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# Analysis of the spatial skills of the degree student in engineering: A gender approach

***Irantzu Recalde-Esnoz[1], Daniel Ferrández[2], Engerst Yedra[2], Alicia Zaragoza-Benzal[2]***

*[1] Departamento de Ciencias de la Educación, Universidad de Alcalá, Aulario María de Guzmán, C/ San Cirilio s/n, 28804, Alcalá de Henares, Spain. E-mail: irantzu.recalde@uah.es*
*[2] Departamento de Tecnología de la Edificación. Universidad Politécnica de Madrid. Avenida Juan de Herrera 6, 28040, Madrid, E-mail: daniel.fvega@upm.es; e.yedra@alumnos.upm.es; alicia.zaragoza@alumnos.upm.es*

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## HIGHLIGHTS

- Spatial thinking plays a key role in the teaching and learning process.
- Three different types of spatial skills have been assessed: spatial relationship, spatial rotation, and spatial visualization
- In engineering degree courses, the difference between men and women in terms of spatial ability is not very significant.

## ABSTRACT

The objective of this work is to carry out an approach to the study of spatial skills by gender in engineering students. For this, the analysis of a test consisting of 12 questions was carried out on a sample of 220 students from the Universidad Politécnica de Madrid, of which 134 were male and 81 were female. The study evaluated three different types of spatial skills such as relation, rotation, and visualization. From the analysis of the results obtained in the sample, it appears that in engineering degree courses the difference between men and women in terms of spatial ability is not significant, with other variables such as the university degree carried out by the sample showing a greater statistical association.

**Keywords:** *Spatial Skills; Gender; University Students; Engineering*

## 1. INTRODUCTION

Learning and strengthening spatial skills at different educational levels is one of the key competences of formal education. According to Ogunkola and Knight [1], scientific literature reflects the importance of the development of spatial skills for the development of the person in different professional careers, cognitive areas, and academic disciplines. The aforementioned authors defend how success in daily and academic life is directly influenced by the level of development of spatial skills since learning is transferred to these contexts.

On the other hand, as Spence and Feng [2] point out, human knowledge depends on different components, among which spatial capacity stands out. For these authors, this capacity is one of the most relevant for being a precursor of action, by allowing mental representations that transfer the position and relation with objects. For example, the precision of people's psychomotricity depends on the acquisition, storage, and manipulation of spatial information, for the representation, organization, understanding, and navigation of the environment. In short, spatial thinking has a key role in teaching and learning many of the skills necessary for the development of people on a day-to-day basis, but the role it maintains in acquiring mathematical and geometric knowledge has also been emphasized by demonstrating correlation between spatial ability and geometry and mathematics [3].

When carrying out the bibliographic review, it has been possible to observe a large number of studies that point to the importance of factors such as age, sex, or the social context as factors that condition the development of spatial skills [1]. For this reason, it has analyzed the development of spatial skills in university students, paying special attention to the sex variable, to check if there are differences by gender among the students. To achieve this objective, the results of tests designed with exercises that measure three of the main spatial skills such as relation, rotation, and plane cutting in the students of different degrees of the Universidad Politécnica de Madrid have been analyzed.

When it came to defining spatial skills, in 1938 Thurstone was one of the first researchers to provide the basis for a scientific definition. For this author, spatial ability consisted of the ability to maintain an image in the mind and be able to rotate it [2]. But undoubtedly, Lohamn stands out as one of the pioneering researchers dedicated to the study of spatial skills and the differences in these abilities according to different factors such as sex [4]. According to Lohamn [4], spatial ability consists of the ability to generate, preserve and manipulate visual and abstract images. It is also made up of three main factors, firstly, the spatial relation, which is the ability to solve problems of mental rotation quickly, secondly, spatial rotation as the ability to imagine the object from another perspective, and by lastly visualization as the ability to mentally manipulate parts of an object and, for example, reconstruct it. A few years later, Linn and Petersen [5] define spatial cognition as "the ability to represent, generate, remember, and transform symbolic non-linguistic information." These authors also identify three components of spatial ability but they are not identical to those proposed by Lohamn in 1979. According to Linn and Petersen [5], spatial ability is made up of the ability of spatial perception, understanding by it the ability to locate, find their bearings and find references; The second component is mental rotation, defined as the ability to imagine how objects rotate in two and three dimensions and, finally, visualization understood as the ability to generate a mental image, carry out transformations and retain the changes produced.

Entering the 21st century, the study of spatial skills continues, as does its commitment to seeking a complete definition. Ecuyer-Dab and Robert [6] define them "as the processing of various aspects such as the apprehension, encoding, storage, representation, retrieval, manipulation, transformation, and integration of spatial information of different elements in two or three dimensions". As they point out, it facilitates the configuration, orientation, location, and movement of elements in environments, whether virtual or non-virtual. Arrieta and Medrano [7] resort to a definition in line with that indicated by Linn and Petersen when stating that spatial ability is the "capacity to form, recognize and manipulate images, figures and objects mentally". In 2016, Villa Sicilia [8] defends his doctoral thesis Development and evaluation of the spatial skills of engineering students. Activities and strategies for solving spatial tasks at the Universidad Politécnica de Cataluña. In this thesis, the author highlights the fact that there is no consensus in the scientific literature to give a clear and concise definition of what spatial abilities are, nor is there a consensus about what components are those that make it up, concluding that there are two types around which to group them: spatial display components and spatial orientation components.

What does seem to have more consensus is how to train spatial skills and improve them. For example, Sorby [9] proposes, as significant factors for the improvement of said skills, construction games in childhood, workshops and mechanics classes in secondary school, the use of video games, certain sports and the training of mathematical skills. These activities are associated with the masculine gender, so it may be one of the factors that facilitates the gender difference in the development of spatial abilities that different authors defend. As Nagy-Kondor [3] affirms, in general, males have a greater spatial ability, caused by biological and environmental factors. For Maeda and Yoon [10] there is a gender difference in these abilities, caused by several factors, among which the biological and experiential, but also the affective, stand out again.

Before continuing, what should be clear is that an activity or a type of game is associated more with men than with women is a matter of gender and not of sex. Being a woman and being a man depend on two realities: biological (sex) and cultural (gender) [11,12]. Social norms, values, the way of understanding the world of a society, determine codes of conduct for each gender. Due to these codes, it is more common for a male person to play construction games than a female one, since construction games are associated with the male gender and therefore with the male sex. Due to these differences, it is assumed that a gap in the training of spatial skills development between women and men is possible. As Varela [12] highlights: “in reality, the roles and stereotypes born from the construction of genders make men and women atrophied beings since neither can develop their capacities, being limited to what is expected of them and not what they are.

There is no consensus in the scientific literature regarding the existence of such a difference between men and women since the results of the investigations in some cases do find evidence of such difference and in other cases, they do not. This is because there are many variables to consider to compare research: the age of the sample, the level of ability of the sample, the moment in which the results are collected, ethnic and social factors, the amount of previous experience or training in spatial skills, the mode of administration of the test (controlling time or not), how the test is scored and the items used to measure spatial ability, among other issues to observe [13]. According to Villa Sicilia [8], there are also discrepancies in how to measure spatial skills. As this author points out, in the case of Spain, the Mental Rotation Test (MRT) and the Space Relations Test (mental folding), from the battery of the Differential Aptitude Test (DAT-SR) have been used.

One of the first investigations that measured gender differences in spatial skills was that of Shepard and Metzler [14], who designed an experiment around the ability to rotate to find out who was faster by identifying the different orientations of the same three-dimensional figure. Among their main results, they found that men showed less reaction time, as well as greater precision than the women who underwent the experiment. Years later, Linn and Petersen [5] studied the differences between men and according to spatial ability activity and age ranges. Their results revealed that the greatest differences were found in the ability of spatial rotation and that these differences become statistically significant after 11 years. Regarding age, Sánchez García [15] obtains similar but applied results in learning mathematics: the differences between men and women become noticeable from the adolescent stage. The aforementioned author mentions gender as a key aspect of such differences, defending those men are provided with games that promote spatial development and mathematics, as well as creativity and motor activity compared to traditional female dolls that train aspects such as caring for other people and empathy.

As Spence and Feng [2] point out, the most popular video games are action and adventure games, mostly played by boys and young men (men). These games, according to these authors, favor planning and problem solving, quick reflection, and visual and motor coordination. Also, they exercise cognitive and social skills required and practiced in social life, which is why they involve “extra” training in certain factors that may affect the difference in their development according to gender.

In 1995, Stumpf and Eliot [13] published a study carried out on two samples, both aged between 12 and 17 years. In this study, they intended to measure the development of spatial skills and verify the existence of differences between men and women. Among his main discoveries stands out the fact that men obtained better scores in mental rotation than women, while women outperformed men in visual memory.

Once the 21st century has entered, Burin, Delgado, and Prieto [16] analyze the responses given by 75 women and 77 men - with an

average age of 23 years - to different stimuli related to spatial manipulation. These authors collect that the greatest gender difference is found in spatial relation tests, while in visualization exercises these differences practically disappear.
The tests carried out on spatial relation consist of showing the two-dimensional development of a surface and the investigated subject must determine which three-dimensional object results from the fold of the pieces. For his part, Barry [17] tries to determine if working memory is an important factor in gender differences related to spatial skills, for this, he performs three-dimensional mental rotation and spatial vision tests, along with working memory tests. Spatial and verbal to 50 men and 50 women, aged between 16 and 18 years. The results show male superiority in the mental rotation and spatial visualization tests, the difference being much more pronounced in the three-dimensional mental rotation tests.

Spence and Feng [2] focus on the importance of video games in the development of spatial skills and on the possible impact on the different development of these abilities according to gender. Among the research that these authors collect, those that use video games stand out, and specifically Tetris to exercise spatial skills, and specifically, rotation skills. In 2016, Nagy-Kondor publishes a study that measures the development of spatial skills in first-year engineering students. Their results reveal that, although there is a slight prevalence of men in the highest scores, these differences are not statistically significant.

Finally, Fontaine and Metz [18] perform a pre-test on 465 male and female first-year engineering students. Those with low scores on the mental rotation test undergo (voluntarily) a reinforcement course. When performing the posttest, improvements are observed in both men and women, but men continue to maintain slightly higher scores despite the reinforcement course.

## 2. METHODOLOGY

In the case of the present investigation, a 12-question test has been designed, in which three spatial abilities called RE, ROT, and SEC have been evaluated. These names correspond respectively to the questions of spatial relation (figure folding), spatial rotation (using exercises proposed by Shepard and Metzler [14], and spatial visualization (determining which section the section is drawn by a plane of a certain figure). Each block consists of four questions. The test has been applied to a sample of 220 undergraduate students from the Universidad Politécnica de Madrid in two waves. A first wave was carried out between the months of February and March 2019, in which a sample of 129 cases was reached, 70 of the Building degree and 59 in the double degree of Building and Business Administration and Management (BAM). The second wave has been carried out between the months of September and November 2019 to 91 students, 24 of the degree in Computer Engineering, and 67 of the double degree in Computer Engineering and BAM. In all cases, the test has been applied in the last ten minutes of class, its participation is anonymous, voluntary, and there is no incentive for students to participate.

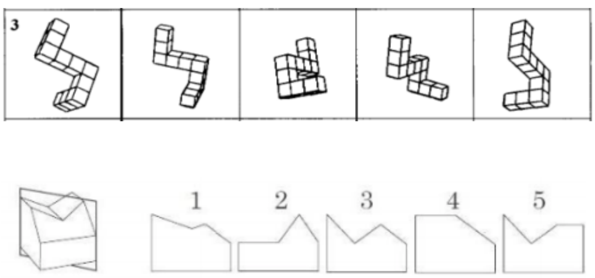


**Fig. 1:** Example of a mental rotation test and mental cutting test, version by Shepard and Metzler [14].

Regarding the statistical treatment of the data collected, initially, purification and validation of the data were carried out. Once ready for exploitation, a univariate statistical analysis was first applied for each exercise and sociodemographic variable collected (sex, university degree, course, and if you have previously completed technical drawing). Secondly, a bivariate statistical analysis has been carried out where contingency tables have been prepared and the statistical association and intensity of association have been studied using the Chi-square, Phi and V statistics of Cramer, for a confidence level of 95.5 %. Furthermore, this analysis has been reinforced with a study of corrected standardized residuals. Lastly, to check the difference in mean scores, the Kruskal-Wallis non-parametric tests and the Mann-Whitney U test were performed for independent samples, after verification of non-compliance with the normality criterion using the Kolmogorov-Smirnov test.

## 3. RESULTS

As for the univariate analysis, it is worth highlighting the composition of the sample according to the sociodemographic variables collected. As Table 1 reflects, of the 220 people who have participated in the study, 61% are men compared to 37% who are women. On the other hand, most of the sample (63%) has previously completed technical drawing, compared to 29% who have not.

**Table 1:** Sample characteristics.

| | Percentage | Number of cases |
|---|---|---|
| TOTAL | 100% | 220 |
| Grade | | |
| Building | 31.8% | 70 |
| Building and BAM | 26.8% | 59 |
| Informatics Engineering | 10.9% | 24 |
| Informatics Engineering and BAM | 30.5% | 67 |
| Sex | | |
| Man | 60.9% | 134 |
| Woman | 36.8% | 81 |
| Do not answer | 2.3% | 5 |
| Have previously completed Technical Drawing | | |
| Yes | 62.7% | 138 |
| No | 29.1% | 64 |
| Do not answer | 8.2% | 18 |

Source: Own elaboration.

Regarding the degree studied by each participant, 31% belong to the Building degree, 27% to the double degree of Building, and BAM. 31% were students of the double degree of Computer Engineering and BAM and, to a lesser extent (11%), students of the degree of Computer Engineering. On the other hand, and to finish with the univariate analysis, it should be noted that, in general terms, the examined students obtained better scores in the rotation exercises, while the worst results returned were the exercises to determine which section draws the cut by a plane of a figure, where there are high percentages of error (see Figure 2). Therefore, it can be concluded that the ability that participants show the most skill is mental rotation, while the least skill is visualization (section cut by a plane). Before proceeding with the bivariate analysis, it is convenient to point out that the contingency tables presented below only consider those variables in which a statistically significant association has been obtained - to know the frequency distribution of the variables that do not have such association, the reader is recommended to consult the annexes section -.

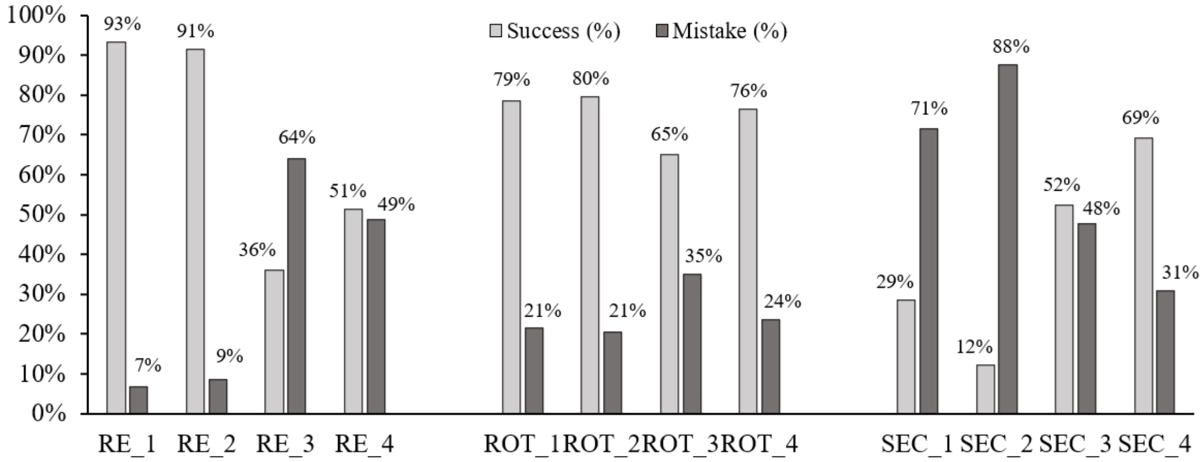


**Fig. 2:** Percentage of success and error in each exercise. Source: Own elaboration.

In the mentioned tables, the percentages of each category of the independent variable must be compared with other rows of the same independent variable or with the total percentage included in the first line (that is, rows are compared with rows). On the other hand, it is important to take note of the notation that accompanies some of the figures. If the number is accompanied by an asterisk (*) it means that this category has several cases less than 20, so its interpretation must be done with great care. Secondly, arrows (↓) or (↑) appear, indicating that said cell presents statistically corrected standardized residuals for a confidence level greater than 95.5%. That is, said cell has more (↑) or fewer (↓) cases than expected if the frequency distribution were random. Regarding the bivariate analysis, firstly, it is worth noting the mean scores that were obtained according to each sociodemographic variable (see Figure 3).

On average, the sample scores 7.3 out of a maximum of 12 possible. According to the grade, they are studying, it is observed that the degree of Computer Engineering and Computer Engineering and BAM obtain the highest scores (7.6) compared to Building (7.2) and Building and

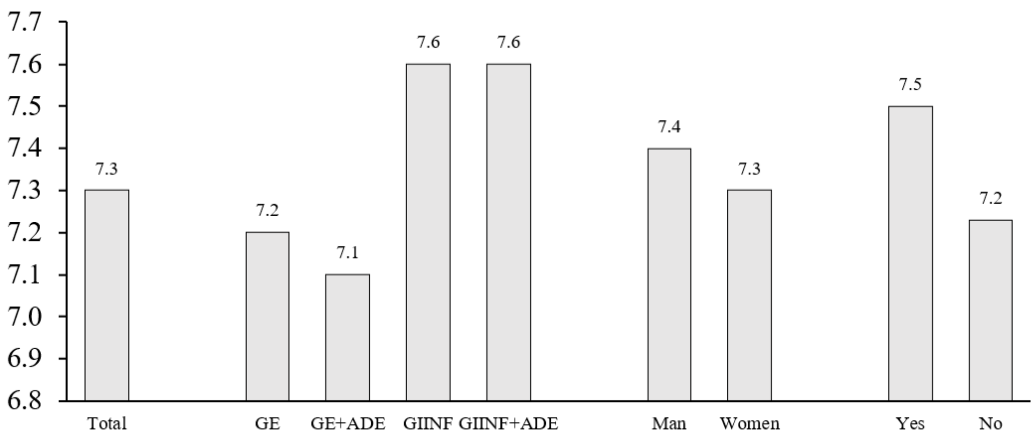


**Fig. 3:** Average scores of each group (over 12 points). Source: Own elaboration. Where: BG (Degree in Building), BD + BAM (Double Degree in Building and BAM), DIE (Degree in Informatics Engineering) and DIE + BAM (Double Degree in Informatics Engineering and BAM).

BAM (7.1), however, when performing the tests, Parametric tests of Kruskal-Wallis, it is obtained that the differences in scores between grades are not statistically significant, the same situation occurs between men and women and between those students who have completed technical drawing and those who have not. Men obtain slightly higher scores (7.4) than women (7.3), without being statistically significant. Students who have previously completed Technical Drawing obtain 0.3 points more than those who have not completed, although this difference is not statistically significant (7.5 points vs. 7.2). As the results obtained reveal, the variable university degree presents a statistically significant association in four of the twelve exercises proposed in the test, specifically: in one spatial relations exercise, two in rotation, and one in visualization.

If these results are analyzed (Table 2), it can be seen that the degree in Computer Engineering and BAM stands out for having obtained the best results in the fourth exercise of spatial relation, this percentage difference being statistically significant (indicated in bold in Table 2). On the other hand, in that same exercise, the Computer Engineering degree student stands out for having obtained the lowest percentage of correct answers. Again, this percentage difference is statistically significant, as shown by the study of corrected standardized residuals. Regarding the rotation ability, the best results are obtained by the students of the Computer Engineering degree. About the fourth proposed rotation exercise, the Building grade student body has discounted because it has the lowest observed percentage and this percentage difference is statistically significant.

On the other hand, in the study of the variable university degree, the statistical association with the third spatial visualization exercise stands out.

In this case, in which the students had to indicate which section of the four proposals was the one

**Table 2:** Bivariate analysis according to results in exercises and the university degree of the sample units: standardized residuals corrected with statistical significance for a confidence level of 95.5%.

| | Error | Success | Number of cases |
|---|---|---|---|
| RE_4_TOTAL | 48.6% | 51.4% | 220 |
| Grade (V: 0.195) | | | |
| Building | 51.4% | 48.6% | 70 |
| Building and BAM | 49.2% | 50.8% | 59 |
| Informatics Engineering | *↑70.8% | *↓29.2% | 24 |
| Informatics Engineering and BAM | ↓37.3% | ↑62.7% | 67 |
| ROT_2_TOTAL | 20.5% | 79.5% | 220 |
| Grade (V: 0.195) | | | |
| Building | *24.3% | 75.7% | 70 |
| Building and BAM | *28.8% | 71.2% | 59 |
| Informatics Engineering | *↓4.2% | ↑95.8% | 24 |
| Informatics Engineering and BAM | *14.9% | 85.1% | 67 |
| ROT_4_TOTAL | 23.6% | 76.4% | 220 |
| Grade (V: 0.187) | | | |
| Building | ↑32.9% | ↓67.1% | 70 |
| Building and BAM | *25.4% | 74.6% | 59 |
| Informatics Engineering | *8.3% | 91.7% | 24 |
| Informatics Engineering and BAM | 17.9% | 82.1% | 67 |
| SEC_3_TOTAL | 47.7% | 52.3% | 220 |
| Building | 50.0% | 50.0% | 70 |
| Building and BAM | ↑59.3% | ↓40.7% | 59 |
| Informatics Engineering | *37.5% | *62.5% | 24 |
| Informatics Engineering and BAM | 38.8% | 61.2% | 67 |

Notes:

(↑)High percentages, figures significantly higher than the average. Corrected standardized residuals (positive value) with a confidence level greater than 95.5%.
(↓)Low percentages, lower than average values. Corrected standardized residuals (negative value) with the same level of confidence.
(*)Cells with less than 20 cases.

Source: Own elaboration.

generated by the cut of a figure by a certain plane, the study of the corrected standardized residuals indicates that the student body that presents a greater percentage difference with the statistically significant rest (in bold in Table 3) is the double

**Table 3:** Bivariate analysis according to results in exercises and the sex of the sample units: standardized residuals corrected with statistical significance for a confidence level of 95.5%.

| | Error | Success | Number of cases |
|---|---|---|---|
| RE_1_TOTAL | *6.5% | 93.5% | 215 |
| Sex (Phi: 0.127) | | | |
| Man | ***$^{\uparrow}$9.0%** | **$^{\downarrow}$91.0%** | 70 |
| Woman | ***$^{\downarrow}$2.5%** | **$^{\uparrow}$97.5%** | 59 |

Notes:

($^{\uparrow}$)High percentages, figures significantly higher than the average. Corrected standardized residuals (positive value) with a confidence level greater than 95.5%.
($^{\downarrow}$)Low percentages, lower than average values. Corrected standardized residuals (negative value) with the same level of confidence.
(*)Cells with less than 20 cases.

Source: Own elaboration.

degree of Building and BAM since it has the lowest percentage of correct answers of all. Regarding the study of the sex variable, the only statistical association has been presented with the first exercise of the test on spatial relation (folding of figures). Contrary to what is indicated in the literature, women have been those who have presented a higher percentage of correct answers, which is reflected in a statistically significant percentage difference with men (Table 4): 97.5% of the women who participated in the test they answered correctly in said exercise, compared to 91.0% of the men.

Finally, when analyzing the results of the sample according to whether they had previously completed a technical drawing or not, the only exercise that had a statistically significant association with this variable was the third exercise of visualization ability.

**Table 4:** Bivariate analysis according to results in exercises and if it has been previously studied Technical Drawing: standardized residuals corrected with statistical significance for a confidence level of 95.5%.

| | Error | Success | Number of cases |
|---|---|---|---|
| SEC_3_TOTAL | 48.0% | 52.0% | 202 |
| Technical Drawing (Phi: 0.112) | | | |
| Yes | **$^{\downarrow}$44.2%** | **$^{\uparrow}$55.8%** | 138 |
| No | **$^{\uparrow}$56.3%** | **$^{\downarrow}$43.7%** | 64 |

Notes:

($^{\uparrow}$)High percentages, figures significantly higher than the average. Corrected standardized residuals (positive value) with a confidence level greater than 95.5%.
($^{\downarrow}$)Low percentages, lower than average values. Corrected standardized residuals (negative value) with the same level of confidence.
(*)Cells with less than 20 cases.

Source: Own elaboration.

In this problem, and as it was foreseeable, those people who declared having completed the technical drawing subject previously obtained a hit rate of 55.8 compared to 43.7% of those people who had not studied technical drawing. The percentage difference between both groups is statistically significant according to the study of corrected standardized residuals.

## 4. CONCLUSIONS

After carrying out this study, it has been found that, although men have presented better results in most exercises than women (see Table 7, in annexes), these differences are not statistically significant and, therefore, not they have to be considered as relevant differences. Thus, among the main conclusions, we find that the sex variable has not been particularly noticeable compared to the rest of the sociodemographic variables studied, having not presented major differences in the evaluation of spatial abilities as noted by some authors (Linn and Petersen, Sorby, Maeda and Yoon, Nagy-

Kondor, [5,9,10,3]; among others). In this way, and considering only the results obtained in the work that present statistical significance, the people who showed the best results in the spatial relations exercises were those who were studying Computer Engineering and BAM and women. On the contrary, those students who obtained worse scores are the persons of the Computer Engineering degree and males (see Table 5).

**Table 5.** Sample characteristics statistically associated with each skill.

| Skill | Success | Error |
|---|---|---|
| Spatial relations | Informatics Engineering and BAM Woman | Informatics Engineering Man |
| Rotation | Informatics Engineering | Building |
| Visualization | Technical Drawing | Building and BAM No Technical Drawing |

Source: Own elaboration.

Regarding the rotation ability, the people with the best results in the sample are those who study the Computer Engineering degree, while the worst results are associated with those who studied the Building degree. Finally, in terms of visualization ability, the highest percentage of success is linked to those who have studied technical drawing in their high school stage, compared to the error, associated with those who had not previously studied technical drawing in the school stage and those who take the double degree of Building and BAM.

Before concluding, we want to highlight that the present study is not representative of the entire Spanish university student body, so the results should not be generalized, although they should be taken as an approximation to the study of spatial skills and their way of evaluating them. On the other hand, as criticism and warning to possible interested readers, the research team considers that the characteristics of the present sample (engineering and building students), may have “hidden” the possible gender differences in spatial skills, since It can be understood that, for the most part, said students have a high training as well as personal motivation for technical drawing, architecture, video game development, 3D modeling... aspects that, as seen in the literature, are factors of skills training space.

Therefore, to further appreciate these possible differences by canceling the "training effect", it is proposed as a future line of research to carry out the study in students of Compulsory Secondary Education, where no technical drawing has yet been taken nor an itinerary chosen curricular.

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## ANNEX

**Table 6.** Bivariate analysis according to results in exercises and the university degree of the sample units: standardized residuals corrected without statistical significance for a confidence level of 95.5%.

| | Error | Success | Number of cases |
|---|---|---|---|
| RE_1_TOTAL | 6.8% | 93.2% | 220 |
| Building | *4.3% | 95.7% | 70 |
| Building and BAM | *5.1% | 94.9% | 59 |
| Informatics Engineering | *8.3% | 91.7% | 24 |
| Informatics Engineering and BAM | 10.4% | 89.6% | 67 |
| RE_2_TOTAL | *8.6% | 91.4% | 220 |
| Building | *7.1% | 92.9% | 70 |
| Building and BAM | *8.5% | 91.5% | 59 |
| Informatics Engineering | *12.5% | 87.5% | 24 |
| Informatics Engineering and BAM | *9.0% | 91.0% | 67 |
| RE_3_TOTAL | 64.1% | 35.9% | 220 |
| Building | 60.0% | 40.0% | 70 |
| Building and BAM | 69.5% | 30.5% | 59 |
| Informatics Engineering | *66.7% | *33.3% | 24 |
| Informatics Engineering and BAM | 62.7% | 37.3% | 67 |
| ROT_1_TOTAL | 21.4% | 78.6% | 220 |
| Building | *25.7% | 74.3% | 70 |
| Building and BAM | *20.3% | 79.7% | 59 |
| Informatics Engineering | *12.5% | 87.5% | 24 |
| Informatics Engineering and BAM | *20.9% | 79.1% | 67 |
| ROT_3_TOTAL | 35.0% | 65.0% | 220 |
| Building | 32.9% | 67.1% | 70 |
| Building and BAM | 37.3% | 62.7% | 59 |
| Informatics Engineering | *33.3% | *66.7% | 24 |
| Informatics Engineering and BAM | 35.8% | 64.2% | 67 |
| SEC_1_TOTAL | 71.4% | 28.6% | 220 |
| Building | 71.4% | 28.6% | 70 |
| Building y BAM | 74.6% | 25.5% | 59 |
| Informatics Engineering | *62.5% | *37.5% | 24 |
| Informatics Engineering y BAM | 71.6% | 28.4% | 67 |
| SEC_2_TOTAL | 87.7% | 12.3% | 220 |
| Building | 92.9% | *7.1% | 70 |
| Building and BAM | 81.4% | *18.6% | 59 |
| Informatics Engineering | 83.3% | *16.7% | 24 |
| Informatics Engineering and BAM | 89.6% | *19.4% | 67 |
| SEC_4_TOTAL | 30.9% | 69.1% | 220 |
| Building | 28.6% | 71.4% | 70 |
| Building and BAM | 35.6% | 64.4% | 59 |
| Informatics Engineering | *37.5% | *62.5% | 24 |
| Informatics Engineering and BAM | *26.9% | 73.1% | 67 |

Notes:

(*) Cells with less than 20 cases.

Source: Own elaboration.

**Table 7.** Bivariate analysis according to results in exercises and the sex of the sample units: standardized residuals corrected without statistical significance for a confidence level of 95.5%.

| | Error | Success | Number of cases |
|---|---|---|---|
| RE_2_TOTAL | *8.4% | 91.6% | 215 |
| Man | *8.2% | 91.8% | 134 |
| Woman | *8.6% | 91.4% | 81 |
| RE_3_TOTAL | 64.2% | 35.8% | 215 |
| Man | 62.7% | 37.8% | 134 |
| Woman | 66.7% | 33.3% | 81 |
| RE_4_TOTAL | 49.3% | 50.7% | 215 |
| Man | 48.5% | 51.5% | 134 |
| Woman | 50.6% | 49.4% | 81 |
| ROT_1_TOTAL | 21.4% | 78.6% | 215 |
| Man | 20.9% | 79.1% | 134 |
| Woman | 22.2% | 77.8% | 81 |
| ROT_2_TOTAL | 20.0% | 80.0% | 215 |
| Man | 17.2% | 82.8% | 134 |
| Woman | 24.7% | 75.3% | 81 |
| ROT_3_TOTAL | 34.4% | 65.6% | 215 |
| Man | 32.1% | 67.9% | 134 |
| Woman | 38.3% | 61.7% | 81 |
| ROT_4_TOTAL | 23.3% | 76.7% | 215 |
| Man | 25.4% | 74.6% | 134 |
| Woman | 19.8% | 80.2% | 81 |
| SEC_1_TOTAL | 72.1% | 27.9% | 215 |
| Man | 73.1% | 26.9% | 134 |
| Woman | 70.4% | 29.6% | 81 |
| SEC_2_TOTAL | 87.4% | 12.6% | 215 |
| Man | 86.6% | 13.4% | 134 |
| Woman | 88.9% | 11.1% | 81 |
| SEC_3_TOTAL | 47.0% | 53.0% | 215 |
| Hombre | 44.8% | 55.2% | 134 |
| Woman | 50.6% | 49.4% | 81 |
| SEC_4_TOTAL | 30.2% | 69.8% | 215 |
| Man | 29.9% | 70.1% | 134 |
| Woman | 30.9% | 69.1% | 81 |

Notes:

(*) Cells with less than 20 cases.

Source: Own elaboration.

**Table 8.** Bivariate analysis according to results in exercises and if it has been previously studied Technical Drawing: standardized residuals corrected without statistical significance for a confidence level of 95.5%.

| | Error | Success | Number of cases |
|---|---|---|---|
| RE_1_TOTAL | *6.9% | 93.1% | 202 |
| Yes | *6.5% | 93.5% | 138 |
| No | *7.8% | 92.2% | 64 |
| RE_2_TOTAL | *9.4% | 90.6% | 202 |
| Yes | *10.1% | 89.9% | 138 |
| No | *7.8% | 92.2% | 64 |
| RE_3_TOTAL | 63.9% | 36.1% | 202 |
| Yes | 62.3% | 37.7% | 138 |
| No | 67.2% | 32.8% | 64 |
| RE_4_TOTAL | 48.5% | 51.5% | 202 |
| Yes | 51.4% | 48.6% | 138 |
| No | 42.2% | 57.8% | 64 |
| ROT_1_TOTAL | 20.8% | 79.2% | 202 |
| Yes | 20.3% | 79.7% | 138 |
| No | 21.9% | 78.1% | 64 |
| ROT_2_TOTAL | 18.8% | 81.2% | 202 |
| Yes | 19.6% | 80.4% | 138 |
| No | *17.2% | 82.8% | 64 |
| ROT_3_TOTAL | 34.2% | 65.8% | 202 |
| Yes | 32.6% | 67.4% | 138 |
| No | 37.5% | 62.5% | 64 |
| ROT_4_TOTAL | 22.3% | 77.7% | 202 |
| Yes | 22.5% | 77.5% | 138 |
| No | 21.9% | 78.1% | 64 |
| SEC_1_TOTAL | 70.8% | 29.2% | 202 |
| Yes | 68.8% | 31.2% | 138 |
| No | 75.0% | 25.0% | 64 |
| SEC_2_TOTAL | 87.1% | 12.9% | 202 |
| Yes | 85.5% | 14.5% | 138 |
| No | 90.6% | *9.4% | 64 |
| SEC_4_TOTAL | 27.7% | 72.3% | 202 |
| Yes | 26.1% | 73.9% | 138 |
| No | 31.3% | 68.7% | 64 |

Notes:

(*) Cells with less than 20 cases.

Source: Own elaboration.