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Is Entering STEM Socially Contagious?

Contextual Factors in Women's Educational Decisions

Abstract: Despite the nonexistence of institutional obstacles, majors in science and mathematics continuously attract women to a greater extent than those in technology and engineering. Based on a series of in-depth interviews conducted with students of various STEM majors in an university and a polytechnic in the same city in Poland, this paper attempts to explore the reasons for this divergence. Analysis of the detailed biographical narrations reveals that the women's choice of male-dominated majors coincides with the presence of a significant role model (SRM) in the close social network. An SRM is an individual who is more experienced in a given domain and who has personal, lasting, and emotional contact with the decision-maker. The presence of an SRM was observed most often among female students of polytechnic, and was hardly observable among their university counterparts. The SRM provided various forms of support and information, and debunked discouraging stereotypes of male-dominated majors. Furthermore, a long-lasting relationship with the SRM led to the development of a strong preference for polytechnics over universities. Those findings fit well with the explanations provided by the theory of social contagion.

Keywords: STEM, gender, Poland, social contagion.

Introduction

The last several decades have witnessed a substantial rise in the number of women entering science, technology, engineering and mathematics majors (STEM). Despite this increasing trend, some maths-related majors (maths, biology) have become more gender-balanced, while other remain strongly male-dominated (technology and engineering) (Wotipka and Ramirez 2001, Smith 2011, Cheryan 2011). One explanation is the stereotypical belief that pursuing technology and engineering career require skills "naturally" attributed to men, e.g. logical thinking or reasoning. Some studies suggest that circulation of such stereotypes may undermine women's self-beliefs on ability, increase anxiety toward science, and finally discouraged from pursuing career in STEM (Smeding 2012). Other explanation argue that gender imbalance in STEM fields is rooted in different vocational interests of men and women: on general women prefer jobs that involves interaction with other people, while men are more like to choose working with machines and tools (Halpern 2012). In line with this, women are generally expected to prefer teaching and medicine where contacts with people are more intense and men are opting for engineering, technology and other occupations more dependent on devices. The above frameworks are often applied to understand why women prefer to choose humanistic and social science majors over engineering, but

they do not explain stratification within STEM majors itself. This poses a question on what distinguishes women who decide to study male-dominated over gender-balanced majors within STEM? In this paper I argue that choice of male-dominated major depends on the composition of individual's social network. The analysis of a series of in-depth qualitative interviews conducted with female students from different STEM majors in two Polish universities suggests that the decision to choose male-dominated majors is more likely when a *significant role model* (SRM) in present in a close social network. An SRM is define here as a person who is more advanced in technology or engineering and has a lasting interaction with the individual who makes the decision. Using the framework of social contagion theory (Burt 1987) I argue that an SRM "infects" other individuals in the social network with the idea to pursue STEM majors.

Gender Gap in STEM Majors in Poland

For some time now the governments of many countries have struggled with shortages in the highly qualified STEM labor force. To prevent this problem, few years ago Polish government initiated a program of financial support for students pursuing the most economically strategic STEM fields. Students who were admitted to the first academic year were entitled to receive a special scholarship. This incentive, supported by labor market demands, contributed to the relative boosting of number of students at the technical universities. Number of students in technical universities has been increasing even though general number of young people who decide to enter tertiary education in Poland has been decreasing (the general net enrolment ratio dropped to 49% in 2013 from 54% in 2010 GUS 2014). Along with this, the number of students and graduates at engineering and technical majors increased, while number of students at social sciences and humanities majors have been shrinking. The number of women among students in technical universities has been systematically increasing since 90. and reached 37% in 2014 (GUS 2013), but the share of women varies significantly between universities. The universities which offer wide range of majors, including social sciences and health sciences, have the highest percentage of women (reaching 50%), but on traditional technical universities women comprise about ⅓ (Report Women on Technical Universities 2016). Similar divergence exists between particular majors. The largest share of women occurred in manufacturing and production (48%) and building and architecture (42%). Women are underrepresented in engineering where they comprise 27%, and only 12% in computer science. Majors in natural sciences, on the other hand, had a large representation of women. In 2014 women make up 79% of total students of biology, 63% in physics, 64% in maths (GUS 2013).

In a large extend, gender stratification between STEM at the tertiary level is determined by the student's decision in high schools. In a current system at the beginning of high school student have to declare which subjects he or she will pass on the extended level of maturity exam (each student has to choose at least one extended subject). Those subjects have more advanced core curriculum and more teaching hours. The decision which courses student will take at the extended level is important because majority of STEM majors usually require a good result in extended exam or exams. The student with the higher scores in math or

physics are more probable to be admitted. The proportion of gender among maturity exam takers reflects gap existing at tertiary level. In 2016 among students who took extended maturity exam in biology women comprised 75%, 73% in chemistry, 37% in maths, 22% in physics and only 8% in computer science (CKE 2016). It might proofs that gender stratification in tertiary education is not a matter of decision taken at the end of a highs schools, but it is rather a result of a long-lasting preferences shaped at previous steps of education.

The gap in number of women between science and engineering fields is certainly no new phenomenon in Poland. Just after WWII women gravitated toward science significantly more often than toward engineering. In 1947 there were 49% women in mathematics and science majors, whereas their representation in engineering, construction, mechanics and electrical engineering comprised less than 2% (GUS 1947). In the following decade this pattern remained almost unchanged. For example, in 1956 women accounted for 75% of students in biology and 45% in university mathematics departments, and those numbers were similar to the share of women in some humanistic majors. The number of women was significantly lower in technical universities, with the average of 16%, but highly varied among majors (e.g. 31% of women studied architecture and less than 4% accounted for machine construction) (GUS 1956). These data suggest that despite the fact that Polish women have steadily outnumbered Polish men in tertiary education since the 1950s, the core mechanism of selection within STEM seems to have changed only to a small extent. Significant changes are certainly visible in absolute numbers, but the relative differences are strikingly similar.

Review of Previous Research on the Role of Social Network

Family and teachers constitute a social network which have the most significant influence on individual's school care er. As Gunderson et al. (2012) explained in their detailed review, parental behaviors, beliefs and attitudes toward maths may strongly affect children's perspective on math-related courses. For example, if parents belief that boys are better in math than girls, they will transmit this belief to their own children during the process of socialization and set different level of expectations toward daughters and sons. In the same way beliefs on "natural" abilities of one gender may be consciously or unconsciously reinforced by teachers. The simplicity of this mechanism has been described in a famous study of Robert Rosenthal and Lenore Jacobson, which showed how expectations of teachers toward some students lead to an increase in their performances. The assumption that boys are better in math is also present among some Polish teachers. In recent studies about 30% of teachers agreed with the statement that boys are doing better in math than girls (Grzęda 2008). Interestingly, this opinion contrast with the fact that in general population of students girls outperform boys in school grades in maths (Grudniewska, Kondratek 2012).

Except direct student-teacher interaction, gendered role models might be also transmitted through content of a textbooks. A study of a polish handbooks of maths has shown that over $4/5$ of infographics portray males and the remaining $1/5$ cover females or both sexes. In other types of content used in handbooks, like text, tasks, or illustrations, differences were smaller, but images of males still were overrepresented (Kopienka, Tomkowiak 2016).

Those asymmetrical presentation might be interpreted as a reflection of cultural stereo-types, but whether it affects individual career choices made by both sexes needs careful investigations.

More direct influence of a role model has been shown in a study of Aschbacher, Li, and Roth (2010) who interviewed a sample of high school graduates once interested in T&E. They argue that students who decide not to pursue education in STEM experienced very little interaction with science mentors, while they had strong relation with people who suggested them different career alternatives. On the other hand, students who persisted in science through the high school received information, coaching and other form of material and emotional help from family members (Aschbacher, Li, and Roth 2010). However, probably the more important difference between those two groups of students is that those who pursued STEM had in majority of cases doctors, scientist or engineers among family members. The parents of "drop-outs" were less educated and had only scant knowledge about science-related career.

The above study suggest that functioning in a milieu where science is highly valued is important to stay on T&E track, but personal relations with an experienced role model might be even more important. Bushor et al. (2015) who interviewed women transferring to science majors has showed that interaction with siblings, neighborhoods and friends who already were students on T&E major or worked in this field, helped them to take non-stereo-typical decision (Buschor et al. 2015). Similar conclusion came from Zeldin and Pajares (2000). In 15 qualitative interviews taken with women who pursue careers in STEM, 10 admitted that they had a family-member who was experienced in maths-related careers. Except an advantage structure of close social network, interviewed women reported that they also had supportive and enthusiastic science teachers at high schools or at the university.

More general framework of an effect of a role model has been offered by Dasgupta (2011). Basic assumption here is that people aspire to the achievements which "feel comfortable with" and are consistent with the prevailing stereotypes. Conversely, people will avoid goals and decisions that are inconsistent with stereotypes and will lead to a feeling of discomfort.

This is why women prefer to choose female-dominated majors instead of male-dominated. Dasgupta explains that a factor which reduces the risk of dropping out from a group where an decision-maker is a numeric minority and is negatively stereotyped is a contact with people who are successful in a given discipline. To describe the crucial meaning of an in-group expert Dasgupta (2011) uses the metaphor of a "social vaccine." Like a real vaccine, contact with professionals protects individuals from "virus" of harmful stereotypes. The interaction with expert may have positive effect on identification with the domain, develop positive self-concept or strengthen motivation to pursue non-traditional decision. The model predicts that the presence of an in-group expert will be most beneficiary for individuals who feel the sense of identification with that person and her or his achievements are perceived as attainable. It also assume that individuals may be unaware that expert has an effect on their aspirations.

The general conclusion from the "social vaccine" theory and previous research is that pursuing a non-stereotypical major requires an advantageous social environment. Presence of a role model may provide a technical, first-hand information on how effectively pursue

non-stereotypical alternative, but also makes this path more attainable. The attainability of a role model has been emphasized by Lockwood and Kunda (1997) who argue that people naturally compare themselves to other people, but others' success will be inspiring only if it is perceived as achievable, otherwise it might bring opposite effects. Hence the exposure on a "superhero," a person who's achievement are perceived as too extraordinary might discourage from achieving a similar goal.

Researchers have been trying to identify factors which mediate in an relation between role model and T&E choice. For example Stout (Stout et al. 2011) draws attention to the importance of a gender of role model and shows that exposure of undergraduate students to successful female role models resulted in a more positive attitude toward maths fields than exposure to a male role model. The finding that same-sex role model is more effective was confirmed by Dasgupta (2011), but not by Cheryan et al. (Cheryan et al. 2011).

There is a widespread belief that boys have greater mathematical abilities than girls and are more prone to success in this math-related occupations. This negative feedback received from different agents (parents, school, society) may undermine some women's confidence in their own talent. It has been widely documented that women systematically underestimate their chances of success in T&E even before they enter STEM (Litzler, Samuelson and Lorah 2014, Correll 2001, Gunderson et al. 2012, Blickenstaff 2005), and those feelings do not disappear after successful admission to maths-oriented majors. Cech et al. (2011) who studied a women who have already been exposed to the STEM environment, show that they suffer from a lack of sufficient confidence to successfully fulfill the role as scientist and have reduced identification with the domain as compared to men (Cech et al. 2011). The message doesn't have to be loud and direct—subtle signals or situational clues might be enough to discourage talented women from taking non-traditional decision. Possibly, support received from a role model may help science-oriented women to overcome those psychological obstacles by diminishing the anxiety toward pursuing T&E.

Theoretical Framework

In the following study I argue that presence of a person advanced in T&E in women's social network has positive effect on pursing male-dominated majors. I will call this element of the social network the *significant role model* (SRM). This concept combines the aspect of personal relations borrowed from the theory of significant other with the notion of emulation, present in the theory of role models. The meaning of an SRM in the social network is to enhance preferences toward science and, through a lasting interaction, to prevent female students dropping out of maths courses.

A suitable framework to explain the role of SRM in decision to pursue male-dominated major is provided by the theory of social contagion. Burt (1987, 2004, 2005) who studied the spread of innovations in social networks has defined social contagion as a process when one individual (ego) adopts a behavior, an idea or a practice from an individual who has already adopted this change (alter). The closer the relation between the ego and the alter is, the more probable it is that the alter will effectively infect the ego with this novelty. The information about innovation (a new idea, habit, behaviour) is transmitted into the social

network by the broker, who bridges different social circles. When the broker is absent, there are no bridges to other, 'external' social worlds. The time necessary to spread innovation in a group is dependent on several factors, e.g. group density (thick or loose), time horizon of decision-making (short or long), or beliefs shared by group members (open-minded or close-minded). In general, a slower flow of information occurs in groups connected by dense ties, more conservative and less flexible. Obviously the successful spread of a new idea depends on many factors. Presumably, if the innovation is costly in terms of financial and non-financial sense, intensive interaction is required and more time must elapse for adaptation. Social barriers, reproduced schemes of actions, and routines are only a few cultural obstacles which affect the time needed for the adjustment to change. However, it is expected that the adaptation will finally occur. A mechanism of social contagion has been showed by Christakis and Fowler (2007, 2008) who found that social contagion was involved in spreading in social network such complex behaviours as becoming obese or quitting smoking. It seems reasonable to assume that if some behaviour is contagious, it might also be cured or replaced by alternative behaviours. This is the reason why the constant presence and intensive interaction with the innovator are needed to maintain effect of innovation.

The theory of social contagion may help to better understand why some women decide to enter non-traditional majors. For the purpose of explanation, it can be assume that for women who traditionally opt for humanistic and social studies, the decision to apply for male-dominated T&E majors is a form of innovation. This form of behaviour is new, possibly risky, non-standard, and has unknown chances of success. The role of SRM here is to 'infect' women with the 'virus' of pursuing male-dominated majors. SRM transmit the idea to the women's social network by providing non-biased information and positive example. Contagion from SRM doesn't mean that an individual will copy exactly the same behavior by choosing the same major, but it direct the way of orientation to science. Similarly to the process of socialization, the transmission of values from SRM to individual doesn't have to be conscious for both sides of the interactions. Women doesn't have to be aware that the exposure on SRM "infect" her decisions to pursue T&E. Similarly the SRM doesn't have to directly influence or persuade women in social network. The natural interaction between two sides is enough to transmit the idea.

The final aspect of theoretical background focus on the relation between choosing T&E and social background. Some pattern of stratification by social background have been explored by Goyette and Mullen (2006). They have shown that students of art and science majors had on average higher socioeconomic status compared to students of vocational majors, with only a few exceptions. Science and maths majors had a lower representation of upper class members, while engineering majors tend to have the highest SES among vocational majors. Heaving this in mind it might be assumed that women with advantageous social background are more likely to pursue male-dominated major even when SRM is absent. Support for this claim comes from, among the other, the theory of social stratification, which suggest that social classes differ in psychological functioning, core values and level of self-direction (Kohn and Slomczynski 2006, Bourdieu and Passeron 1990). Upper classes usually uphold less traditional values and are more open to innovations. This feature distinguishes them from lower class who maintain more traditional beliefs on a gender

roles. Generally speaking, a women from lower social class will be more like to choose majors coherent with traditional roles, while women from upper social strata are more likely to gravitate toward less traditional majors.

Data and Aims of Analysis

This article utilizes data from qualitative in-depth interviews with 20 female students from different STEM majors. The interview utilized a detailed biographic approach in order to better understand educational decisions in the widest social context possible. The questions covered early educational experiences, the influence of school at different levels of education, the influence of peers and teachers and more importantly science interests at different stages of education. The study was aimed primarily on high validity of biographical information, hence the primacy was given to qualitative detail over quantitative representativeness of the sample.

Table 1. shows how does the number of interviewees relate to the gender balance in their majors. Students were recruited from Polytechnic (Technical University) and from science majors in University. Both institutions are located in the same, average size city in North-Eastern Poland, therefore the decision to study at one or another has not been determined purely by socio-economical considerations (as is often the case with the universities in cities of different size). The higher number of interviews conducted at the Polytechnics (14) than at the University (6) reflect the fact that Polytechnics encompass more STEM majors, with intended overrepresentation of mathematics in both cases (as this major exists at both universities).

Table 1

Sample Design

Type of institution	Major	Number of interviews	% of women in that major
University	Biology	1	85
	Physics	1	47
	Mathematics	3	78
	Chemisty	1	81
Polytechnic	Mathematics	4	46
	Electrotechnics	2	6
	Mechanical engineering	2	9
	Computer science	3	12
	Construction	3	37

Real names of interviewed women were replaced by fictional ones to protect their identity. All the interviewed women were students of the undergraduate studies. Their ages ranged between 21 and 27. The interviews were recorded, transcribed and coded using the RQDA package in R.

The main idea of this paper is that an SRM, by his or her constant presence in the social network, increases the probability that women will choose T&E major. The analysis of interviews has shown that SRMs were often present in women's circles, but there were

noticeable differences between the University's and the Polytechnic's students. An SRM was present in the social networks of 8 out of 14 cases of Polytechnic students and in 1 out of 6 cases of University students. This sheer lopsided distribution suggests that the presence of an SRM is more important for women who pursue male-dominated majors than for women who opt for more gender-balanced majors. The narratives of the interviewed women help to better understand the mechanism behind this pattern. Depiction of those mechanisms is the main goal of the following sections.

The Role of SRM in Choosing Male-Dominated Major

The first example illustrating the impact of an SRM on a decision came from the interview with Ewa. Here is how this self-confident young woman remembered her maths activities in her girlhood years:

I had a grandfather who, when I was a child, tortured me with … you know two plus two, this multiplied by this. In turns, the grandfather and the grandmother took care of me and tortured me with multiplication tables and so on … and, you know, I was still a small child.

Thanks to the grandparents' "tortures" Ewa, who is currently a student of mathematics at the polytechnic, became fluent in basic multiplication two years before her peers did. As she recalled in different parts of the interview, she was raised in a family where her grandparents and parents had a mathematical inclination, although none of them held a degree in STEM or even any tertiary degree. Despite their lack of formal education, Ewa believes that her own maths skills have been inherited from the previous generations. At the same time, when she described in details the "mathematical climate" at home, she distanced herself from suggestions that her parents or other family members might have had an influence on her decision to study maths. Understandingly, she have preferred to believe that she had been fully independent in her decision. However, the structure of her social network suggests otherwise. The fact that her core family circle was maths-oriented, or as she preferred to call it: 'science-minded,' must have been a circumstance which facilitated choosing a similar path. Apart from the fact that science in a various forms was present in her girlhood daily life, she also had an opportunity to develop other important skills. She have proudly emphasized that her father was a handyman, and this fact gave her the opportunity to get familiar with the construction of machines and devices. Although it might seem trivial, taking part in home repairs allowed her to develop some behaviours which are linked with boys.

Effect of Ewa's social milieu explains why she decided to pursue mathematics, but why did she choose to do this at a polytechnic rather than University? Her own response to this question was straightforward: she had not even considered University. She seemed to be neglecting the fact that her older brother studied Robotics Engineering at the same polytechnic. The brother, who plays the role of her primary SRM, seemingly induced her with visions of studying in a male-dominated academic environment instead of a University. Ewa reluctantly admitted that he had some influence on her own decision and that she could count on him when she needed help in doing homework. Also, from time to time,

they discussed lucrative job opportunities after graduation from the polytechnic. The role of an SRM in Ewa's biography is even more meaningful, because her parents were poorly educated and could not provide professional support to her. It seems that the brother was actually the main bridge connecting Ewa to the polytechnic.

Ewa and other interviewed students of mathematics at the Polytechnic, had at least one bridge which connected them with this academic environment, or at least with the idea of engineering and technical studies. In most cases SRM was a member of core family, usually a sibling. Another illustration was given in Sylwia's interview. One of her sisters also studied at Polytechnics, but in different major. This is how Sylwia explained why she had decided to follow her sister footsteps:

I've noticed… that I have chosen a desired path, right? I did the same high school as my older sister. Maybe I was afraid to take the risk and take different decision myself, right?

Sylwia remembers that her sister took care of her and helped her with homework in younger ages. She also recalls that she felt much more comfortable at the beginning of the first year of studies heaving in mind that her older sister was around. The effect of social contagion manifests also in the decision of younger sister of Sylwia, who planned to study computer science, also at Polytechnic. Similarly like in previous case—of Ewa, Sylwia claimed that she and her sisters had a "scientific mind" and the talent has been inherited from their mother who works as an accountant.

Not always, like in case of Ewa or Sylwia, the SRM was a member of the core family or even family at all. In some cases, the role of the SRM was played by schoolmates. However, what all the analyzed biographies have in common is that the SRM stayed in a stable, lasting interaction with interviewed women. Time and the direct or indirect support provided by an SRM effectively infected young women with the idea to choose non-stereotypical major.

The Meaning of a Multiple SRMs

The above illustrations reflects how a single SRM provides the resources needed to enter male-dominated environment, but what would be the effect if the number of SRMs increased? In the sample there were few students whose social network contained more than one role model. One of those women is Emilia, a student of building construction. In her family, studying at polytechnic has been a tradition. In the extract below she explains in her own words the reasons for choosing construction at the Polytechnic:

I think that my parents had a big influence on me. In my family everyone is an engineer. One of my brothers, my dad, well… all the relatives, grandparents and everyone are involved in construction, except for my mother, because my mother is a chemist, the rest are construction engineers.

No doubt Emilia represents an extreme case. Her narratives echoes the theory of social reproduction (Bourdieu and Passeron 1977), which offers the explanation of how the educational achievements are reproduced in an intergenerational cycle of family inheritance. In this particular example it is not only the level of education that has been reproduced, but also the major. Emilia has been fully immersed in a environment where engineering-oriented thinking is a way of looking at the world. In such a densely packed network there is no place to develop 'deviant' behaviour and enter non-engineering fields.

Emlia's case suggest that the presence of more than one SRM is especially needed to pursue a major with a significant gender disproportion rather than a more balanced one. This hypothesis might be supported by the narration of Magda. Here is what she replied when she was asked about the decision to study electrical engineering:

I think in high school I went to an open day [at the Polytechnic]. I went there every year in my second and third grade with my friends. It interested me. Besides, my [female] cousin graduated from electrical engineering and found a well-paid job, so I think it had an impact.

According to Magda, the female cousin who graduated from exactly the same major before her, had little influence on her decision because no direct persuasion or urge were involved here. Probably it was not necessary. The close emotional relationships of these two women, combined with the high value ascribed to the cousin's career, was enough to make Magda follow her footsteps. She underscores the impact of an SRM, but similarly to other women, she does it in a rather careful manner. In the eyes of Magda, her own strong abilities in maths were the primary reason to choose electrical engineering. Indeed, a closer look at her rather poor family social capital suggests that to a large degree her talent and a lot of learning led her to pursue this major. She did not receive any support from her core family, nor from her two older sisters, both of whom are students of social sciences, nor from her parents, who do not have any college education. Her decision to study electrical engineering was met with a rather sceptical reaction from her parents, because they were worried that she could fail when faced with such a demanding major. This does not mean that they had not believed in her talent. On the contrary. The fact that Magda entered her primary school with a strong math-orientation means that parents stimulated her skills in early years. The critical point in the Magda's biography was the decision to choose a polytechnic path in the high school. This decision placed her among schoolmates with similar interests, skills and aspiration for future. For three school years she was surrounded by teenage girls, all of whom went to strongly male-dominated universities, including Military University or Air Force Academy.

It seems that in the case of Magda her talent was the primary reason for her interest in STEM majors, but it was the contagion effect of her social network that led the precise choice of the particular major. Her female cousin introduced her with this male-dominated major, showed her that, though "difficult," it is attainable for women like her and offers interesting job opportunities after graduation. The effect of contagion was boosted in high school, when she put herself in relatively homogenous environment of peers and teachers with strong polytechnics preferences.

Emilia and Magda have two things in common. They were exposed on the influence of more than one SRM—Emily grew up in a family where majority of members had an engineering degree, while Magda had a female cousin with polytechnic experience and was exposed on the influence of peers and teachers at high school. Secondly, both women pursue highly male-dominated major. Those educational biographies might suggest that the decision to do STEM majors requires a stronger net of support compared to more gender-balanced ones, even within technical universities. Hypothetically, it seems possible that the number of SRMs might be inversely proportional to the share of women studying those majors.

The SRM as a Broker and Informer

The presence of an SRM may be beneficial for a variety of reasons, but for many women it serves mostly as a source of information. Here, Anna, a student of electrical engineering, recalls what the impact of her older brother on her decisions was:

[…] I learned about this major from my brother. Because my brother graduated from the same University, just in a different faculty—Microprocessor Technology and I've heard about this major directly from him, right? I saw a little of what he does and I can honestly tell you that it directed me to this. Also, he told me that I could try, why not?

The brother mentioned in the quotation is not the only link that connected Anna to the Polytechnic. She had another older brother who studied Construction Engineering at the Polytechnic, but because he dropped out due to low grades, he is not considered by Anna as an example to follow. Nonetheless, two older brothers with the experience on Polytechnic creates a unique enclave for developing her own preferences. By their constant presence and physical proximity, Anna soaked up with the idea that technical or engineering major is a good choice. Not surprisingly, heaving no attractive alternative around, she admitted that she did not even consider studying at University. Interestingly, although interaction with brothers protected Anna from developing anxiety toward male-dominated majors, she is aware that her decision was incompatible with the gender role. In some sense she perceived it as a form of stigma. For instance, she often has to explain to new acquaintances why she studies Electrical Engineering.

The impact of an SRM on decision-making goes far beyond the function of advice, mentoring or providing information. The narratives of many interviewed women clearly show that a durable interaction with an SRM shapes stable preferences for polytechnics. Here are two short examples showing that certain assumptions are built in before the educational choice. Those quotes come from different interviews:

(1) *From the beginning I was thinking about a polytechnic because the polytechnic was my first idea. I only had to decide which major to take.*

(2) *I rejected humanistic majors from the beginning.*

When asked in interviews why they have such unwavering opinions, the young women were barely able to rationalize it. They have often highlighted that they always were interested in science or had special gift. Closer look on the biographies of students suggest that values, attitudes, and subtle signals sent by an SRM developed something what might be called a "polytechnic preference." Technical University became the "default" choice. However, it doesn't mean that the choice of polytechnic wasn't accompanied by unpleasant feelings or anxiety. This aspect has been touched upon by Ewa, whose parents and siblings graduated from a Technical University:

Generally, my parents advised me to do this major at this department. Because it is a very future-oriented major and you can achieve a lot. So I thought, why not to try? But of course it was hard, because there are only few girls there, and in general I was very afraid. You know, it is different for girls. I was able to get used to this. I was the only girl who "survived" in my student group.

It might seems counterintuitive that despite the fact that Ewa had been surrounded by SRMs who supported her at each step of her career, she still developed a form of anxiety

toward male-dominated majors. Interestingly, this feeling do not arise from underestimation of own abilities, but it is rather a reaction to significant gender disproportion. Emilia's worries have been not unique for women who enter male-dominated environment. Murphy et al. (2009) show that situational cues such us gender unbalance may result in vigilance and a lesser feeling of belonging when it comes to a career in STEM. One solution to this is an exposure of women to a more gender balanced environment (Murphy et al. 2007), the other, as Emilia's case show, are regular interactions with male peers.

Is the Absence of a SRM Related with Unstable Educational Carriers in T&E?

The reasons for an entry to a polytechnic among women who didn't interacted with SRMs were varied. Usually, motivation to follow own interests played a dominant role. The example might be Aldona, a student of computer science, the daughter of a working-class single mother, and the sister of four older brothers, none of whom completed college. At high school she was in class with extended math and computer classes, but after graduation she decided to entered two-year post-secondary school instead of the University. She explained that she had not felt qualified enough to pursue full major at Polytechnic. Nevertheless, she did that just after post-secondary school.

Aldona wasn't exposed to any SRM, but it might be interesting to consider whether the 4 older brothers indirectly influenced her decision. It's possible that socialization with older brothers, observation of their behaviors, participation in plays and everyday activities may developed in Aldona some interests typical to men. Using a classic two-dimensional scale of vocational interest, it may suggest a presence of a stronger orientation on things, preferences for interaction with machines and opting for working with gadgets (Halpern 2006). Arguably the effect of "older brother" may play some role in decision to choose male-dominated majors in situation when SRM is absent. Certainly Aldona was less "male-shy."

In most cases however, the absence of an SRM resulted in decisions being subject to a random circumstances rather than certain guidance. One of the examples is Izabela, a student of biology at a University, who have explained that she was partly inspired by the books of Robin Cook. Here is how she comments on it:

You know, there is a doctor and there is an epidemic, and he is trying to figure out where the epidemic started and so on. So I think that I ended up studying biology because of that and this type of laboratory biology. You know—white coats and stuff like that.

Izabela, whose parents both completed lower vocational schools, and whose older brother have studied Management at University, already changed her majors twice. After high school she took up biology at the University, but as she explained, the courses were too challenging for her and soon she decided to switch to Environmental Protection at the Technical University. After a short period of time she decided to resume her biology studies. Her decision was driven by her disappointment with the curriculum and herself being overwhelmed by the number of engineering subjects at polytechnic.

It seems that the reason for her unstable career is partly the lack of essential information about the studies, the requirements and full curriculum. In the interview she have not men-

tioned even one person who mentored her during school career. Instead, her fundamental vision of science was shaped by fiction book which uses a popularized image of a scientist in a laboratory coat. She had to experience this firsthand to see that this was, in some degree, indeed fictional.

Her early interest in science met with a rather neutral reaction from her parents, but from the first class of primary school on she attended extra curricula classes in mathematics. Biology was her second passion. Sadly, even though she is currently a hard-working student in the second year of a Bachelor's degree, she is deeply worried about her future job opportunities. Her dream is to continue her academic career, but she is aware that the poor financial condition of her family may stop her from fulfilling this plan. She was afraid that she will "end up" in a low skill job and her effort during studies would have been for nothing. Discrepancy in aspirations and perceived life possibilities is the second, next to the lack of contact with SRM, attribute which distinguished Polytechnic students' biographies from those of University students'.

Even more illustrious example of the decision-making taken in absence of SRM is represented by Maria. When she was asked to explain why she decided to study mathematics at the University, she replied:

It happened quite by accident, it's … I mean, in high school I thought: 'I will go and study maths'. But I also wanted to go for biology and I submitted documents there, right? Well, but fate decided it would be mathematics.

Similarly to the previously discussed case of Izabela, Maria also migrated between University and Polytechnic. After passing maturity exam she entered the major which combine mathematics and computer science at the Polytechnic, but in her view the curriculum included too many computer science classes. In an emotional tone she emphasized that she was not aware how much programming she would have to master. Clearly, the lack of reliable information from an SRM seems to have exposed Maria to taking an unfavorable decision. Without any guidance she had to follow her own intuition. Today, her feelings concerning the time spent at a Technical University are mixed—on the one hand she regrets having failed in this major offering better job opportunities, on the other hand she underestimated her chance to pass all exams.

Final illustration of how decisions are made when the social circle lacks the presence of an SRM might be found in the narrative of Ela, a student of maths at the University. She and her baby sister were raised by their unemployed mother and provided for by their unskilled father. Here is how she described her struggle with thoughts at the end of the high school:

I saw it on the folder, I had a folder from the University that… and I marked some majors which I wanted to do.
Interviewer: *Where did you get this folder? On open day?*
Yes, and I've marked mathematics, that's for sure, also library science, financial mathematics and computer science. I think that's it.

Two aspects of Ela's decision are significant. First is the discrepancy of majors she was interested in. Library Science has little in common with Financial Mathematics, and both are far from Computer Science. She could not explain why she had considered Library Science, but she knew why she had finally abandoned this idea. Like many STEM-minded women she associated humanistic studies with simple memorizing routines, while

she strongly preferred the logical reasoning used in mathematics. With no hesitation she described herself as 'science-minded,' even though at the early stages of education she preferred humanistic subjects, and switched over to mathematics much later. As a person with no access to SRM, she made the decision to study mathematics completely by herself, guided only by promotional folders provided by the university. She does not have any specific plans for the future, and was not able to explain what her next step after graduation will be.

The above examples suggest that talent in math is not enough to pursue a stable career is T&E. Women described here lacked an SRM who could guide them in choosing majors coherent with their interests and ambitions. No doubt, the interrupted education was also related to poor support from working class parents. Simultaneous absence of those two factors might have cumulative, negative effect on school decisions.

Conclusions and Limitations

The present study analyzes the influence of social network on women's decision to enter male-dominated majors. The fact that science-minded young women make profoundly different decisions at the end of secondary school posed an intriguing puzzle. Some of them decide to study science or maths while other choose engineering or technology. To address this problem I have employed the framework of the social contagion theory which is usually used to study patterns of a spread of innovations in social networks (Burt 1987, 2004, 2005). The theory suggests that people who function in the same social network finally become infected with a particular idea—in this case with the idea to pursue male-dominated major. I assume that an SRM might, but not necessarily uses direct persuasion. In most cases spread of the idea is rather an effect of emotional and physical proximity.

SRM brings truthful information which allows the students to realistically estimate the potential costs and benefits of making decision contrary to stereotypes on gender roles. Having a brother, cousin or parent who experienced education or work in STEM means that women's knowledge about polytechnic will be more fact-based and less dependent on stereotypes about it. However, exploration of the interviews proves that the role of an SRM goes beyond guidance. Interaction with SRM shaped something that could be called a 'polytechnic preference'. It might mean that decision to enter T&E is a process which starts relatively early in a lifetime and has to be constantly maintained later. From this point of view shaping the preferences for studying on male-dominated academia is as any process of socialization.

Furthermore, it became clear that the educational careers of women who were deprived of an SRM were more dependent on other, sometimes random circumstances. The narratives of these women exposed the helplessness of teachers towards the dilemmas of young people concerning their next step in career. Although the preference for or against a polytechnic was a the result of long-lasting processes, it seemed that such support would help students to avoid misguided choices. Schools and other institutions cannot perfectly replace an SRM, but at least they can provide reliable information on majors and the consequences of particular choices.

This study has some obvious limitations. Comparison of social network of women with and without SRM show a difference in the social background. Namely, students of polytechnic more often had parents from higher social strata compared with students of University. This pattern might suggests that social background itself is an important predictor of the choice of major. Hypothetically, interaction between advantageous social background and the presence of an SRM increase the probability that women will choose a male-dominated field. To establish the direct effect of SRM, that is after controlling the influence of social background, more detailed quantitative study is needed. Secondly, the sample used in this study represents a particular academic environment in one city with a specific educational market, thus further research is necessary to establish whether the pattern of gender selection between different academic environments is reliable. The answers to these questions are necessary in order to gain more insight into the processes generating various dimensions of gender gap.

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