DEVELOPMENT OF MATHEMATICAL COMPETENCES IN A FOREIGN LANGUAGE

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OVERVIEW

- The main objective is to evaluate the development of mathematical competences when a foreign language (namely English) is employed for teaching. Specific goals:
  a) Evaluate how the deep knowledge of a foreign language is decisive when considering mobility between different countries.
  b) Provide a complete statistical study of these results and analyze them.
- Preliminar results show that the English language skills do **not** seem to be a decisive factor in the development of mathematical competences.

INTRODUCTION

- Evaluating the development of **mathematical competences** is interesting to understand how the deep knowledge of a **foreign language** is decisive when considering mobility between different countries.
- Evaluation of the learning process in the module of **"Statistics for Engineering"** in the degree on "Mechanical Engineering" in the UEM.
- **Three different groups** of students with similar characteristics: age, social status, timetable, materials, etc. and the lectures are taught by the same teacher.

DESCRIPTION OF THE EXPERIENCE

- In order for the students to obtain their Mechanical Engineering degree, at the end of the bachelor degree they must have a **UEM lab level** of at least **15**.
- Since 2011, all students of Mechanical Engineering must take one module per semester studied in English; "**Statistics for Engineering**" is the third module studied in English during the whole degree.
- Evaluation system is divided into different parts: **two tests** (30% final grade each), **two team projects** (15% final grade each) and a **general skills** assessment (10% final grade).

MATHEMATICAL BACKGROUND

- We compute the value of three **coefficients** that evaluate in different ways the correlation between two samples of data $\{x_1,\ldots,x_n\}$ and $\{y_1,\ldots,y_n\}$:

a) the **Pearson's coefficient**,

b) the **Kendall's coefficient**

c) the **Spearman's coefficient**.

MATHEMATICAL BACKGROUND

- The **sample Pearson's coefficient** measures the linear dependence between two given samples by estimating the covariance of the associated variables divided by the product of their standard deviations:

$$r = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{\sqrt{n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2}\sqrt{n\sum_{i=1}^{n} y_i^2 - \left(\sum_{i=1}^{n} y_i\right)^2}}$$

MATHEMATICAL BACKGROUND

- The **Kendall's correlation coefficient** measures the rank correlation. It is based on the similarity of the orderings of the data when ranked by each of the attributes measured by each sample. It is usually used on a non-parametric hypothesis test for statistical dependence.

$$\tau = \frac{2(a-b)}{n(n-1)}$$

where

$$a = \#\left\{(i,j) \in \{1,\cdots,n\}, i<j \,|\, \left(x_i < x_j \text{ and } y_i < y_j\right) \text{ or } \left(x_i > x_j \text{ and } y_i > y_j\right)\right\}$$

$$b = \#\left\{(i,j) \in \{1,\cdots,n\}, i<j \,|\, \left(x_i < x_j \text{ and } y_i > y_j\right) \text{ or } \left(x_i > x_j \text{ and } y_i < y_j\right)\right\}$$

MATHEMATICAL BACKGROUND

- **Spearman's correlation coefficient** measures the rank correlation by assessing how well the relationship between the two samples or variables considered can be described using a monotonic function. It is used on non-parametric hypothesis tests for statistical dependence

$$\rho = 1 - \frac{6\sum_{i=1}^{n}(r_i - s_i)^2}{n(n^2 - 1)}$$

where r_i and s_i are the ranks of the i-th element of each sample when they are sorted

ANALYSIS OF THE RESULTS

- A possible correlation between the **grades** obtained in each of the **tests** of the module of Statistics and the previous **knowledge of English language** (measured by the UEM Lab Level) is measured. Results for **Test 1/UEM Lab Level** are:

Test 1	Group 1	Group 2	Group 3	All students
r	0.263	0.000	0.470	0.123
τ	0.218	-0.067	0.283	0.091
τ_{norm}	1.222	-0.413	1.531	0.958
ρ	0.409	0.002	0.485	0.211
ρ_{norm}	1.637	0.007	1.880	1.524

ANALYSIS OF THE RESULTS

- Results for **Test 2/UEM Lab Level**:

Test 2	Group 1	Group 2	Group 3	All students
r	0.254	-0.109	0.446	0.190
τ	0.253	-0.116	0.361	0.119
τ_{norm}	1.418	-0.715	0.243	1.259
ρ	0.365	-0.101	0.494	0.218
ρ_{norm}	1.461	-0.439	1.914	1.574

- Results for **all students** and **final grades** (both tests):

r	τ	τ_{norm}	ρ	ρ_{norm}
0.263	0.218	1.222	0.409	1.637

ANALYSIS OF THE RESULTS

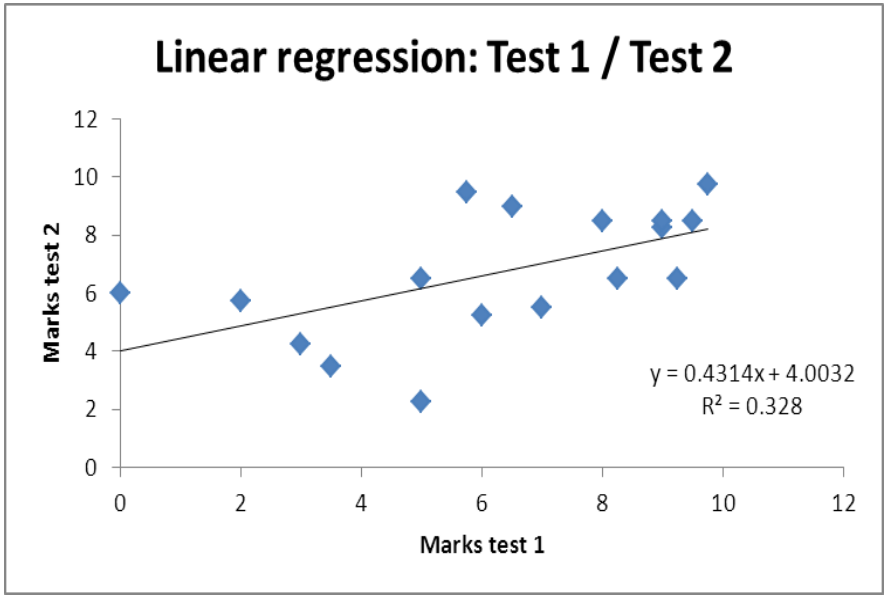
- **Pearson's coefficient:**: all values are between -0.5 and 0.5, indicating that the correlation between the English level and the mathematical knowledge acquired is not strong. In fact, most values are very close to 0.
- For **Kendall's** and **Spearman's coefficients**: use the normalized values. All absolute values of τ_{norm} and ρ_{norm} are below $z_\alpha = 1.96$ (95% sl), then the analyzed data do not provide enough evidence to state that the English level and the mathematical knowledge acquired are correlated. Even if we take 90% sl (critical value $z_\alpha = 1.65$), once again the result of the test is accepting the hypothesis of independence in all but a couple of cases.

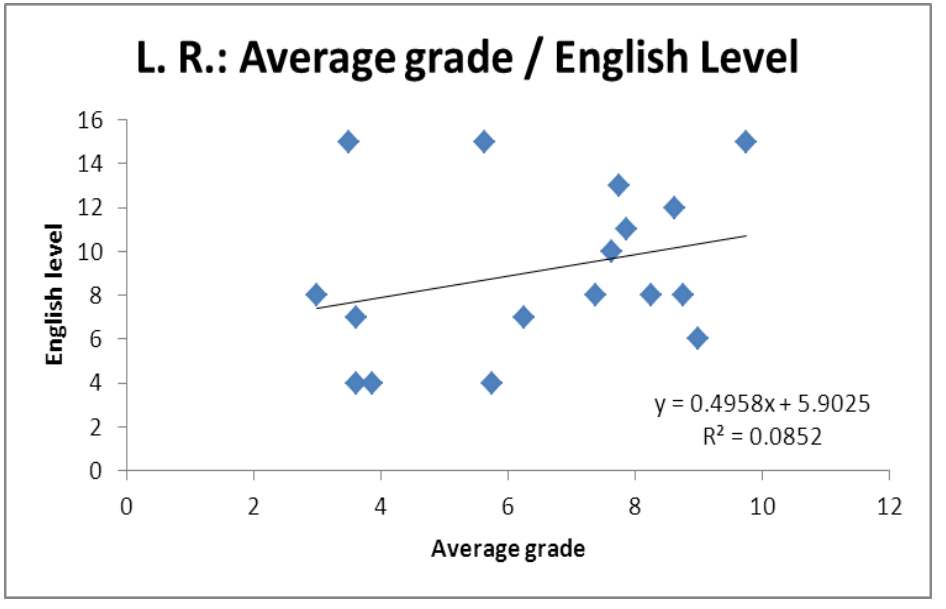
ANALYSIS OF THE RESULTS

- In general, **English level** and **mathematical knowledge acquired** are not correlated, but the three groups do not behave completely identically.
- **Group 2** shows the **largest evidence of non-correlation**, even providing positive and negative coefficients.
- All coefficients for **Group 1**, though not leading to reject the null hypothesis, are all positive, indicating that the correlation, if any, would be positive;
- The **coefficients** for **Group 3** are always the **largest**, leading in a few cases to reject the null hypothesis and admitting that some positive correlation could exist.

ANALYSIS OF THE RESULTS

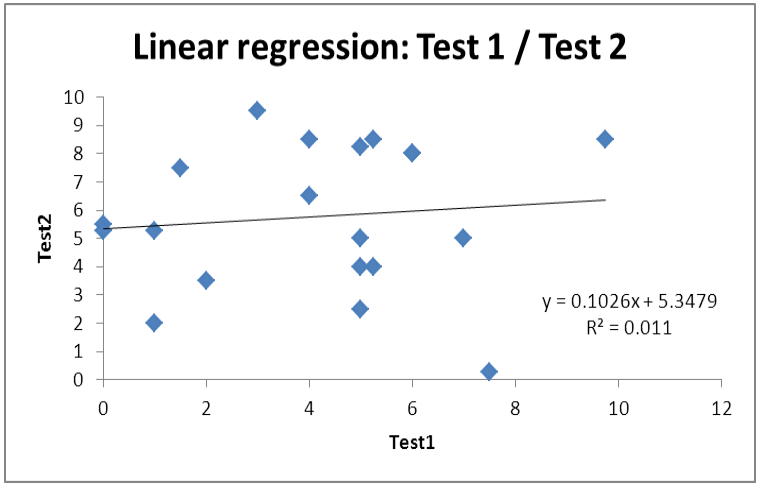
- A new analysis, aimed to compare the performances of the students in Test 1 and Test 2 to try to find out if the groups also behaved differently in this context.
- Linear regression analysis for Group 1:

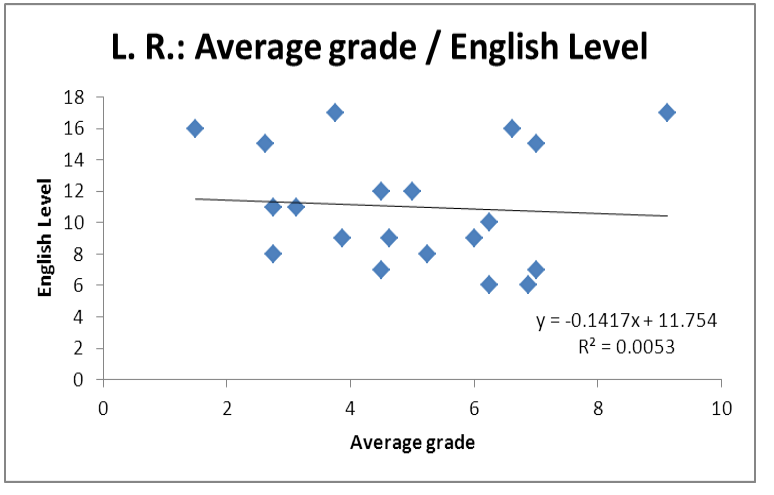


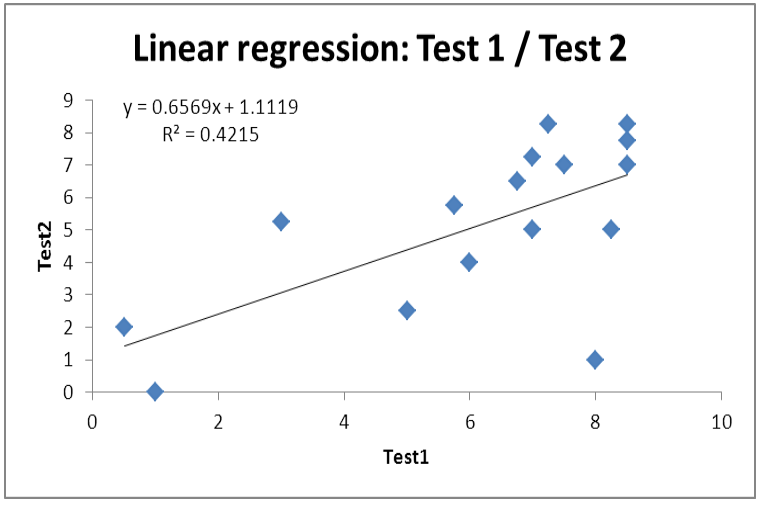


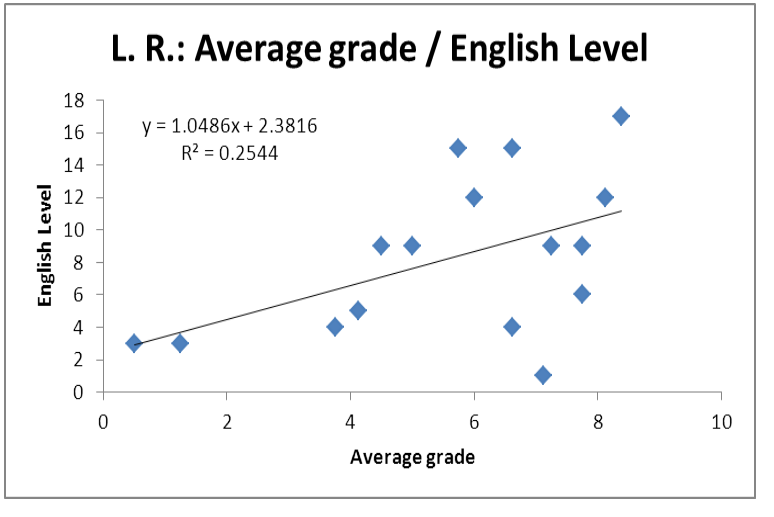
ANALYSIS OF THE RESULTS

- Linear regression analysis for Groups 2 and 3:



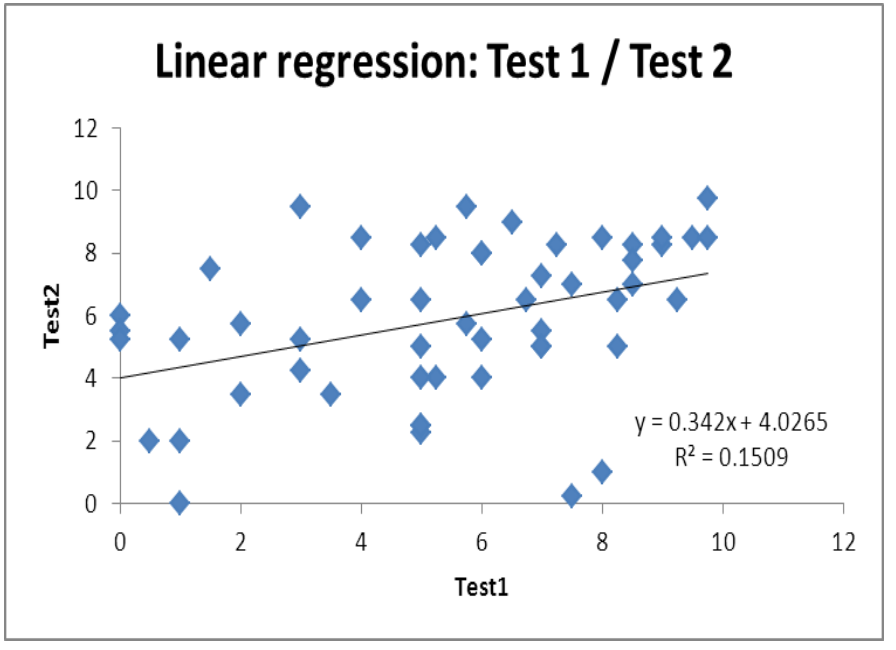


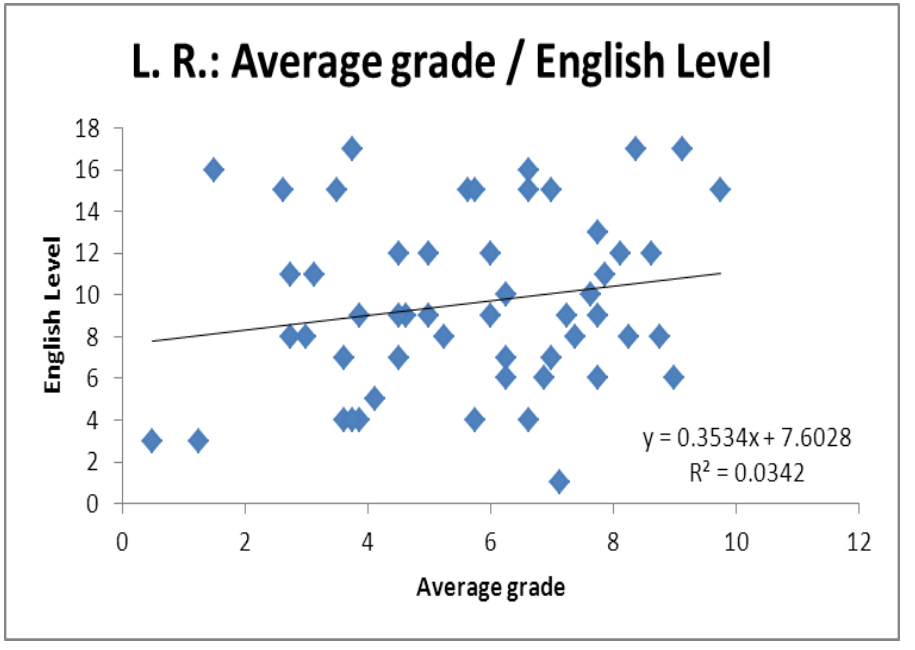




ANALYSIS OF THE RESULTS

- Linear regression analysis for all students together:





ANALYSIS OF THE RESULTS

- **Grades in group 2** are much **less correlated** than in the other groups and thus suggesting that this group is somehow different: if the grades of the students vary much from one test to the other, it is not surprising that they are not correlated at all with the English level.
- The graphs on the right illustrate the correlation between average grades on the module and the English level: group 2 behaves differently, but in general **it seems there is not a high dependence between mathematical skills learning and English background.**

CONCLUSIONS

- The statistical study presented in this paper provides a **first approach** to the **evaluation of statistical competences** when a **foreign language**, English in this case, is employed.
- It is shown that there is not enough statistical evidence to state that there is any correlation between the **student grades** and their **level of English**.
- We can state that within the context of the ESHE, **students can consider mobility between different countries** despite of their own level of the correspondent foreign language. At least, this has been **observed in degrees** directly related with **mathematics**, but it seems to be transferable to scientific degrees in general (work in progress).

THANKS FOR YOUR ATTENTION!

ANY QUESTION?