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Prevalence of the student's gender in their daily interactions with devices on the Internet

Predominio del género del alumno en sus interacciones diarias con los dispositivos en Internet

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Abstract

The health crisis caused by COVID-19 views technological innovation as a way to improve equity in education. Gender differences in education are under constant investigation due to the long-term consequences on the personal and professional future of students. The goal of this work is to analyze the prevalence of the student's gender in their daily interactions with devices on the Internet. Supported by a comparative education research methodology. A representative sample of a population of students of Spain, countries of the EU (European Union) and the OECD (Organization for Economic Cooperation and Development) are contrasted. The regression analysis and an adjustment by coefficient of determination determined the intensity of the dependency relationship between the independent variables: daily participation in social networks, daily participation in online games, daily reading of online news and the dependent variable is the average mathematical score. The results are compared with other investigations conducted in virtual teaching and learning environments. In fact, there are patterns of behavior and responses of students when considering gender differences in their daily interactions with devices on the Internet. This work highlights the importance of a gender approach to improve virtual educational proposals.

Keywords: PISA; studen; gender differences; Mathematics; Internet; online games; social networks; virtual education.

Resumen

La crisis sanitaria COVID-19 visualiza la innovación tecnológica como una forma de mejorar la equidad en la educación. Las diferencias de género en la educación están bajo investigación constante debido a las consecuencias a largo plazo en el futuro personal y profesional de los estudiantes. Este trabajo pretende analizar la prevalencia del género del alumno en sus interacciones diarias con los dispositivos en Internet. Apoyado en la metodología de investigación de educación comparada, se contrastan muestras representativas de una población de estudiantes de España, de la UE (Unión Europea) y la OCDE (Organización para la Cooperación y el Desarrollo Económicos). El análisis de regresión y un ajuste por coeficiente de determinación determinaron la intensidad de la relación de dependencia entre las variables independientes: participación diaria en redes sociales, participación diaria en juegos online, lectura diaria de noticias online y la variable dependiente es la puntuación media de matemática. Los resultados se comparan con investigaciones similares, se muestra la existencia de patrones de comportamiento en las respuestas de los estudiantes atendiendo al género en sus interacciones diarias con dispositivos en Internet. Este trabajo destaca la importancia de un enfoque de género para mejorar las propuestas educativas en entornos virtuales de enseñanza.

Palabras clave: PISA; estudiantes; diferencias de género; Matemáticas; Internet; juegos en línea; redes sociales; educación virtual.

1. Introduction

Global educational system at all levels has been affected by the closing of educational centers, caused by the global health emergency due to COVID 19 (Azorín, 2020). Face-to-face classes became virtual as the only possible modality to continue the educational process (Gutiérrez and Espinoza, 2020). In many families the students could not maintain the desired academic rhythm: digital and social gaps became evident, virtual education has evidenced class differences (García Aretio, 2020b).

Rural and low populated areas in Spain which normally have insufficient connection speed have been also affected (Sala, 2020). However, this scenario constitutes an opportunity to achieve a higher level of equity and innovation in virtual educational proposals (Crawford, Butler-Henderson, Rudolph, Malkawi, Glowatz, Burton and Lam, 2020).

In these circumstances, virtual education in formal educational environments must guarantee offers focused on the needs of society in general, depending on the student and their personal autonomy, that allow the acquisition of knowledge and skills necessary for the labor market (Raventós and Prats, 2012). Some authors argue that technological innovation applied to Education is the driving force behind the processes of democratization of knowledge (Pallarès Piquer, Chiva Bartoll, Planella and López Martín, 2019). A new paradigm of Education arises from the values of justice and freedom in a society of knowledge and information (García Aretio, 2020a; Salinas, 2012).

Virtual environments bring with them immense possibilities for pedagogical work, making it possible to configure different learning scenarios (Castañeda and Selwyn, 2020). Based on this, it is necessary to redefine a series of formal processes in educational institutions and analyze how emerging technologies affect Education (López, 2019).

Within this framework, personalized learning environments promote changes in habitual, individual, and collective educational practices; and have opened a way to a continuous educational process throughout life (Zhang, Basham and Yang, 2010). The management and control of learning, and the communication between students and teachers is enriched which can contribute to the achievement of educational objectives (Adell and Castañeda Quintero, 2013).

On the other hand, adaptive hypermedia systems constitute an evolution of virtual teaching and learning environments and can combine open learning models and social comparison to support learning (Wang, Christensen, Cui, Tong, Yarnall, Shear and Feng, 2020). Adaptive teaching means approaching the educational needs of students by previously analyzing the social and dynamic context of the classroom, leading to careful planning of the teaching process (Schipper, van der Lans, de Vries, Goei and van Veen, 2020).

At the same time, virtual teaching and learning environments that combine instruction with virtual educational games and built-in adaptive systems are promising (Feinstein and Mach, 2020). These systems build a student profile with relevant information (example: gender, learning style and objective, social behavior, performance, motivation) the objective is to generate educational proposals according to their needs and preferences (Troussas and Virvou, 2020). This proposal will help reduce the possible feeling of isolation, failure or frustration that may arise in virtual teaching and learning environments (Brusilovsky, and Millán, 2007).

Previous studies have recognized that the knowledge of the influence of gender differences in the student can positively influence the pedagogical proposals and adaptation mechanisms carried out by the system (Rahimi and Hashemi, 2013). Gender differences are

the key to knowing how to intervene and what recommendations should be favored in virtual teaching and learning environments (Arroyo, Burleson, Tai, Muldner and Woolf, 2013).

The term gender refers to the natural sexual dichotomy, however some authors relate the term "gender" to those characteristics and traits that are considered socioculturally appropriate for men and women (Unger, 1979; Delphy, 1993).

In this context, this study analyzes the prevalence of the student's gender in their daily interactions with devices on the Internet and its relationship with the estimated average score for science and mathematics. To do this, first a study of the previously published scientific literature is carried out, referring to the behavior of students according to their gender, in the domain of mathematics and in virtual teaching and learning environments. Then, an empirical study is carried out that analyzes the interactions of students with online digital devices in function, all this by observing the differences in student behavior according to their gender. Finally, a comparative analysis is carried out, this analysis looks for common points, or differences in the behavior of students when interacting with digital devices online versus the behavior of students in virtual teaching and learning environments according to gender.

It was found that female students have greater daily participation in social networks than male students. However, male students obtained greater participation in daily online news reading activities than female students. Aspects related to online gaming environments related to the student's gender are displayed.

This work contributes to identifying cognitive, affective and social information based on the student's gender behavior in their daily interactions with devices on the Internet. This information may be useful in future pedagogical approaches in virtual teaching and learning environments.

This paper presents a section on Related works to this research, relevant publications are analyzed in this regard, this analysis allowed us to approach some new conceptions and reflect on the behavior and gender differences in students. In the Results section, supported by the data collected from the edition of the PISA 2018 report (Cebrián, Trillo and González, 2019) and the descriptive statistics, the daily interactions of students are analyzed according to gender, with digital devices on the Internet and it is related to the average estimated score for math and science. A section is also presented where a Comparative study is carried out, which analyzes aspects related to affective and cognitive information, and social nature. Finally the Conclusions, the forecast of future works, limitations and bibliographic References used are shown.

2. Related work

This section links the empirical research with other published work. The goal is to analyze the influence of gender on the behaviors of students in virtual environments, as well as the influence of cognitive, affective and social informations support in the process of teaching and learning mathematics and science.

To begin with the analysis, it is important to point out that some studies found no differences regarding self-efficacy in mathematics according to the student's gender (Tekola, Getahun and Hagos, 2020). Male and female students both achieve similar results with cognitive support (Boyer, Phillips, Wallis, Vouk and Lester, 2008). However, significant gender differences were found in the efficacy of self-regulation or confidence in the use of self-regulated learning strategies that favor female students (Vail, Boyer, Wiebe and

Lester, 2015). Female students felt significantly less frustrated and more engaged with the teaching and learning process when it provided an emotional return than without it, in contrast, in male students, the levels of frustration and commitment are not significantly altered (Boyer *et al*., 2008).

Some authors point out that factors related to the student's cognitive ability are the best predictor of academic performance in mathematics (Semeraro, Giofrè, Coppola, Lucangeli and Cassibba, 2020). Although the affective aspects and the quality of the student-teacher relationship are also important factors (Craig, Graesser, Sullins and Gholson, 2004). However, few studies have been detected in the literature that explore the affective domain in the context of students and teachers (Ingram, Hatisaru, Grootenboer and Beswick, 2020). In this sense, interventions dedicated to improve the quality of the student-teacher relationship can play a positive role both in improving affective states as well as having a positive influence on promoting learning in mathematics (Semeraro, Giofrè, Coppola, Lucangeli and Cassibba, 2020; Rahimi and Hashemi, 2013).

In virtual mathematics tutoring systems, female students tend to accept more comments from tutors and spend more time including available learning aids (Bouvier, Sehaba and Lavoué, 2014; Boyer *et al*., 2008). Male students, in general, would benefit more from adjustments to balance their cognitive, motivational, self-confidence, and engagement support (Dennis, Masthoff and Mellish, 2012).

These differences in behavior according to the gender of the student , justify adaptive technology in virtual teaching and learning environments (Dennis, Masthoff and Mellish, 2012). That is why it is very important to create adaptive systems that allow the integration of personal characteristics and student preferences (Wongwatkit, Panjaburee, Srisawasdi and Seprum, 2020; Desmarais and Baker, 2012). The use of adaptive technologies in learning environments to teach mathematics improves performance for both male and female students and minimizes existing differences (Muldner, Burleson, Van de Sande and VanLehn, 2011).

The analysis of the amount of content feedback was directly correlated with the student's learning gain (Jackson and Graesser, 2007). About feedback, in other studies female and male students tend to differ in their receptiveness to feedback, for instance, in a study with a mathematics tutoring system, female students tended to accept more of the tutor's feedback (Rahimi and Hashemi, 2013; Arroyo *et al*., 2013).

For example, the Mastery Grids self-regulated learning system combined adaptive navigation functionality and performance-oriented aspects of social comparison. The results showed a relationship between different factors such as gender and its impact on student participation, performance, and motivation (Guerra, Hosseini, Somyurek and Brusilovsky, 2016).

Other studies indicate that gaming environments can virtually eliminate a gender difference in spatial attention and significantly reduce the gender disparity in mental rotation capacity (Feng, Spence and Pratt, 2007). These results are important for the development of spatial skills in domains such as mathematical and engineering sciences, these findings have practical implications for the future professional preferences of female and male students and their commitment to STEM (Science, Technology, Engineering, and Mathematics) careers (Johnson, Mohr-Schroeder, Moore and English, 2020).

3. Materials and Methods

This research is based on the research methodology in comparative education, applying the comparative method. Comparatism is used in the educational area as a methodological, relational and critical operation with technological implementation (Martí Marco, 2019).

The objective is to analyze the prevalence of the student's gender in their daily interactions with devices on the Internet and its relationship with the Estimated Average Score in Science and Mathematics, based on data published in the PISA report (Cebrián *et al.*, 2019). To meet this objective, previous studies with the influence of the student's gender in virtual environments were analyzed.

Referring to the description, composition and selection of the study sample, the PISA 2018 report collects data that focus on skills in the digital environment, applied a questionnaire on the use of Information and Communication Technologies (ICT) in 53 countries. It works with a representative sample collected from the populations of Spain, the member countries of the OECD, and the EU (Cebrián *et al.*, 2019). The sample of students belongs to an age group between 15 and 16 years old, who are in the tenth or fourth year of Compulsory Secondary Education in Spain (Cebrián *et al.* 2019). The students were asked questions related to the frequency of use of digital devices and the purpose of said uses: daily participation in social networks, daily participation in online games and daily reading of online news.

The descriptive statistics analyze the behavior of the student according to their gender in their daily interactions with devices on the Internet. The daily use of digital devices is a complex variable composed of the following dimensions: daily participation in social networks, daily reading of online news and daily participation in online games, as well as average grades in science and mathematics respectively.

In the PISA 2018 report study, the Reading comprehension was a main assessment of competence (Cebrián *et al.*, 2019). However, these results are not considered directly, due to the complex nature of reading itself, and the growing influence of information and communication technologies on this variable.

It is essential to justify why the daily use of digital devices is selected, in this sense, previous works link the appropriate use of ICT and the availability of digital devices at home with a positive effect on the student's school performance (Fuentes and Gutiérrez, 2013).

The achievement of academic goals due to gender differences is a constant concern among researchers in education, as they can have long-term consequences for the personal and professional future of female and male students. The gender achievement gap in subjects such as math and science could explain gender differences in STEM majors that are among the highest-paying professions today (Tam, Chan, and Lai, 2020).

4. Results

In this section, this study seeks to find significant differences according to the student's gender in their daily interactions with devices on the Internet.

The frequency table (table 1) reflects the percentage of students who use devices on the Internet according to their gender. The values show different behaviors among students according to their gender. For example, it is more common for female students to participate in social media daily, while it is more common for male students to participate

in daily online games and daily reading of online news. Given this, it is interesting to analyze these results and correlate them with performance in mathematics and science.

Table 1.
Frequency table daily interactions with devices on the Internet.

	Daily participation in social networks		Daily participation in online games		Daily reading of online news	
	Female	Male	Female	Male	Female	Male
OCDE	60	47	4	28	18	23
UE	66	51	4	31	20	26
Spain	77	59	3	21	16	21

Source: PISA 2018 Report data, LibreOffice Calc).

In this sense, the data collected in the PISA 2018 report shows that in Spain, male students obtain 1.65 percent more in mathematics than female students. In OECD countries there is a difference of 5 points; in the EU countries, the difference is 7 points in favor of male students (Cebrián *et al*., 2019). That is, male students still have significantly higher average mathematics performance than female students. However, the mean achievement in science for male students and female students is similar. The mean achievement in science for male students and female students is similar. The science performance distribution of male students is more dispersed than that of female students.

Table 2.
Frequency Table.

	Daily participation in social networks		Estimated Average Science Score		Estimated Average Math Score	
	Female	Male	Female	Male	Female	Male
OCDE	60	47	490	488	492	487
UE	66	51	490	490	491	498
Spain	77	59	482	484	478	485

Source: PISA 2018 Report data, LibreOffice Calc.

In general, the data in table 2 shows that Spanish students have the highest daily participation in social networks than their colleagues belonging to the member countries of the OECD and the EU. In addition, in all three cases, female students have a greater daily participation in social networks than male students. If the case of Spain is analyzed, when daily participation in social networks decreases, the average grades for science and mathematics increase. However, the average science grades of female students in the OECD and EU countries is higher compared to their male colleagues. Therefore, at first glance there is no evidence of a trend in the data.

Table 3.
Frequency Table.

	Daily participation in online games		Estimated Average Science Score		Estimated Average Math Score	
	Female	Male	Female	Male	Female	Male
OCDE	4	28	490	488	492	487
UE	4	31	490	490	491	498
Spain	3	21	482	484	478	485

Source: PISA 2018 Report data, LibreOffice Calc.

The data in table 3 show that Spanish students have less daily participation in online games than their peers in the OECD and EU member countries. However, in all three cases female students have less daily participation in online games than male students. In Spain, it is observed that male students obtained better average scores in science and mathematics than female students. For OECD and EU countries, these data do not describe an obvious relationship.

Table 4.
Frequency Table.

	Daily reading of online news		Estimated Average Science Score		Estimated Average Math Score	
	Female	Male	Female	Male	Female	Male
OCDE	18	23	490	488	492	487
UE	20	26	490	490	491	498
Spain	16	21	482	484	478	485

Source: PISA 2018 Report data, LibreOffice Calc.

In relation to the data shown in table 4 it is evident that Spanish students (both female and male students) declare that they read less daily news online than the average of their colleagues from OECD and EU member countries. However, in the three object groups analyzed (OECD, EU and Spain), female students reported reading less news online than male students. If the case of Spain is analyzed, at first glance, it can be seen that males obtained better means in science and mathematics than female students. In the case of OECD and EU countries, these data do not at a glance describe an obvious relationship between daily news reading according to the gender of the students compared to the average grades in Science and Mathematics.

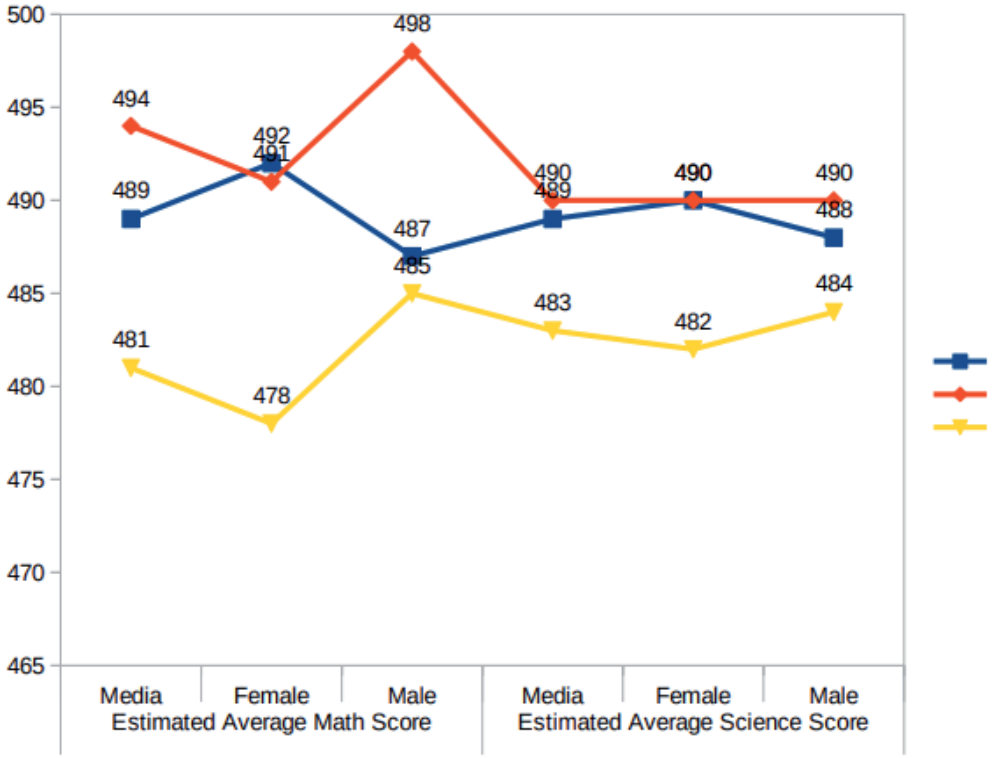

Figure 1. Scatter plot of student gender influence in values average of Mathematics and Science note. *Source:* (Statistics LibreOffice Calc)

If all the above information is summarized in a single graph (figure 1), it is evident that male students from the EU have the highest value in the average grade in mathematics. Spanish female students have the lowest average grade in mathematics. However, OECD female students score slightly higher in science than male students. It is also observed that the greatest slopes of the lines represented correspond to the average grade in mathematics. Therefore, there were greater differences according to gender in the values of the average mathematics grade than in science.

Table 5.
Frequency table ordered by Estimated Average Math Score

Estimated Average Math Score	Daily participation in social networks	Daily participation in online games	Daily reading of online news	Sex	Countries
498	51	31	26	Female	UE
487	47	28	23	Female	OCDE
485	59	21	21	Female	España
492	60	4	18	Male	OCDE
491	66	4	20	Male	UE
478	77	3	16	Male	España

Source: PISA 2018 Report data, LibreOffice Calc.

From the previous results, it would be interesting to determine the dependency relationship between the variables. To do this, we prepared a frequency table (table 5) with information regarding daily participation in social networks, daily participation in online games, daily reading of online news, country of origin and gender. From these data we performed a regression analysis, it is defined as a dependent variable: average grade in mathematics and the independent variables are daily participation in social networks, daily participation in online games, daily reading of online news.

To make this relationship, a functional relationship between the variables must be postulated. The regression analysis will determine the intensity of the dependency relationship between the variables using correlation and determination coefficients (figure 2). Regression analysis helps to understand how the value of the dependent variable varies as the value of one of the independent variables change, keeping the value of the other independent variables fixed.

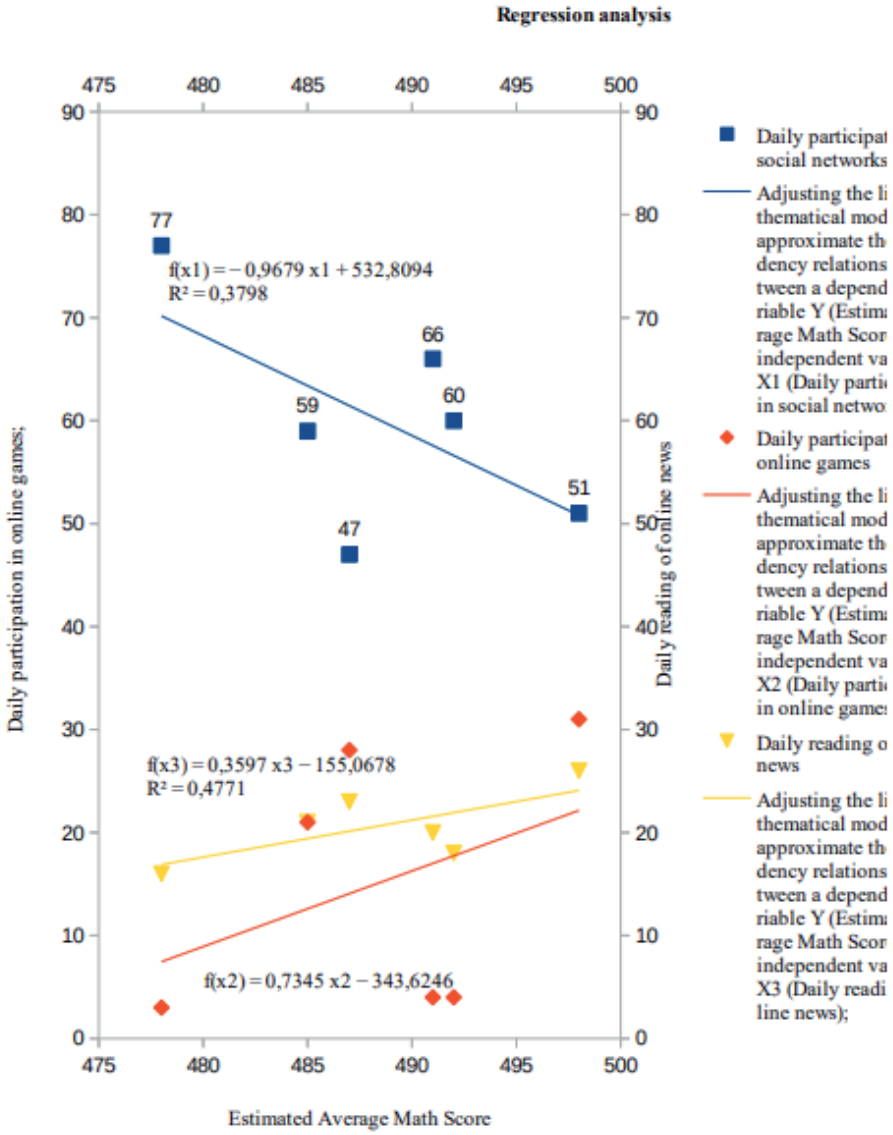

Figure 2. Regression analysis with line and trend equation, and correlation coefficients. *Source*: Own elaboration based on the PISA 2018 Report, LibreOffice Calc.

The results of the regression study are shown in figure 2. The variables daily reading of online news and daily participation in online games, show a positive relationship in relation to the average grade in mathematics. However, daily participation in social networks has a negative relationship to the estimated average score in mathematics. The signs of the slopes of the line equations confirm these relationships. The R^2 is the percentage of variation of the response variable that explains its relationship with the predictor variables. In general, the higher the R^2, the better the model will fit your data. R^2 is always between 0 and 1. Neither model achieved adequate coefficient of determination values.

The analysis is continued with the positive slope models. The adjusted R^2 is the percentage of variation in the variable estimated average mathematical score, that is explained by its relationship with one or more predictor variables adjusted by the number of predictors in the model. The adjusted R^2 is the percentage of variation in the variable estimated average mathematical score, that is explained by its relationship with one or more predictor variables adjusted by the number of predictors in the model. The new models have R^2 values of 0.8850% and 0.9042%. This means that as we include more variables in the model, the R^2 will increase to become the most efficient model. By adding the second term, the adjusted R^2 did not improve. Then, a third term was necessary, so a model with a base 3 polynomial was necessary to achieve better adjusted R^2 values (Figure 3).

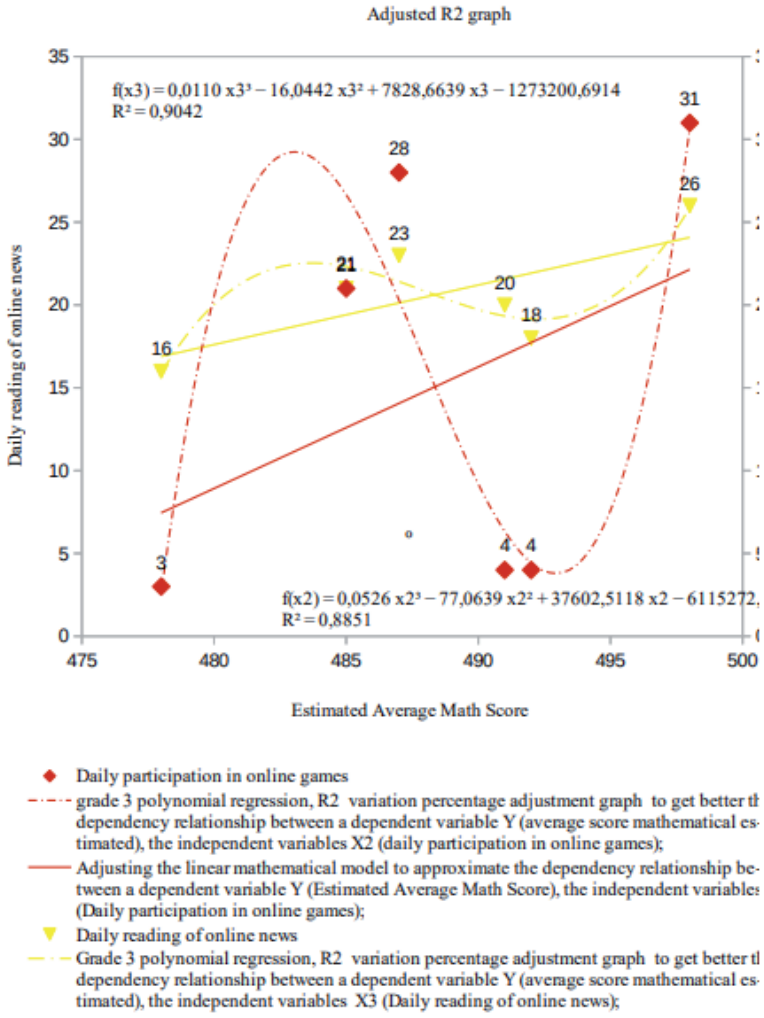

Figure 3. Scatter plot, regression analysis with line and trend equation, and R^2 variation percentage adjustment graph. *Source*: Own elaboration based on the PISA 2018 Report, LibreOffice Calc.

The new mathematical models of adjusted R^2 have sinusoidal characteristics. The model that relates the variables estimated average mathematical score and the daily participation in the online games, shows adjusted R^2 values equal to 0.9042%. It is also observed in figure 3, that the data have a behavior according to the gender of the student. That is, all the values of daily participation in online games in the case of female students are located in the negative half cycle of the sinusoid (3, 4, 4 points), these values being lower with respect to the scores of male students (28 , 23, 21 points) which are located in the positive half cycle of the curve (figure 3 and table 5).

In the case of the dependent variable of daily reading of online news, an adjusted R^2 value equal to 0.885% is obtained. In the graph it is observed (with a smaller gap than in the previous case) that all the data are grouped according to a student's gender behavior, as in the previous case. That is, all the values of the daily online news reading of female students are in the negative half cycle (16.18.20 points), these values are lower, if compared with male students (21, 23, 26 points) (figure 3 and table 5) that are located in the positive half cycle of the sinusoid.

In light of the results, it appears that there is a predominance of the student's gender in their daily interactions with devices on the Internet. However, it should be noted that the small number of data used constitutes a limitation, in this sense, the results obtained constitute the starting point for future work.

5. Comparative Study

In order to find similarities and differences, the results of the empirical research are compared with the previous works. When those previous works are analysed: female students tended to participate less in the video games of the virtual educational system (advanced adaptive technology for learning mathematics) than male students, especially when they were provided with a built-in tutorial agent (Arroyo, I. *et al.*, 2013). Instead, male students interacted with elements of gamification more than females (Vail, AK *et al.*, 2015). In this sense, it is pointed out in the literature that action video games can virtually eliminate the gender difference (Spencer, Steele and Quinn, 1999; Feng *et al.*, 2007). However, it is important to say that some investigations warn that a large number of hours of playing is related to poor school performance, therefore, a safe play model should be promoted and controlled (Irles, Perona and Baños, 2015).

The previous section of this work shows that in general, females have less daily participation in online games than male students (table 3). The values of female students in the daily reading of online news and daily participation in online games, were located in the negative half cycle of the sinusoid, if we observe Figure 3. These values are lower than those of male students who are in the positive half cycle of the sinusoid. Hence, daily reading of online news and daily participation in online games were influenced by the gender of the student.

Some studies referring to self-efficacy in mathematics did not find significant gender differences (Tekola *et al.*, 2020). However, previous publications point out the differences in performance in mathematics between students according to their gender and how these can be reduced with the use of virtual tutoring systems (Arroyo *et al.*, 2013).

Analyzing the previous section, figure 1, we find differences according to the gender of the students, in the values of the average grade in mathematics and in science. Male students from the EU had the highest average score in mathematics. Spanish female

students have the lowest average grade in mathematics. It was observed that the greatest slopes of the lines represented correspond to the average grade in mathematics. Therefore, there were greater differences according to the gender of the students in the values of the average grade in mathematics and in science.

Several works indicate the different responses to support for the adjustment of affective, cognitive and social aspects, taking into account the gender of the student (Boyer *et al.*, 2008; Arroyo *et al.*, 2013; Vail *et al.*, 2015; Rahimi and Hashemi, 2013; Boyer *et al.*, 2008; Jackson and Graesser, 2007; Desmarais and Baker, 2012; Jackson and Graesser, 2007).

Based on the results of the previous section, the previous approach makes sense. This work showed that female students obtained more points in the activities of daily participation in social networks, while male students participated more in the activities of daily reading of online news and online games (table 1). This speaks to us in favor of student preferences related to their gender differences.

In short, the use of adaptive technologies could be justified in virtual teaching and learning environments, due to the existence of differences in the behavior of students according to gender (Dennis, Masthoff and Mellish, 2012). Some studies have shown that the use of adaptive learning technology could improve student performance (Muldner *et al.*, 2011).

The outcome obtained in the Results section shows that there is a prevalence of the student's gender in their daily interactions with devices on the Internet (figure 3), which also seems to be equivalent in virtual teaching and learning environments as already compared with previous works.

6. Discussion

After the COVID19 crisis, discussions have been opened in the technology-mediated education framework that deserve our attention. Inequality of opportunities according to the gender of the student is not a conjunctural element of COVID19 crisis, but rather the educational model. Addressing a gender approach in virtual educational proposals should be one of the main tasks and challenges in education.

This work contributes to the existing research on the understanding of the behavior of students attending to gender differences. This work carries out a preliminary study on the prevalence of the student's gender in their daily interactions with devices on the Internet.

This study showed the dependency ratio between the dependent variable estimated average mathematical scores and the independent variables: daily participation in social networks, daily participation in online games and daily reading of online news.

In this sense, behavior patterns were detected according to the student's gender, taking into account affective, cognitive and social aspects. The results of the estimated mean math and science scores were related to the students' daily interactions with virtual devices on the Internet. It was evidenced that male students were more motivated by daily participation in online games. While girls have a greater daily participation in social networks. Male students scored more active points in daily online news reading.

An adjustment of R2 was made that relates the estimated average mathematical score and the daily participation in variables of online games, an adjusted R2 equal to 0,9042% was obtained. The adjusted R2 for the model that links the estimated average mathematical score and the daily reading of the online news variables sample, was 0,8850%. The graphs obtained shows differences in the behavior of male and female students.

This research is a contribution to the state of the art; it shows the prevalence of the student's gender in their daily interactions with devices on the Internet and the importance of the gender approach in future virtual teaching and learning environments.

7. Limitations

It should be pointed out the small number of data used, the results obtained are preliminary and constitute the starting point for future work.

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