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## SPATIAL IMAGINATION OF STUDENTS COMMENCING THE COURSE IN DESCRIPTIVE GEOMETRY ON TECHNICAL FACULTIES IN THE YEARS 2011-2014

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**Abstract.** In the years 2011-2014, a research on geometrical predispositions was conducted among the first-year students of the Faculty of Environmental Engineering and Land Surveying at the Agricultural University of Cracow. Students of four faculties were included in the research. Each of the 280 included students answered 10 simple questions regarding geometry, which were designed to assess to our best ability especially the spatial imagination of the students. Also, the knowledge of basic geometry, acquired in primary and secondary school, was essential. What is more, the students could also show their drawing abilities, but it was the oral exam that prevailed. To sum up our research, we can support the thesis, that the predispositions of the spatial imagination of the students Faculty of Environmental Engineering and Land Surveying at the Agricultural University of Cracow in the years 2011 – 2014 were directly connected to the field of study. It could result from the attractiveness of the faculty itself, which is strictly connected to the number of candidates – different on each faculty.

**Keywords:** spatial imagination, descriptive geometry

### 1 Introduction

The research on geometrical predispositions was launched at a time (after 1995) when persons commencing the studies were found to present lack of geometric predisposition. The observation may have come from the author's subjective perception relating, for instance, to the students' lower level of knowledge in the basic topics of geometry covered by the teaching curricula for secondary-school mathematics. The lower knowledge indicators may have stemmed from the fact of suspension of mathematics entrance examinations to the above studies in those years. Admissions to the studies in that period were made on the basis of grades awarded on secondary-education certificates [2,3,4].

Probably the reasons for the lower level of knowledge in geometry among persons admitted to the studies lay in the absence of selectivity previously exercised during mathematical entrance examinations, as well as in the lack of specification, by defining an adequate scope of the entrance examination, of the necessary mathematical requirements including, admittedly, geometry. The abandonment of the aforementioned examination resulted in a rise of interest in this line of studies and a larger number of aspiring candidates. However, it may be surmised that it was a consequence of the facilitation of admission to the studies, and that the candidates did not necessarily have adequate knowledge of geometry [4].

## 2 The research methodology

In the years 2011-2014, a research on geometrical predispositions was conducted among the first-year students of the Faculty of Environmental Engineering and Land Surveying at the Agricultural University of Cracow. Students of four faculties were included in the research. Each of the 280 included students answered 10 simple questions regarding geometry, which were designed to assess to our best ability especially the spatial imagination of the students. Also, the knowledge of basic geometry, acquired in primary and secondary school, was essential. What is more, the students could also show their drawing abilities, but it was the oral exam that prevailed.

As a result of the studies carried out, each student under examination yielded a value within the range 0-10 corresponding to the number of correct answers.

Below there are some exemplary questions included in the Test on Spatial Abilities (designed by the author):

1. How many various length segments one may draw between various vertices of a cube (the same length segments are considered to be one segment)?
2. How many faces (maximum) one may see from an optionally chosen viewpoint?
3. How many squares one may create using various vertices of cube?
4. How many cubes one can insert into a cube of a side-length equal to triple-length of the searched cubes?
5. If 4 points neither lie on a single straight line nor make a plane – what geometrical shape do they create?
6. An intersection of a cylinder with the base of diameter  $D$  and height  $h$  may be a rectangle. When does this case occur and what are the dimensions of this rectangle?
7. An intersection of a cube with a plane may be a square. When does this case occur?
8. A sphere with radius  $R$  and a plane have 2 common points. What is the shape of a line of intersection and what is the special dimension of this line of intersection. Please give the name of this special case's shape.
9. Taking into account the property, that a sphere has the largest ratio between its volume and surface if compared to the other 3D solids, please choose the solid with the largest volume among: a sphere with diameter  $D = 8$  cm, a cube with a side length = 8 cm or a cylinder of revolution with the base's diameter  $d = 8$  cm and height  $h = 8$  cm. What solid can be circumscribed or inscribed into another solid?
10. If a cone of revolution with the base of radius  $R$  and height  $h$  is intersected with a plane perpendicular to its axis of revolution a  $\frac{1}{4}$  height  $h$ , then what shape will we get and what dimensions in reference to the base circle will it be?

## 3 Results and Discussion

Results of the study were presented in a table form. In order to allow better presentation of observed tendencies the results were also presented as figures.

As a result of the studies carried out, each student under examination yielded a value within the range 0-10 corresponding to the number of correct answers. The results are presented in Table 1 and Table 2.

Table 1: The number of correct answers among the students

	Land Surveying and Cartography	Spatial Management	Environmental Engineering	<i>In general</i>
The number of subjects	94	91	95	280
Arithmetic mean	5,87	4,96	3,83	4,88
Standard deviation	1,92	2,71	1,85	2,19
Median	6	4,5	4	4

Table 2: Relevance levels for variations between particular groups (according to the t Student s test)

	Land Surveying and Cartography	Spatial Management	Environmental Engineering
Land Surveying and Cartography		0,010	0,001
Spatial Management	0,010		0,006
Environmental Engineering	0,001	0,006	

At the Agricultural University of Cracow, Land Surveying students received the highest (5.87), and Environmental Engineering students the lowest (3.83) mean results, respectively (Tab. 1). The curves on the graph confirm that tendency (Fig. 1 and Fig. 2).

Table 2 show that there were significant differences between students' groups ( $\alpha \leq 0,01$ ) as far as spatial imagination was concerned.

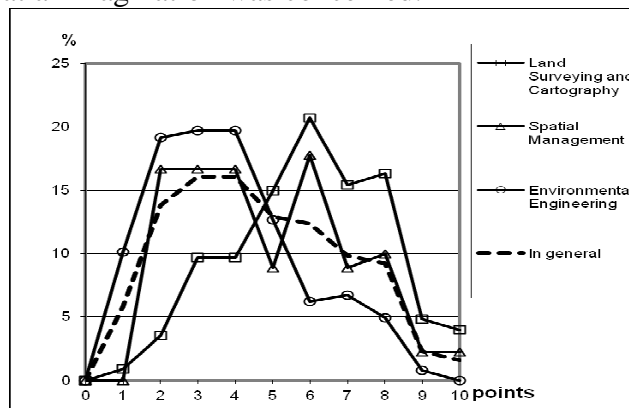


Figure 1: A percentage frequency distribution for attainment of particular scores (points) in the successive years of research

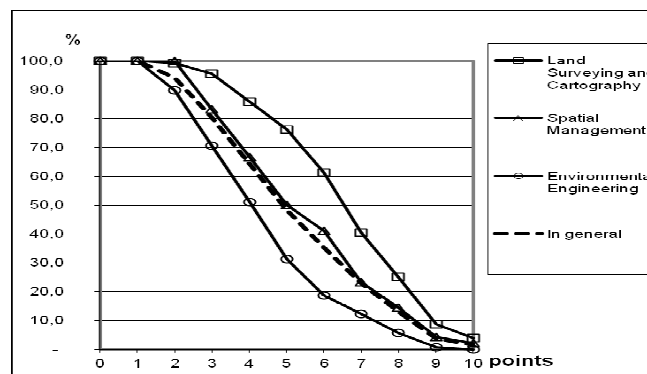


Figure 2: Percent proportion of persons from particular scoring no fewer than the specified numbers of points

Table 3: Presents comparison of the results between male and female groups

	Sex (Men / Women)	Land Surveying and Cartography	Spatial Management	Environmental Engineering	<i>In general</i>
The number of subjects	M	51	47	47	145
	W	43	44	48	135
Arithmetic mean	M	6,03	5,2	3,97	5,09
	W	5,68	4,72	3,69	4,66
Standard deviation	M	1,93	2,18	2,00	2,21
	W	2,20	2,18	1,90	2,24
Median	M	6	5	4	5
	W	6	4	3	4

Table 3 shows that male students had higher scores than female students of the same faculty. However statistical analysis, presented in table 4, confirmed significance of these differences only when whole population of male and female students were compared.

Table 4: Relevance levels for variations between particular groups (according to the t Student s test) take into consideration sex

		Women			
		Land Surveying and Cartography	Spatial Management	Environmental Engineering	In general
Men	Land Surveying and Cartography	0,085			
	Spatial Management		0,356		
	Environmental Engineering			0,117	
	In general				<b>0,042</b>

The curves on the Figure 3 and Figure 4 seems to prove it, though female students received the highest scores (10 points) more often.

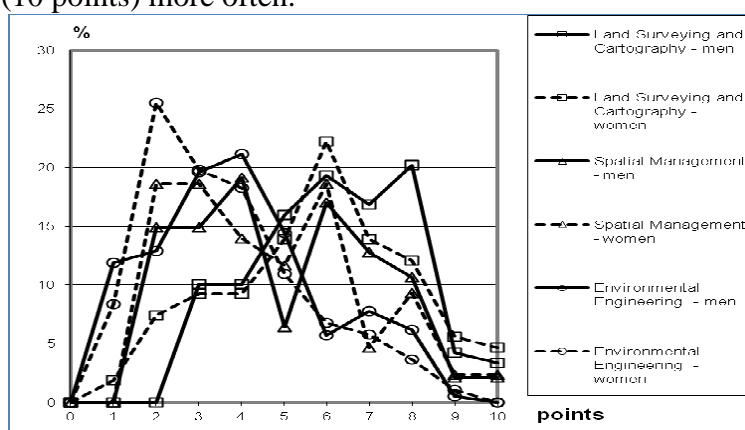


Figure 3: A percentage frequency distribution for attainment of particular scores (points) take into consideration sex

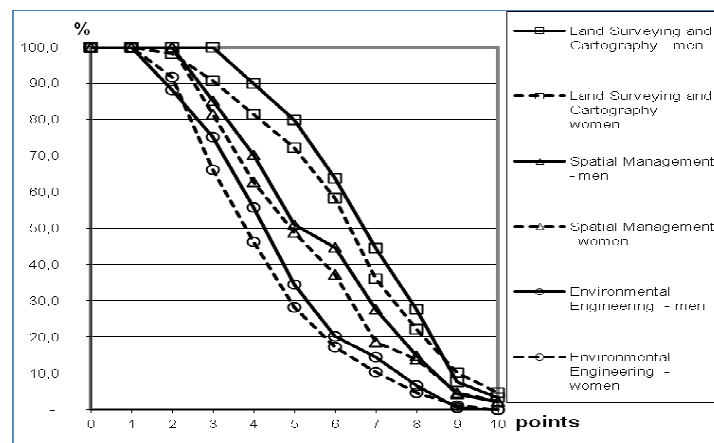


Figure 4: Percental proportion of persons take into consideration sex scoring no fewer than the specified numbers of points

In conclusion it can be said that the results confirm the findings of previous studies by the same method in the same department [2,3,4]. Unfortunately there is no possibility to compare the findings with another author's research with different methods based on questions with graphical nature of the research [1,5]

#### 4 Conclusions

1. Significant differences ( $\alpha < 0.01$ ) between mean scores in spatial imagination evaluation (based on 0-10 point scale) were observed. At the Agricultural University of Cracow, Land Surveying students and Environmental Engineering students received the highest (5.87) and the lowest (3.83) mean results, respectively.
2. When all faculties were concerned, female students presented lower mean scores in spatial imagination evaluation than males. However, statistical significance ( $\alpha < 0.05$ ) was confirmed after results for each gender and whole population of students were taken into account.
3. Attention should be paid to the fact that more female than male students received the highest score (10 points).

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## **WYOBRAŹNIA PRZESTRZENNA U STUDENTÓW ROZPOCZYNAJĄCYCH KURS GEOMETRII WYKREŚLNEJ NA KIERUNKACH TECHNICZNYCH W LATACH 2011-2014**

W latach 2011-14, wśród studentów rozpoczynających I rok studiów na Wydziale Inżynierii Środowiska i Geodezji Uniwersytetu Rolniczego w Krakowie przeprowadzono badania predyspozycji geometrycznych. Objęto nimi osoby przyjęte na cztery kierunki studiów.

Każdy z badanych 280 studentów odpowiadał na 10 prostych pytań z zakresu geometrii, pozwalających ocenić w miarę możliwości przede wszystkim wyobraźnię przestrzenną, przy czym niezbędna była również wiedza z podstawowych zagadnień geometrycznych uzyskiwana w szkole podstawowej i średniej. Ponadto studenci mogli wykazać się umiejętnością rysowania, ale liczyła się odpowiedź słowna.

W podsumowaniu badań, można przychylić się do tezy, że predyspozycje wyobraźni przestrzennej u studentów Wydziału Inżynierii Środowiska i Geodezji Uniwersytetu Rolniczego w Krakowie w latach 2011-14 były bezpośrednio związane z kierunkiem studiów. Mogło to wynikać z atrakcyjności kierunku, a co za tym idzie liczbą kandydatów - różną na poszczególnych kierunkach.