Investigating the Relationship between Gender and Subject Attainment: Influencing Further study of Technology Subjects in Malta

Marilyn Stellini[1*], Sarah Pulé[2]

[1]St. Aloysius College, Triq il-Ferrovija l-Qadima, Birkirkara, Malta

[2]The University of Malta, Faculty of Education, Department of Technology and Entrepreneurship Education, Imsida, Malta

[*]Correspondence: marilyn.stellini.07@gmail.com

Abstract

This work expands on the prior research of Stellini and Pule (2019) which investigated the relationship between subject attainment and the factors governing students' decisions in relation to the further study of design and technology areas. The study for the year 2019 by these authors indicated positive perceptions of the subject of design and technology by state-middle school students of both genders. Meanwhile, other variables were discovered, showing that sociocultural considerations and future career objectives impact students' decision-making interests in subject taking. The subjects chosen by students have implications for future employment, societal mobility, and the knowledge and skills required to drive the economy (Davies & Ercolani, 2018). According to the most recent National Statistics Office report on the labour force survey in Malta, public administration, defence, education, social work, and human health have the highest distribution of jobs. Manufacturing, industry, quarrying, and construction are all mid-level jobs with a large male representation (Labour Market and Information Society Statistics Unit, 2020).

The research presented in this paper investigates the relationship between gender and students' attainment in their ordinary level exams at the age of 16, for technology education subjects over a span of 12 years. This longitudinal study is based on quantitative data derived using official Matriculation and Secondary Education Certificate Examinations, MATSEC statistical reports (https://www.um.edu.mt/matsec/reportscommunication). The Statistical Package for the Social Sciences was used to test the secondary quantitative results. The hypothesis of an association, for the association between gender and subject attainment in most topics, is accepted. Other variables associated with gender are present in this study, such as grades and the type of school from which students applied. The study concludes that, even though male registrations dominate technological subjects and the gender-achievement relationship is weak, girls attain slightly higher marks. Furthermore, as their rate of registration and accomplishment was seen to increase, females seem to be moving away from stereotypical traditions.

Key Words: Technology Education, Gender Representation, Subject Attainment

1. INTRODUCTION

The earliest form of technical subject in the Maltese island dates to 1893, when Canon P. Pullicino introduced geometric forms and linear designs in elementary schools. Pullicino was not particularly interested in technical education, but he did feel that industrial education offered a context for learning via application at the time. The first technical school in Malta was established in 1893, with the introduction of the initial form of technical education (Sultana, 1992). Shortly following World War II in 1945, the Maltese government established the second technical school where subjects including technical and engineering drawing, electrical engineering and practical were taught (Vella, 1954). Along the years technical drawing

was provided in boys' Secondary schools in 1956 and then in 1987 for all students in Junior Lyceums (Sultana, 1992). Due to low responses from girls, technical drawing was offered in boys' secondary schools only (Darmanin, 1992). In 1972, trade schools were introduced in Malta, until they phased out in the early 2000s (Navarro Carmel & Pulé Sarah, 2015; Purchase, 2005). Here the former title of Technology Education experienced a change and transitioned into Design and Technology, D&T in 2012 (Purchase, 2005). In 2015/6 Vocational Education and Training, VET Engineering Technology was introduced to all state schools and a few church and independent schools in Malta (Joseph Micallef, 2014).
The issue of low female representation in technology-related subjects can be traced to its roots. Sultana (2017), outlines that the history of technology education is mainly that of male education. Over the years there has been an emphasis on gender equity in classrooms, especially through the STEM movement (Fergusson & Horwood, 1997; Ro et al., 2021). However, through statistical data collected by Matriculation and Secondary Education Certificate Examinations, MATSEC (https://www.um.edu.mt/matsec/reportscommunication), the number of female students registering for technology-related subjects at an ordinary level remains under-represented compared to male registrations. In the meantime, research into female performance in technological subjects is being conducted to determine if females have yet to achieve parity with their male counterparts due to their performance. Wang and Degol (2016) present a theoretical framework for policymakers' proposed practice recommendations based on six explanations, some of which are relevant to this study. The present issue of low gender representation in design and technology subjects in Malta is presented as part of the research objective of this paper. Hereunder, the research questions are listed:

1. Is there a relationship between gender and students' attainment in technology education subjects, at an ordinary level exam aged 16 years?
2. Are there any patterns or variables in how students perform in technology subjects at an ordinary level?
3. Is there a relationship between grades obtained at an ordinary level by gender and the type of school students are registering from?

2. LITERATURE REVIEW

Children begin to form a notion of themselves and attempt to relate themselves with their gender identity as early as their second birthday. A child can achieve gender constancy between the age of three and seven (Wolter & Hannover, 2016). Identity-based motivation, IBM, explains why people prefer to act in ways that they feel are consistent with their social identities, particularly their gender identity (Elmore & Oyserman, 2012). The formation of youth growth, such as interest, is heavily influenced by their identity (Philp & Gill, 2020). Interest is identified as a motivating factor that is elicited by psychological, physical, social, and biological factors. It progresses through four stages: triggered situational interest, sustained situational interest, emerging individual interest, and well-developed individual interest (Hidi & Renninger, 2006). Interest development theories and other motivational theories address how interest influences attention, objectives, and learning levels, as well as how interest interacts with child development contexts (Philp & Gill, 2020). Interests influence subject choices as they guide students' future decisions about what they want to be when they grow up (Sharp & Coatsworth, 2012). This is assumed to begin at the end of primary school and progress throughout the following education and professional careers (Vulperhorst et al., 2019).

2.1. Skills and Knowledge

Skills and knowledge are two aspects that are interdependent. Martin and Owen-Jackson (2013) examine how knowledge affects skills and how one gains knowledge through the practice of skills. According to prior studies mentioned, interest is a fundamental determinant for learning, and information is its driving source in certain aspects (Martin & Owen-Jackson, 2013). Interest is also an independent variable, whereas knowledge is a dependent variable (Rotgans & Schmidt, 2017). One of the earliest forms of technological knowledge is related to Walter G. Vincenti's book as he classifies technological knowledge into six different categories (Vincenti, 1990). Ever since other frameworks of technological knowledge were distinguished over the years (Bayazit, 1993; Broens & de Vries, 2003; De Vries, 2016; Ropohl, 1997; Rossouw et al., 2011; Williams, 2012).

The aim of Kovierienė's (2010) study investigates the relationship between technological expertise and technological jobs that are related to engineering and technology in relation to gender. The study suggests that employment independence, as manifested in technology occupations, is a prerequisite for improving applied technological knowledge, particularly among boys. Furthermore, the results show that autonomous girls have more theoretical knowledge than boys (Kovierienė, 2010).

2.2. Prior Attainment

In this study, subject attainment is investigated to determine whether it correlates to or is subject to being affected by different variables. D&T originated as a male-dominated subject, but in some countries, girls soon outperformed boys in terms of grades (Spendlove, 2000). Some other studies show that boys are overrepresented in lower school tracks due to their grades, whereas girls are overrepresented in high school tracks (Kessels et al., 2014). The association between gender inequalities and academic grades was investigated among 1.6 million students in a study dominated by the North American dataset. According to the latter study, the top 10% of pupils in a STEM class are split evenly between males and females. Alongside, results indicate female students are generally over-represented in non-STEM related subjects (O'Dea et al., 2018). The gender difference in STEM academic grades is relatively small, with male-skewed statistics only at the very top of the rankings. In comparison to non-STEM areas, the researchers claim that the internal and external pressures of being heavily dominated by male rivals have an impact on females' decision to pursue STEM employment hence excluding the influence of scholastic achievement.

Wang and Degol (2016) presented a theoretical guide using a social cognitive perspective by identifying six empirical factors that cause female underrepresentation. Among these factors, the authors explain how cognitive ability and strengths are indicating factors in quantitative and verbal reasoning. In the meantime, career preferences, lifestyle choices and field-specific abilities are motivators that reflect personal interest, mindset goals and values. These cognitive and motivational factors are potentially affected by stereotypes and biases as students experience and reinforce the gender gaps over time. Throughout this theoretical guide, the issue of mindset is presented where it is emphasized that a growth mindset in women leads to persistence against challenges which makes them more likely to succeed.

According to 2020 research on secondary school courses and student enrolment in Germany, Ireland, and Scotland, women are less likely to enrol in fields and settings related to STEM (Jacob et al., 2020). It also establishes a pattern across countries, claiming that the main gender divide is in Engineering and Technology enrolment. In 2002, Harding claims that when a masculine bias exists within a field of study, girls are less comfortable to opt for these subjects. The same applies to boys as they are excluded from female-related disciplines. However, research in educational science implies that female students are more likely to pursue courses dominated by male students in single-sexed classes since they result in superior performance by girls in these male-dominated fields (Schneeweis & Zweimüller, 2012). Through the years, Maltese secondary schools phased out from single-sexed to co-ed since 2014/5 (Times of Malta, 2014). A report produced by John Baptist Galea in 2007 was financed by UNESCO in the University of Malta and intended to identify the rate of women engaging in science and technology subjects in four secondary schools in Forms 2 and 3. According to the findings, the performance of individuals in the minority, females is superior to that of the dominating group, males. This is since such a group is prepared to go against the traditions of the opposite gender. As a result, they are eager to prove themselves capable (Galea, 2007).

3. METHODOLOGY

The research in this paper is based on quantitative secondary data gathered from a major qualifying body in Malta recognized as the Matriculation and Secondary Education Certificate Examinations MATSEC's official statistics releases from 2008 to 2019 (https://www.um.edu.mt/matsec/reportscommunication). Secondary data can be derived from research conducted for purposes unrelated to the research topic, yet it can be useful in other contexts (Hox & Boeije, 2005; Wyse et al., 2016). The number of 16-year-old students applying for their ordinary level examinations in technological subjects and all other subjects is detailed in the MATSEC statistical reports. These reports also include information on the applicant's gender, the type of school they applied from, and their grades. Design and Technology, Graphical Communication, and VET Engineering Technology are the three subjects provided at the ordinary level in Malta that are classified as technological subjects, apart from the digital technologies.

4. RESULTS

4.1. Statistical Scenario of Subjects at ordinary level

Secondary data of registered students by year for D&T, Graphical Communication, and Engineering Technology was collected over a 12-year period from MATSEC's official statistics releases (https://www.um.edu.mt/matsec/reportscommunication). Figure 1 depicts the number of students who have enrolled for the Design and Technology at O-level exam during the last twelve years. The data is broken down by gender, registering male students at a higher rate each year with a total of 2440 registrations in 12 years, when compared to girls' 540 registration also in these 12 years.

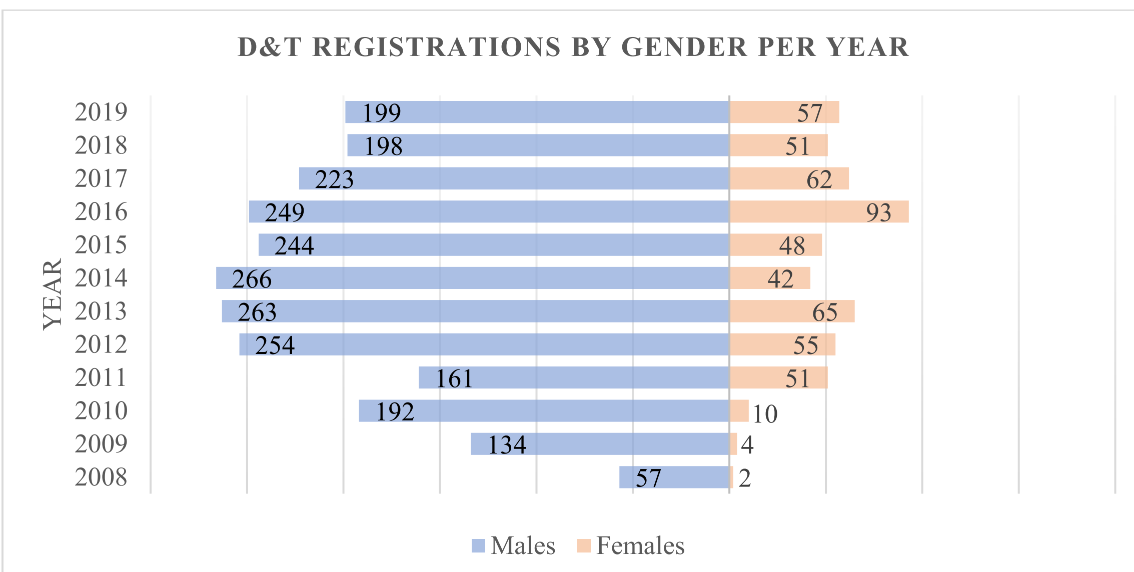

Figure 1. Design and Technology Registrations by Gender Per Year

Registrations for Graphical Communication and VET Engineering Technology demonstrate that these subjects have long been dominated by males, with a low female participation rate (Figure 2 and 3). The rate of students registering for Graphical Communication is greater than for the other subjects, with a total of 5518 male and 1316 female registrations.

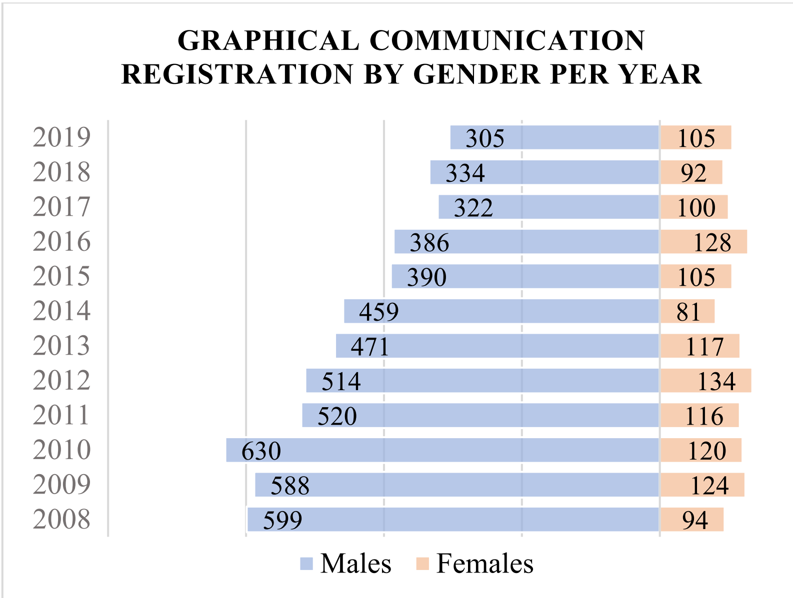

Figure 2. Graphical Communication Registrations by Gender Per Year

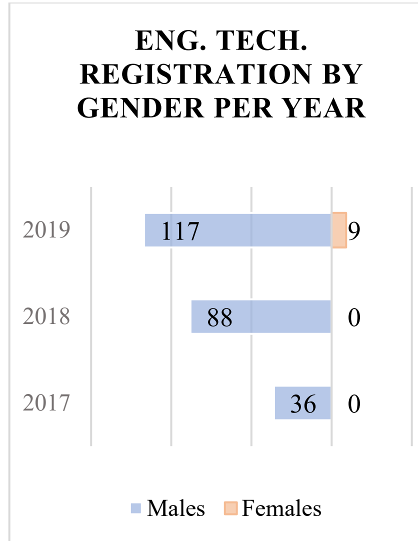

Figure 3. Engineering Technology Registrations by Gender Per Year

The Statistical Package for the Social Sciences, SPSS is used to generate the chi-square test used in Table 1 to evaluate the relationship between two categorical variables for D&T. The student's grade will be provided by one of these variables, while the student's gender will be indicated by the other. The null hypothesis states that there is no relationship between the two categorical variables and is accepted when the p-value is greater than 0.05. The null hypothesis states that the two categorical variables have a significant relationship and are accepted if the p-value is less than the 0.05 threshold.

As seen in Table 1, the null hypothesis must be accepted since the resulting p-value of <0.001 is less than the 0.05 standard of significance. This suggests that there is an association between gender and academic achievement grades.

Although there is evidence of an association between achieved grades and gender, it is worthwhile to look at the strength and magnitude of any such association through Pearson’s coefficient. Although the chi-square test indicates that there is a significant relationship between the two variables, the strength of the relationship is weak since Pearson's coefficient is 0.114.

Table 5. Crosstab showing attainment of students in the past twelve years, grouped by gender for D&T.

			Gender		
			Male	Female	Total
Grade	1	Count	54	28	82
		%	2.3%	5.3%	2.9%
	2	Count	122	48	170
		%	5.3%	9.1%	6%
	3	Count	178	53	231
		%	7.7%	10.1%	8.1%
	4	Count	391	83	474

		%	16.9%	15.8%	16.7%
	5	Count	357	53	410
		%	15.5%	10.1%	14.5%
	6	Count	366	76	442
		%	15.8%	14.5%	15.6%
	7	Count	176	41	217
		%	7.6%	7.8%	7.7%
	U	Count	666	143	809
		%	28.8%	27.2%	28.5%
Total		Count	2310	525	2835
		%	100%	100%	100%

$X^2(7) = 36.637$, p = <0.001, Cramer's V /Phi = 0.114

Similarly, when the data are used to analyse the association between gender and grades in Graphical Communication as in Table 2, the null hypothesis is accepted because the p-value is 0.023, which is less than the 0.05 level of significance. Although there is evidence of an association between grades and gender, it would be interesting to investigate the strength and size of this relationship. Since the percentages in Table 2 indicate a little difference in grades, the Phi (φ) and Cramer's V tests were used. Even though the chi-square test indicates that there is a significant relationship, the relationship has a weak strength since the Phi (φ) coefficient is 0.05. Tests for Engineering Technology could not be presented because this subject is a recent introduction in Maltese secondary schools and sufficient data does not yet exist.

Table 6: Crosstab showing attainment of students from 2008 till 2019, grouped by gender for Graphical Communication.

			Gender		
			Male	Female	Total
Grade	1	Count	319	85	404
		%	6%	6.7%	6.1%
	2	Count	583	150	733
		%	10.9%	11.9%	11.1%
	3	Count	732	188	920
		%	13.7%	14.9%	13.9%
	4	Count	1010	230	1240
		%	18.9%	18.2%	18.8%
	5	Count	1205	294	1499
		%	22.6%	23.3%	22.7%
	6	Count	321	57	378
		%	6%	4.5%	5.7%
	7	Count	292	43	335
		%	5.5%	3.4%	5.1%
	U	Count	878	217	1095
		%	16.4%	17.2%	16.6%

Total	Count	5340	1264	6604
	%	100%	100%	100%

$X^2(7) = 16.220$, $p = 0.023$, Cramer's V /Phi = 0.05

The weak relationship between gender and grades obtained in D&T, is displayed in a cluster bar graph with respective trendlines for male and female students in Figure 4. From 1 (highest grade) to U (lowest grade), this bar graph depicts the percentage of students divided by gender in each grade. Similarly, trendlines are also created in Figures 5, and 6 to assess the relationship between students' gender and the grade they obtain in the subjects of graphical communication and engineering technology. It is clear from these findings that girls acquire a higher percentage of grades ranging from 1 to 3 than males, except in engineering technology's highest grade 1. Males outnumber females in the lower classes, which range from 6 to U (Unclassified).

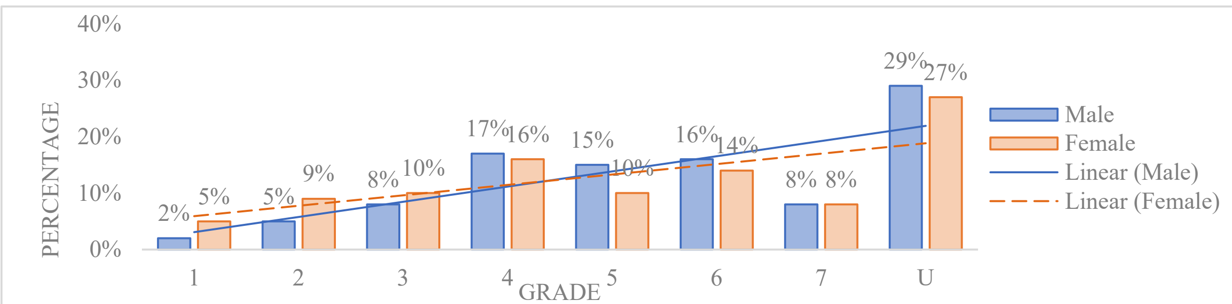

Figure 4. Clustered bar graph showing attainment of students from 2008 till 2019, grouped by gender for D&T

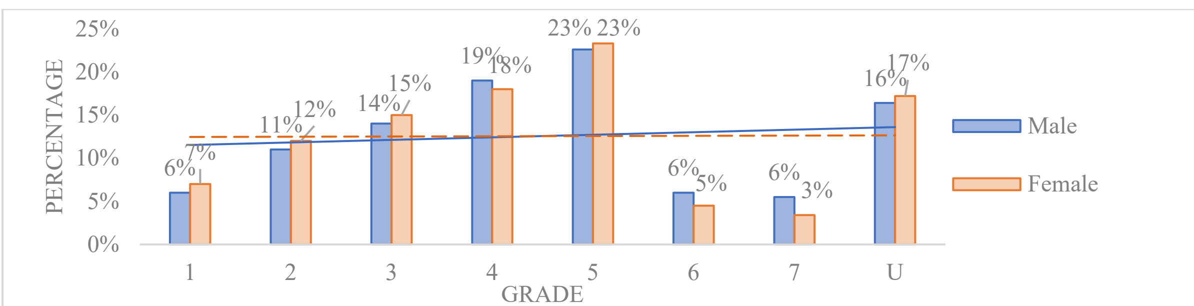

Figure 5. Clustered bar graph showing attainment of students from 2008 till 2019, grouped by gender for Graphical Communication

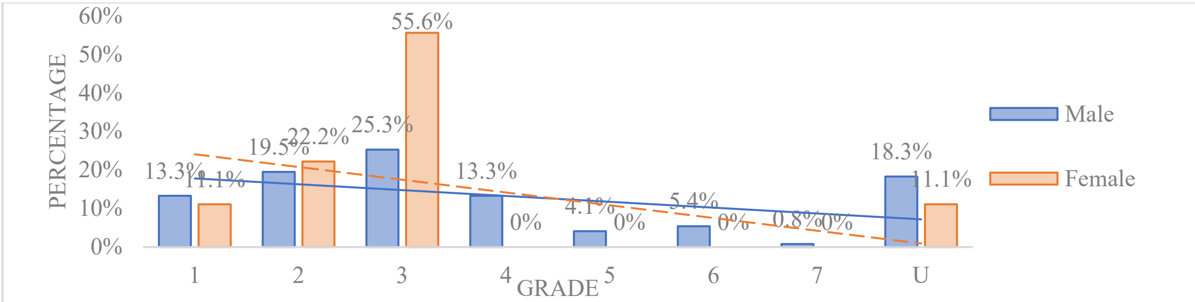

Figure 6. Clustered bar graph showing registration of students from 2008 till 2019, grouped by gender for Engineering Technology

4.2. Evaluating the association between gender and school type registration

The official statistics releases of MATSEC provide more data on which to test the various assumptions. The statistical data presented in each report provides a summary of students' type of registration school, with State, Church, and independent schools having the most registrations. Table 3 shows that most D&T student registrations come from state schools. Meanwhile, Graphical Communication registrations are common in State, Church, and independent institutions. Engineering Technology is exclusively taught in State schools and only a few Church and independent schools.

Table 7. Design and Technology Crosstab Registration of Students by School Type and Gender.

			Gender		
			Male	Female	Total
School	State	Count	1424	423	1847
		%	59.6%	78.3%	63%
	Church	Count	488	0	488
		%	20.4%	0%	16.7%
	Independent	Count	5	0	5
		%	0.2%	0.0%	0.2%
	Post-secondary	Count	9	0	9
		%	0.4%	0%	0.3%
	Malta private candidate	Count	40	7	47
		%	1.7%	1.3%	1.6%
	Gozo	Count	421	109	530
		%	17.6%	20.2%	18.1%
	Gozo private candidate	Count	3	1	4
		%	0.1%	0.2%	0.1%
Total		Count	2390	540	2930
		%	100%	100%	100%

$X^2(6) = 140.107$, p = <0.001, Cramer's V /Phi = 0.219

Table 8. Graphical Communication Crosstab Registration of Students by School Type and Gender.

			Gender		
			Male	Female	Total
School	State	Count	1846	726	2572
		%	33.6%	56.7%	38.0%
	Church	Count	2431	63	2494
		%	44.3%	4.9%	36.8%
	Independent	Count	445	222	667
		%	8.1%	17.3%	9.8%
	Post-secondary	Count	70	28	98
		%	1.3%	2.2%	1.4%
	Malta private candidate	Count	179	41	220
		%	3.3%	3.2%	3.2%
	Gozo	Count	504	197	701
		%	9.2%	15.4%	10.4%
	Gozo private candidate	Count	16	4	20
		%	0.3%	0.3%	0.3%
Total		Count	5491	1281	6772
		%	100.0%	100.0%	100.0%

$X^2(6) = 716.502$, p = <0.001, Cramer's V /Phi = 0.325

The chi-square test was used to examine the association between registered students' gender and school type. Table 3 demonstrates a significant discrepancy between male (59.6%) and female (78.3%) students enrolled in D&T in State schools. Males dominate church school registrations in D&T since no female Church school offers D&T as an optional subject. As to other schools or institutions, there is a little discrepancy between the number of registrations for male and female students. Nevertheless, the null hypothesis which states that there is an association between gender and type of registration is accepted since the resultant p-value is <0.001, which is less than the 0.05 level of significance. This indicates that the two variables being gender and type of registration have a significant link. Although the connection is apparent, Phi (φ) and Cramer's V are useful for determining the strength of the link weak, with a Phi (φ) value of 0.219. The same test is applied for Graphical Communication (Table 4), indicating that the null hypothesis that there is an association between gender and type of registration is accepted with a p-value of <0.001 which is below the 0.05 level of significance. It is of interest to test the magnitude of such strength and since Phi (φ) value is 0.325 and exceeds the 0.3 level of weakness, the magnitude of such relation shows a medium strength between gender and type of registration

5. DISCUSSION AND CONCLUSION

This research presents a clear image of the association between gender and subject attainment in technological subjects at the ordinary level, with a particular emphasis on D&T. Other unforeseen patterns have been recognized within a wider study and will eventually be reported elsewhere.

5.1. Gender disparities in students' achievement in technological subjects

The number of students registering for technological subjects at the ordinary level, such as D&T, Graphical Communication, and VET Engineering Technology, was examined (section 4.1.). The statistical data in figures 1, 2, and 3 show a clear spectrum of registrations submitted during a twelve-year period, segregated by gender. The data for D&T and Graphical Communication reveals a clear picture of how male registrations dominate these fields year after year. It is also widely acknowledged that the representation of women in these fields has been steadily rising throughout the years. Spendlove's (2000) argument recognizes that these subjects have been highly dominant by the masculine gender, which can be associated with the result obtained in this study. As a result, the pressures caused by the idea of technological subjects being male-dominated, effects internal and external pressures on the decisions students make about pursuing STEM-related employment. Hence, it can be a result of these pressures rather than subject achievement (O'Dea et al., 2018). Statistical results obtained by Stellini et al. (2019) showed that students' career goals were a significant factor in their decision to study D&T. The data revealed a substantial association between gender and career aspiration, with a moderate strength of contingency coefficient.

Spendlove (2000), O'Dea et al. (2018) and Galea (2007) clearly discuss how the minority group in these technological subjects are those students who achieve excellent marks compared to the largest male-dominated group. This hypothesis was tested by using chi-square, Phi (φ) and Cramer's V tests to examine the association between gender and subject attainment at the ordinary level. Only D&T and Graphical Communications tests were analysed due to their largest number of years within the educational system (Tables 1 and 2). Results determine that although there is an association between these two variables their strength is weak. A clear spectrum of this longitudinal study shows in figures 4 and 5 that females are well represented in higher grades compared to their male counterparts which correspond to Kessels et al., (2014) statement. Girls exhibit lower test scores in STEM disciplines compared to their grades, whereas boys have higher test scores in standardized examinations rather than grades. Wang and Degol (2016), presented a framework on how cognitive ability and motivation are key factors that direct students with growth mindsets to succeed as they go against challenges. The small number of females registered for their ordinary exams, respectively shows how they performed what Wang and Degol (2016) have explained in their theoretical framework of a growth mindset. Field-specific abilities potentially emerge at a young age, which comes mostly into play during middle school and teenage years. Girls are more likely to outperform boys in exams due to their verbal performance while mathematical performances favour male students. Therefore, as sociocultural factors have a strong impact on students on decision making, we should intervene to improve female representation in Maltese technological subjects.

5.2. The effects of co-educational and single-sexed schools/ institutions

Findings of this study showed that across all subjects the largest number of registrations is from State schools as they offer all these subjects. Commonly both D&T and Graphical Communication are generally offered in State, Church, and independent schools. Tests showed that there is an association between gender and type of registration (tables 3 and 4). This association is of weak strength for D&T but of moderate strength for Graphical Communication. Ever since 2014/5, Maltese State secondary schools shifted from single-sexed to co-educational, having schools with mixed-gender (Times of Malta, 2014). Meanwhile, Church schools are still largely single-sexed although some are in the transition to co-educational, whereas independent schools are mixed-gender in Malta. In single-sexed schools, females are more likely to pursue technological subjects that are dominated by males whereas in co-educational schools they may feel less comfortable being in minority (Harding, 2002; Schneeweis & Zweimüller, 2012). This can result in a disservice for girls in Maltese Church schools that are single sexed as these do not offer D&T as an optional subject. In fact, results showed that the largest number of female registrations is from State schools that are co-educational. This shows that females are in the transition of going against traditions of the opposite gender in co-educational schools and subject attainment as stated by Galea (2007).

In Malta, the dissemination of information and research in technology-related educational areas is strengthening and deepening its roots inside the educational system. Students' perspectives and attitudes may be impacted by the new modifications in the syllabus that will go into effect in 2022/3, affecting their interest in pursuing courses in technology fields. Within the academic sector, it would be beneficial to research and invest in the advanced level of D&T to give a longitudinal development similar to that provided for Graphical Communication. As a result, research relating to gender and the uptake of these subjects with career opportunities is vital, since career aspirations were found to be one of the main motivators for pursuing studies in technology-related domains (Potvin & Hasni, 2014; Stellini, 2017; Wang & Degol, 2016).

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