العنوان: Prediction of Academic Success through Spatial Ability and Spatial Representation among University Students

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Prediction of Academic Success through Spatial Ability and Spatial Representation among University Students

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Abstract

The main objective of this study is to predict the academic success of students from different academic disciplines through spatial orientation ability and spatial representation and to study the differences between males and females in these variables.Three groups of participants from various academic disciplines: architecture students, and students in English teaching and student learning Arabic language, have completed three tests designed to measure spatial representation using maps and a spatial orientation ability test. The final sample consisted of 97 subjects (17 males, 80 females) aged between19 and 21 years.The results indicate that the ability of orientation and spatial representation does not predict the academic success of students from different disciplines.The results also indicate that gender affects the performance in the spatial orientation ability and spatial representations in specific academic specializations.

Keywords

Spatial Representation-Spatial Orientation-Academic Success.

Prediction of Academic Success through Spatial Ability and Spatial Representation among University Students

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Introduction

The main focus of this study is to investigate the Predictive value of academic success through the spatial representation as measured by spatial knowledge representation tests and the individual spatial orientation ability as measured by spatial orientation test.

The study also analyzes the differences in both spatial orientation ability and spatial representations of the information acquired from a map of a virtual city in different academic specializations between males and females.

The history of research concerning spatial ability can be divided into three general phases of research activity. Eliot and Smith (1983) described these phases in terms of efforts in defining spatial ability:

In the first phase (1904-1938), researchers investigated the evidence for and against the existence of a spatial factor over and above a general factor of intelligence. In the second phase (1938-1961), they attempted to ascertain the extent to which spatial factors differed from one another. and in the recent phase (1961-1982), researchers have attempted to designate the status of spatial abilities within the complex interrelationship of other abilities and to examine a number of sources of variance with affect performance on spatial tests (Elliot & Smith, 1983, p.1).

Spatial orientation involves "the comprehension of the arrangement of elements within a visual stimulus pattern, the aptitude to remain unconfused by the changing orientations in which a spatial configuration may be presented, and the ability to determine spatial orientation with respect to one's body in the space" (McGee 1979b, 897). This refers to the ability to keep a clear idea of where the individual is situated in relation to the environment elements around him. (Gilmartin and Patton, 1984)

Spatial knowledge is the cognitive ability to determine, understand, and remember relationships between objects and locations within an environment. This concept refers to the subset of people's knowledge that represents their immediate or remote environmental space (Denis, 1997). Siegel and White (1975) proposed a theoretical framework for describing and explaining the process of knowledge development over time in new environments (called spatial cognitive micro genesis). In their framework, internal representations of spatial knowledge of a new place progress over time from an initial stage of landmark knowledge to a stage of route knowledge to an ultimate stage of survey knowledge. Landmark knowledge is knowledge about the identities of discrete objects or scenes that are salient and recognizable in the environment.

The space between landmarks is at first "empty" and receives "scaling" with accumulated experience; in other words, route knowledge is initially nonmetric. Route knowledge consists of sequences of landmarks and associated decisions (e.g., "turn left at the gas station and go straight for three blocks"),(Ishikawa & Montello,2006). The final stage of knowledge in their framework is survey knowledge; configurationally knowledge is the contemporary terminology of survey knowledge; this is a two-dimensional and "map-like," quantitatively scaled representation of the layout of the environment. Survey knowledge represents distance and directional relationships among landmarks, including those between which direct travel has never occurred. For survey maps to emerge, routes need to be metrically scaled and interrelated into a global all centric reference system..

Siegel and White's developmental three-stage theory also assumed that spatial knowledge developed in ontogenetic, sequential stages.

Ittelson (1973) discussed that the environment is larger than and surrounds the human body, so that a person cannot get the holistic layout of the environment in his mind from a single viewpoint. Instead, the individual must wandering in the place by transports or on foot, integrate his knowledge about the environment acquired from separate viewpoints and travel experiences.

Space can be classified into two categories based on scale .Downs and Stea's classified it to small- and large-scale spaces. Typically small-scale spaces can be apprehended from one single perspective, from outside of the space itself (Ittleson 1973; Mandler 1983).

Small-scale spaces include maps that enable the individual to have a holistic perspective of the environment that won't be available to him through wandering in the place by transports or even on foot. The term "manipulable space" has been used to describe this type of space (Montello, 1998).

Arguments for and against Gender Differences in Spatial Ability:

Researchers have only been able to find sex differences in specific subdivisions of spatial ability. For example, Linn and Peterson (1985) reported a large gender difference in mental rotation tasks favoring males, and Alexander (2005) reported a gender difference in visual memory tasks favoring females.

Brownlow et al. (2003) suggests that women's poor performance on mental rotation tasks may be due to the knowledge of negative social stereotypes.

Recently, a study conducted by Ginn and Pickens (2005) examined whether participation in different types of spatial activities would affect women's performance on mental rotation tasks. Ginn and Pickens administered a mental rotation test to 31 male and 59 female participants who were either enrolled in a music or art class or who participated in athletics at a local college. Ginn and Pickens found that women's scores on the mental rotation test were affected by their participation in spatial activities. Women who participated in music, art, or athletics had more experience with spatial activities and scored higher on the mental rotation test than did women who did not participate in these activities. It seems that practice is an important factor affecting the existence of sex differences in spatial abilities.

There is considerable evidence supporting the existence of gender differences in spatial abilities; however, researchers have only been able to make claims of sex differences in specific subdivisions of spatial ability. Moreover, many claims have been made about possible social and environmental causes of sex differences in spatial abilities.

In contrast to the evidence found in previous researches mentioned above that support the existence of gender differences in spatial orientation ability, an equal number of researchers maintain that substantial gender differences in spatial abilities do not exist. While some researchers make claims about possible environmental causes for gender differences in spatial abilities, Lohman (1979) maintained that gender differences in spatial abilities can be eliminated with exposure and practice. Thus, he believed that if female children or adults are given the same opportunity to practice a spatial task, no gender difference will exist.

2. Method

2.1 Participants

The final sample of the study was 97 subjects (17 males and 80 females) from different academic specializations: Architectural engineering students, English language teaching students and Arabic language teaching students at Helwan University. Their age ranged between 20 and 22 years. All subjects have spent at least three years in their academic specializations at the university.

2.2 Materials

Participants were asked to complete two tests that measure spatial representation and spatial orientation ability as follows:

- *Spatial Knowledge Representation Test:*

Three tests were constructed to measure the representation of the spatial information acquired from a map.

3D map of a virtual place and/or city were constructed designed and produced using E-Draw max v.5.

The map contains buildings and roads connecting these buildings. Each building identified by its name written behind it. The map was oriented to the North for the spatial orientation test considerations.

The spatial representation test consists of three sub-tests as followed:

(1-a) landmark knowledge test.

(2-a) Route Knowledge test.

(3-a) Configurational Knowledge test.

(1-a) landmark knowledge test:

Landmark knowledge is the knowledge of distinctive objects or scenes stored in memory (Montello, 1998). The test aimed at measuring the landmark location memory and object-to-object relations (klatezky, 1998). The test consists of 4 questions with a maximum score of (17) starting with a map presented to the subjects to study it (Fig. 1).

Figure 1.The map represented in the spatial representation test

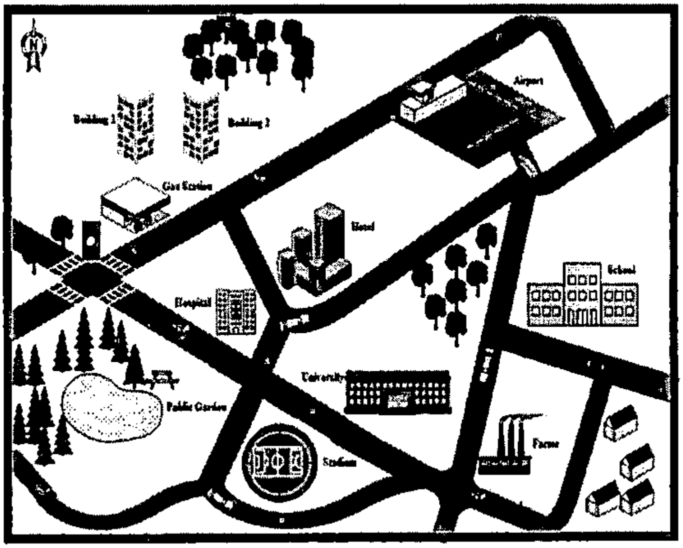


Figure 1. Illustrates a map of a virtual place contains 11 buildings, landmarks, and roads connecting them. Each building identified by its name just behind it. Participants should study this map for 3 minutes then they took the same map without the buildings and asked to localize the landmarks in its right position.

Participants should study the map very well for only 3 minutes to know the locations of the buildings, spatial relations represented in the map, then the observer give them the same map contains a menu with all landmarks written and numbered behind the empty map (Fig.2) and asked participants to localize all landmarks in their correct places.

Figure 2.Empty map in the spatial representation test

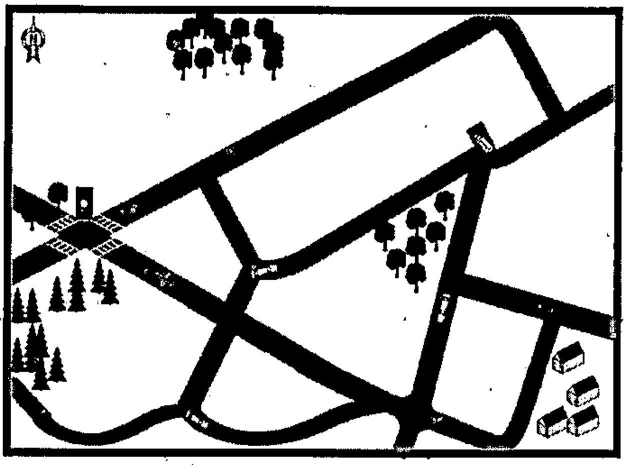


Figure 2. Illustrates the empty map represented to participants as the first question in the test. Participants should localize all landmarks in their correct location.

1) Building1	2) building2	3) Gas Station	4)Hotel
5) Hospital	6) Public Garden	7) Stadium	8) University
9) Factory	10) School	11) Airport	

(2-a) Route knowledge test:

Route knowledge is the knowledge of travel paths connecting landmarks (Montello, 1998).In this test participants will draw the road that connects two landmarks depending on the verbal description of the road (Fig.3). Also they have to choose the correct landmark that the road ends at it.

The test aims at measuring route knowledge and the ability to keep your mind concentrating to reach a specific goal through verbal description.In order to answer the test items, one's should be able to distinguish his right from left hand. The Test includes seven questions with total score (7).

Figure 3. An example of the Route Knowledge test

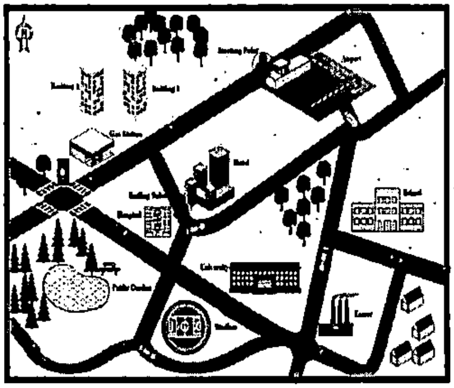


Figure 3. Question for Example:

You are standing in the road and the airport is on your left, and this is your starting point, now walk a few steps until you reach the cross roads, now turn left and keep walking for a few steps then stop.

From Your current position, choose the correct landmark that located to your right side from the alternatives below:

1) Hospital.

2) Hotel.

3) Public Garden.

The correct answer should be the first alternative which is hospital. The participant should draw the road connecting these two landmarks and choose the correct answer.

(3-a) Configurational knowledge test:

Survey knowledge is the Configurational knowledge of the locations and extents of features in some part in the environment that is not limited to particular travel paths (Montello, 1998).The test designed to measure the ability to build shortcuts for the routes that connect landmarks so that one's could use shorter route to reach from one place to another and the longest route that connects two places. Participants asked to draw the shortest route that connects two landmarks. Also, they were asked to draw the longest route that connects two designate landmarks (Fig. 4).

Figure 4. Spatial Configuration test

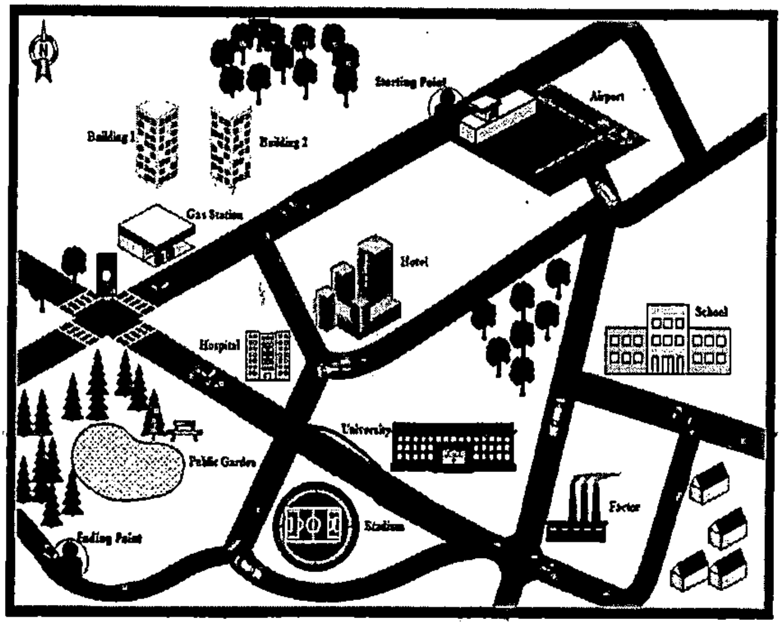


Figure 4. Question for Example:

Draw the tallest route that connects the airport as a starting point with the public garden as an ending point considering not repeating the route you previously walked in.

Participants should draw the tallest route as illustrated in the map. There is only one tallest route in the map for each question.

The test includes (8) questions with Maximum score (8) marks.

- Spatial Orientation test:

A test consists of (15) questions were constructed to measure the spatial orientation ability. The map participant's studied before in the spatial representation test showed on a screen in front of participants, so that they could not be able to orient the map to solve questions represented to them in the test. (Fig.5)

Figure 5. Spatial Orientation test

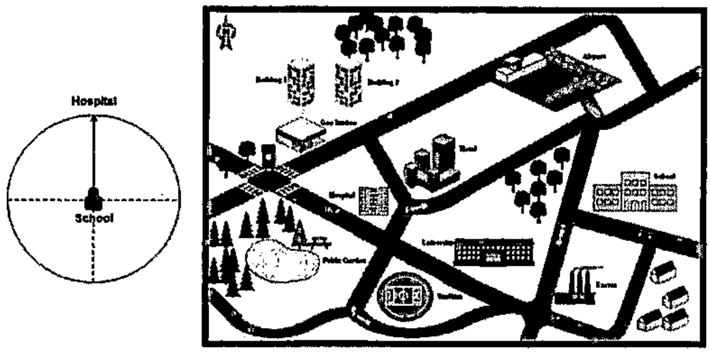
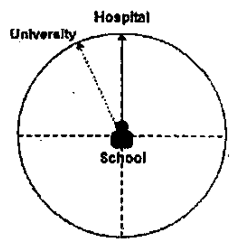


Figure 5. Question for Example:

Imagine your self standing in the school and facing the hospital. Now, from your current position, draw on the circle the arrow that refers to the direction of the university.

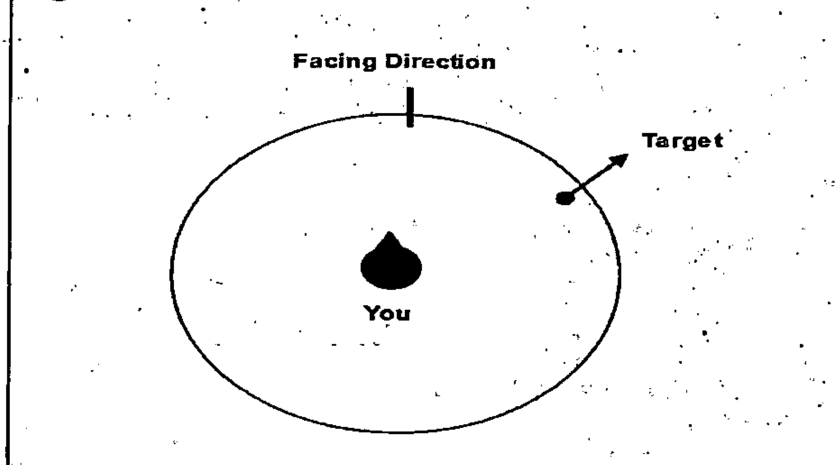
The correct answer should be drawn as follow:



The test allows participants to imagine oneself in standing in a specific position and facing another place and he had to locate a third place on a direction circle.

Direction circles: a direction circle consists of both a larger, outer, circle with a small dot or circle in its center. Figure 5 illustrates a direction circle. Participant facing location is represented by a mark at the top (0/360°) of the circle, figure 6. participant's should draw a line that reflects the angle of a target object relative to his position at the center of the direction circle in response to a question such as "Where is the hotel?" (Douglas, 2008).

Figure 6. Direction circle



2.3. Data analysis

The data collected from the subjects was analyzed using PASW v.18.Table 1 illustrates the descriptive statistics for the variables.

Table 1

Descriptive statistics

		Landmark test	Route test	Configuration test	Orientation test
N	Valid	97	97	97	97
	Missing	0	0	0	0
Mean		14.34	4.45	5.18	9.66
Variance		21.539	2.459	2.834	15.331
Minimum		0	0	2	0
Maximum		17	7	8	15

An analysis of variance was applied to the three tests measuring the spatial knowledge representation acquired from a map. Table 2 summarizes results below.

Table 2

ANOVA table for gender and academic specialization in spatial representation tests

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Specialize	Landmark test	153.598	2	76.799	3.688	.02
	Route test	46.302	2	23.151	11.694	.000
	Configuration test	4.095	2	2.048	.725	.487
gender	Landmark test	.144	1	.144	.007	.934
	Route test	4.688	1	4.688	2.368	.127
	Configuration test	.581	1	.581	.206	.651

Results showed significant differences in the performance on both landmark knowledge test [F (2) =3.688, P=.029] and route knowledge test [F (2) =11.694, P=.000] between different specializations. A post hoc shiffee test was applied. It showed no significant values in the mean differences in the landmark knowledge test and that result was due to weak effect.

On the other hand, results of shiffee post hoc for route knowledge test showed that engineering students outperform Arabic and English language teaching significantly as shown in table 3. in details.

Table 3

Post hoc comparison for the route knowledge test

Scheffe

Dependent Variable	(I) Specialize	(J) Specialize	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Route Score	Architecture Engineering	English Language	1.20*	.318	.001	.41	1.99
		Arabic Language	1.85*	.464	.001	.70	3.01
	English Language	Architecture Engineering	-1.20*	.318	.001	-1.99	-.41
		Arabic Language	.65	.496	.425	-.58	1.89
	Arabic Language	Architecture Engineering	-1.85*	.464	.001	-3.01	-.70
		English Language	-.65	.496	.425	-1.89	.58

For the spatial orientation ability, an analysis of variance was applied. Results showed statistically significant differences in performance on the spatial orientation test in different academic specializations and between males and females. Results represented in table 4 below.

Table 4

ANOVA table for the spatial orientation test

Tests of Between-Subjects Effects

Dependent Variable: Orientation Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Specialize	145.348	2	72.674	4.217	.016
Gender	141.328	1	141.328	8.201	.005

a. R Squared = .132 (Adjusted R Squared = .106)

A post hoc shiffee test was applied to compare the three different academic specializations in their spatial orientation ability. Table5. Below illustrates the results.

Multiple Comparisons

Table5

Post hoc comparison for the spatial orientation ability test

Scheffe

(I) Speciali	(J) Specialize	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Engineering	English Language	.36	.763	.896	-1.53	2.24
	Arabic Language	2.97*	.853	.003	.86	5.08
English Language	Engineering	-.36	.763	.896	-2.24	1.53
	Arabic Language	2.61*	.983	.031	.19	5.04
Arabic Language	Engineering	-2.97*	.853	.003	-5.08	-.86
	English Language	-2.61*	.983	.031	-5.04	-.19

Based on observed means.

The error term is Mean Square (Error) = 17.233.

*. The mean difference is significant at the 0.05 level.

Results showed a statistically significant difference between architecture engineering students and Arabic language teaching student favoring the first one. Gender differences emerged in the spatial orientation ability as shown in results above table4. Males outperform females in spatial orientation ability test [F (1) =8.201, P=.005].

In order to compute the predictive value of the academic success through the spatial representation and spatial orientation; a hierarchical regression analysis was applied, table (5) summarize the main results.

Results showed that spatial representation tests could not predict the academic success of the university students as measured by their cumulative GPA

Table 6

Hierarchical regression analysis results for spatial representation tests

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.409	.248		9.699	.000
Landmark Total Score	-.008	.017	-.057	-.490	.625
(Constant)	1.938	.287		6.763	.000
Landmark Total Score	-.017	.016	-.118	-1.039	.302
Route Total Score	.136	.047	.330	2.914	.005
(Constant)	1.861	.329		5.657	.000
Landmark Total Score	-.017	.016	-.120	-1.053	.296
Route Total Score	.128	.050	.310	2.571	.012
Configuration Total Score	.023	.048	.058	.484	.630

a. Dependent Variable: GPA

In consistent with these results, a simple regression analysis was applied to the spatial orientation ability test to compute the predictive value of the test to the academic success. Results shown in table 6 showed no prediction value at 0.05 significant level.

Table 7

Simple regression analysis results for spatial orientation test

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.056[a]	.003	-.011	.677

a. Predictors: (Constant), Orientation Total Score

To sum up, the spatial representation knowledge and spatial orientation ability are not good predictors of university students' academic success.

Discussion:

Results from the analysis of variance shows that studying architecture engineering has a weak effect on the spatial relation representation efficacy. Also, gender differences do not emerge in the performance on memory for location tasks as measured by landmark knowledge test. These results are in consistent with many previous research in the literature, Lachini and Giusberti, 2004; Dabbs et.al, 1996; Lawton et.al, 1996.

Gender differences are considered to be a critical issue in the literature of psychology of differences.

Also, the measurement tool constructed to measure the one's ability to tracking with the route depending on the verbal description of this route, is similar the maze learning tasks. The participant has to use his visual cues given to him during the question; i.e. I am in the middle of Tahrir square, and it's not far away from the Nile River, then I am close to the Egyptian Museum… etc. And that's what we all thinking in our daily life. We depend on our memory trying to reach our destination with help with a verbal description from others.

The ANOVA results shows that studying engineering led to more developing in the route knowledge representation. In addition to that, as shown from the ANOVA results. To sum up, the high ability in spatial orientation, the more sufficient in representing routes acquired from a map is sufficient representing routes and landmarks linked to it.

These results shed the light on processes and representations explicit in the cognitive mapping and try to answer the question of how we solve our daily spatial problems and our thoughts about the space and making decisions which reflects our spatial behavior (Kitchen and Freundschuh, 2000). The cognitive map also gives us an indicator of the mental capacity realizing, memorizing, organizing and representing spatial information of places and locations related to it.

On the other hand, these variables were not good predictors of academic success as measured by grade point average GPA during the 5 years of studying at the university. Based on findings obtained in this study it can be suggested that studying at the faculty of architecture engineering should emphasize more on subjects that required designing cities, as it improves student's ability in creating shortcuts in routes and makes traffic easier … etc.

also, they should encourage updating projects of the current heavy traffic cities during their studies and that should improve their student's abilities in designing also.

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التنبؤ بالنجاح الأكاديمى لطلاب الجامعة
من خلال القدرة المكانية والتمثيل المكانى

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ملخص البحث:

الهدف الرئيسى لهذه الدراسة هو التنبؤ بالنجاح الأكاديمى للطلاب من تخصصات أكاديمية مختلفة من خلال القدرة على التوجه المكانى والتمثيل المكانى ، و كذلك دراسة الفروق بين الذكور والإناث فى هذه المتغيرات. وقد أكملت ثلاث مجموعات من تخصصات متنوعة شملت الهندسة المعمارية – تدريس اللغة العربية – تدريس اللغة الانجليزية ثلاثة اختبارات صممت لقياس التمثيل المكانى باستخدام الخريطة واختبار القدرة على التوجه المكانى. وقد شملت العينة النهائية ٩٧ طالب وطالبة (١٧ ذكور و ٨٠ إناث) تراوحت أعمارهم ما بين ١٩ و ٢١ عاماً. وقد أوضحت النتائج أن كلاً من القدرة على التوجه المكانى والتمثيل المكانى لا يمكن التنبؤ من خلالهما بالنجاح الأكاديمى للطلاب ، كما أوضحت النتائج أيضاً أن النوع يؤثر فى الأداء فى كل من التوجه المكانى والتمثيل المكانى فى بعض التخصصات الأكاديمية.