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# The Causal Effect of Single-Sex Education versus Coeducation on Motivation and Educational Attainments. Evidence from a Randomized Experiment in Secondary Education<sup>1</sup>

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## 1. Introduction

Mixed-sex education, also known as coeducation, has been extensively studied during the last century. 3-1 presents a density distribution of book counts where ‘coeducation’ has been recorded as a proportion of all Google-digitized books in English from 1880 until 2008. The graph starts around the time that the ‘Welsh Intermediate Education Act’ in 1889 led to the foundation of a considerable number of new coeducational secondary day-schools in Wales. Its positive effects inspired various other European countries as the Netherlands, Norway, Sweden and Denmark. In Norway, coeducation was adapted by law in 1896. Despite these early initiatives, in the beginning of the 20<sup>th</sup> century, there was still large resistance against coeducation. Catholics argued that it would raise debauchery and create an unhealthy competition between sexes. This view was further strengthened by the opinion that boys and girls were considered to have different purposes to fulfill. Most Catholic secondary schools remained single-sex institutions until 1940s.

Due to the second World War there was a radical shift in gender roles. Labor force participation of women increased such that educational opportunities were increasingly considered to be equal. After 1940 coeducation was generally accepted in primary and secondary education (for an excellent overview, see Rury, 2008).

Still after years of practicing coeducation, the debate reemerged in the 1970s. Academic research suggested higher levels of female academic achievement in single-sex institutions compared to mixed-sex educational institutions (e.g. Finn, 1980; Finn et al.,

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1979; Ormerod, 1973). In 1992, the American Association of University Women triggered the debate about coeducation by their report 'How Schools Shortchange Girls'. Their report suggests that women are ignored in class discussions and are subject to threats of sexual harassment. Following this report, there were experiments with single-sex education. While before the 21th century the social position and academic achievement of women played a central role in the coeducation debate, since 2000 it became clear that boys are underperforming girls (e.g., Alloway and Gilbert, 1997; Jackson, 2002; Jha and Kelleher, 2006; Whitmire, 2010). Besides differences in learning style and curriculum (Coffield et al., 2004), the lack of male teachers (Dee, 2005) and gender stereotypes (Guiso et al., 2008), various researchers point to coeducation as the origin of this underperformance (e.g. Houtte, 2004; Warrington and Younger, 2003).



Source: Google Books Ngram Viewer (2014). Graph indicates the density of book counts where coeducation have been recorded as a proportion of all Google digitized books in English from 1880 to 2008

Figure 3-1 Coeducation in the literature

The fact that boys are underperforming can be observed from international studies. The following overview lists some of the studies carried out in the last few years:

1. PISA-Study (Programme for International Student Assessment)

The survey aims 15-year-olds in terms of their skills in reading, mathematics and natural sciences. For this purpose, an appropriate research design was developed under the auspices of the OECD. With regard to differences between girls and boys generally two main results can be summed up:

- The difference between the tested boys and girls in reading and mathematical literacy is particularly clear (in terms of reading capability gender differences are significant).
- The difference in gender for mathematical literacy in 2012 was larger than that of the test phase in 2003.

2. TIMSS (Trends in Mathematics and Science Study)

The international comparative Study, TIMSS is carried out since 1995, in a rhythm of every 4 years by the International Association for the Evaluation of Educational Achievement (IEA). It examines mathematics and science performances in primary and secondary

education. Since 2003, the acronym TIMSS stands for Trends in International Mathematics and Science Study.

In regard to the results, it can be stated in summary, that there is no unified picture what the mathematical performance is concerned. Especially in terms of performance weaker countries, a significant advantage in performance is observed for girls. In the countries of the European Union relevant gender differences are rarely observed.

The status of research on gender issues in the evaluation of academic performance is limited to date mostly to the mathematical-scientific part and is summarized by Nagy as follows: "The relationship between motivational attitudes and achievement differences in mathematics and natural sciences is well documented. Girls have less favourable attitudes than boys towards the education of mathematics and natural sciences, which are related to stereotyping in and towards the respective subject. There is evidence that favourable motivational attitudes towards mathematics and natural sciences are linked to didactic characteristics of teaching (...)"(Nagy 2009).

### 3. PIRLS (Progress in International Reading Literacy Study)

With PIRLS, the reading comprehension of students of the fourth grade is tested in an international comparison. PIRLS, as well as TIMSS, is conducted by the International Association for the Evaluation of Educational Achievement.

Comparing the results of girls and boys in their entirety, it can be concluded that with the exception of Luxembourg and Spain, girls statistically score significantly better in all participating countries than boys.

4. A further study on 'Gender Differences in Educational Outcomes: Study on the Measures Taken and the Current Situation in Europe' (European Commission 2009) had the initial idea to examine to what extent and in what ways gender inequality in educational attainment was an issue of concern in European countries. Although the situation has changed radically in the last decades regarding participation rates in education, gender differences persist in both attainment and choice of courses of study. It states that:

- The most pronounced gender difference in achievement is the advantage of girls in reading. On average, girls read more and enjoy reading more than boys.
- In mathematics, boys and girls have similar results in the fourth and eighth grade in most countries. The advantage of boys emerges in the later school years and is especially noticeable among students who attend the same teaching programmes and grades.
- Gender differences in science achievement are the smallest. Despite performing equally well as boys in most countries, girls tend to have a weaker self-concept in science than males, i.e., on average, girls had lower levels of belief in their science abilities than boys. Yet, both boys and girls are similarly interested in science; and there is no overall difference in boys' and girls' inclination to use science in future studies or jobs.
- Boys are more likely to be amongst the poorest performers in reading. In mathematics and science, there are no gender differences amongst low achievers in most countries.
- Gender is only one of the factors that affect achievement in various subject fields. Socio-economic status is a very strong factor; thus it is important to consider family background alongside gender when supporting children who are underachieving (European Commission 2009, p. 11).

As mentioned before, one of the solutions to reduce gender inequality is by making single sex groups. Given that making separate education groups for boys and girls is expensive and difficult to implement, given the significant impact of single-sex education on the education system and given the inconclusive evidence today, further research is necessary. After arguing the drawbacks of earlier literature, this paper provides experimental evidence from a large school in Flanders (the Dutch speaking region of Belgium). By randomly dividing students to single-sex and mixed-sex education groups, we can estimate the causal effect of coeducation on students' motivation and educational attainments. The evidence is obtained from both a quantitative analysis of survey and multiple choice data, as well as from a qualitative assessment by observational studies. We will answer the following research questions:

Do students in single-sex groups outperform students in coeducational groups in terms of motivation and educational attainments?

Are the effects of coeducation different for different age groups?

The remainder of this chapter is structured as follows. Section 2 discusses the inconclusive evidence from earlier literature, some didactical tools to reduce underperformance, as well as earlier shortcomings which might lead to biased inferences. Section 3 present the Flemish education system, while section 4 discusses the data and experiment. Section 5 and 6 outline the quantitative and qualitative analysis, respectively. We finally conclude and provide policy recommendations.

## 2. Literature review

### Inconclusive evidence

The academic literature is inconclusive on whether the educational outcomes of boys and girls are influenced by mixed-sex education (Munns et al., 2012). Figure 3-2 provides a summary of literature on the effects of single-sex education (see also Munns et al. (2012) for a more extensive review). Focusing on educational achievement (the upper row of Figure 3-2), we observe studies with positive, as well as insignificant results of single-sex education. Regarding the classroom climate, the literature argues that single-sex classes have a better class atmosphere.

The underlying mechanisms which support the views on coeducation are diverse. It has been argued by Sukhnandan et al. (2000) and Younger and Warrington (2005) that single-sex education provides less distraction to both boys and girls. This argument is rooted in biological and social psychological theories. Lee, Marks and Byrd (1994) suggest that boys dominate in class groups such that they receive a disproportionately large share of the teacher's attention. This in turn would reduce girls' interest in Science-Technology-Engineering-Math (STEM – Sadker and Zittleman, 2009), as would it reduce their academic achievements (Shapka and Keating, 2003).

Park, Behram and Choi (2013) examine in a randomized experiment the causal effects of single-sex schools on college entrance and college exams. They observe that single-sex schools produce a higher percentage of graduates, even after controlling for observed heterogeneity. Similar observations have been made by Nagengast, Marsh and Hau (2013). Using a matching analysis they observe little evidence for positive effects of single-sex

schooling on the outcomes in the final two years of high school. On the contrary, using the variation in single-sex education originating from an assignment algorithm, Jackson (2012) observed that most students do not perform better in single-sex schools. Also Van de Gaer et al. (2004) and Harker (2000) observed similar findings.

While the aforementioned papers focused on school outcomes, Sullivan, Joshi and Leonard (2010) examine the effects of single-sex schooling in the long run. They observe in terms of educational attainments that single-sex schooling is positive for girls at age 16, but neutral for boys, while both genders attain qualification in more gender-atypical subject areas due to single-sex schooling. The influence of single-sex education has also been studied with respect to choices for particular study programs. For example Cherney and Campbell (2011) observe that students from single-sex schools have more participation in physical sciences.

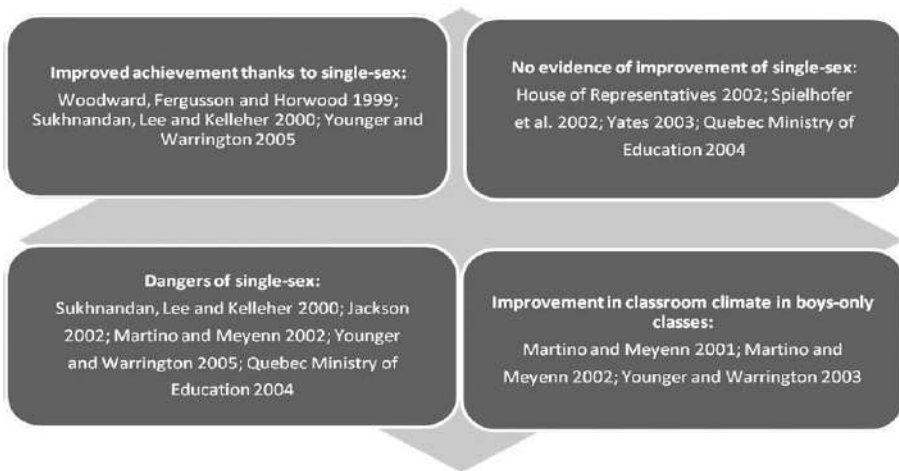


Figure 3-2 Earlier literature on single-sex education (adapted from Munns et al., 2012)

## Didactics for gender-equitable education

The coeducational school as a sphere of social interaction is gender-dynamically charged. Girls and boys spend a weighty part of their time in the school's community. Until the entry into adolescence, both gender spheres often tend to be highly differentiated. Boys set themselves usually apart from girls and prefer to keep to themselves, where girls also prefer the presence of other girls. In this regard the learning processes that can be found in single-sex peer groups, is of great importance for gender education.

An important influence on the behaviour of girls and boys is attributed to the interaction with male and female teachers. The importance of gender and the charging of gender images are produced as well as reproduced by the participating teachers. Thus, the teachers are involved and instrumental in the success or failure of coeducational learning situations.

These featured comparative studies reflect different accents of gender differences. The accompanying question regarding the implementation of single-sex and coeducational classes is raised repeatedly.

Undoubtedly, the array of coeducational programmes for female and male students is one of the achievements of the educational policy of recent decades. Gender-appropriate and gender-sensitive teaching has received a new significance in the wake of these developments. It must be emphasized that in this context, coeducation is not only limited to the simultaneous teaching of boys and girls. Rather, co-education – as already pointed out higher above – is a conscious examination of gender specific prejudices. It is important to select learning contents that appeal to both girls and boys and to make lessons so that they meet the needs of girls and boys. In addition, it is important to create a climate of mutual attention and respect. Coeducation does not exclude the forming of nor teaching in homogeneous groups. "Teaching in gender homogeneous groups can contribute to an expansion of the behavioral and interest range of girls and boys. Therefore, it may be useful in connection to specific issues or situations, (...) for the lessons to be carried out separated by gender." (Federal Ministry for Education, Science and Culture 2011, p. 21f).

## Improving motivation

How can gender-sensitive work on and in the school take place, so that motivation and academic performance (in particular) of the boys can be improved? Selected aspects should be identified at four different levels (not exhaustive).

### 1. Lesson content

Internal school curricula must be set up and teaching materials should be selected in such way that dealing with gender issues and a gender-sensitive approach are made possible. The teaching and learning materials should deviate from traditional male norms. They should correspond to the interests and different previous experiences of both sexes. In addition, all teaching and learning materials should value the strengths of both sexes, creating another approach towards the so long unfamiliar and new.

### 2. School (School culture)

Quality standards for equality must be firmly anchored in the mission statement of the school. Equal rights for girls and boys (and male and female teachers). The school as an institution is responsible for the staff on its payroll. The regular professionalisation of teachers is obvious. The initiative therefore, lies both with the teachers and with the school administration. Professional guidance for girls and boys may decisively contribute to the reduction of traditional role patterns and stereotypes. The selection of appropriate teaching and learning materials as well as intensive work with parents regarding the professional orientation of their children are particularly important here. The implementation of 'girls-days' and 'boy-days' raises awareness of gender issues. The integration of parental involvement in school life – both mothers work and fathers work – can be used by the school body to address gender issues and to bring these into the consciousness of girls and boys. Also working with foreign parents can – in terms of understanding other cultures – occupy an important place. The implementation of gender-related projects (for example 'girls-days') should not be understood

solely as a (stand-alone) event – on the contrary: gender education processes should be and become part of daily school life.

### 3. Interaction

Female and male teachers must be able to reflect on their own roles – to be a role model, making a decisive contribution to raising awareness of gender issues. Teachers should talk in a gender-neutral language. They should be aware of expectations and stereotypes and be careful not to fall into certain patterns (for example to commend girls for their diligence and boys for their performance). This includes clearly the ability of female and male teachers to perceive girls and boys in their gender-specific embossments. Just as the cooperation with parents make for an important contribution to gender-sensitive behaviour, cooperation with external partners (recreational facilities, etc.) should be taken into account.

### 4. Organisation (and didactics) of teaching

The promoting of the talented and the social training of disadvantaged girls and boys goes without saying and should therefore not be further analyzed. Initially the existence of profound didactics for gender-equitable education was questioned. If there were these didactics, the question for single-sex and/ or coeducational institutions would be less (or not) relevant. But, and this is confirmed by the studies of Woodward, Fergusson, Harwood, i.e., learning situations in single-sex classes result in a higher motivation of boys and girls and to better learning outcomes (compared with coeducational classes). Nevertheless, it should be emphasized that previously redeveloped proposals to improve the teaching methods from a gender perspective are still lacking a systematic analysis and the empirical evidence of efficacy, as stated by Niederdrenk-Felgner, dealing with issues of gender-specific didactics (particularly in mathematics). To speak of separate didactics for boys or for girls, seems inappropriate. Rather, selected didactic and methodological approaches and accesses are necessary to positively influence the motivation of girls and boys and in their consequence lead to better learning outcomes. These include for example:

- Project-oriented teaching and group work: With a comprehensive analysis of a problem, gender-homogeneous groups can come together and generate together ideas for solutions. The social skills of girls would be more recognized and the skills of boys would be much better promoted and strengthened.
- Open learning (individual work): Through internal differentiation measures, the learning is individualized and may lead to the aforementioned results. This may, for example, include a variety of physical activities through which the increased urge to move of the boys is met.
- Forms of conversation in the classroom: To avoid and overcome comprehension problems, in appropriate situations communication should be held (much) more in colloquial speech.
- Open classes – Temporary waiver of coeducation: Even if this requires special skills of the teachers, in a mixed gender class, group work can take place in single-sex groups. The waiver of coeducation in a mixed class can increase the motivation of boys and girls (see also project work).



To make lessons (methodologically) gender-sensitive, means to use forms of open education, through which independent learning becomes possible, for example action-oriented learning, project-based learning, group work, etc. "Because these considerations double immediately the heterogeneity of the student body (...): Students can bring aboard their respective interests much more and establish many social relations. Thus they also learn to recognize their individual personality." (GEW 2007, p. 26)

## Methodological issues

The inconclusive results might be driven by methodological issues. In a recent meta-review, Pahlke et al. (2014) show that the methodology matters for the direction and size of the effect. In particular, they observe that studies without a control group show some modest advantages for single-sex education, for both girls and boys. Studies with a proper control group indicate little effect of single-sex education, while experimental studies do not support any benefit from single-sex education.

Looking at earlier literature, we can distinguish six issues which prevent us to draw from earlier literature causal conclusions on the effects of coeducation. A main reason for this lack of causal evidence comes from the longitudinal data where the studies rely on. First, longitudinal data are prone to selection effects. Students (and their parents) who select themselves in single-sex schools have other aspirations and expectations about education and society than students who select themselves in mixed-sex schools. By simply comparing the motivation, classroom climate or educational attainments in both groups, biased evidence will be observed. This is the case in, e.g., Younger and Warrington (2005).

Second, the unit of analysis is often the class or the school. Given the existence of peer-effects, this creates a clustering of standard errors. While classes and schools have numerous pupils, due to the clustered standard errors, the effective unit of observation decreases dramatically such that the internal validity of the results can be questioned. An example of a similar bias can be found in Jackson (2002).

Third, there might be various sources of unobserved heterogeneity influencing the results. Many longitudinal studies lack information on the teachers' perceptions and stereotypes, the pupils' motivation or the parental interest in schooling. Similar unobserved heterogeneity might result in biased estimates. For example, if teachers' stereotypes result in a different attitude towards pupils, the observed differences in (existing) coeducational classes might be overestimated.

Fourth, some studies are prone to a 'Hawthorn effect'. If respondents know that they are subject of a research, they will answer differently – for example, more socially accepted answers. An example of a similar bias can be found in Martino and Meyenn (2002) who made a qualitative research on teachers' perceptions.

Fifth, some studies have only a limited number of observations. This limits the internal validity of the results. For example, the results of Martino and Meyenn (2002) draw on 7 interviews, Martino (2001) is based on a survey of 42 boys, while Sukhnandan et al. (2000) uses 19 case studies.

Using a large experiment with random assignment at the pupil level and with a combined quantitative and qualitative identification strategy, this chapter avoids the previous shortcomings and biases.

### 3. Flemish education system

The Flemish educational system foresees compulsory education until the age of 18. Its education is structured along nursery (age 2.5 until 6), primary education (6 until 12), secondary education (12 until 18) and higher education (from 18 years onwards). The Flemish school system draws on a few general principles (for an extensive discussion, see [www.flanders.be](http://www.flanders.be)). First, primary and secondary schools are financed by the government and are free of charge for parents. In nursery and primary education, parents are even exempted from paying school materials and school related activities. Second, there is freedom of education such that (1) every person has the right to organize education and establish institutions for this purpose and (2) parents and children have the right to choose a school. Thanks to this freedom of education, a large majority of the students attend publicly subsidized private catholic schools (68%), while only a minority of the students (15%) attend community education. The remaining 16% of the students attend subsidized publicly run education. Third, all children receive equal opportunities in education. Therefore, the government foresees significant resources for student counseling and extra support for additional needs provision.

Secondary education (the education level of interest for this chapter) is structured along three stages of two years. The majority of the teaching periods in the first stage are devoted to the core curriculum (math, languages). From the second stage onwards, there is some form of ability tracking. First, general education (aso) prepares students for higher education. Second, technical education (tso) focusses on technical subjects and prepares its students for a profession or for higher education. Third, secondary arts education combines broad general education with active arts practice. Finally, vocational education (bso) is practice-oriented and prepares students for a specific occupation. A commonly agreed disadvantage of the four forms of secondary education is that general education is higher perceived than the other forms. This creates an unequal composition of the ability groups in that children from higher socio-economic status (SES) groups are overrepresented in general education, while children from lower SES groups are overrepresented in vocational education. This system shortcoming, combined with the high number of early school leavers (i.e., youngsters below the age of 23 who leave education without a higher secondary degree) is the main motivation for a serious reform of the secondary education system by 2016.

Regarding coeducation, since the Second World War, an increasing amount of public schools became coeducational. By the early 1970, also the private Catholic schools followed. By the 1980s, most schools were mixed, although only on January 26, 1994 the law obliged schools to be coeducational. While today schools cannot refuse pupils on the grounds of gender, there is an increasing interest in single-sex education. Some middle schools offer parents the choice for single or mixed-sex education. While there is no empirical evidence, they argue that single-sex education allows teachers better to 'deal with difficult' students (Klasse, 2010).

The only existing study regarding coeducation in Flanders estimates in a longitudinal design the differences in learning outcomes and academic discipline between single and mixed-sex schools (Brutsaert, 2001). He observes that there are no clear advantages (nor disadvantages) of coeducation in Flanders.

While the number of boys equals in secondary education the number of girls, this is not the case for their teachers. About 32% of the teachers in secondary education are male, while 68% are female. This gender imbalance is even larger in primary education where 86% is female. While most of the teachers are female, a large majority of the school management are males.

## 4. Data and experiment

To examine the impact of coeducation versus single-sex education, we run an experiment in a large Flemish school. The school is located in the area of Brussels (i.e., Herzele). It has both the general education track (aso) as well as technical education (tso). The student population of the school is representative for other Flemish schools – it does not attract a specific socio-economic status group, nor a specific gender or ability group. It has about one third of male teachers, and a female school management.

By running an experiment, the researchers can perfectly control all observed pupil characteristics (e.g., gender, prior class and earlier test scores). As all observed characteristics are randomly distributed across control and treatment groups, we can effectively assume that also unobserved characteristics are randomly distributed across both groups. The experiment is therefore not prone to omitted variable bias as in earlier studies on single-sex education.

The experiment took place on two different days on which we focussed on two different age groups. A first age group are students between 12 and 13 years old, while a second age group are 13 till 14 years old students. We included those two age groups as an a priori power analysis reveals that these include a sufficient number of students to find with a reasonable probability an effect. Before the experiment took place (i.e., during regular education), these students are grouped in 10 mixed classes (5 per age group) of, on average, 20 students. The experiment involved one full day of teaching in the experimental setting.

### Random assignment

We randomly assigned students to (1) a boys-only group, (2) a girls-only group, and (3) two mixed-sex groups. A first mixed-sex group had exactly the same amount of girls as boys, while a second mixed group had more boys than girls for the age group 13-14 and more girls than boys for the age group 12-13. The descriptive statistics in Table 1 indicate that besides for gender, the groups were perfectly equal on all observable characteristics, including average school exam scores (only available for age group 13-14). We can therefore assume that also on the unobservable characteristics (e.g., income of the parents, socio-economic status) the groups are equal in expectation.

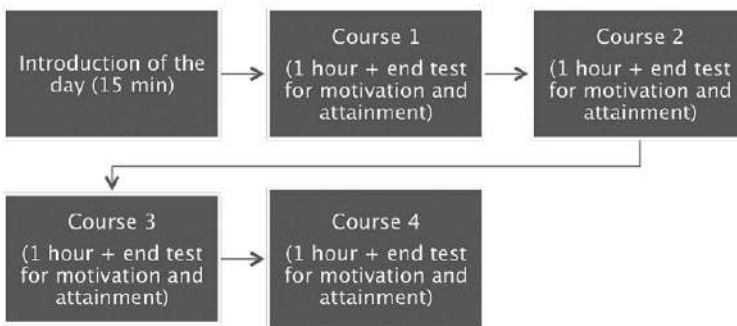
### Timing and tests

The experimental days took place as follows. In the first 15 minutes of the day, all students received some general information about the day. They were told that they would follow 'an international day' in which they receive didactical content which is made by school partners in various European countries (including UK, Turkey, Austria, Norway and

Poland). The students were not informed about the experimental setting, nor about the true purpose of the day. At the end of the 15 minutes, they were regrouped in the new groups according to the random group assignment by the researchers. Next, each group of students went to a particular class where they received during one hour a course about sexuality, interculturality or lifestyle. After a break of 30 minutes, the students went to a different course. The structure of the day is visualized in Figure 3-3.

To avoid biases arising from differences in the teaching style, the same teacher taught the same content (to different groups) the whole day. At the end of each class, students filled out a motivation questionnaire, which is a short version of the 'Motivated Strategies for Learning Questionnaire – MSMQ (the questionnaire is included in the appendix). The scale reliability coefficient (cronbach's alpha) for the questionnaire is 0.86, which indicates a high internal consistency.

Besides these quantitative assessments, there was also an observer in the class who made a qualitative analysis of the differences between the student groups. The qualitative analysis aimed to complement the quantitative findings. Similar to the teacher, the observer followed four times the same subject. The focus of the qualitative assessment lied on the attitude of students and the teacher during the course, the classroom management, the class dynamics and the peer-effects. The observers were experienced teachers with some basic knowledge of qualitative analysis.



*Figure 3-3* Structure of the day – Each course takes one hour, is taught by the same teacher, observed by the same observer and ends with a motivation and educational attainment test

## Course content

As the experiment took only one day, we tried to maximize its impact by focusing on 'sensitive' issues as interculturality, sexuality or lifestyle. Thanks to this course content, we can estimate an upper bound impact of single-sex education versus coeducation. For this purpose, we found interesting, publically available, course content on the website of an European project 'Education and Gender'. This content was slightly adapted to the Flemish setting. The full content is available on the following website: <http://www.education-and-gender.eu/gedge/index.php/en/ects-en>.

## 5. Quantitative analysis

### Descriptive statistics

The descriptive statistics are presented in Table 3-1. Group 0 denotes the single-sex group with only boys, group 1 and 2 are the mixed-gender groups, while group 3 is the girls-only group. In group 1 there are more girls for age group 12-13 and more boys for age group 13-14, while group 2 has an about equal percentage of boys and girls. Thanks to the randomization, there are no significant differences between the four groups on the average school grade (only available for age group 13-14). Table 3-1 indicates that students were also effectively reshuffled among the original class groups. Note that information on the educational attainments is only available for some courses, such that this variable has a lower number of observations. The descriptive statistics are roughly the same for the two age groups separately. To save space, they are available upon request.

Group	Variable	n	Mean	S.D.	Min	Max
<b>Boys-only (group 0)</b>						
	Gender (boys = 0)	308	0.00	0.00	0.00	0.00
	Regular class	308	3.25	2.46	0.00	8.00
	Average exam score*	161	70.88	7.91	57.11	88.23
	Post-test: Motivation	308	3.87	3.15	1.22	28.60
	Post-test: Educational attainments**	129	6.53	2.81	0.00	10.00
<b>Coeducation but unequally distributed in gender (group 1)</b>						
	Gender (boys = 0)	327	0.61	0.49	0.00	1.00
	Regular class	327	3.53	2.39	0.00	8.00
	Average exam score	154	69.74	17.28	0.00	83.77
	Post-test: Motivation	327	3.86	2.73	1.40	20.86
	Post-test: Educational attainments**	135	6.82	2.92	0.00	10.00
<b>Coeducation and equally distributed in gender (group 2)</b>						
	Gender (boys = 0)	313	0.53	0.50	0.00	1.00
	Regular class	313	3.78	2.27	0.00	8.00
	Average exam score*	147	71.83	6.26	59.63	86.47
	Post-test: Motivation	281	4.30	4.50	1.40	35.25
	Post-test: Educational attainments**	125	6.34	3.02	0.00	10.00
<b>Girls-only (group 3)</b>						
	Gender (boys = 0)	312	1.00	0.00	1.00	1.00
	Regular class	312	3.76	2.46	0.00	8.00
	Average exam score*	147	73.82	7.82	55.83	85.80
	Post-test: Motivation	312	3.71	2.97	1.43	24.50
	Post-test: Educational attainments**	129	6.78	2.96	0.00	10.00

Note: Except for gender, there are no significant differences in observed characteristics between the four groups. (\*) Average school grades are only available for age group 13-14. (\*\*) Educational attainments is only available for some courses, such that this variable has a lower number of observations

Table 3-1 Descriptive statistics

## Regression specification

To control for observed heterogeneity in the sample, we estimate the following regression specification:

$$Y_{ij} = \beta_0 + \beta_1 \text{group}_i + \beta X_i + \varepsilon_i \quad (1)$$

where  $Y_{ij}$  denotes the post-test on motivation or educational attainments of student  $i$  in course  $j$ . It should be noted that thanks to the randomization the prior motivation and educational attainments of the students will be equal across all groups, such that even in the absence of a pre-test unbiased inference will be obtained.  $\beta_0$  is a constant,  $\text{group}$  indicates whether student  $i$  was assigned to a treatment (single-sex education) or control group (coeducation). We will also examine alternative specifications in which  $\text{group}$  denotes the boys-only group (reference group), a coeducational group with unequal gender distribution (group 1), a coeducational group with equal gender distribution (group 2) or a girls-only group (group 3).  $X$  is a vector of observed characteristics of the students and  $\varepsilon_i$  is an i.i.d. error term with mean 0 and a constant variance. Thanks to the random assignment of the students to the groups, we can interpret the estimated correlation of treatment with  $Y$  as a causal effect. The coefficient of the  $\text{group}$  variable is the variable of interest. In what follows below we only present this estimate, although the full regression results are available upon request.

Various alternative specifications of equation (1) are estimated. A first model specification estimates the effect of participation to the experiment. It does not include any variables to capture the heterogeneity among students. A second model specification adds control variables to Model 1. In particular, we add a course fixed effect to capture the heterogeneity that arises from the subject of the course (e.g., lifestyle, interculturality, sexuality). Model specification 3 further adds postcode fixed effects to capture potential heterogeneity arising from peer effects in the neighbourhood the child is living in. Finally, to account for the fact that some students might know each other from their original (traditional) class, we include class fixed effects. The latter capture the heterogeneity arising from the original peer group.

## Effect of coeducation on motivation

We first examine the effects of single-sex education versus coeducation on the motivation of students. By running the four model specifications, which gradually add fixed effects, we can test for the robustness of the results. The outcome variable is the average on the 9 motivation questions. The results in Table 3-2 are presented for the full experimental population, as well as for the two age groups separately. The latter distinction might be interesting to reveal potential differential treatment effects for different age groups.

First consider the estimated effects for all age groups. The negative treatment indicator reveals that students in single-sex groups have a lower motivation compared to students in coeducational groups. This effect is significantly different from 0 at 1% level. The effect size ( $\eta^2$ , which is the proportion of the total variance that is attributed to an effect) varies between -0.005 (model 1) and -0.019, which is modest. For the relatively large group of 645 students, the  $R^2$ -adjusted reveals that we can explain about 27% of the variation in the motivation of students in the most rich model specification Model 4.

If we split the dummy treatment indicator in the four groups, the results in Table 3-2 show that the negative coefficient is mainly driven by the girls-only group who experienced a significantly lower motivation than the boys-only group, which in turn also have a lower motivation in comparison to the coeducational groups.

Effect of Coeducation on motivation	Model 1	Model 2	Model 3	Model 4
<b>All age groups Treatment dummy</b>				
Constant	4.390***	4.304***	4.513***	4.724***
Treatment (ref = mixed-sex groups)	-.171***	-.172***	-.219***	-.188***
n	645	645	645	645
R <sup>2</sup> -adjusted	0.012	0.033	0.084	0.274
Treatment groups				
Constant	4.358***	4.272***	4.460***	4.704***
Group 1 (mixed; ref = boys)	.152**	.150**	.161**	0.067
Group 2 (mixed)	-0.112	-0.115	-0.055	-0.123
Group 3 (girls)	-.279***	-.286***	-.293***	-.370***
n	645	645	645	645
R <sup>2</sup> -adjusted	0.044	0.066	0.112	0.308
<b>12-13 year old Treatment dummy</b>				
Constant	4.781***	4.806***	4.817***	4.885***
Treatment (ref = mixed-sex groups)	-.249***	-.249***	-.322***	-.326***
n	312	312	312	312
R <sup>2</sup> -adjusted	0.037	0.036	0.112	0.183
Treatment groups				
Constant	4.348***	4.372***	4.217***	4.351***
Group 1 (mixed; ref = boys)	.567***	.567***	.631***	.650***
Group 2 (mixed)	.271***	.271***	.413***	.474***
Group 3 (girls)	.339***	.339***	.376***	.390***
n	312	312	312	312
R <sup>2</sup> -adjusted	0.097	0.096	0.165	0.231
<b>13-14 year old Treatment dummy</b>				
Constant	4.060***	4.019***	4.713***	4.699***
Treatment (ref = mixed-sex groups)	-0.086	-0.088	-0.118	-.127*
n	334	334	324	324
R <sup>2</sup> -adjusted	0.001	0.008	0.075	0.080
Treatment groups				
Constant	4.419***	4.373***	4.700***	4.6458***
Group 1 (mixed; ref = boys)	-.256***	-.255***	-.257***	-.319***
Group 2 (mixed)	-.480***	-.480***	-.422***	-.439***
Group 3 (girls)	-.981***	-.986***	-.932***	-.987***
n	334	334	324	324
R <sup>2</sup> -adjusted	0.276	0.288	0.300	0.317
<b>Fixed effects</b>				
Subject fixed effect		YES	YES	YES
Postcode fixed effects			YES	YES
Class fixed effects				YES

where \*, \*\* and \*\*\* denote significance at 1, 5 and 10% respectively; full regression results available upon request; model specifications are robust for including previous grade as a control variable (only available for 13-14 years old)

Table 3.2 Regression outcomes for motivation (outcome variable is the average of the 9 questions)

Slightly different observations are made if we examine the two age groups separately. Significant effects are mainly observed for the 12-13 years old children, while for the 13-14 years old children most model specifications do not indicate a significant influence from coeducation. Interestingly, if the four treatment groups are separately compared to the boys-only groups, all estimated coefficients are significantly different from zero. For the 12-13 years old students, coeducation and girls-only groups experience a significantly higher motivation than the boys-only group, while the 13-14 years old students in coeducation and girls-only groups experience a lower motivation than the boys-only group. This makes clear that the age of children matters for the effect of coeducation. For these two groups, younger students like better coeducation than older students.

## Effect of coeducation on educational attainments

We next discuss in Table 3-3 the effect of coeducation on educational attainments. Again, three different samples are examined: all students, age group 12-13 and age group 13-14. First, consider the estimates for the pool of all age groups. In contrast to earlier literature, in all model specifications we do not find any significant effect of coeducation on educational attainments. Even the sign of the estimated coefficient differs in direction between the model specifications. This finding is in line with Spielhofer et al. (2002) and Yates (2003), but contrasts findings by Sukhnandan et al. (2000) and Woodward et al. (1999).

For the youngest age group under study, 12-13 years old, we observe a significant difference between boys-only and girls-only groups. In particular, the girls-only group significantly outperforms the boys-only group. This is in line with a large bulk of research stating that girls acquire higher grades than boys. It is therefore not surprising that girls-only groups perform better than boys-only groups in terms of educational attainments. Nevertheless, it has been argued before that coeducation might be a reason for this underperformance of boys (e.g. by Houtte, 2004 and Warrington and Younger, 2003). The experimental evidence in this chapter indicates that it is not the gender class composition which underlies the difference in performance between boys and girls.

Nevertheless, this finding is not confirmed for the oldest age group. A notable exception is the most rich model specification, which captures fixed effects at subject, postcode and class level. For this model 4, we observe a significant lower level of educational attainments in the girls-only group than the boys-only group. However, this model specification can only explain about 8.7% of the observed variance, such that its outcome should be treated with caution.



Effect of Coeducation on educational attainments		Model 1	Model 2	Model 3	Model 4
<b>All age groups Treatment dummy</b>					
Constant		6.589***	6.057***	6.962***	7.161***
Treatment (ref = mixed-sex groups)		0,065	0,074	-0,068	-0,049
n		518	518	518	518
R <sup>2</sup> -adjusted		-0,001	0,030	0,047	0,053
<b>Treatment groups</b>					
Constant		6.534***	6.022***	6.730***	6.999***
Group 1 (mixed; ref = boys)		0,286	0,262	0,327	0,268
Group 2 (mixed)		-0,195	-0,203	0,018	0,041
Group 3 (girls)		0,241	0,224	0,218	0,199
n		518	518	518	518
R <sup>2</sup> -adjusted		-0,001	0,030	0,046	0,051
<b>12-13 year old Treatment dummy</b>					
Constant		6.712***	6.889***	7.648***	7.660***
Treatment (ref = mixed-sex groups)		0,326	0,326	0,085	0,110
n		246	246	246	246
R <sup>2</sup> -adjusted		0,000	-0,001	0,171	0,167
<b>Treatment groups</b>					
Constant		6.411***	6.589***	6.994***	7.115***
Group 1 (mixed; ref = boys)		0,449	0,449	0,549	0,655
Group 2 (mixed)		0,121	0,121	0,444	0,615
Group 3 (girls)		1.193***	1.193***	1.028**	1.203***
n		246	246	246	246
R <sup>2</sup> -adjusted		0,025	0,023	0,185	0,187
<b>13-14 year old Treatment dummy</b>					
Constant		6.473***	5.737***	5.997***	6.325***
Treatment (ref = mixed-sex groups)		-0,151	-0,146	-0,494	-0,427
n		272	272	260	260
R <sup>2</sup> -adjusted		-0,003	0,092	0,083	0,080
<b>Treatment groups</b>					
Constant		6.631***	5.900***	5.557***	5.971***
Group 1 (mixed; ref = boys)		0,148	0,148	0,365	0,141
Group 2 (mixed)		-0,455	-0,466	-0,205	-0,359
Group 3 (girls)		-0,647	-0,647	-0,821	-1.035*
n		272	272	260	260
R <sup>2</sup> -adjusted		-0,002	0,095	0,087	0,087
<b>Fixed effects</b>					
Subject fixed effect			YES	YES	YES
Postcode fixed effects				YES	YES
Class fixed effects					YES

where \*, \*\* and \*\*\* denote significance at 1, 5 and 10% respectively; full regression results available upon request; model specifications are robust for including previous grade as a control variable (only available for 13-14 years old).

Table 3-3 Regression outcomes of the treatment variables on educational attainments (outcome variable is an average test score)

## 6. Qualitative analysis

To open the black box of the quantitative analysis, the experiment also includes a qualitative analysis. The observations by the four observers in the back of the room provide valuable information on the class dynamics, the behaviour of the two genders and the actions of the teachers.

The observers marked significant differences in behaviour between the four randomly divided groups. While the boys-only group was active and participated well to the class, the girls-only group asked less questions, was more quiet, collaborated less, and was more silent during class. It was observed that the coeducation groups had exactly a mix of those two patterns. In general, the observers noted that the more girls in the class group, the more 'relaxed' the group became. Despite this 'relax attitude', half of the observers noted that the girls-only group was the group which was most intrigued by the course content. In the coeducation groups, it is observed that the boys are more actively seeking the attention of the teacher and the fellow students. For example, the enthusiasm to respond to questions posed by the teacher is higher in groups with boys than groups without or less boys. This finding is in line with Martino and Meyenn (2002). The observations are summarized in Table 3-4.

If the observers were asked to place the different groups on an interval scale, they all agreed on the position of the groups. For both age groups and for the four courses, the observers stated that the boys-only group participated much better to the class than the girls-only group, which posed less questions during the class. There does not seem to be a difference between coeducation groups, but rather between gender groups. At the same time, the girls-only group was much more quiet during class, than the boys-only group. Finally, it was observed that the single-sex groups were more able to discuss sensitive and emotional topics in class than the coeducation groups.

Not only the behaviour of the students differed between the groups, but also the behaviour of the teacher changed. It is observed that the teacher had to make a significantly higher effort to convince the girls groups to participate. On the contrary, in the boys-only group the teacher speaks faster and the course content is more quickly discussed (although by the end of the course, the four groups received exactly the same information). Classroom management in terms of law and order in the class and class participation is the most easy for the teacher in coeducation groups. It should be noted that during regular courses, the teachers are also teaching for coeducation groups, which might bias this observation.

Boys only	Girls only	Equally divided	More boys
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**Class management**

'Under control'	Calm	Very good	Very good
Requires more discipline from the teacher	At the end, the teacher has to ask the students not to talk to each other	During the group work, the pupils collaborate well	Few structure
Throw with pencils			Teacher says two times 'do not talk to each other'

**A lot of noise**

Attitude of the students during the course			
Very vivid	sweet	Boys give a lot of answers, girls do not participate	Boys and girls give answers
Very enthusiastic	Few answers	Motivated	
Everybody wants to present	Not responding		
Students bully the teacher by using a laser pointer			

**Dynamics during the class**

Very active, positive	Slow (due to the group, not to the teacher)	Excellent	Excellent (but more noise after 40 minutes)
Very tiring for the teacher			
Are there students hiding or asking a lot of attention?			
Everybody is actively involved in the class	All girls hide	4 boys are very active	Nobody is hiding

Table 3-4 Qualitative analysis by observer

Did the students actively participate during class by posing questions?



If necessary, the class group was quiet during class?



Was the class group able to discuss 'sensitive and emotional' topics?



Where 0, 1, 2, and 3 denote boys-only, mixed-gender group with majority of a gender, equal mixed-gender group and girls-only group, respectively.

Figure 3-4 Position of the single-sex and coeducation groups on interval scales

## 7. Conclusion and policy recommendations

Despite being common practice in most western education systems, coeducation is becoming increasingly under pressure. Among other reasons, the lower educational performances of boys have been attributed to the gender composition of classes. In many countries, both progressive and conservative opinion makers argue that single-sex education might be beneficial for both genders. The literature lacks, however, sound empirical evidence which verifies these claims.

This chapter examines by a randomized experiment the effect of single-sex education versus coeducation. By randomizing 12 to 14 years old pupils to single-sex and coeducation groups, we can estimate the causal effect of the gender class composition on students' motivation as well as on educational attainments.

The results reveal that single-sex groups have a significantly lower motivation compared to students in coeducational groups. Analysing the results more in detail shows that boys-only groups outperform the girls groups in terms of motivation. Boys-only groups have a higher motivation than girls and mixed groups. The effect is, however, different for different age groups. For young adolescents of 12-13 years old, coeducation and girls-only groups experience a significantly higher motivation than the boys-only group, while the 13-14 years old pupils in coeducation and girls-only groups experience a

lower motivation than the boys-only group. The results of the qualitative analysis confirm that the class dynamics in the single-sex groups are different from the class dynamics in the coeducation groups.

While the effect of single-sex education is rather outspoken for motivation, its impact on educational attainment is modest at best. Only for the youngest age group under study, 12-13 years old, we observe a significant difference between boys-only and girls-only groups. In particular, the girls-only group significantly outperforms the boys-only group. Given the random assignment to coeducational and single-sex groups, the persistent difference in educational outcomes between boys and girls indicates that it is not the gender class composition which creates the different outcomes. Further research should focus on other mechanisms which can explain these differences (e.g., biological differences).

The results provide some interesting insights for policy. First, the debate on the effects of coeducation is too general. Given that its effect on motivation and educational attainments is heterogeneous across different age groups, the debate should be more nuanced and focussed on students' age. Second, as the effect of single-sex education is more outspoken for motivation than for educational attainments, and given that single-sex education is an expensive intervention, policy makers should also explore other tools to foster boys' motivation for schooling.

This chapter provides various lines for further research. First, it would be interesting to add different age cohorts and subjects to the analysis. The differential effects suggest that this might matter for the effects of coeducation. Second, the chapter argued that the experimental evidence provides a higher internal validity than correlational evidence. To increase the external validity of the results, additional experiments should be run, preferable in combination with a mixed-methods set-up. Third, while this experiment provides an upper-bound analysis on the effect, more research is necessary to examine the effects of single-sex education on core subjects as mathematics and languages.

Finally, it should be noted that boys and girls are biologically different. It might therefore not be surprising that the two genders can be motivated by different tools, and that the education system has a different effect on them. The first piece of the puzzle provided in this chapter might indicate a route for further improvement of educational systems, which is not defined on uniform paradigms (e.g., education should be coeducational), but simply on what works best.

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## Appendix A

### Motivation questionnaire

All questions are on a 6 point Likert scale, where 1 corresponds with 'Totally disagree' and 6 to 'totally agree'.

1. I liked the past course
2. I feel good in this new class group
3. I thought the teacher could handle the class group well.
4. I tried to perform as well during last class because it is important.
5. I tried to perform as well during last class because the teacher expect this from me.
6. I tried to perform as well during last class because I liked the class group.
7. I can work well together with the other students in the class.
8. During last class there were various disagreements (e.g. discussions or quarrels) which disturbed the class.
9. In my opinion, the other students collaborated well during the class.



