Adam Rużyczka

SPATIAL IMAGINATION AMONG STUDENTS COMMENCING THE COURSE OF DESCRIPTIVE GEOMETRY AT TECHNICAL STUDIES IN 2003 AND 2004

Abstract

In 2003 and 2004, we started a research project on the geometrical predisposition of students of the Faculty of Environmental Engineering and Land Surveying at the Agricultural University of Cracow. For both the studies of Land Surveying and Cartography the entrance examination in mathematics has been cancelled, while for Environmental Engineering studies there is now no compulsory mathematics examination at all.

During those years, students of Land Surveying and Cartography, Higher Education Professional College of Nowy Sącz, joined the research group.

Each of about 700 students answered 10 simple questions within the field of geometry, which allowed, within boundaries of possible means, evaluation especially of spatial (three-dimensional) imagination, although equally essential was knowledge pertaining to the basic problems of geometry. The students were allowed to execute auxiliary drawings.

As a result, differences concerning levels in spatial imagination between groups of participants were found.

Keywords

Spatial imagination, descriptive geometry

1 Introduction

In 2003 and 2004, we started a research project on the geometrical predisposition of students of the Faculty of Environmental Engineering and Land Surveying at the Agricultural University of Cracow. For both the studies of Land Surveying and Cartography the entrance examination in mathematics has been cancelled, while for Environmental Engineering studies there is now no compulsory mathematics examination at all.

During those years, students of Land Surveying and Cartography, Higher Education Professional College of Nowy Sącz, joined the research group.

Below there are some exemplary questions included in the TEST ON SPATIAL ABILITIES.

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. An intersection of a cube with a plane may be a square. When does this case occur?
3. 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.
4. 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?
5. 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 ¼ height h, then what shape will we get and what dimensions in reference to the base circle will it be?
6. How many faces (maximum) one may see from an optionally chosen viewpoint?
7. How many squares one may create using various vertices of cube?
8. How many cubes one can insert into a cube of a side-length equal to triple-length of the searched cubes?
9. If 4 points neither lie on a single straight line nor make a plane – what geometrical shape do they create?
10. 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?

2. Results of the research

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.

Table 1: The number of correct answers among the students

	Land Surveying and Cartography (Cracow)	Land Surveying and Cartography (Nowy Sącz)	Environmental Engineering (Cracow)	In general
The number of subjects	227	90	386	703
Arithmetic mean	5,96	4,86	3,81	4,64
Standard deviation	2,02	2,75	1,95	2,23
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 (Cracow)	Land Surveying and Cartography (Nowy Sącz)	Environmental Engineering (Cracow)
Land Surveying and Cartography (Cracow)		0,000	0,000
Land Surveying and Cartography (Nowy Sącz)	0,000		0,000
Environmental Engineering – (Cracow)	0,000	0,000	

Tables 1 and 2 show that there were significant differences between students' groups ($\alpha \leq 0{,}001$) as far as spatial imagination was concerned. Land Surveying students from Cracow received the highest results, and Environmental Engineering students received the lowest results. The curves on the graph confirm that tendency (figure 1).

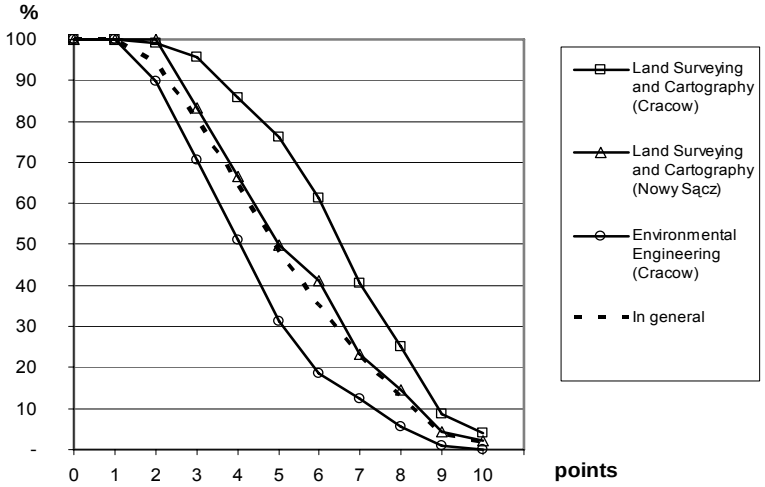

Figure 1: Percental proportion of persons from particular scoring no fewer than the specified numbers of points

Table 3: The number of correct answers among the students takes into consideration sex

	Land Surveying and Cartography (Cracow)		Land Surveying and Cartography (Nowy Sącz)		Environmental Engineering (Cracow)		In general	
	Men	Women	Men	Women	Men	Women	Men	Women
The number of subjects	119	108	47	43	194	192	360	343
Arithmetic mean	6,17	5,74	5,00	4,70	3,95	3,66	4,82	4,44
Standard deviation	1,93	2,20	2,18	2,18	2,00	1,90	2,21	2,24
Median	6	6	5	4	4	3	5	4

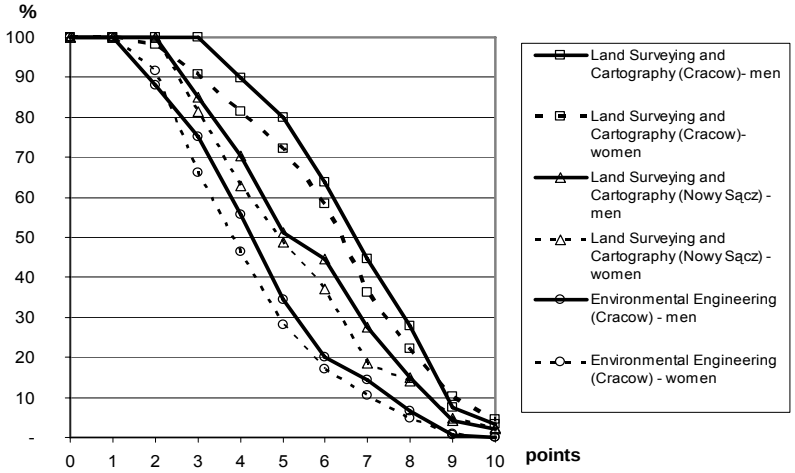

Figure 2: Percental proportion of persons take into consideration sex scoring no fewer than the specified numbers of points

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 (Cracow)	Land Surveying and Cartography (Nowy Sącz)	Environmental Engineering (Cracow)	In general
Men	Land Surveying and Cartography (Cracow)	0,058			
	Land Surveying and Cartography (Nowy Sącz)		0,256		
	Environmental Engineering (Cracow)			0,067	
	In general				**0,012**

Table 3 presents comparison of the results between male and female groups. It 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.

The curves on the figure 2 seem to prove it, though female students received the highest scores (10 points) more often.

3. Conclusion

1. Significant differences (alpha $\leq$ 0.001) 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 (5.96) and the lowest (3.81) 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 $\leq$ 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).

References

[1] C. Leopold, R. Górska, S.A. Sorby: *International Experiences in Developing the Spatial Visualization Abilities of Engineering Students*. Journal for Geometry and Graphics Volume 5, 2001, No. 1, 81-91.

[2] A. Rużyczka: *Spatial imagination among students commencing the course of descriptive geometry in a technical studies*. Journal for Geometry and Graphics Volume 7 (2003) Vien No. 2, s.247-252

[3] A. Rużyczka: *The relationship between students spatial imagination, commencing the course of descriptive geometry in the 2002, and their final exams results***.** „Sbornik 23. Konference o geometrii a počítačové grafice" Hojsova Straż-Brcalnik 8-12—11.09.2003 st 169-174.

[4] T. Saito, K. Shiina, K. Suzuki, T. Jingu: *Spatial Ability Evaluated by a Mental Cutting Test*. Proc 7th ICECGDG, Cracow, Poland, 1996, pp. 569-573.