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ASSESSING THE CAPABILITY OF SPATIAL ABILITY IN PREDICTING SUCCESS IN THE BEGINNING DESIGN STUDIO

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ABSTRACT

The beginning studio sometimes described as the most traumatic period for the architecture students. Many challenges in visualizing, imagining and comprehending spatial relations over the stages of the design process have been observed. Educators confirmed that spatial ability is central to design studio demands. The main goal of this research is reducing beginners' obstacles and enhancing design education. A total of 353 first-year architecture students were selected via random sample from three universities in Cairo. The students' spatial ability skill-level were measured using two spatial ability test instruments. Three scores of the first design course were used in determining the students' design performance. Inferential statistics, as well as correlation analysis and crosstab chi-square test with SPSS were employed to analyze the research data. The outcomes presented strong significant correlation at (< 0.01) points between students' spatial ability and students' design course performance. It has proved that spatial ability is a valid predictor of success in the beginning studio. Also, measuring spatial ability helps to identify students who are not ready for studio requirement. Findings suggest enhancing students' spatial ability among the all pre-university education levels and during the preparatory year course subjects. This will increase the probability of success.

KEY WORDS: Spatial Ability, Beginning Studio, Prediction of Success

1. INTRODUCTION

The beginning studio sometimes described as the most traumatic period for the architecture students. It is the place where students explore multi-tasks and activities and form their first ideas about design and architecture [1].

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Some researchers defined the beginning studio as the melting pot for architecture education [2]. Others described it as a backbone of architecture education [3]. For all architecture students, design studio has become the core of architecture education and the gathering point for all knowledge and skills [4, 5].

It's observed that many students are facing obstacles in most studio tasks, when they must comprehend spatial relation activities in the early stage of design process. Also, when they have to use drawing, sketching, or building scale models to represent and externalize their ideas during design stages. Moreover, understanding the relationship between three-dimensional objects and its abstraction views is a challenge for many students. Similarly, understanding and orienting the proportions of a given space and realizing the relationship between various spaces are challenging too. All of those activities are visual-spatial tasks, essential to every design studio, and must be solved spatially.

Many studies indicate that students' spatial ability serves directly those common activities of the design at all stages [4-7]. Therefore, researchers suggest that visual spatial ability must come at a head of the mental abilities set we need in our architecture students because it is essential factor for their understanding [4, 8-11]. Students with a good spatial ability are ready to study architecture [12].

Motivated by this review and the observations, this research assumes that there is a correlation between students' spatial ability skill level and their success in the beginning studio. It also assumed that assessing spatial ability might predict students' performance and identifies those students who are at risk of facing beginning obstacles. Thus, the objectives of this paper is to test these assumptions by; examining and analyzing the relationship between spatial ability and students' performance in design studio; examining the capability of spatial ability test instruments score on predicting success in beginning design studio. On the way to achieve that, the research used the experimental approach through a case study of random sample of beginner architecture students.

2. SPATIAL ABILITY

Spatial ability when seen as a component of cognitive abilities is generally defined as the innate ability to visualize and understand the relationships between objects and the ability that a person can formulate mental images and manipulate those images in mind [13,14]. Visual-spatial ability is important for success in solving many tasks in everyday life. For example; using a map to guide you in a new city; orienting yourself in your environment; guiding you through traffic jam, are all activities that involve spatial ability. It's one of the components of human intelligence [15]. Spatial ability has been a significant area of research in educational psychology since the 1920s or 30s [13].

In educational psychology, spatial ability is defined as "the innate ability to visualize that a person has before any formal training has occurred" [13], p.21. On the other hand, it was found that the concept of spatial ability is related to the persons' mental manipulation of objects and their parts in two-dimensional and three-dimensional spaces could be developed [16]. The term spatial ability is also known as "the ability to formulate mental images and to manipulate these images in the mind" [14], p.5.

Previous and contemporary studies provide strong support to dividing this ability into two main components; spatial visualization and spatial orientation [13, 14, 17]. The term spatial visualization was described as the ability to imagine rotation of objects as a whole or their parts in three dimensional space [13]. Spatial visualization is defined as "the mental manipulation of spatial information to determine how a given spatial configuration would appear if portions of the configuration were to be rotated, folded, repositioned, or otherwise transformed" [13], p.21.

The spatial visualization component is also subdivided into two categories; mental rotation and mental transformation (Fig. 1). The difference between these two is that in mental rotation, "the entire object is transformed by turning in space, however in mental Transformation, only part of the object is transformed in some way" [13], p.22.

Spatial orientation was also described as the ability to determine relationships between different spatial objects and identity of an object when it is seen from different angles, or when the object is moved. Moreover, it involves the ability to perceive spatial pattern and to compare them with each other [18].

Spatial orientation involves the ability to mentally move your viewpoint while the object remains fixed in space [19, 20].

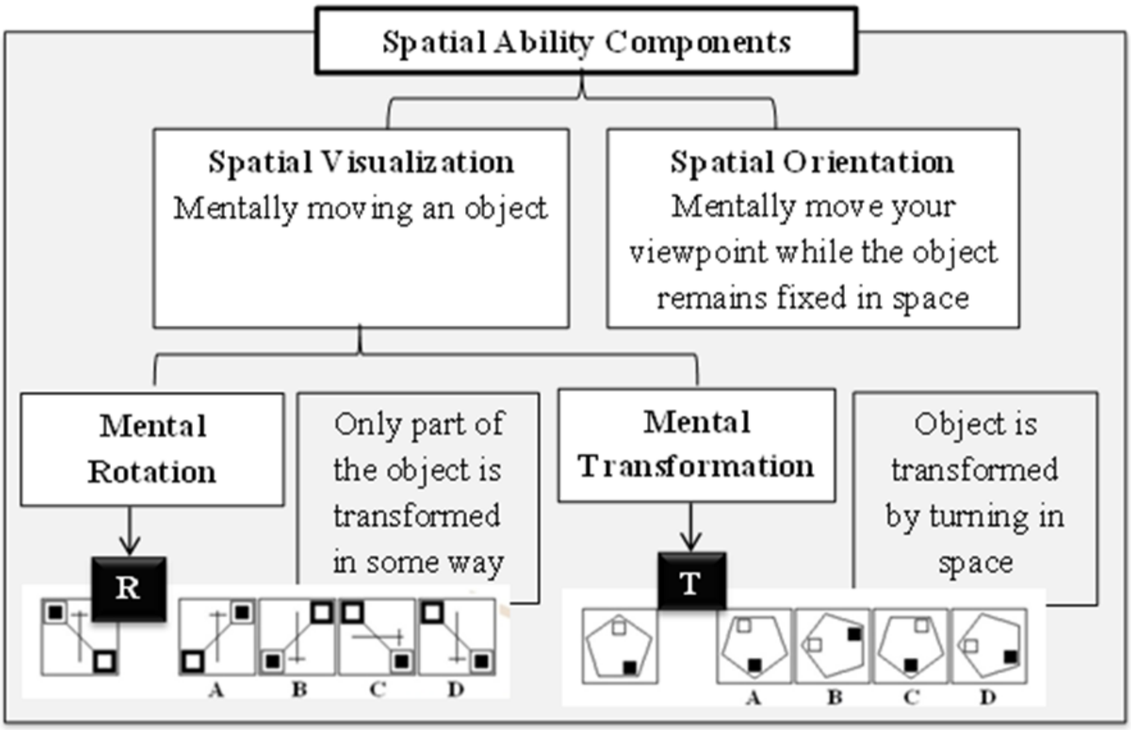

Fig. 1. The components of spatial ability.

2.1 Spatial Ability in the Context of Design Studio

In the context of design studio, spatial ability mainly involves the ability to mentally represent or transform the three-dimensional form of building, interior spaces, and the spaces around building [9]. It helps students solve spatial problem by forming an accurate representation and establishing a crucial link between abstract drawings and concrete design. Also, spatial ability involves the capability to realize the relation between design components and design problem [21].

Educators agree that spatial visualization ability allows students to deal with the design problem at early stage of the design process. Then, it allows them to gather the appropriate information and realize the relationships within it to tackle the design problem [21-24, 27]. Manipulate location and spatial data structure is relative to visualized one-dimensional data, which usually represents by architecture students by using graphics or algorithms to illustrate their works during the different levels of design [27]. This ability helps students to find references to previous similar designs through drawing which seems to play a key role in analogical stage of solving design problem.

Spatial ability is essential to architecture students'. It allows them to understand and orient the proportions of a given space and realize the relationships between various spaces [23].

Mental rotation as a component of spatial visualization is commonly used strategy to solve spatial problem in architecture design such as to determine if three dimensional model view match the orthographic views and vice versa [24]. It is a basic ability for both orthographic projection and perspective representation. Spatial orientation allows students to create physical or digital models and create animation using the process of visualization of the design from various aspects [28].

It seems that spatial ability helps students to visualize, imagine, think and interpret spatially through an iterative visual process in the design studio (Fig. 2). It is also predicting students' success in design education [19, 25, 27, 31-33].

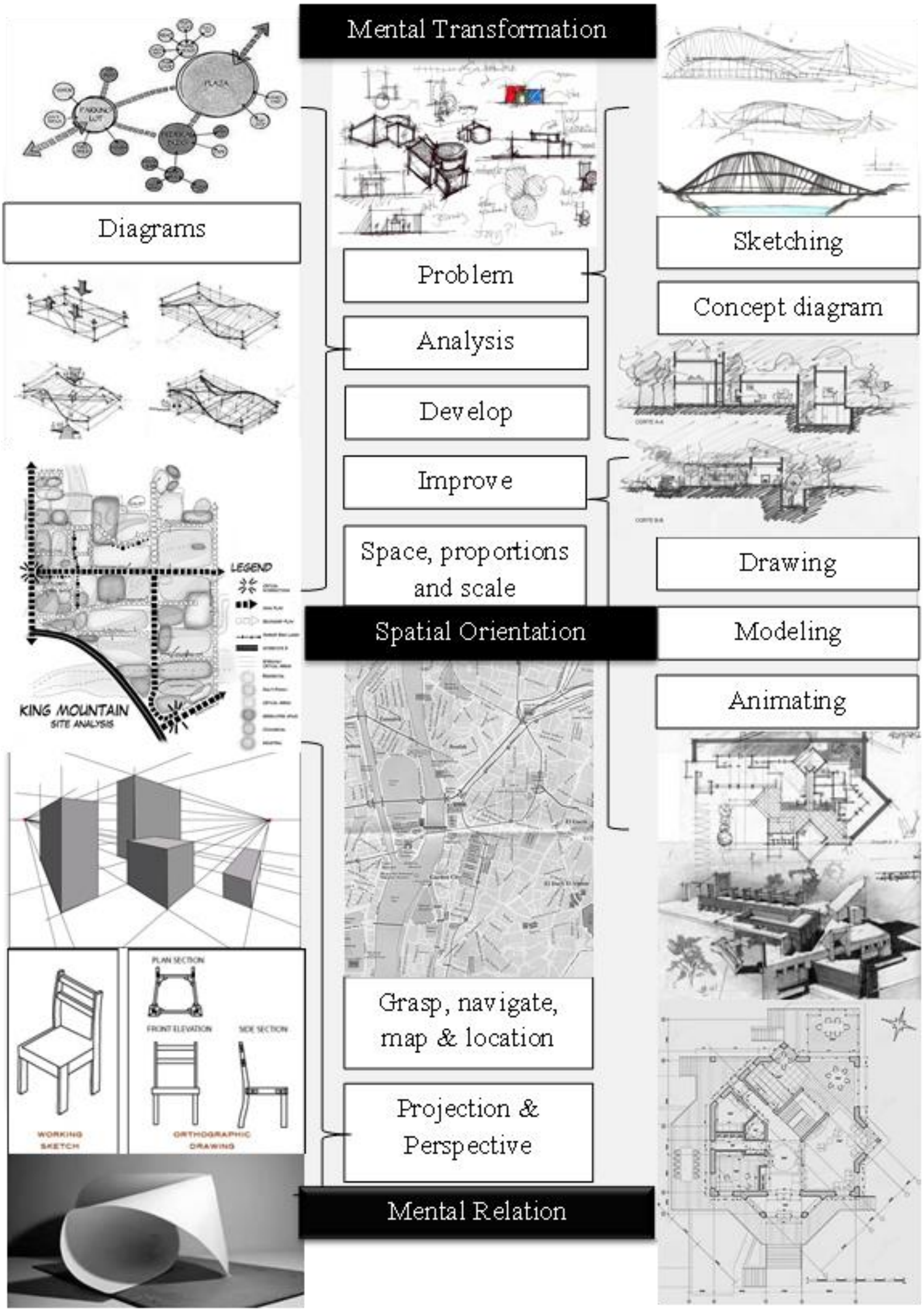

Fig. 2. Spatial ability is central to all design studio activities'.

3. METHOD

This research is an empirical quantitative case study method. The methodology used to test the research assumptions involved using two tests instruments to assess the students' skill level in spatial ability and to examine its correlation with design performance and how this ability could predict the student's success in design course during the first year. The two tests covered a comprehensive range of spatial ability components; spatial relation and spatial visualization to represent correlated dimension of performance speed, power, and complexity. The two tests were administered to a random sample of students currently enrolled in architecture departments' in three universities at Cairo during the first three weeks of the first academic year. The students had been informed by the research objectives. No emotional or academic harm had been addressed while conducting the tests. All participants' students were volunteers.

3.1 Participants

A total of (353) student participated in this study, 201 male and 152 female, with a mean age of (19.39) years (SD = 0.682). A set of two spatial ability test instruments and a self-report survey were administered to three groups of students: 126 students of mainstream architectural engineering at Cairo University; 87 students of the high institute of architectural engineering at Shrouk Academy; 140 students of the high institute of architectural engineering at Modern Academy. The three departments are representing three different types of university education (mainstream; private; and credit hours system). All students were first-year architecture education, not yet instructed on professional architectural education and not prepared by any preparation course for design. All students had completed their Engineering preparatory year.

3.2 Testing Spatial Ability

The two tests got students to stretch their imagination. The first instrument test was Spatial Ability Practice Test1 "denoted as SA1" [4]. It was used to measure the student skill level on spatial ability. The test contains 45 questions required to solve in only twenty minutes. The questions have been varied between speed questions meant measuring spatial relation and power questions that are related to complex tasks to measure spatial visualization ability. The reliability was 0.79 points.

The SA1 test was prepared in a way that contained the important spatial ability components, each set of questions focuses on one or more of spatial abilities. For example some questions illustrated in Fig. 7.(see Appendix.1) are focusing on the mental rotation ability; Students should select which one of four choices are identical to the first 2D object in the left, although the whole object had been rotated or only some parts within it. Other questions focused on the mental visualization space relation ability by identifying the correct fold; Objects were presented as an isometric projection “Cube” and four patterns were presented as a two-dimensional unfolded pattern. The students should identify which pattern can be folded to make the given cube. However other questions focus on the ability of imaginary navigation to find the direction and exact location in space by using plan or map. Students given a street map with north direction symbol arrow (N), they should choose the correct direction from the four cardinal directions (North, South, East, West) according to the given instructions

The second test was Santa Barbara Solid Test2 “denoted as SBST” that designed to assess spatial visualization ability by measuring the students capability of identifying cross-sections that are two dimensional of three dimensional objects [18]. Alpha coefficient for reliability of this test was found (0.76). This test is a developed test from the well-known Mental Cutting Test “MCT” which is one of the most effective and widely known assessment method used to assess spatial ability of engineering students’ [17-20, 33]. The test contained 30 multiple choice slices problems. Some problems illustrated in Fig. 8 (see Appendix.1) were simple, that the student must identify the cross section that was 2D from single 3D object (Cube, Cylinder, or Cone). Other problems were complex that the 3D objects were attached or intersected by each other. The students spent 30 to 40 minutes to complete the SBST test and write their answers down on a separate designed bubble card sheet. For both tests, scores were measured out of 100, and divided to non-skilled spatial ability students for those awarded between (0 to<50), and skilled spatial ability students for those awarded between (50 -100).

3.3 Variables

Independent variables are as follows:

1/ Student's score in Spatial Ability Practice Test1 denoted as SA1.

2/ Student's score in Santa Barbara Solid Test denoted as SBST.

3/ The interaction value of the student's score in the two tests denoted as (inter.tests).

The following are the dependent variables that are organized as measurements to the student performance in the beginning design studio:

1/ Average score of first design project grades "denoted as 1stp"

2/ Average score of design studio tasks grades -assignments and projects- during the two terms of the first- year "denoted as sub-d"

3/ The final score of design course for the first- year (denoted as D)

3.4 Limitations

This research was limited to a random sample of beginner architecture students in three architecture departments in Cairo only, due to accessibility limits. This research deals with the participants as a whole number (n=353) to get a statistical sample number and results. The academic grades achieved by students in design studio (D) had been classified as follows; A=85, B=75, C=65, D=50 and F=failed for all three groups of participant students. The research realizes that these limitations might affect the generalization of the outcomes.

4. RESULTS

All data were analyzed with the help of the Institute of Studies and Statistical Researches at Cairo University and SPSS v.24 had been used to analyze and test the collective data with standard and appropriate statistical procedures.

4.1 Mean and Scores

As in Table 1-a, the mean value of students was 72.9 point in SA1 test, which is higher than the mean value of students in SBST test which scores 43.3 point. Standard deviations of SA1 and SBST test were found as (0.119 and 0.204) respectively. The mean value of the interaction of students' scores in both tests was 32.16 point and SD was 0.171. For N=353, the mean value of the age was found 19.39.

Table 1-a. Descriptive Statistics, (n=353).

	Min.	Max.	Mean	Std. D.	N
Age	18	22	19.39	0.682	353
S A 1	0.00	0.96	0.7297	0.1196	
SBST	0.00	0.97	0.4331	0.2047	
inter. tests	0.00	0.76	0.3216	0.1719	

4.2 Skilled and Non-skilled Students' on Spatial Ability

Scores are measured for both spatial ability tests out of 100 as mentioned, and divided into skilled students and non-skilled spatial students regarding their spatial ability. The result in Table (1-b) shows descriptive statistics for the students' skill-level in the three universities. Skilled students in Cairo University (CU) on both tests SA1 & SBST got the highest percentage "61.1% and 65.9%". However, the lowest percentage on SA1 test was for Shrouk Academy students' (SHA), 47.1% and the lowest percentage on SBST test was (11.4%) for Modern Academy students' (MA).

Table 1-b. Descriptive Statistics for skill and non-skill students in the 3 Universities.

Descriptive Statistics for (skill & non-skill) in the three Universities										
Tests	GROUP	**CU**			**SHA**			**MA**		
		non-skill	skill	Total	non-skill	skill	Total	non-skill	skill	Total
	Frequency	49	77	126	46	41	87	67	73	140
SA 1	**%**	38.9	61.1	100.0	52.9	47.1	100.0	47.9	52.1	100.0
SBST	**%**	34.1	65.9	100.0	47.1	52.9	100.0	88.6	11.4	100.0
N		353								

The results in Fig. 3 shows how much the difficulty of SBST test than SA1 test, even it was unlimited time test. It also shows that the skilled students got 18% points on SBST, while skilled students on SA1 test, got 48% points. However, the non-skilled students got 52.8% on SA1 test and got 81.9% on SBST test. The integration of two test shows that 57.8% of the whole sample n=353, are non-skilled on spatial ability. However, 42.2 % are skilled students on spatial ability

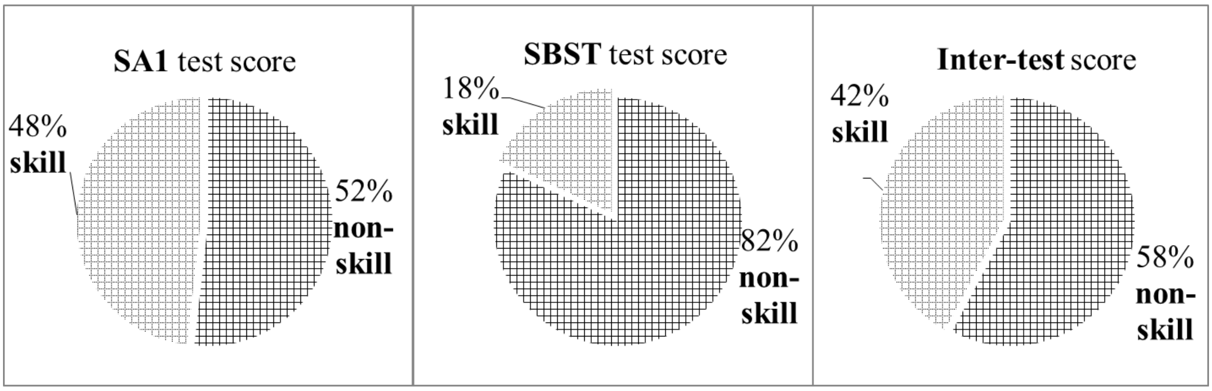

Fig. 3. The differences in the students' performance in both tests "n=353".

4.3 Correlations

The following analyses examine the degree of relationship between the three scores achieved by students in spatial ability tests SA1, SBST & inter. tests, with the three measurements of student performance in the first design studio. The results in Table 2 shows a strong significant correlation at 0.01 levels between the first studio measurements correlation; 1st-p, sub-d and D at 0.01 levels. These results indicate that the three scores of the first design course that were used in determining the students' design performance have strong relationships with each other.

Table 2. Correlations are statistically significant between all studio measurements.

Correlations					N
measurements		Ist-p	sub_d	D	353
Ist-p	Pearson Correlation	1	0.585**	0.702**	
	Sig. (2-tailed)		0.000	0.000	
sub_d	Pearson Correlation		1	0.700**	
	Sig. (2-tailed)			0.000	
D	Pearson Correlation			1	
	Sig. (2-tailed)				

**. Correlation is significant at the 0.01 level (2-tailed).

The results in Table 3, shows that there is a strong correlation between students' SA1 score result and both the average score of first design project grades 1stp and the average score of design studio tasks grades sub-d for the 1st year. The P- value was found highly significant at 0.01 levels. Table 3 also shows a positive correlation between SA1 score results and the average score of design course final grades "D", the P- value was found significant at 0.05 levels.

Table 3. The both spatial ability tests SA1, SBST and their interaction value are statistically significant with three scores of the first design course, "n=353".

Correlations				
		Ist-p	**sub_d**	**D**
S A 1	Pearson Correlation	0.146**	0.169**	0.135*
	Sig.	0.01	0.00	0.01
SBST	Pearson Correlation	0.264**	0.220**	0.136*
	Sig.	0.00	0.00	0.01
inter. tests	Pearson Correlation	0.264**	0.228**	0.143**
	Sig.	0.00	0.00	0.01
	N	353		

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Also, accordingly, it was clear that the correlation coefficients showed strong significant correlation between the SBST test score results and both the average score of first design project grades 1stp and the average score of design studio tasks grades sub-d at 0.01 levels. And also SBST score correlated significantly with design course final grades D at 0.05 levels. For all studio measurements, the achieved grades by students in, 1st-p; sub-d and D, were statistically significant correlated with their skill-level on both spatial ability tests SA1, SBST and were strongly statistically significant with their interaction value Inter-tests at 0.01 levels.

4.4 Prediction of Success

To examine the possibility of spatial ability test(s) score on affecting or predicting the students' success in first design, and to see how testing spatial ability may identify those students who are at risk of facing beginners' obstacles, the cross tabulation statistical analysis had been used. The academic grades achieved by students in the final design course “D” had been classified as following; A=85, B=75, C=65, D=50 and F=failed. Table 4 illustrates the varied percentage awarded by students in final design D crossed with their skill level on SA1 test. Also, it shows a statistically significant correlation of crossed data, that Chi-Square was found significant at 0.01 levels.

Table 4. The cross relation is statistically significant between students’ grades on D and their spatial ability on SA1 test score. “n=353”.

Crosstab									**Chi-Sq Tests**	
			D_R					Total	Pearson Chi-Sq	df
			F	**D**	**C**	**B**	**A**			
SA1_R	**non _skill**	Count	8	48	67	41	19	183		
		% within SA1_R	4.40%	26.20%	36.60%	22.40%	10.40%	100%		
	skill	Count	16	37	42	46	29	170		
		% within SA1_R	9.40%	21.80%	24.70%	27.10%	17.10%	100%		
Asymptotic Significance (2-sided)									0.019	4

The following analysis in Fig. 4 indicates that students with non-skilled spatial ability on SA1 test achieved 33% of (A and B) scores which were lower than the skilled students who achieved 44% of (A and B) scores. Also, the non-skilled students’ achieved 63% of (C and D) scores which is higher than the skilled students who achieved 46% of (C and D). Skilled students’ got 5% on F score which is a little higher percent than the non-skilled students. The analysis denotes that those students with spatial ability who were awarded between (50 -100) on SA1 test, have the better chance to get the higher scores in first design studio.

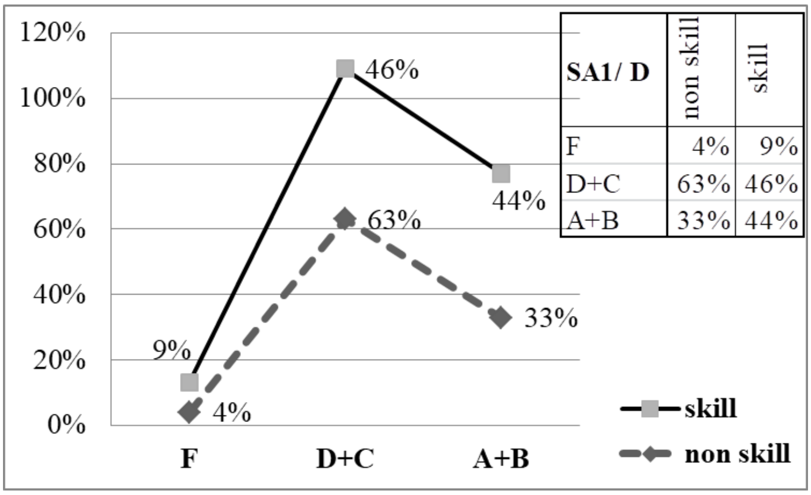

Fig. 4. Students' skill level on SA1 is predicting their academic grades in design.

The following cross Table 5, shows a significant correlation between academic grades awarded by students in final design D with their skill level on SBST test, Chi-Square was found significant at 0.01 levels.

Table 5. The cross relation between students' grades on D and their SBST score is statistically significant.

Crosstab									Chi-Sq Tests	
			D_R					Total	Pearson Chi-Sq	df
			F	D	C	B	A			
SBST_R	non _ skill	Count	24	71	90	60	44	289		
		% within SBST_R	8.30%	24.60%	31.10%	20.80%	15.20%	100%		
	skill	Count	0	14	19	27	4	64		
		% within SBST_R	0.00%	21.90%	29.70%	42.20%	6.30%	100%		
Asymptotic Significance (2-sided)									0.001	4

The analyzed data on Fig. 5 indicates that skilled students who got (50-100) on spatial ability test SBST, were achieved 48% of (A and B) scores which is higher than the non-skilled students who achieved 36% of (A and B) scores. Also, the skilled students achieved 72% of (C and D) scores which is higher than the non-skilled students who achieved 52% of (C and D) scores. It is clear that skilled students were away from failing in their final design score; however non-skilled students got 8% on the F grade.

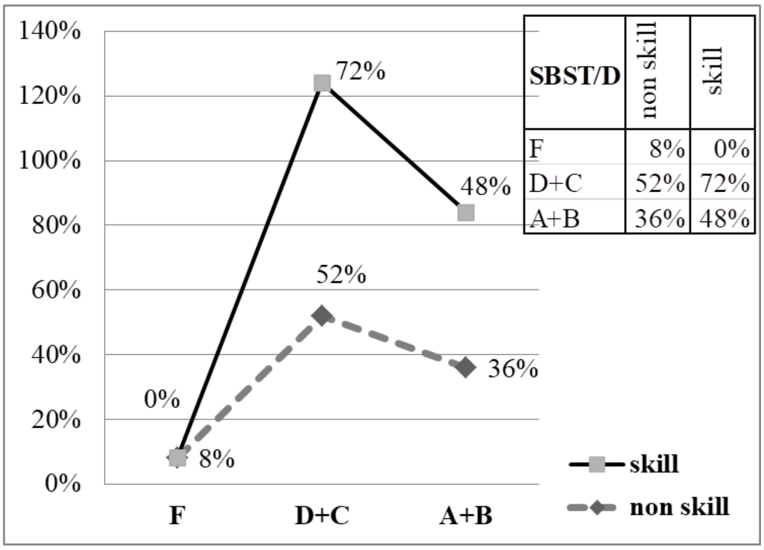

Fig. 5. Students' skill level on SBST is predicting their academic grades in design.

5. DISCUSSION

There can be no doubt that spatial ability becomes increasingly important in the development and growth of new technologies such as computer graphics, data visualization, film making, sciences, and engineering. Researchers acknowledge that spatial ability influences the academic achievements in engineering related subjects such as structural design, graphic design, integral calculus, mathematics, chemistry, and computer aided design. They are declaring that spatial visualization is critical for solving problems and improving success in the field of engineering [10, 13, 14].

This research aims to reduce beginners' obstacles and enhance design education in the design studio. The above results confirm the validity of two developed spatial ability instruments' to examine the participants' spatial ability skill level among the first year architecture students' in Cairo. Both instruments SA1, SBST are proved to be statistically reliable on 0.79 and 0.76.

The results show how much the difficulty of visualization on SBST test than SA1. Skilled students' got 18% points only on this test. This test directly measures the spatial visualization only. It seems very challenging task to identify the cross section that was 2D from the 3D objects from slides images on screen representation. However, SA1 test was varied between speed questions that are related to measure spatial relation and power questions that are related to complex tasks that measure spatial visualization ability and meant to cover all component of spatial ability. Skilled students got 48% on this test. This might explain why most of our architecture students struggle to identifying the orthographic views and matching them with the isometric views and vice versa. Most students suffer from lack of the visualization ability. This mental activity is used as a common strategy by students for understanding and solving the spatial problems through the design process. This clarifies one of the most common difficulties faced by beginner students, when they should use drawing, sketching, or scale models to represent and externalize their ideas during design stages. The results also denote a limited ability to imagine the rotation and transformation of 2D or 3D objects as a whole body. It also indicates a difficulty in comprehending relationship between objects or their parts and interprets the whole image in the mind. For architecture students, those are essential mental activities that enable them to realize the relation between design components and design problem. This difficulty in comprehending relationship between objects might affect their ability of using graphics or algorithms to illustrate their works, or finding references to precedent designs. Also, the results show limited sense of navigates and finds the direction or exact location in space by using a map. For students in their early design education the ability to mentally move their viewpoint while the object remains fixed in space is a challenging task. As well, the ability of visualizing, understanding and orienting the proportions of a given space and realize the relationships between various spaces is challenging too. Furthermore, the integration of the two tests results indicate that more than half of participants students' in this research, already arrived to the first studio with poor spatial ability.

The other results of this research indicate that the three measurements indicating the students' performance; "the average score of 1st projects; the average score of design studio tasks grades during the two terms; and the final score of first design course" have a strong significant correlation with each other's. Also, they have a strong positive significant correlation with students' skill level on both spatial ability tests scores SA1and SBST and also correlated significantly with its interaction score (inter-tests). This result confirms two issues, firstly, the strong link between students' performance in all designing tasks, beginning with their first design projects until the end of first year architecture. Secondly, it does confirm that the spatial ability has a significant impact on students' performance in the beginning studio. Also, these findings explain why students in the early architecture education, especially in the beginning studio, usually struggle with the challenge of visualizing or comprehending spatial relations. Those students with poor spatial ability usually spend more mental effort to understand the represented drawings through floor plans, elevation and sections or even transform those drawing from two dimensional representations to three dimensional representations. In the way of examine the capability of spatial ability in predicting success in the beginning design studio, the results of the two tests indicate that students with spatial ability who got ≥ 50 in both tests score, have the possibility of getting the highest score (A or B) than the others, with non to limited spatial ability of who got 0-50 (Fig. 6). Also, the possibility of failure in the final first design studio score is increased on the non-skilled students on SBST test. Achieving the average score between (C and D) is lower on SBST test than SA1 test score also.

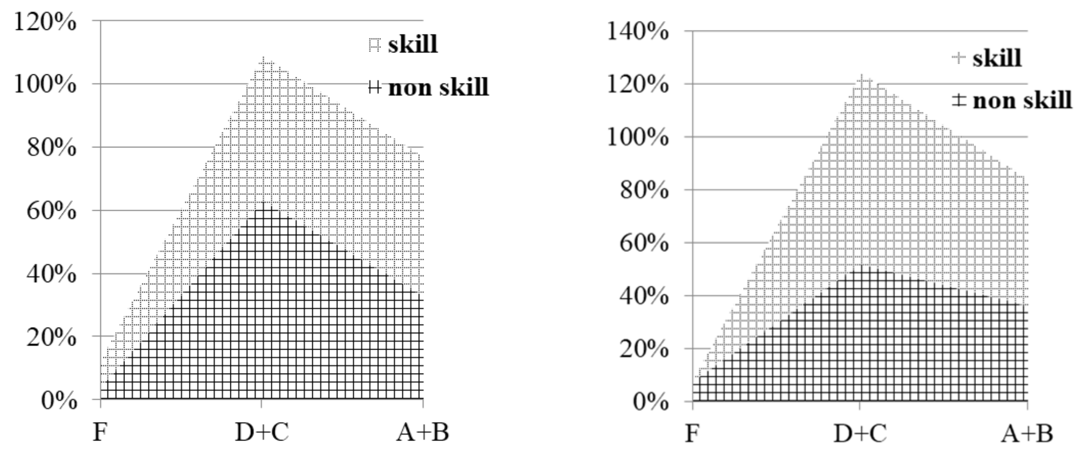

Fig. 6. The capability of spatial ability skill-level, on SA1 on the left and SBST on the right, in predicting academic performance from A to F in Design.

Furthermore, the correlation between the achieved grades of students on design course was found to be statistically significant with their skill level on both tests. The findings of this research indicate that the spatial ability tests “SA1 and SBST” score has the potential to be a very strong predictor of the performance level and success in the beginning studio. It is clear that students with this ability are at minimum risk of failing to cope with studio tasks.

Since standardized and developed spatial ability instruments have been used to evaluate and assess the spatial ability of engineering students, many researchers advocated that spatial visualization ability is a vital ability for students’ success in engineering education [10, 13, 19, 20, 23]. In spite of its relevance and importance in architecture education, few studies had been carried out in the domain of the design studio.

The SA1 test indicated a strong correlation with the performance of freshmen and sophomore architecture students at the architectural engineering program at the American university in Cairo [4]. However, the three Differential Aptitude Test (3DAT) test as one of the famous instruments, has been used to assess spatial ability on 170 of first year architecture design students. Results indicated that spatial ability can be used as a moderate predictor of success in graphics based design courses [32]. Also, the Mental Cutting Test “MCT”, as the well-known and old measurements of visualization, developed to Plan Interpretation Test “PIT”. Both tests, MCT “Mental Cutting Test” and PIT “Plan Interpretation Test” applied to assess the visualization skill-level of 253 Osaka University students in Japan. The scores of two tests were significant in measuring the ability of architecture students on identifying interior and exterior spaces [33].

SBST “Santa Barbara Solid Test” has been used to assess spatial visualization ability among controlled and experimental group of student mathematics teachers in geometry education [18]. The developed test showed significant in assessing the visualization skill level on both groups, Alpha coefficient for reliability was found 0.86 for this test [18]. Another new named “The architectural spatial ability Test” had strongly correlated with studio performance score of the college of architecture and environmental design in Kent State University [27, 31]. On the other hand, other old instrument like "The Mental Rotation Test", showed a lack of tool to assess the correlation with performance when used in earlier years on Kent State University [27, 31]. It seems that, further studies to develop specific-tools that measure spatial ability of architecture students are required. An appropriate architectural spatial ability instruments must be developed to fit with the uniqueness of architecture education. Longitudinal experiments are needed too, to measure and compare the effect of students' spatial ability over their performance on the early and late years in architecture education.

6. CONCLUSION

In conclusion, spatial ability is integral to all design studio needs. The form of mental images plays an important role in all stages of design process. Scores on spatial ability tests in this research are valid to predict the beginning studio performance. Also, it has been proved that testing spatial ability helps to identify those students who may not be ready for essentials of early design studio. It is believed that spatial relation and visualization abilities can help students gain some kind of mastery over their design process. This may enable them to understand, imagine, clarify and convey ideas in a better and creative manner. This research would be of interest to policymakers, educators and test developers who are charged with improving and predicting success in education. In that sense, this research suggests merging spatial visualization among all pre-university education levels to improve thinking abilities and imagination. Also, this research recommends developing a spatial ability objective course for the preparatory year of engineering and architectural students'. This will improve the performance and success in all engineering education and will complement the readiness of our potential students. However, developing and practicing an appropriate spatial ability instrument is suggested as an admission procedure to architectural departments. Further studies on spatial ability are still needed in architectural domain.

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Appendix 1

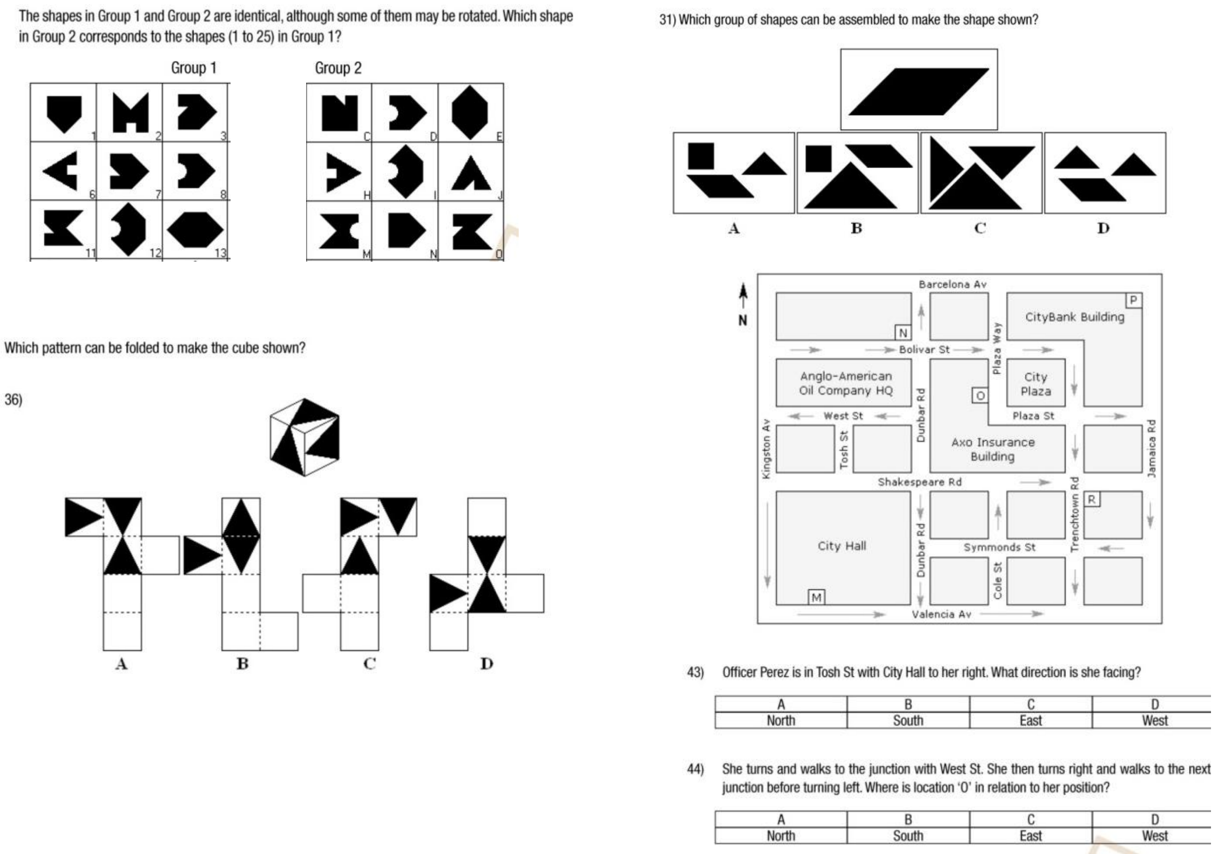

Fig. 7. Examples of Spatial Ability Practice Test1 (SA1), **45** Questions.

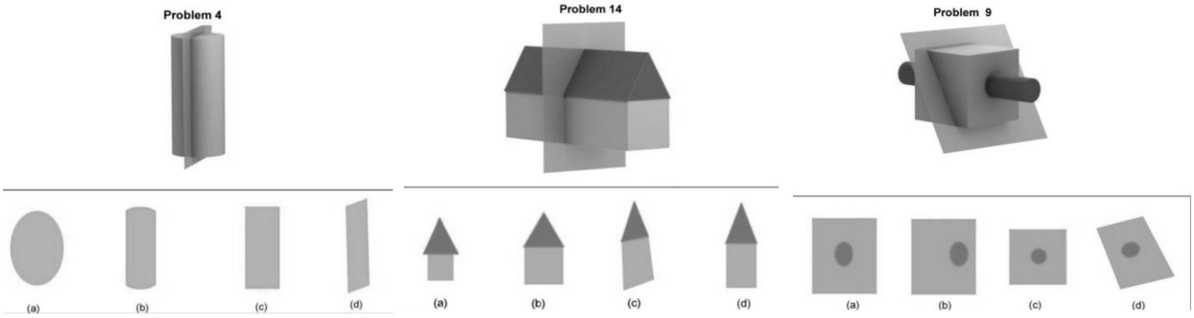

Fig. 8. Examples of Santa Barbara Solid Test2 (SBST), **30** Questions

اختبار مدى قدرة المهارات الفراغية فى التنبؤ بالنجاح فى استوديو التصميم الأول

يهدف البحث إلى تحسين الأداء داخل استوديو التصميم المعمارى الأول والعمل على التقليل من الصعوبات فى فترة البداية وتم استخدام اثنان من اختبارات الأداء لقياس القدرات الفراغية لعدد ٣٥٣ من طلاب السنة الأولى ممن ينتمون الى ثلاث من اقسام العمارة فى كليات هندسيه مختلفه داخل القاهرة. كما قام البحث برصد وتحليل درجات الطلاب التى حصلوا عليها داخل استوديو التصميم الأول. اثبتت التحليلات الاحصائية وجود علاقة ذات دلالة احصائيه قوية بين مستوى أداء الطلاب فى اختبارات القدرات الفراغية وبين ماحصلوا عليه من درجات فى مادة التصميم المعمارى وان الطلاب الذين حصلوا على درجة (اكبر من او تساوى ٥٠) فى اختبارات القدرات الفراغية، كان لديهم الفرصة الأكبر فى الحصول على تقديرات أعلى فى المعدل النهائى لتلك المادة مما يؤكد قدرة اختبارات الأداء لقياس القدرات الفراغية فى التنبؤ بأداء الطالب داخل استوديو التصميم الأول وتم إقتراح تصميم اختبار باستخدام المهارات الفراغية لقبول للطلبة المقدمين على دراسة العمارة والذى قد يساعد فى التنبؤ بدرجة نجاحهم وتطوير القدرات الفراغية لجميع الطلاب من خلال دمج التدريبات المناسبة لتطوير هذه القدرات فى مراحل التعليم ماقبل الجامعى ومنهج تدريبى بالسنة الإعدادية فى كليات الهندسة لزيادة تحسين الاداء.