

NUDGING TO EQUALITY: HOW IMPROVEMENT OF THE ENVIRONMENT IN SCHOOLS CAN REDUCE A GENDER GAP?

Author : Lukoperova Veronika

Thesis Director : Johannes Johnen

Thesis Reader : Giovanna D'Adda

Academic Year 2019-2020

In order to obtain the joint degree:

Master 120 en Sciences économiques, Orientation générale,

Finalité spécialisée (UCL/UNamur)

and

Dottore magistrale in Economics and Political Science

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Johannes Johnen, for his continued guidance through each stage of the writing process and for the assistance he provided to arrange my thoughts and make me stay focused on the topic. I am grateful for being able to have this opportunity to write my Thesis on the topic “Nudging to equality: How improvement of the environment in schools can reduce a gender gap?”, which is very relevant for me from the female point of view and which helped me to learn more new arguments and facts that I can contribute in the future from the professional point view.

I would also like to thank my reader of the Thesis, Giovanna D’Adda, for her deep interest to my work, for all the useful materials and ideas that she has provided to me and that helped a lot to get the full picture of the problem I was making research on.

I kindly appreciate all the support that I received from my family during this uncertain time of pandemic while being far away from home, but still studying and working remotely. I should admit that it was especially hard to accept all the challenges of being abroad under pressure of chaotic situation in the world.

I would like to express my special thanks of gratitude to my manager Dag Cummings for his strong belief in the success of my work and for his impressive encouragement. This support helped me to keep aligned with the tasks even when it seemed that motivation and inspiration left me.

Finally, my work on this research could not have been accomplished without the females’ surrounding. I want to express my deep and sincere gratitude to all the main women of my life that play a crucial role by inspiring and empowering me in my decision-making: my mom, my grand mom, my sister and all my females’ friends. My heartfelt thanks.

Sincerely,

Veronika Lukoperova

NUDGING TO EQUALITY:

How improvement of the environment in schools can reduce a gender gap?

Veronika Lukoperova

August 2020

ABSTRACT

Instead of focusing on inherent biological features, environmental factors are coming to be seen as the driving force behind both behavioral and brain differences between males and females. The present research sought to consider alternative policies for promoting gender equality formation that are targeted to primary schools in the UK. The paper demonstrates the importance of building the right school environment in accounting for gender gaps. Girls tend to underperform while competing with boys, such that facing stereotype threat their efficiency is undermined, moreover, this leads to the possibly biased decisions in the future. The paper focuses on early interventions in schooling environment that could facilitate the reduction in gender disparities in further education and therefore, will result in decline of male dominance at the workplace, precisely in such fields as Mathematics, Computer Science, Engineering, etc.

Keywords: Competition, Gender Differences, Mathematics, Primary Schools, Stereotypes

TABLE OF CONTENTS

ACKNOWLEDGEMENTS.....	2
ABSTRACT	2
ABBREVIATIONS AND SYMBOLS	5
INTRODUCTION.....	6
1. RELEVANCE OF THE TOPIC	9
2. LITERATURE REVIEW	12
2.1. EXPLANATION I: MALE-PRESENCE IN COMPETITION.....	12
2.2. EXPLANATION II: UNCONSCIOUS GENDER BIAS	14
2.3. EXPLANATION III: WOMEN ARE MORE RISK AVERSE	15
3. EDUCATIONAL SYSTEM IN THE UK.....	18
4. EXPERIMENT DESIGN	20
4.1. DESCRIPTION OF THE PRIMARY MATHEMATICS CHALLENGE.....	21
4.2. TREATMENT GROUP 1 AND 2: SINGLE-SEX CLASSES.....	21
4.3. MAIN QUESTIONS OF THE STUDY	23
4.4. CONDITIONS OF INTERVENTION	23
4.5. EXPERIMENTAL VARIABLES AND PUPILS' CHARACTERISTICS.....	23
5. DISCUSSIONS AND LIMITATIONS	25
6. CONCLUSION.....	28
REFERENCES.....	31
APPENDIXES	37

ABBREVIATIONS AND SYMBOLS

A-level, Advanced level

AGCE, Applied General Certificate of Education

AI, Artificial Intelligence

ECLS-K, Early Childhood Longitudinal Study Kindergarten Cohort

GAFAM, America's largest tech companies: Google, Amazon, Facebook, Apple, Microsoft

GCSE, General Certificate of Secondary Education

HESA, Higher Education Statistics Agency

ICT, Information and Communication Technologies

ISC, Independent Schools Council

IT, Information Technology

NGCP, National Girls Collaborative Project

OCR, Oxford Cambridge and RSA Examinations

OECD, Organization for Economic Cooperation and Development

PMC, Primary Math Challenge

RSA, Royal Society of Arts

SAT, Scholastic Aptitude Test

STEM, Science, Technology, Engineering and Mathematics

UCAS, Universities and Colleges Admissions Service

UK, United Kingdom

UNESCO, United Nations Educational, Scientific and Cultural Organisation

VCE, Vocational Certificate of Education

WEF, World Economic Forum

INTRODUCTION

In recent years, many relationships and attitudes have evolved. The adjustment of workplace policies has had a decisive impact on the retention and empowerment of female employees (World Bank, 2012). However, according to several studies (Gneezy & Rustichini, 2004) (Sutter & Glätzle-Rützler, 2010), it has been shown that the gender gap is already observed at an early age, indicating that gender differences in competitiveness (Niederle & Vesterlund, 2007) are manifested even before people encounter the labour market. These findings make it possible to focus on primary schools in this work.

The main purpose of the present study is to develop an experiment that would determine the extent to which personal prejudices (biases) affect women's behavior and create a favorable environment in primary schools in the UK.

The choice of the country, namely the UK, was influenced by its education system. In this system, when deciding on further education, students must choose the subjects they are willing to study. According to the latest data (Joint Council for Qualifications, 2019), this shows the main imbalance. Mathematics remains the most popular subject among English A-level students, but the proportion of girls who study A-level Mathematics is half that of boys. This leads to an imbalance in the labour market due to the lack of qualifications.

The main contribution of this study is its focus on primary schools. Although gender differences in competitiveness manifest at an early age, previous researches have mainly focused on adolescents and adults. Focusing on second-grade children, who range in age from six to eight years, helps provide evidence of early gender differences in competitiveness and how this could be reduced.

The study offers three possible explanations for the existing gender gap based on the basic literature. These are avoidance to compete with men, stereotype-threat and risk aversion due to opposed beliefs in actual abilities. One of the goals of this article is to conduct an experiment on mathematics lessons in primary schools in the UK by organizing gender composition in these classes, dividing them into two single-sex groups and one mixed. The current study examines preliminary results regarding the effectiveness of Mathematics lessons for single-sex groups. More specifically, the study sought to answer the following broad questions. First, do single-

sex Mathematics studies affect the competitiveness of girls positively? Second, do single-sex Mathematics lessons affect the competitiveness of boys?

A strong advantage and novelty of current learning that distinguishes it from the existing ones, is that the gender composition of classes changes only during Mathematics lessons, which does not affect the social life of children in their free time and helps focus only on the current subject. This criterion was based on longitudinal studies of British cohorts conducted by Sullivan et al. (Sullivan, Joshi, & Leonard, 2011) (Sullivan, Joshi, & Leonard, 2012), which proved that same-sex learning affects careers of women positively and affects social life of men negatively.

The effect of intervention will be measured by the desire to participate in the Primary Mathematics Challenge based on the responses of an anonymous questionnaire, which will be provided before and after the intervention. The results of the proposed experiment will help develop a policy proposal that could eliminate the impact of biases on students, which will reduce the gender gap in the future.

The main problems and difficulties of the present study are related to the experimental plan. One possible problem of the purposed class composition is parental approval, which can be difficult to achieve since an alternative intervention can be offered by composition of smaller classes. Another difficulty that will have to be encountered is the financial part of the study, since attracting additional teachers is expensive. However, the question of whether such an intervention could affect the gender gap and student choices in the future remains open, as it will take a long time to see if girls decide to continue their journey to further Mathematics studies.

A number of methodologies have been adopted to achieve the objectives of the study. The first method is a qualitative approach, involving the analysis of theoretical fundamental literature and articles on gender inequality in education, the competitive environment and the labor market. Based on the literature review, a theoretical framework model was created. Second, to understand the educational model of the UK, its history and overall system were investigated based on analysis of secondary sources. Finally, projections of implementations that could be performed and an experiment plan to justify policy proposals were presented.

The rest of the study is conducted as follows. The next section describes the relevance of the topic. Section III defines relevant biases affecting women's competition behaviour on the basis of theory and a fundamental literature review. Section IV presents an analysis of the UK

educational system and identifies key performance indicators for major changes and trends. Section V provides a random control test plan to assess the effect of the intervention applied and to highlight the main results and indicators to be achieved and compared. Finally, Section VI discusses all possible limitations and alternative interventions that may occur, and Section VII summarizes.

1. RELEVANCE OF THE TOPIC

“If the cure for cancer is forming in the mind of one of our daughters, it is less likely to become a reality than if it is forming in the mind of one of our sons. Until this changes, everybody loses.”

(Sadker & Sadker, 1994)

The relevance of the topic is determined by the increasing public awareness of the gender gap, especially in occupations that are historically considered male. As the World Economic Forum noted in the report on gender inequality in 2018 (World Economic Forum, 2018), “More than ever, societies cannot afford to lose out on the skills, ideas and perspectives of half of humanity to realize the promise of a more prosperous and human-centric future that well-governed innovation and technology can bring.”

In their social life and at work, women have long suffered from male dominance and have experienced impairment of their abilities. According to the World Economic Forum report in 2020 (World Economic Forum, 2020), even in countries with affordable and accessible education, women cannot occupy positions that are in great demand in the labor market. This mismatch of skills leads to a larger gender gap and also faces barriers to employment in the most dynamic occupations. Moreover, this has widened the wage gap, and the Global Gender Gap Index 2020 (World Economic Forum, 2020) shows that progress in narrowing the gender breach has stalled: none of the countries (including the top-ranked countries) has yet achieved gender pay parity. Women are still paid less than men.

Equal access to science is not only a social and ethical requirement for development, but also a necessity (UNESCO, 1999). In the era of the Fourth Industrial Revolution, technology skills are very important. According to the professional platform of social media platform LinkedIn (LinkedIn Learning, 2020), the most sought-after professional skills in 2020 will be data processing, artificial intelligence and cloud/scientific computing. All these skills take technical training into account. Women constitute 47% of the total workforce and 28% of science and technology workers (Google for Education, 2016). Women represent only 23% of the total labor force in such large technology companies as Facebook, Apple, and Google (see Appendix 1) (Richter, 2020). Although, taking into account the latest obstacles of 2020, when the COVID-

19 pandemic emerged, the traditional view of business and a company as such changed sharply towards new technologies. The demand for senior developers for many different programming languages (e.g. JavaScript, Python, and Ruby), computer engineers, data processing specialists is growing and is not limited to the technical sector, as more companies hire technical groups to launch and expand. Due to the role that technology plays in modern business, technical specialists are needed in all types of sectors: banks, retail, and media companies. These are current and future occupations that should be considered by women too. However, the total number of STEM graduates is increasing, companies still cannot take positions with the necessary skills and close the gap. This phenomenon is called the global STEM paradox (Kramer, Tallant, Goldberger, & Lebus, 2018).

While the number of women exceeds the number of men in terms of higher education and contradicts the expectations of the existing history, women are significantly underrepresented in Mathematics, science and technology, starting from high school, with the largest differences in engineering and computer science and beyond (Murphy & Whitelegg, 2006) (Lynch & Feely, 2009) (NGC Project, 2018). One such example is the University of Oxford, which in 2017 admitted more women than men to its undergraduate programmes for the first time in its history. Although, according to the annual statistical report of the University of Oxford (University of Oxford, 2020), the largest number of applicants enter the following courses: Economics (16,8 applicants per place), Computer science (14,8), and Mathematics (8,4) (see Appendix 2). In 2017, 2018, and 2019, the University of Oxford admitted more female students living in the UK than men (see Appendix 3), but the proportion of women from the total number of British students admitted to the course of Informatics is only 15,2%, the course of Economics - 29,6%, Mathematics and Computer science - 14%, Mathematics - 30,2%, Physics - 18,2%. This gender gap is reflected in the fact that the number of women enrolled in these courses is significantly lower than that of men (see Appendix 4). This situation is typical for the whole country: female students are considered as 39,3% of A-level Mathematics entries in 2018, and 28,3% studying Further Mathematics (see Appendix 5). While Mathematics is the most demanding and preferred A-level subject choice for male students, for female students it is fourth behind English, Psychology, and Biology. Meanwhile, girls show the same results by solving standard math tests, but do not consider choosing this path in terms of professional development and further education, this results in the STEM pipeline.

Performance in Mathematics predicts future earnings (Murnane, Willett, Duhaldeborde, & Tyler, 2000) (Bertrand, Goldin, & Katz, 2010). Recent literature documents the link between

gender differences in competitiveness and labour market outcomes (Croson & Gneezy, 2009) (Niederle & Vesterlund, 2011). In the Competitiveness Progress Report, Professor Niederle stated that competitiveness is a psychological feature that helps predict the choice of Mathematics and science in school, and such gender differences in competitiveness can help describe the differences in these educational choices (Niederle, 2017). The labour market outcome, such as the STEM pipeline described in current research, is strongly associated with willingness of individuals (especially women) to enter the competition. The main results of the experiments are that women avoid competition. This effect is stronger if they compete with men (Niederle & Vesterlund, 2007). A study based on fifteen-year-old students in the Netherlands (Buser, Niederle, & Oosterbeek, 2014) found that boys are more competitive than girls and that the level of competitiveness of people determines further academic choices, so that more competitive people choose a more prestigious education - the direction of nature and technology (which includes Physics, Mathematics, and IT). Another experimental evidence showed that competitiveness correlates with the choice of educational programmes in colleges of Norway (Ingvild, Cappelen, Salvanes, Sorensen, & Tungod, 2016). A study by Buser, Peter, and Wolter (2017) found that in high schools in Switzerland, competitiveness describes the gender gap in specialities with intensive mathematical analysis (Buser, Peter, & Wolter, 2017). In the Kamas and Preston study (2018), the results showed that the most competitive students achieve technical and business degrees (Kamas & Preston, 2018).

Although we mainly focus on the results of the top of the pyramid, i.e. the labor market, some studies prove that the problem of gender and competition arises at a young age (Gneezy & Rustichini, 2004) (Sutter & Rützler, 2014) (Rothgerber & Wolsiefer, 2013), which motivates this study to conduct an experiment in primary schools, the very beginning of pipeline formation. Fryer and Levitt (2010) in their study data from the Early Childhood Kindergarten Cohort (ECLS-K) in the United States found that when children entered kindergarten, girls and boys performed on the same level, but by the end of 5th grade girls were significantly worse than boys from the point of view of all mathematical skills. The poor performance of girls is present in all sectors of society (Fryer & Levitt, 2010).

The main questions arise: is this due to the preference of the female participants or due to the presence of entrance barriers? Answering this question can address the mismatch of skills and gender gaps, and lead to more innovation and development.

2. LITERATURE REVIEW

This research paper determines whether girls and boys differ in their willingness to participate in math competition. An obvious explanation for gender differences in participation choices is that females and males differ in their level of competitiveness and ability to solve mathematical tasks, hence they should select whether they will participate in a challenge according to their level of competitiveness and own beliefs about their ability.

A main contribution of this research paper is to generate an environment in math classes in UK's primary public school such that it would be possible to affect the participation choice of pupils and compare this to their actual choice of participation. Controlling for ability, there are considered three possible explanations or hypotheses why girls and boys may differ in their choice of participation.

2.1. EXPLANATION I: MALE-PRESENCE IN COMPETITION

Through a large number of recent studies, the concept of behavioral differences between men and women in the face of competition has been proposed (Niederle, 2017) (Niederle & Vesterlund, 2007) (Croson & Gneezy, 2009). The results of the studies show that females are less responsive to competition as than males of the same ability level (Gneezy & Rustichini, Gender and Competition at a Young Age, 2004) (Niederle, Gneezy, & Rustichini, 2003). Therefore, personal attitude towards tournaments generally depends on gender (Backus, Cubel, Guid, Sanchez-Pagez, & Mañas, 2016), while the main finding of the experiments is that women 'shy away from competition' (Vandegrift & Brown, 2005) (Niederle & Vesterlund, 2007) (Gupta, Poulsen, & Villeval, 2013). The effect is the most significant if women compete against men, and especially if male rivals are in majority (Hogarth, Karelaia, & Trujillo, 2012). This finding is also reflected in the research of Inzlicht and Ben-Zeev (2000). The authors found that mathematical performance of female college students outnumbered by men in mixed-gender groups is substantially lower. By comparison, the majority of women in study groups do not affect the performance of men. These results put weight on gender composition of classrooms (Inzlicht & Ben-Zeev, 2000).

The study of Gneezy et al. (2009) shows that the competitive attitude of individuals is strongly affected by cultural and social environment. The authors conducted an experiment in two different societies: a patriarchal society and a matrilineal society and found that the men of the

patriarchal society are more willing to compete than women, while the representatives of the matrilineal society behave completely differently. Besides that, the results show that women of the matrilineal society are a bit more competitive than men of the patriarchal society. The obtained results of the study are crucial for understanding the fundamental role of a society and cultural patterns for competitiveness of an individual (Gneezy, Leonard, & List, 2009).

Another two studies involving secondary school students demonstrate similar conclusions. After losing a competition, girls are usually reluctant to participate again. Obviously, competitiveness and willingness to compete are affected by the attitude towards failure (Buser & Yuan, 2016) (Rothgerber & Wolsiefer, 2013).

In the paper of Rothgerber and Wolsiefer (2013), authors study scholastic chess competition among elementary, secondary and high schools. The results show that girls perform worse than expected when facing male competitors and reach only 83% of the expected success estimated in accordance with their own pre-rating of each opponent. It is of importance to note that female losers experiencing stereotype threat were less likely to enter chess tournaments in the future. The field data of Year Four and Year Five secondary school students in the pre-university track participating in Dutch Mathematical Olympiad were examined in the research of Buser and Yuan (2016). The authors found that gender affects feelings and perception of loss along with the maintenance of the effect in the longer term. A year after participating in the Olympiad, losing women are much less likely to participate in competitions again, which is not the case of losing men.

Although the majority of the above-mentioned experiments are focused on adult or adolescent participants, multiple studies have proven that gender and competition problems emerge at a very young age (Gneezy & Rustichini, 2004) (Sutter & Rützler, 2014) (Rothgerber & Wolsiefer, 2013). This fact motivates to run an experiment in elementary schools, where personality begins to form. In the research of Sutter and Rützler (2014), they studied differences in willingness to compete among kids and teenagers aged three to eighteen years. The main result of the paper shows that boys are more likely to participate in competitions than girls of all ages, and that the gender gap in competitiveness is observed in the early years of life and does not change significantly after the age of three. Another experiment by Gneezy and Rustichini (2004) performed on 9-year old children determines that boys facing a competitive environment usually improve their performance. However, this is not typical for girls. Iriberry and Rey-Biell (2016) demonstrate that this effect in the framework of a Mathematics competitions for students

aged 10 to 16 years: girls lag behind their Mathematics scores, and at later stages of the contest, where competitive pressure is higher, the effect of girls' underperformance is even stronger (Iriberry & Rey-Biel, 2016).

2.2. EXPLANATION II: UNCONSCIOUS GENDER BIAS

“Unconscious gender bias is defined as unintentional and automatic mental associations based on gender, stemming from traditions, norms, values, culture and/or experience. Automatic associations feed into decision-making, enabling a quick assessment of an individual according to gender and gender stereotypes” (International Labour Organization, 2017).

Another study of Iriberry and Rey-Biel (2017) showed that women's productivity is highly dependent on tasks used to measure performance, information provided before competitions, and existing stereotypes (Iriberry & Rey-Biel, 2017). The evidence showed that women tend to be inferior in a competitive environment exceptionally when tasks are seen as traditionally masculine and performed in favor of men. Moreover, this effect is manifested only when women are given preliminary information about their opponents. These results lead to the next possible prejudice that women face when they participate in competitions, i.e. stereotype threat.

In his work on intellectual identity and performance in schools, Claude M. Steele (1997) identified social and psychological pressure on women as gender roles, segregation of social practices, restrictive cultural orientations, and limits of historical impact with stereotype threat. The author associates it with lower productivity in standardized tests (Steele, 1997). An experimental study of Ambady et al. (2001) demonstrated the direct impact of stereotype threat on girl's behavior while solving mathematical tasks. The experiment was based on participation of primary and junior schools, as well as secondary school girls, aged 5 to 13 years. Primary and secondary school participants demonstrated significantly worse results on the Mathematics test when their gender identity was activated. Although the result of the upper primary school participants was different, this laboratory experiment shows evidence that girls are vulnerable to stereotypes from an early age and proves the fact that such an influence can adversely affect their performance (Ambady, Shih, Kim, & Pittinsky, 2001).

Studies by Keller (2002) and Keller and Dauenheimer (2003) found that young women (the average age 18) and teenage girls (the average age 15) are vulnerable to stereotypes in the classroom environment. The authors asked one group of women to solve a Mathematics test and informed some participants about the fact that the test has evidence of gender differences.

The control group that did not have conditional information performed better than the group informed about gender differences (Keller, 2002) (Keller & Dauenheimer, 2003).

Huge and Regner (2007) continued their research by modifying the previously mentioned study and focusing on younger girls (10-12). They conducted two studies trying to replicate the natural environment of a classroom. The standardized recall memory tasks such as Geometry tests and memory games have led to different performance of girls. The results showed the presence of stereotype threats in a typical school environment (Huguet & Regner, 2007). Another study of stereotype threats in the natural environment was presented by Rothgerber and Wolzifer (2014). The study was based on data taken from 12 school chess tournaments. Girls facing an opponent of the opposite sex demonstrated worse results than expected. The strongest effect was observed among the youngest chess players from elementary schools. This is logical, since other chess players have already passed the selection for competitiveness in previous years. To test stereotypical understanding and to measure the impact of this socio-psychological threat, the authors conducted an oral questionnaire asking whether girls or boys should perform better in chess competitions. The results show that girls are more vulnerable to stereotype threats and are less likely to continue playing games and participating in chess matches in the future. In addition, these results are not reflected in male group, which confirms the results of previous studies: stereotype threats are not common among all young chess players and are harmful to girls only.

2.3. EXPLANATION III: WOMEN ARE MORE RISK AVERSE

There is a growing body of evidence that women and men differ in their attitude towards risk due to their confidence and subjective ability (Croson & Gneezy, 2009) (Iriberry & Rey-Biel, 2016) (Niederle & Vesterlund, 2007) (Niederle & Vesterlund, 2011) (Dweck, 2008). Although men tend to be overconfident in their abilities and participate in competitions even if the chances of winning are low, high-performing women are more willing to avoid competition and lower expected results. Niederle and Vesterlund (2007) found that women who control their performance are used to have significantly lower beliefs about their subjective ability than men. In addition, in challenging and more competitive tasks (such as competitions), the gender gap in beliefs is much higher than the gender gap in non-competitive events. This gender gap in beliefs accounts for almost one third of the gender gap in tournament entry. A study by Dohmen and Falk (2011) found that people with high relative self-esteem choose tournaments, because their outcome depends on the outcomes of other participants, while more risk-averse and less

productive people choose fixed schemes, and this effect is much stronger among women. In a controlled laboratory experiment, women were more likely to choose fixed results (Dohmen & Falk, 2011). This confirms the fact introduced by Niederle and Vesterlund (2007). In the study by Preckel et al. (2008) they found support for the findings of Eccles (1998) that girls subject to academic achievement are less confident in their relative ability than boys, but the difference increases among gifted, i.e. high-ability children (Preckel, Goetz, Pekrun, & Kleine, 2008). Using a self-report questionnaire to measure academic self-concept, interest and motivation in studying Mathematics among girls and boys from 6th grade (the average age of the sample was 12,77 years) in German schools, Preckel et al. found that boys are generally more confident in their Mathematics knowledge, and especially gifted ones give significantly higher self-esteem and interest scores than boys and girls with average abilities. At the same time, there is no significant difference between the scores of gifted girls and girls of medium ability. This leads to the conclusion that girls tend to underestimate themselves when measuring mathematical ability regardless of their actual grades and performance. The study suggests that socialization practices related to gender roles are more important than cognitive abilities. Another paper proposed by Niederle and Yestrumskas (2008) shows that women are very uncertain about whether they can perform complex tasks well, but generally there is no difference in their perceptions of relative ability (Niederle & Yestrumskas, 2008). After providing feedback on completing the first task, the authors found no gender difference when choosing the difficulty level of the follow-up tasks, which can be explained by the fact that women no longer have confidence in their future success. On the other hand, Wozniak et al. (2014) conducted experimental research on mathematical and writing tasks. The research presented evidence to prove that relative productivity feedback has a positive effect on high-ability women (Wozniak, Harbaugh, & Mayr, 2014). The results of the experiment show that providing feedback on the relative performance of all participants will force women to be more likely to participate in the competition. Women with high ability have much stronger influence on this, while men with weaker ability moved towards less competitive forms. The gender gap in competition selection has been narrowed, with no significant differences between men and women. Indeed, the study showed that the choice depended on relative performance information and on human improvements through tasks. Another result of the experiment confirms previous observations that men are more confident in their abilities. Namely, men are more confident in their subjective abilities in Mathematics. Men preferred to compete more than women, both in mathematical and written problems. However, their self-confidence was higher in mathematical tasks.

In the study of Iriberry and Rey-Biel (2016) based on Mathematics competition, women missed answers to questions in proportion to increasing competitive pressure. What is more, the number of correct answers was reduced (Iriberry & Rey-Biel, 2016). Same evidence of females skipping answering in case of penalty for wrong answer or reward for not answering was found by Espinosa and Gardezabal (2013), and Baldiga (2014), where using a laboratory design she shows that women are reluctant to guess on multi-part choice tests. The increase in women's underperformance is due to the fact that female participants are more likely to be at risk, lack confidence in the likelihood that someone will know the correct answer when encountering a problem, and lack confidence in common abilities (Espinosa & Gardezabal, 2013) (Baldiga, 2014).

The above-mentioned literature on integrated research with field data gives the following conclusions. The gender gap arises at an early age and can be explained by differences in attitudes to competition, stereotypes, risks, and confidence. Women tend to avoid competition, are less confident in taking risky and complex decisions, and are more influenced by such socio-psychological factors as stereotypes. This effect is enhanced in the presence of men, especially when men make up most of the group. According to Sunstein and Thaler (2008), changing the composition of the environment can reduce the influence of biases faced by people and lead to an increase in the general well-being of the society. Thus, by applying the knowledge gained from existing experiments and research, it is possible to create a more optimal environment in Mathematics lessons of primary schools in order to reduce the gender gap in this sector and push individuals, namely girls, to get better choices (Thaler & Sunstein, 2008).

3. EDUCATIONAL SYSTEM IN THE UK

The education system in the UK is divided into four main parts: primary education, secondary education, additional education and higher education. Children in the UK must attend primary and secondary school, which lasts from age of 5 to 16 years. The choice of the educational system is justified by its narrowness and has a reputation for favoring disciplinary specialization over multidisciplinary diversification. This leads to the outcome of the STEM pipeline.

Students are assessed at the end of each stage of educational levels. The most important assessment takes place at the age of 16, when students receive their General Certificate of Secondary Education (GCSE). After completing GCSE students have a choice: to continue their education and obtain a potential higher education, or to finish school and start working.

Studying Mathematics is compulsory in primary and secondary schools. Mathematics along with English and Sciences (either combined or separate Biology, Chemistry, and Physics) is the core subject tested for obtaining GCSE. Later students select four or five additional subjects, e.g. French, German, Business Studies, Design and Technology, Music, etc. Students in public schools usually take 5 to 10 GCSEs based on their ability and motivation. For private schools, which are usually a lot more results driven, it is common for students to focus on academic subjects and to take up to 11 or 12 exams. Additional and higher education is optional, and students are not obliged to take further Mathematics.

In the UK boys and girls achieve broadly similar GCSE results, nevertheless, the numbers of students studying Mathematics at an advanced level reveals a gender-based gap (Joint Council for Qualifications, 2019). A fairly small proportion of students aged 16-18 chooses these courses. Although the interest in Further Mathematics has increased, the proportion of female students remains at the same level. If girls studying A-level¹ Mathematics is half the proportion of boys, but Further Mathematics studies - less than one third of the total number. Female students accounted for 39,3% of A-level Mathematics entries in 2018. Speaking about Further Mathematics, this dropped even further to 28,3%. While Mathematics is the number one A-level subject choice for boys, for girls it is fourth behind English, Psychology, and Biology.

¹ **A-level** – The General Certificate of Education Advanced Level (GCE A-level, or more commonly, the A-level), is an academic qualification taken in England, Wales, and Northern Ireland by students completing further education (secondary or pre-university education).

In Smith and Golding studies (2018), the authors examined important practices that could affect the participation of girls in A-level Mathematics, as well as to support their interest in the future. They found that one of the possible reasons why girls did not study Further Mathematics was that previously teachers believed that studying this subject was everyone's personal choice, and students choosing Further Mathematics to study already had a sense of commitment. At the same time, some girls reported that they simply did not think about such an opportunity. This may indicate that the school environment plays an important role (Smith & Golding, 2018).

As for further education, most schools in the UK have a "6th grade". Students can enter it after passing GCSE exams. As an alternative, there are many "6th grade colleges". Here, students usually study A-level subjects. A-level, like GCSE, is carried out according to a two-year programme. Students usually study two to three A-levels depending on academic ability and aspiration. Students of independent schools can take up to five A-levels. Subjects are evaluated by a series of exams. To enter college and a specific programme, students typically must meet the following requirements: at least five GCSE final exams for grades 9 to 4 (A * to C)² and at least 7 grades (B) in a specific subject or subjects they are interested in. However, special requirements for studying A-level subjects vary between schools and colleges. Depending on grades and interest, students in the UK are forced to choose a course of study even before entering a university. At this stage, girls who achieve the same level as boys can choose to study Further Mathematics.

After graduating from college, depending on their A-level qualifications and university requirements, students can apply for up to five undergraduate courses. These can be five courses at five different universities or five courses at one university. Academic performance is the main criterion for applications in the UK University courses should be connected with the subjects studied at the college.

The choice of college courses represents the future choice of university programmes. This means that if the choice is wrong or the willingness to make any changes is strong, it is difficult to switch to another theme and take the risk. This means that the UK education system is not flexible and that in primary and secondary schools, students should receive assistance and to have a full understanding about subjects that reflect their true preferences and will lead to the right results in the future.

² The grading varies depending on the region.

4. EXPERIMENT DESIGN

One of the goals of this paper is to conduct an experiment in Mathematics lessons in primary schools of the United Kingdom. The main contribution of the research would be an outcome that will help to build a policy proposal in order to eliminate the effect of the bias against female pupils, which would lead to a noticeable reduction of the gender gap in the future. The effect of the intervention will be measured through willingness to compete in the Primary Mathematics Challenge. The choice in favor of this event was made due to participation of both genders, as well as the fact that all results depend on effort and ability, not luck. The Challenge is as important as chess tournament competitions. Both activities are mainly dominated by males. It also considers the fact of stereotyping towards males in Mathematics competition, naming that it's not a female type of occupation and contributing to the continuing stereotype that women and girls lack mathematical ability. What is more, there is no convincing evidence that any gender has inherent advantages in Mathematics.

The experiment should take place in a state coeducational primary school in the UK with a focus on the three second forms' classes. According to Independent Schools Council, all primary schools are mostly concentrated in the cities, accordingly with the biggest concentration around London urban area. In order to be able to represent the most significant and the closest to validity effect, free coeducational school in London urban area should be tested. Taking the studies of Buser et al. (Buser, Niederle, & Oosterbeek, 2014) on competitiveness and its effect on educational choices as an example of the experiment design, four schools should be considered as the minimum requirement to estimate the significant effect of the intervention. The reason of focus on second formers is justified by the fact that such pupils have already learned their preferences in the subjects during the first year and could give a clear idea whether they like and are good at Math or other subjects. In order to make an intervention natural, the experiment should be presented as the National Math Campaign that could be driven by Ministry of Education or might be purposed by National Numeracy³, which could be highly interested as it aims to challenge negative attitudes, influence public policy, and provides practical ways of helping children to improve their numeracy. During the experiment 1 additional teacher will be provided to each school exceptionally for Math classes

³ National Numeracy is an independent charity established in 2012 to help raise low levels of numeracy among both adults and children and to promote the importance of everyday maths skills.

in order to divide classes into 2 treatment groups and one control group, keeping all the conditions except intervention the same.

4.1. DESCRIPTION OF THE PRIMARY MATHEMATICS CHALLENGE

The purpose of this competition is to understand the ability of elementary school students aged 5 to 7 to think out of the box. The test focuses on problem-solving rather than formal knowledge of a standard programme. The questions do not affect the curriculum, and children should be forced to use logical reasoning to give answers.

The PMC paper (see Appendix 6) contains 25 questions. 20 questions are multiple choice questions. The questions are graded on a simple starting with simple questions and graduating to harder questions. The last five questions have no possible answers. Students are given 45 minutes to answer the question, starting with 10 simple ones. Students with high scores will be invited to participate in the PMC bonus round, which will lead to the next stage of the competition - world level. The PMC provides participation certificate “Took the Challenge” to every participant.

4.2. TREATMENT GROUP 1 AND 2: SINGLE-SEX CLASSES

Two previously mixed classes will be divided into two single-sex groups, that consists 30 girls in one group and 30 boys in another group. This gender composition of the class has been long time discussed as effective way to decrease the effect of the previously mentioned unconscious gender bias, eliminate effect of the men presence and reduce doubts and risk fears.

According to Smithers, until the 1960s all schools in the UK were single-sex schools attended today by 6% of children only (Smithers & Robinson, 2006). A controversial evidence exists among studies on single-sex education. A study by the Institute of Physics (Murphy & Whitelegg, 2006) and other studies have shown that girls often have different learning patterns, and trainee teachers need to be aware of these differences so that both boys and girls can engage the same level of interest from both boys and girls during their lessons. Advocates of single-sex education believe that the gender composition in a classroom can influence a girl’s investment in both Mathematics and science. In fact, Fryer and Levitt (2009) provided evidence in a recent study that single-sex education may increase girls’ self-confidence and make girls less stereotyped about gender roles in Middle Eastern countries with a high level of gender inequality. Niederle et al. (Niederle, Segal, & Vesterlund, 2013) demonstrate that a quota can

affect tournament entry (in environments without any discrimination) because females are willing to compete with other women rather than with men. Booth and Nolen (2009) have examined competitiveness among 260 fifteen-year-old British teenagers and found the evidence that girls from single-sex schools were more willing to enter the competition than girls from co-educational schools (Booth & Nolen, 2012). This fact raises awareness about differences in behavior and is a great support to a conclusion that social learning is of utmost importance. Gneezy and Rustichini (2004) in their experimental study draw a parallel between girls competing while running and girls competing while studying. Their findings are related to discussions regarding single-sex schools. Girls who are as talented as boys will end up performing poorly because they are not as competitive and do not perform as well as boys. A study of Seifert (2009) based on three classes of Algebra at the secondary school with different gender composition showed an evidence that single-sex classes perform much better and that female pupils achieve the highest scores (Seifert, 2009). An important study of the attitudes of American students from independent schools as they entered colleges found that female students in single-sex schools have significantly higher self-confidence in Mathematics, academic engagement, and aspirations (Sax, Riggers, & Eagan, 2013). The study has been repeated recently, and the interim results confirm the persistence of the advantages of single-sex school girls. A longitudinal study of single-sex schooling of British cohorts born in 1958 provided the following results: positive effect on wages of women that have been attending schools for girls only, which was accounting by better performance in comparison to those who came from coeducational and had no effect on performance of men (Sullivan, Joshi, & Leonard, 2011). Another study of Sullivan et al. (Sullivan, Joshi, & Leonard, 2012) shows a significant link to attending a single-sex school a lower level of absence for both genders. The absenteeism rates of single-sex schools are relatively low for both genders, while men are tended to get divorced and disgruntled at age of 42. The authors explain it by the fact that communication with diverse people during the years of schooling helps boys to be more social and build healthy relationships. This justifies the choice of splitting the class on two genders only during the lessons of Mathematics. All pupils can freely communicate during breaks. It will not affect their social outcomes in the future and will help to get rid of the biases during lessons.

Control group 3 will consist a regular size of 30 pupils with the same proportion 1:1 of female and male ones. This control group will experience the same intervention in face of new teacher, all the other conditions will remain the same as in the natural environment of the school.

4.3. MAIN QUESTIONS OF THE STUDY

This study investigated preliminary findings related to the effectiveness of single-sex and smaller classes in math. More specifically, the study sought to respond to the next two broad question:

1. Do single-sex math classes positively affect the willingness to compete in Math Competition among girls?
2. Do single-sex math classes affect the willingness to compete in Math Competition among boys?

4.4. CONDITIONS OF INTERVENTION

Intervention will take place in the beginning of the new academic year of the second form classes. During their first week pupils will be informed about the Primary Math Challenge and new composition of the Math classes. Children will be notified that everyone will have to take part in the challenge as a part of preparation for the SAT that will take part in the end of the academic year, but only those who want to participate in the Challenge on the national level will have to write it anonymously in the questionnaire that will be provided to each pupil.

4.5. EXPERIMENTAL VARIABLES AND PUPILS' CHARACTERISTICS

Pupils attitude towards Math and competition will be measured through the next questionnaire that will be provided before the intervention (on the first day of school) and after intervention (right before the PMC):

1. Competitiveness: Do you want to participate in Primary Math Competition?
Yes/No
2. Confidence: Do you think you will perform:
Very well, Good, Ok, Bad, Very bad
3. Subjective ability: For you, Math is
Very Easy, Easy, Ok, Hard, Very hard
4. General preferences: Do you like math? What is your favorite subject?
list of subjects
5. Stereotypes: Who you think is better at math?
Girls, Boys, Both

6. Pupil characteristic: name, gender, birth date

It is important to mention as if the study is focused on a very young age, in order the kids would feel comfortable, the questionnaire will be provided on the computer with cartoon images in an interactive manner, therefore kids would less stressed. The questionnaire was replicating the example of the research of Buser, Niederle and Oosterbeek (2014) on the choice of academic track of secondary school students in the Netherlands, where they use similar type of questionnaire to measure competitiveness, confidence, risk attitudes and subjective ability. Similarly, to measure for stereotype awareness Ambady et al. (Ambady, Shih, Kim, & Pittinsky, 2001) in their study were asking each participant the following question “Are boys better at math, girls better at math, or are they the same?”. Another study on stereotype threat was asking girls if they have heard that good chess players are usually boys (Rothgerber & Wolsiefer, 2013). Preckel et al. (2008) in their study checked for interest, self-concept and motivation through a similar questionnaire (Preckel, Goetz, Pekrun, & Kleine, 2008).

Anonymity of the questionnaire should provide true preferences of the children, as well as the fact that everyone will have to take part in the Math Challenge in any case, might encourage those who are vulnerable to opinion of the society to enter the competition with no risk of publicity. The differences in the answers on the questionnaire before and after the intervention will provide us with information on the effects of it and it helps with dealing with biases.

Taking into account the relevant literature on competitiveness the main hypotheses are:

1. Single-sex classes will positively affect girls in terms of competitiveness and stereotype threat;
2. Single-sex classes won't have any significant effect on competitiveness and stereotype thinking of boys.

After completing Primary Math Challenge, every kid that decided to participate in national competition will receive a cheerful certificate with description of their strengths and will be asked if they are willing to participate next year.

5. DISCUSSIONS AND LIMITATIONS

The described Random Control Study represents an ideal intervention model. In fact, the experiment may face a number of limitations:

1. The cost of the intervention. Starting with financial support, the National Account Organization, and the Department of Education may find it costly to provide additional Mathematics teachers for each participating school, since the average salary is £30,847 per year. Meanwhile, the Primary Mathematics Challenge package consists of 10 tests, and costs £11. The number of tests needed for one school is 90. These financial requirements make it difficult to conduct the experiment without support, and funding.
2. Psychological effect. Second grade pupils will have to adapt to new teachers after getting used to their regular teachers. Moreover, some of them will face a new composition of a class. Such changes may affect the outcome and the full effect of the trial, making it less natural, providing the same teacher to all three groups, including treatment and control groups, should smooth this effect and see whether the treatment had a significant effect, as all three groups would experience the same changes from the teacher's point of view. However, this makes it impossible to work with previous teachers, because some students may get used to them and are not stressed, which makes such trials less random.
3. The effect of teaching methods. It is impossible to control the methods and talent of a teacher. The study may encounter a problem of outcomes depending on the teaching style of each teacher in different schools. It is impossible to provide the same teacher to all four schools too, which makes it difficult to control whether students are inspired to be more competitive and participate in activities.
4. Time limits. Since the presence of the STEM pipeline is one of the reasons for the relevance of the experiment, time constraints make it impossible to see if this experiment will affect the future decisions of these students. The trial will show the direct impact on participation in the Primary Mathematics Challenge but will not guarantee whether a year of intervention will be enough to show the same results in the future when the intervention is no longer conducted. A possible solution is to conduct

the intervention throughout primary and secondary school to see the impact on academic choice and competitiveness.

5. Parental approval. In addition to sponsorship, it is important to note that since the study is aimed at children, it automatically takes into account the fact of communication with their parents. Some parents may oppose the intervention, as they will see it as unnecessary stress and avoidable harm to their children. Although, according to children, the uniqueness of this study is that it is socially friendly. Students still have an opportunity to spend their breaks and free time separate from Mathematics lessons, and the gender composition changes only during this particular lesson, so they do not show isolation as such. Moreover, they can focus on the subject much better.
6. Small sample. Another problem that this research faces is that the sample size might not be enough to show the significant effect. As well as the study will be focused mostly on urban London area, while not covering all the schools in the UK. This might lead to underrepresentation of the real situation that is happening in primary schools there and might lack justification and arguments towards changing whole educational policy.
7. Kid's mentality. Dealing with kids might be a very demanding process as at the very young age they still are understanding and developing their character. The study might face problems of kid's stress due to the questionnaire and uncertainty of the Math Competition, as well as change of the teacher and whole composition of class, even though just for the Math lessons might be very nervous for pupils. It might bias the results as won't be absolutely natural environment. As well as the kids from other mixed gender math lesson might inform that their gender composition of the class didn't change, therefore make an effect and disturb the intervention process.

The division of classes into smaller co-educational groups and the study of the effect of smaller classes on the competitiveness of students is one of the possible solutions to the problem of class composition and environment. It is more common and favorable for parents too. Niederle and Vesterlund (Niederle & Vesterlund, 2010) argue that single-sex evidence is not clear and that all recent studies do not take into account the fact that schools of this type are usually private. What is more, religious affiliation and self-choice can play a very significant role, so identifying mathematical differences is not definitive. The size of a class is one of the main advantages of a private school. Smithers and Robinson (2006) argue in their study that it is

difficult to compare single-sex schools since they differ not only in gender, but also in size, abilities and origin of students. In addition, such factors as leadership and qualifications of teachers should also be taken into account when comparing socioeconomic status, ethnicity and school. The success of school management for girls and boys does not only depend on their gender status (Smithers & Robinson, 2006).

According to statistics (Stevens, Parkes, Chan, & Chan, 2019), there are only 6,5% of independent schools in the UK, while 17% of them are single-sex schools. Although, it can be seen that there are many other schools where single-sex approach predominates (see Annex 7). One of the main advantages of private schools is the size of classrooms. According to statistics (Department for Education, 2020) from a study provided by the UK Department of Education, the average class size in primary school is 27,1. This is one of the highest rates in OECD countries, while the average size of an independent primary school is almost twice lower. The data shows that students in private schools are twice as likely to receive a matriculation certificate in Mathematics, Physics, and Chemistry as their peers in public schools. These subjects are required for admission to Oxford, Cambridge and 18 other leading universities (Russell Group, 2011).

It is known that teachers of smaller classes can pay more attention to each pupil. The quality of education is better too, since teachers can control the situation and understand the needs of their pupils. These results may justify the choice of a smaller class size, but such a trial is more difficult to carry out and control for teacher's characteristics becomes almost impossible. Although, it gives ideas for new future researches to identify whether it is a gender composition or the size of the class or the both that nudge students towards right choices and better educational outcomes.

6. CONCLUSION

The increased interest in narrowing the gender gap motivates more and more researchers to seek a solution to this problem. The problem of the pipeline in science is remediable. However, this will require time, money, and joint efforts from the side of many people and institutions. First of all, schools. It is crucial to create a suitable learning environment so that each child feels comfortable studying any subject. Numerous studies have presented the idea that women avoid competitive situations and are nascent from an early age.

This research provides us three main explanations for the fact that women are less likely to compete and less involved in Mathematics. Firstly, the attitude to competitions among men and women differs. Women avoid competition, and the effect is especially strong if they encounter a male rival. Men-presence affect behavior of women. Secondly, the threat of stereotyping plays a very important role in decision-making. Social and cultural pressure forces girls to behave as they think they all expect them to behave and deviating from this behavior makes them feel wrong. By embarking on the study of Mathematics, which is supposed to be a male-dominated sphere, women face increasing stereotypes that they have to deal with too. And the last reason is risk aversion due to a lack of confidence and wrong beliefs in own ability. Women are more prone to risk and prefer certain outcomes. Having the same ability or even higher, women underestimate themselves, which leads to taking less risky decisions and avoiding competition. Although men with lower abilities prefer to try their chance and take a challenge.

The current study focuses on the UK educational system. The choice is justified by the fact that Mathematics is not a compulsory subject. The proportion of girls who study A-level Mathematics is half that of boys and the proportion of those who study Further Mathematics is less than one-third despite the fact that Mathematics remains the most popular subject among English A-level students. This leads to an imbalance in the labor market due to the lack of qualifications.

To solve the current problem, the following random control trial was proposed: single-sex Mathematics lessons in primary schools. The experiment helps to identify the differences in attitudes to competition among second-graders and to show the effect of gender composition on readiness to participate in the Primary Mathematics Challenge programme. To measure the attitude of students to Mathematics and competition, a questionnaire is provided before and after the intervention. Providing the same teacher for single-sex treatment groups and for the

mixed gender control group helps to create the same conditions and smooth out the psychological effect of new teacher in every group. The result of the intervention answers the following questions: does the gender composition of a class affect the willingness of children to compete and can become a solution to the gender gap.

The novelty and advantage of the research is due to the age of all participants and the division by sex only during Mathematics lessons. Previous researches have focused on adolescents and adults, ignoring the fact that differences in competition-related behaviors manifest at an early age. This fact encourages intervention in early learning methods and processes. The research on same-sex education mainly focuses on single-sex schools, which tends to be more private and specialized and makes researches more selective than random. The common result is that girls achieve better results and perform better, while boys do not suffer from their academic and professional performance but suffer from anxiety and are less sociable. This research avoids the above-mentioned problem by separating classes only during Mathematics lessons and allowing students to communicate in their free time.

It is important to note that despite the contribution of the study, the following problems may arise: a funding problem, parental approval, and the influence of teaching and/or learning methods. Providing an additional teacher for Mathematics lessons in each school can be too expensive. Parents can compete against single-sex education, considering it less effective yet more stressful for children. New methods can affect the attitude of students to competitions and not on gender composition. This issue cannot be controlled, since one teacher cannot be provided to all participating schools.

One of the alternative ways to change the schooling environment, which will affect the behavior of students towards greater competitiveness, is to divide classes into smaller groups. It is well known that private schools with smaller classes provide more competitive and confident students. Such separation may have positive feedback from parents but will require more funding.

Now, in the era of new technologies and advanced science, it is important not to lose the workforce in the face of women and to move towards a progressive society in which women feel comfortable and confident. Creating an enabling environment for both sexes not only helps to narrow the gender gap, but also helps to increase overall well-being and reduce barriers to high-level posts. Institutions understand that instead of making science more attractive in

general, they should focus on the biggest educational goal, i.e. women who are left behind. Further research should find a solution to how to get rid of unconscious gender biases.

REFERENCES

- Ambady, N., Shih, M., Kim, A., & Pittinsky, T. L. (2001). Stereotype Susceptibility in Children: Effects of Identity Activation on Quantitative Performance. *Psychological Science*, 12(5), 385-390.
- Backus, P., Cubel, M., Guid, M., Sanchez-Pagez, S., & Mañas, E. (2016). *Gender, Competition and Performance: Evidence from Real Tournaments*. Institut d'Economia de Barcelona (IEB): Working Paper.
- Baldiga, K. (2014). Gender Differences in Willingness to Guess. *Management Science*, 60(2):434-448.
- Bertrand, M., Goldin, C., & Katz, L. F. (2010). Dynamics of the Gender Gap for Young Professionals in the Financial and Corporate Sectors. *American Economic Journal: Applied Economics*, 2 (3): 228-55.
- Booth, A., & Nolen, P. (2012). Gender Differences in Risk Behaviour: Does Nurture Matter? *Economic Journal*, 122(558), F56-F78.
- Buser, T., & Yuan, H. (2016). Do Women Give Up Competing More Easily? Evidence from the Lab and the Dutch Math Olympiad. *AMERICAN ECONOMIC JOURNAL: APPLIED ECONOMICS*, 11, 225-252.
- Buser, T., Niederle, M., & Oosterbeek, H. (2014). Gender, Competitiveness, and Career Choices. *The Quarterly Journal of Economics*, 1409–1447.
- Buser, T., Peter, N., & Wolter, S. C. (2017). Gender, Competitiveness, and Study Choices in High School: Evidence from Switzerland. *American Economic Review*.
- Crosan, R., & Gneezy, U. (2009). Gender Differences in Preferences. *Journal of Economic Literature*, 47 (2): 448-74.
- Department for Education. (2020, June 25). *Schools, pupils and their characteristics: January 2020*. Retrieved from The UK Government Services and Information: <https://explore-education-statistics.service.gov.uk/find-statistics/school-pupils-and-their-characteristics>
- Dohmen, T., & Falk, A. (2011). Performance Pay and Multidimensional Sorting: Productivity, Preferences, and Gender. *American Economic Review*, pp. 556-590.
- Dweck, C. S. (2008). *Mindsets and Math/Science Achievement*. Institute for Advanced Study. New York.
- Espinosa, M. P., & Gardeazabal, J. (2013). Do Students Behave Rationally in Multiple-Choice Tests? Evidence from a Field Experiment. *Electronic Journal*, 9(2):107-135.

- Fryer, R. G., & Levitt, J. S. (2010). An Empirical Analysis of the Gender Gap in Mathematics . *American Economic Journal: Applied Economics* , pp. 210-40.
- Gneezy, U., & Rustichini, A. (2004). Gender and Competition at a Young Age. *American Economic Review*, 94(2): 377-381.
- Gneezy, U., Leonard, K., & List, J. (2009). Gender Differences in Competition: Evidence from a Matrilineal and a Patriarchal Society. *Econometrica*, 1637- 1664.
- Google for Education. (2016). *Diversity Gaps in Computer. Science: Exploring the Underrepresentation of Girls, Blacks and Hispanics*. California: Google Inc. & Gallup Inc.
- Gupta, N. D., Poulsen, A., & Villeval, M. C. (2013). Gender Matching and Competitiveness: Experimental Evidence. *Economic Inquiry*, pp. 816-835.
- Hogarth, R. M., Karelaia, N., & Trujillo, C. A. (2012). When should I quit? Gender differences in exiting competitions. *Journal of Economic Behavior & Organization*, 83(1), 136–150.
- Huguet, P., & Regner, I. (2007). Stereotype Threat Among School Girls in Quasi-Ordinary Classroom Circumstances. *Journal of Educational Psychology* .
- Ingvild, A., Cappelen, A. W., Salvanes, K. G., Sorensen, E. O., & Tungod, B. (2016). What Explains the Gender Gap in College Track Dropout? Experimental and Administrative Evidence. *American Economic Review*, 106 (5): 296–302 .
- Institute of Physics. (2012). *It's different for girls: The influence of schools*. Retrieved from Institute of Physics [IOP].
- International Labour Organization. (2017). *Breaking barriers: Unconscious gender bias in the workplace*. Geneva: The Bureau for Employers' Activities.
- Inzlicht, M., & Ben-Zeev, T. (2000). A threatening intellectual environment: Why females are susceptible to experiencing problem-solving deficits in the presence of males. *Psychological Science*, 11(5), 365–371.
- Iriberry, N., & Rey-Biel, P. (2016). Competitive Pressure Widens the Gender Gap in Performance: Evidence from a Two-Stage Competition in Mathematics . *CEPR Discussion Paper No. DP11493*.
- Iriberry, N., & Rey-Biel, P. (2017). Stereotypes are only a threat when beliefs are reinforced: On the sensitivity of gender differences in performance under competition to information provision. *Journal of Economic Behavior & Organization*, 99-111.
- Joint Council for Qualifications. (2019, August 15). *Examination Results: Applied GCE, AEA, Extended Project: English A-level students*. Retrieved from Joint Council for

- Qualifications: <https://www.jcq.org.uk/wp-content/uploads/2019/08/A-Level-and-AS-Results-Summer-2019.pdf>
- Kamas, L., & Preston, A. (2018). Competing with confidence: The ticket to labor market success for college-educated women. *Journal of Economic Behavior & Organization*.
- Keller, J. (2002). Blatant stereotype threat and women's math performance: Self-handicapping as a strategic means to cope with obtrusive negative performance expectations. *Sex Roles*, 47, 193–198.
- Keller, J., & Dauenhimer, D. (2003). Stereotype Threat in the Classroom: Dejection Mediates the Disrupting Threat Effect on Women's Math Performance. *Pers Soc Psychol Bull*, 29(3), 371-381.
- Kramer, M., Tallant, K., Goldberger, A. O., & Lebus, F. (2018). *The Global STEM Paradox Report*. New York: The New York Academy of Sciences.
- LinkedIn Learning. (2020, January). *Workplace Learning Report*. Retrieved from LinkedIn Learning : <https://learning.linkedin.com/resources/workplace-learning-report>
- Lynch, K., & Feely, M. (2009). *Gender and Education (and Employment): Gendered imperatives and their implications for women and men. Lessons from Research for Policy Makers*. Brussels: European Commission.
- Murnane, R. J., Willett, J. B., Duhaldeborde, Y., & Tyler, J. H. (2000). How important are the cognitive skills of teenagers in predicting subsequent earnings? *Journal of Policy Analysis and Management*.
- Murphy, P., & Whitelegg, E. (2006). *Girls in the Physics Classroom: A Review of the Research on the Participation of Girls in Physics (Technical Report)*. London: Institute of Physics.
- NGC Project. (2018). *The State of Girls and Women in STEM*. Seattle: NGC Project.
- Niederle, M. (2017). A Gender Agenda: A Progress Report on Competitiveness. *American Economic Review: Papers & Proceedings* , 107(5): 115–119.
- Niederle, M., & Vesterlund, L. (2007). *Do Women Shy Away from Competition? Do Men Compete Too Much?* Quarterly Journal of Economics.
- Niederle, M., & Vesterlund, L. (2010). Explaining the Gender Gap in Math Test Scores: The Role of Competition . *Journal Of Economic Perspectives* , 129-44.
- Niederle, M., & Vesterlund, L. (2011). Gender and Competition. *Annual Review of Economics*, pp. 601-630.
- Niederle, M., & Yestrumskas, A. H. (2008). Gender Differences in Seeking Challenges: The Role of Institutions . *NBER Program(s):Labor Studies*.

- Niederle, M., Gneezy, U., & Rustichini, A. (2003). Performance In Competitive Environments: Gender Differences. *Quarterly Journal of Economics* , 118(3):1049-1074.
- Niederle, M., Segal, C., & Vesterlund, L. (2013). How Costly Is Diversity? Affirmative Action in Light of Gender Differences in Competitiveness. *Management Science, INFORMS*, vol. 59(1), 1-16.
- Preckel, F., Goetz, T., Pekrun, R., & Kleine, M. (2008). Gender differences in gifted and average-ability students: Comparing girls' and boys' achievement, self-concept, interest, and motivation in mathematics. *Gifted Child Quarterly*, 52(2), 146–159.
- Richter, F. (2020). *GAFAM: Women Still Underrepresented in Tech* . Statista.
- Rothgerber, H., & Wolsiefer, K. (2013). A naturalistic study of stereotype threat in young female chess players. *Group Processes & Intergroup Relations*, 17(1):79-90.
- Russell Group. (2011). *A Russell Group guide to making decisions about post-16 education*. London: Russell International Excellence Group.
- Sadker, M., & Sadker, D. (1994). *Failing at Fairness: How America's Schools Cheat Girls*. New York: C. Scribner's Sons.
- Sax, L. J., Riggers, T. A., & Eagan, M. K. (2013). The Role of Single-Sex Education in the Academic Engagement of College-Bound Women: A Multilevel Analysis. *Teachers College Record*, 115, 1-27.
- Seagull, B. (2019, May 15). Women and maths — what’s not adding up? *Financial Times*.
- Seifert, A. (2009). *Single Sex Mathematics Classes: A Critical Analysis of the Impact at a Secondary School*. Charlotte: Charlotte-Mecklenburg Schools.
- Smith, C., & Golding, J. (2018). Raising girls’ participation in A-level mathematics: initial findings from ‘good practice’ case studies. *Conference: 42nd Conference of the International Group for the Psychology of Mathematics Education* .
- Smithers, A. G., & Robinson, P. (2006). The Paradox Of Single-Sex And Co-Educational Schooling. *Headmasters’ and Headmistresses’ Conference*. Buckingham: Carmichael Press .
- Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist* , 52(6), 613–629.
- Stevens, D., Parkes, J., Chan, S.-K., & Chan, S.-Y. (2019). *ISC CENSUS AND ANNUAL REPORT* . Kent: Lazervision Ltd.

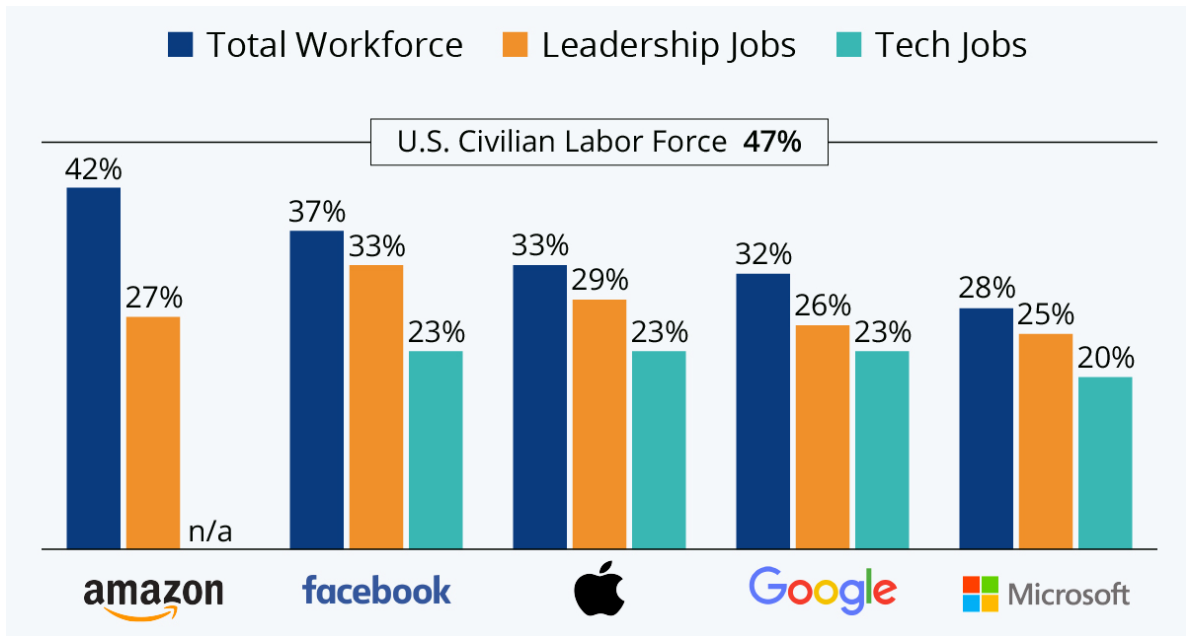
- Sullivan, A., Joshi, H., & Leonard, D. (2010). *Single-Sex Schooling and Academic Attainment at School and Through the Lifecourse*. *American Educational Research Journal - AMER EDUC RES J.* 47. 6-36.
- Sullivan, A., Joshi, H., & Leonard, D. (2011). Single-sex schooling and labour market outcomes. *Oxford Review of Education*, 311-332.
- Sullivan, A., Joshi, H., & Leonard, D. (2012). Single-sex and co-educational schooling: What are the social and family outcomes, in the short and longer term? . *Longitudinal and Life Course Studies*.
- Sutter, M., & Glätzle-Rützler, D. (2010). *Gender Differences in Competition Emerge Early in Life*. IZA Discussion Papers 5015, Institute of Labor Economics (IZA).
- Sutter, M., & Rützler, D. G. (2014). Gender Differences in the Willingness to Compete Emerge Early in Life and Persist. *Management Science*.
- Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving decisions about health, wealth, and happiness*. Yale University Press.
- The Primary Mathematics Challenge. (2019, November 11). *Downloads*. Retrieved from The Primary Mathematics Challenge:
<http://www.primarymathschallenge.org.uk/downloads>
- UNESCO. (1999). *Declaration On Science And The Use Of Scientific Knowledge*. Budapest: The World Conference on Science.
- University of Oxford. (2020). *Annual Admissions Statistical Report*. Oxford:
www.ox.ac.uk/study.
- Vandegrift, D., & Brown, P. (2005). Gender differences in the use of high-variance strategies in tournament competition. *Journal of Behavioral and Experimental Economics*, 834-849.
- World Bank. (2012). *World Bank. 2012. World Development Report 2012 : Gender Equality and Development*. World Bank.
- World Bank. (2012). *World Development Report 2012 : Gender Equality and Development : Main report*.
- World Economic Forum. (2018). *The Global Gender Gap Report*. Geneva: World Economic Forum.
- World Economic Forum. (2020). *The Global Gender Gap Report*. Geneve: World Economic Forum.

Wozniak, D., Harbaugh, W. T., & Mayr, U. (2014). The Menstrual Cycle and Performance Feedback Alter Gender Differences in Competitive Choices. *Journal of Labor Economics* , 161-198.

APPENDIXES

APPENDIX 1

Figure 1. *GAFAM: Women Still Underrepresented in Tech. Percentage of female employees in the workforce of major tech companies.* (Richter, 2020)



APPENDIX 2

Table 1. *Courses with the highest number of applicants per place (all domiciles, three-year total 2017-2019).* (University of Oxford, 2020)

COURSE	NUMBER OF APPLICANTS PER PLACE	COURSE	NUMBER OF APPLICANTS PER PLACE
Economics & Management	16.8	History & Politics	9.1
Computer Science	14.8	PPE*	9.0
Medicine	10.8	Mathematics	8.4
Biomedical Sciences	10.5	Law**	8.4
Maths & Computer Science	9.3	Physics	7.3

*Philosophy, Politics and Economics **Including Law/Law with Studies in Europe

APPENDIX 3

Table 2. UK applications to Oxford, offers made and students admitted by gender, 2015-2019. (University of Oxford, 2020)

	FEMALE			MALE			FEMALE PROPORTION OF TOTAL UK STUDENTS ADMITTED
	APPLICATIONS	OFFERS	ADMITTED	APPLICATIONS	OFFERS	ADMITTED	
2019	7,144	1,677	1,406	6,733	1,378	1,180	54.4%
2018	6,342	1,543	1,317	6,671	1,417	1,253	51.2%
2017	6,139	1,502	1,275	6,444	1,426	1,272	50.1%
2016	6,007	1,476	1,283	6,186	1,513	1,347	48.8%
2015	5,746	1,402	1,234	5,983	1,489	1,365	47.5%

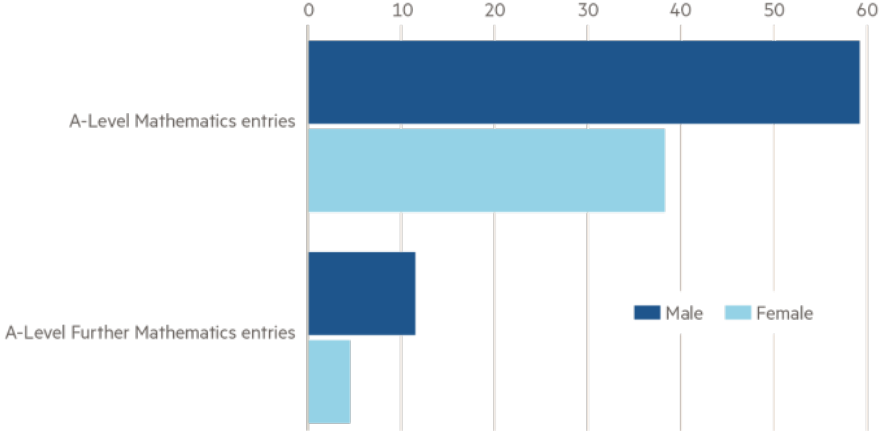
APPENDIX 4

Table 3. UK applications to Oxford, offers made and students admitted by gender and course, three-year total 2017–2019. (University of Oxford, 2020)

	FEMALE			MALE			FEMALE PROPORTION OF TOTAL UK STUDENTS ADMITTED
	APPLICATIONS	OFFERS	ADMITTED	APPLICATIONS	OFFERS	ADMITTED	
Biochemistry	630	155	139	472	121	110	55.8%
Biology	709	218	168	480	135	104	61.8%
Biomedical Sciences	505	80	68	177	25	20	77.3%
Chemistry	556	233	180	651	282	245	42.4%
Classics	410	189	166	339	151	145	53.4%
Computer Science	119	9	7	665	44	39	15.2%
Earth Sciences	122	55	46	129	46	40	53.5%
Economics & Management	593	66	55	1,432	151	131	29.6%
Engineering Science	344	104	84	1,075	308	267	23.9%
English	1,857	528	460	576	203	181	71.8%
Experimental Psychology	471	121	91	120	42	33	73.4%
Geography	619	157	127	411	121	92	58.0%
History	1,358	371	324	1,364	330	281	53.6%
History & Politics	346	66	56	418	52	43	56.6%
Law*	1,930	334	277	1,060	200	165	62.7%
Materials Science	88	43	32	149	50	45	41.6%
Mathematics	963	119	105	2,018	266	243	30.2%
Mathematics & Computer Science	97	8	8	440	52	49	14.0%
Medicine	1,980	289	270	1,203	179	160	62.8%
Modern Languages	731	328	283	413	169	153	64.9%
Music	252	116	91	256	124	101	47.4%
Oriental Studies	218	75	55	144	51	39	58.5%
PPE**	964	207	187	1,922	350	314	37.3%
Physics	712	68	64	2,053	294	288	18.2%
Theology and Religion	125	56	45	135	52	45	50.0%

APPENDIX 5

Figure 2. *Student entries for Mathematics and Further Mathematics.* (Seagull, 2019)

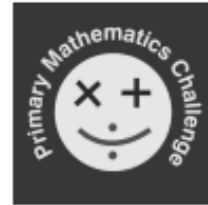


APPENDIX 6

Figure 4. Example of the Primary Mathematics Challenge. (The Primary Mathematics Challenge, 2019)

Primary Mathematics Challenge

11 – 15 November 2019



Name Class

Please do not start to answer questions until you are told to do so. When you do turn over the page you will have 45 minutes for the challenge.

You must do all the work on your own. You should use rough paper for this.

For questions 1 – 20, write down A B C D or E in the space for each answer.

For questions 21 – 25, write down your answer in the space.

Each correct answer gains one mark.

Good Luck. Enjoy the challenge!

Practice Questions

P1 Mrs Truelove shares £30 equally between her three children.

How much does each child receive?

A £3 B £5 C £6 D £10 E £90

P2 Today Burp, my baby sister, is 9 weeks and 2 days old.

In how many days will she be 10 weeks old?

A 1 B 2 C 3 D 4 E 5

APPENDIX 7

Figure 3. Girls as a percentage of all pupils. (Stevens, Parkes, Chan, & Chan, 2019)

