INVESTIGATION OF THE MEASURES AND MEANS FOR THE DEVELOPMENT OF SPATIAL SKILLS

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Abstract.. Educators and researchers in the field of spatial ability have at their disposal various psychometric tests as measures of the levels of these skills. Basically the tests are constructed with the use of 2D and 3D geometrical figures, which undergo various processes such as: rotations, translations, developments, etc. In general these are so called "multiple-choice tests', which have a criterion figure and a set of possible answers, among which one or more items are correct choices. At present new testing instruments are being developed (e.g. TPS [3], [6]). There is a chance to employ the new testing instrument into didactics of engineering students. The levels of spatial skills of engineering students as measured by the chosen test should become an indicator for those who need additional help and extra training in solving 3D problems. This work is a trial to provide evidence on the correlations between the TPS results and the other psycho-diagnostic tests administered at the Cracow University of Technology.

Key Words: spatial ability, engineering education

1. Introduction

H. Stachel [8] pleads the role of descriptive geometry to be a subject of basic importance for any engineering education and states that "the education in Descriptive Geometry provides a training of the students' intellectual capability of space perception. Drawings are the guide to geometry but not the main aim". Górska R.A. and Juščáková Z. have discussed in [5] the position, the goals and the changes in Descriptive Geometry over the decades. In conclusion of the both papers the authors state that

- complicated manual constructions [5, 8] ,
- hard theoretical proofs [8],
- the theory of how to obtain images of particular 3D objects [8]

should be substituted or enhanced with

- basic knowledge of 3D geometry [8],
- promoting creativity and problem-solving skills [8]
- activating passive theoretical information by manual activity (models building and sketching) ([5] and [8]),
- providing examples of applying of theory into engineering practice ([5], [8]),
- producing attractive illustrations ([5], [8]).

Stachel in [8] points out that the additional demands on Descriptive geometry are:

- handling software for geometric modeling and visualization,
- treating new geometric shapes (e.g., B-spline surfaces),
- competence in handling graphics files (in different formats),
- design of animations.

We can see that the role of all the teachers of Descriptive Geometry is highly demanding and challenging. How many of us, the teachers of Descriptive Geometry and Engineering Graphics, are able to meet the conditions listed above?

Already several years ago S. Sorby [7] introduced a special, additional course for enhancement of 3D Spatial Skills into her educational process. This course (GN102) was aimed at freshmen engineering students who have a demonstrated weakness in their ability to visualize,

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as measured by the Purdue Spatial Visualization Test: Rotations (PSVT:R) [4]. Additionally chosen course helped the students to make up their deficiency in spatial skills.

At present the researchers dealing with spatial abilities have at their disposal various psycho-diagnostic, standardized tests, among others there are the Mental Rotations Test [9], the Mental Cutting Test [1], OTRS [10], IST [11], and many others. In the last 5 years a new testing tool TPS (Test Priestorovej Priedstavivosti) has been developed by Zuzana Juščáková ([3], [6]) and it still undergoes standardization process. The testing with the use of TPS has been conducted in international co-operation among engineering students of technical universities in many countries (Slovakia and Czech Republic, Poland, Austria) ([2], [3], [5], [6]). Some results and correlations between these tests will be presented below.

2. TPS test Results at the CUT – Faculty of Civil Engineering

The test TPS has been described in details in earlier works ([2], [3], [5], [6]). In the Table 1 the mean scores (in percentage values) together with standard deviations (s.d.) and number of cases are given. Each Subtest's maximum score is 10 points in absolute scale (=100%). The results show that Subtest 1 was the most difficult for students (finding mutual position between the line and the plane), while Subtest 3 was the easiest (missing part of a cube).

Table 1: Mean TPS scores, Standard deviation (s.d.) and Number of cases (n) in two subsequent years 2004/05 and 2006/06

	Subtest 1	Subtest 2	Subtest 3	TPS
2004/05				
Group Result	44.95 s.d.=24.66 (n=95)	57.28 s.d.=28.87 (n=92)	72.69 s.d.=18.25 (n=93)	59.00 s.d.=18.61 (n=90)
Men	47.91 s.d.=24.53 (n=67)	58.75 s.d.=28.65 (n=64)	76.15 s.d.=17.29 (n=65)	61.20 s.d.=18.26 (n=64)
Women	37.86 s.d.=23.94 (n=28)	53.93 s.d.=29.61 (n=28)	64.64 s.d.=18.15 (n=28)	53.59 s.d.=18.71 (n=26)
2005/06				
Group Result	37.05 s.d.=21.30 (n=105)	42.84 s.d.=27.05 (n=102)	61.47 s.d.=19.47 (n=102)	47,07 s.d.=17,86 (n=98)
Men	37.37 s.d.=21.25 (n=76)	42.53 s.d.=26.56 (n=75)	62.74 s.d.=20.09 (n=73)	47,27 s.d.=17,99 (n=72)
Women	36.21 s.d.=21.78 (n=29)	43.70 s.d.=28.84 (n=27)	58.28 s.d.=17.74 (n=29)	46.54 s.d.=17.83 (n=26)

3. Correlation between TPS and OTRS

In 2005/06 the OTRS test has been administered to find out the relation between the TPS test and another standardized test. OTS is the Orientation Test of Cognitive Skills, Subtest: Cube Selection (OTRS-VK) [10]: The tested person must determine the number of cubes (in a limited space), which have an opening but are not damaged. This number must be recorded in an answer form. A circle in the front marks the cube with an opening and this symbol applies to all the cubes standing behind it. A cross on the top face or on its side marks the damaged cube and this symbol applies to all the cubes in a column and/or in a row.

In Table. 2 the number of cases n together with the Pearson's product moment of correlation between the two tests has been presented. The test consists of three independent parts: Subtest 1, Subtest 2 and Subtest 3. The whole test has been denoted with TPS.

Table 2: Pearson's product moment of correlation between TPS and OTRS (2005/06)

	CRACOW UNIVERSITY OF TECHNOLOGY(CUT): TPS			
	Subtest 1	Subtest 2	Subtest 3	TPS
OTRS - 2005/06	0.2609 (n=73)	0.3531 (n=73)	0.3876 (n=73)	0.4131 (n=73)

One can see above there is no high correlation between the OTRS and TPS tests.

4. Correlation between TPS and MRT

In 2004/05 and 2005/06 both the MRT [9] and TPS tests have been administered to the similar groups of subjects at the Faculty of Civil Engineering (CUT). In Table. 4 the number of cases (n) together with the Pearson's product moment of correlation between the two tests has been presented. The TPS test consists of three independent parts: Subtest 1, Subtest 2 and Subtest 3. The whole test has been denoted with TPS.

Table 3: Pearson's product moment of correlation between TPS and MRT in two subsequent years 2004/05 and 2005/06

	CRACOW UNIVERSITY OF TECHNOLOGY(CUT): TPS			
	Subtest 1	Subtest 2	Subtest 3	TPS
MRT - 2004/05	0.35342 (n=95)	0.36615 (n=92)	0.40911 (n=93)	0.4655 (n=89)
MRT - 2005/06	0.4394 (n=76)	0.4137 (n=76)	0.5273 (n=76)	0.5629 (n=76)

5. Correlation between TPS and Descriptive Geometry

Descriptive geometry has always been considered as the means for enhancing spatial abilities of engineering students. There appears the question if one can justify the final outcome of the exam in Descriptive geometry based on the specific test. There is also an important question, which test is the best representative of the students' skills. The results obtained in the last two-year research are shown in Table 4.

Table 4: Pearson's product moment of correlation between TPS and Descriptive Geometry Final Exam Results in two subsequent years 2004/05 and 2005/06

	CRACOW UNIVERSITY OF TECHNOLOGY(CUT): TPS			
	Subtest 1	Subtest 2	Subtest 3	TPS
Descriptive Geometry - 2004/05	0.3494 (n=95)	0.4461 (n=92)	0.2995 (n=93)	0.4644 (n=97)
Descriptive Geometry - 2005/06	0.2307 (n=98)	0.2433 (n=98)	0.3785 (n=98)	0.3766 (n=98)

6. Conclusions

Based on the research conducted in the years 2004/05 and 2005/06 conducted at the Cracow University of Technology, Faculty of Civil Engineering with the use of the TPS test we can conclude:

- TPS test consists of three parts, not all the Subtests constituting the TPS are of the same difficulty to engineering students (Table 1),
- There is a vague correlation between the TPS and OTRS,

- There exists a considerably high correlation between the TPS and the MRT (Table 3),
- Based on the results of the TPS it is not possible to anticipate the final outcome in the Descriptive geometry final exam (Table 4). The latter may be due to the fact that the result in exam does not only correlate to spatial ability but also to individual knowledge of geometry,
- The TPS test may be the measure of spatial skills and the basis to propose to a student taking up an additional course for developing spatial skills,

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[11] OTRS

POMIAR ZDOLNOŚCI POSTRZEGANIA PRZESTRZENNEGO A METODY WSPOMAGANIA WYOBRAŹNI

Naukowcy zajmujący się pomiarami psycho-diagnostycznymi w dziedzinie wyobraźni przestrzennej mają do dyspozycji wiele „narzędzi" w postaci standaryzowanych testów, które w zasadzie opierają się na geometrycznych obrazach obiektów dwu- i trój-wymiarowych. Testy są na ogół testami wyboru, w których wzorzec podlega manipulacji (obrót, przekrój, rozwinięcie, przesunięcie), a badany ma wskazać prawidłową odpowiedź, wybierając jedną lub więcej pozycji spośród zaproponowanej gamy odpowiedzi. Obecnie powstają nowe narzędzia w postaci testów (np. TPS [3], [6]), które mają szanse stać się narzędziami powszechnie stosowanymi do oceny wyobraźni przestrzennej przez dydaktyków przedmiotu *Geometria wykreślna*. Niniejsza praca jest próbą pokazania niektórych zależności występujących między standardowo stosowanymi testami a nowym testem TPS na przykładzie badań przeprowadzonych wśród studentów Wydziału Inżynierii Lądowej Politechniki Krakowskiej.