of technical drawing experience on the relationship between cognitive style and visual-spatial experience.

The number of participants in this study was limited to 84 freshman students of architecture. This sample size is reasonable when compared to the sample sizes used in similar studies by Alias et al. (2002) and Adanez and Velasco (2004) (which were 57 and 163, respectively). However, repeating the same exercise with more freshman architecture students from different countries could provide an insight on the influence of social and cultural effects.

This study shows that the cognitive styles of architecture students play a role in their design education since they frequently need to use three dimensional visualization when creating new designs and building models. Development of personalized methods for architectural students with different cognitive styles could be a fruitful area of research. Furthermore, Zhang (2002) reports that the academic performance of students increases when their cognitive style matches the cognitive style of their instructors. In architectural design courses, the number of students per instructor is usually limited to 10 to 15 students. In line with this, matching the cognitive styles of instructors and their students could be taken into account when forming the study groups, when possible.

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