

Women in Computing

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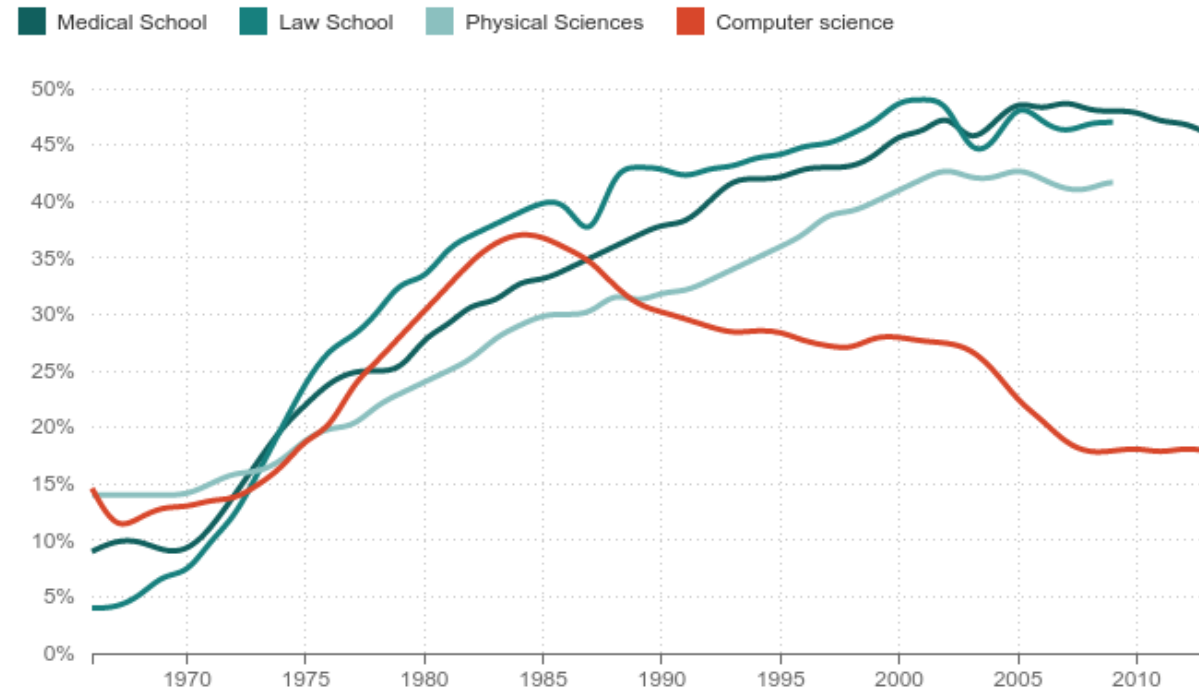
What questions I will try to answer:

- Why many people (including me) view a decreased participation of women in computer science (and STEM – Science, Technology, Engineering and Mathematics in general) as problem? Why it could be regarded as a question of ethics, whether to direct efforts to help this problem or not?
- Why there are so few women in IT (STEM)?
- What could we increase number of women in computer science?

Some figures

What Happened To Women In Computer Science?

% Of Women Majors, By Field



Source: National Science Foundation, American Bar Association, American Association of Medical Colleges

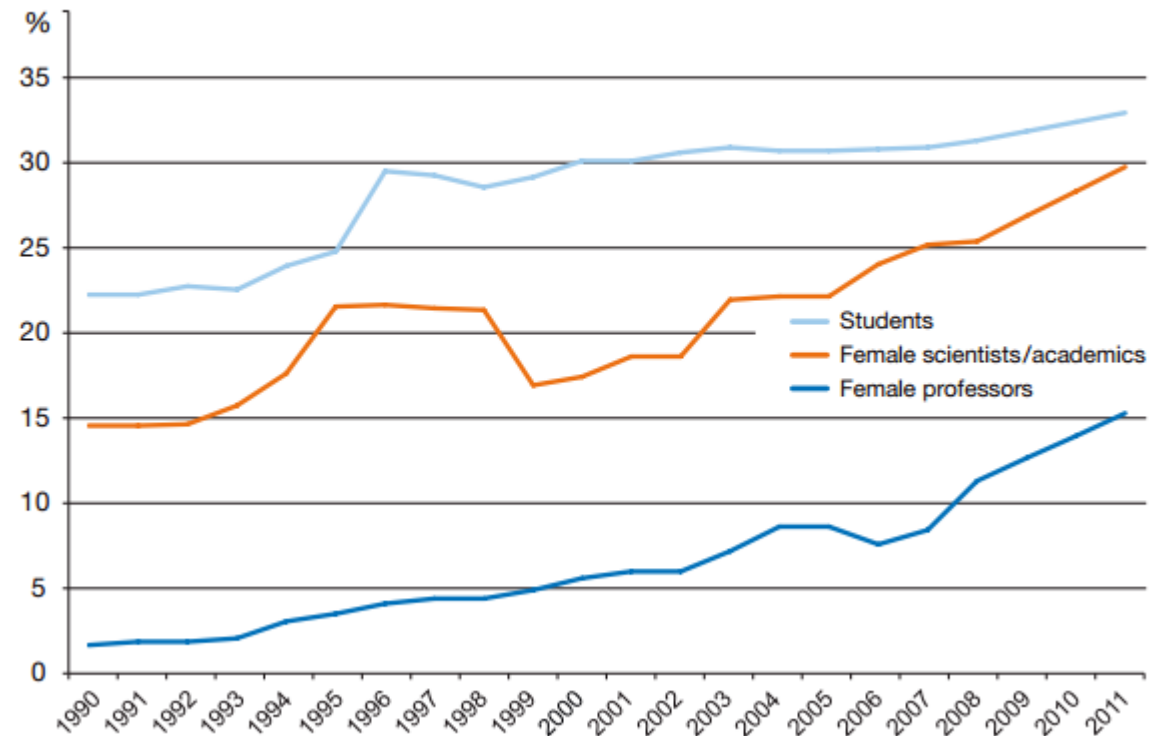
Credit: Quoc Trung Bui/NPR

(See [1].)

TUM Figures

- 33% of students,
 - 39% of PhD students,
 - 33% of scientists,
 - 14% of professors are female.
- [2]

Percentage of women at the TUM since 1990



Taken from [3].

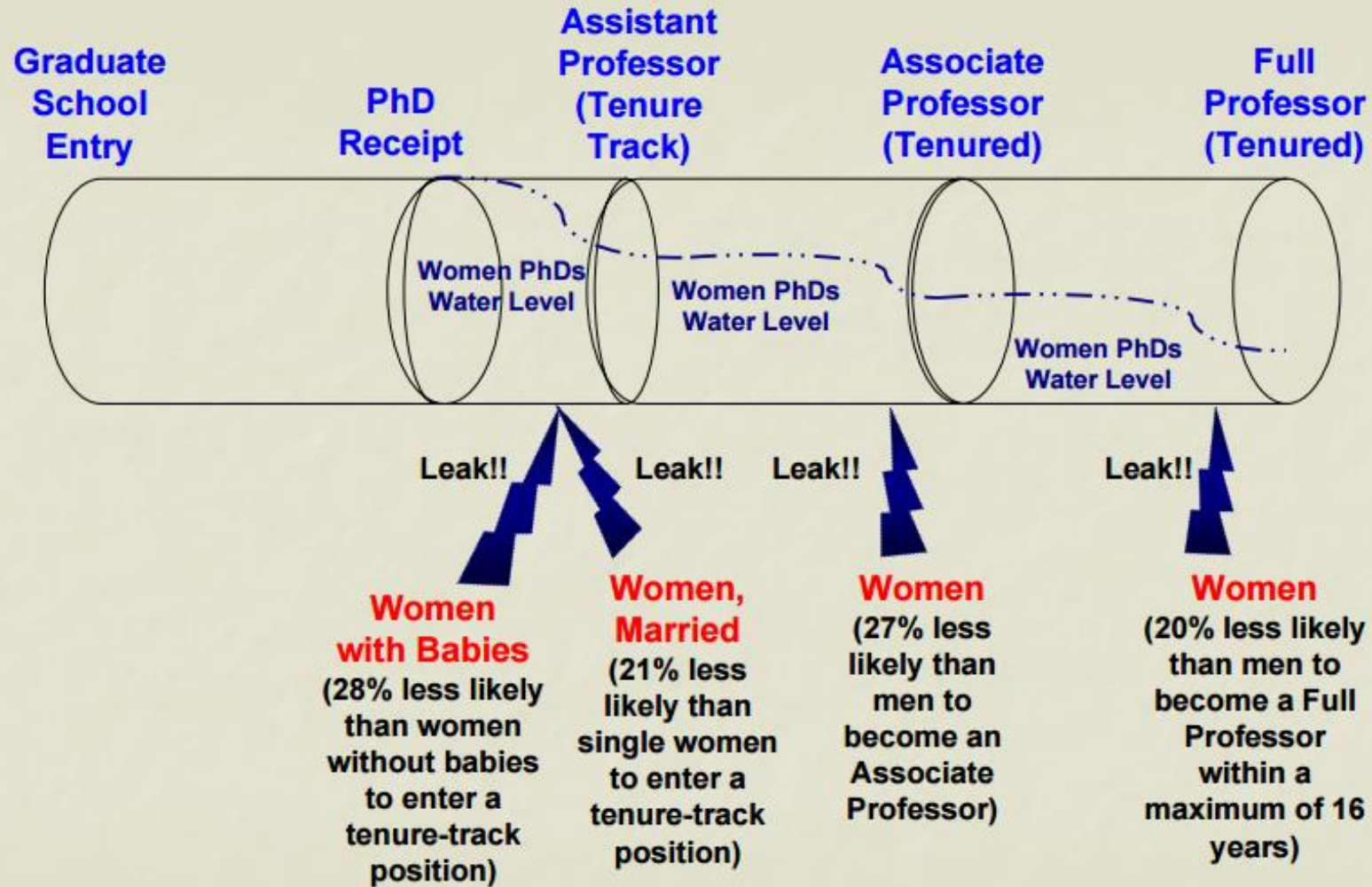
TUM Figures: by major overall [2]

Students by Department	% of females	Students by Department	% of females
Architecture	56%	Munich School of Engineering (MSE)	31%
Chemistry	41%	Physics	18%
Civil, Geo and Environmental Engineering	34%	Sport and Health Sciences	53%
Electrical, Electronic and Computer Engineering	14%	TUM School of Education	63%
Informatics	16%	TUM School of Life Sciences Weihenstephan	53%
Mathematics	30%	TUM School of Management	33%
Mechanical Engineering	14%	TUM School of Medicine	62%

TUM Figures: PhD by major [2]

Department	% of female	Department	% of female
Architecture	50%		
Chemistry	39%	Physics	18%
Civil, Geo and Environmental Engineering	22%	Sport and Health Sciences	54%
Electrical, Electronic and Computer Engineering	9%	TUM School of Education	92%
Informatics	8%	TUM School of Life Sciences Weihenstephan	55%
Mathematics	29%	TUM School of Management	42%
Mechanical Engineering	15%	TUM School of Medicine	61%

Leaks in the Academic Pipeline for Women*



* Preliminary results based on Survival Analysis of the *Survey of Doctorate Recipients* (a national biennial longitudinal data set funded by the National Science Foundation and others, 1979 to 1995). Percentages take into account disciplinary, age, ethnicity, PhD calendar year, time-to-PhD degree, and National Research Council academic reputation rankings of PhD program effects. For each event (PhD to TT job procurement, or Associate to Full Professor), data is limited to a maximum of 16 years. The waterline is an artistic rendering of the statistical effects of family and gender.

Taken from [4].

Why is this a problem?

- According to prediction, in USA by 2018 there will be **1.4 million open technology jobs** in the United States and, at the current rate of students graduating with degrees in computer science, **only 61% of those openings will be filled**—and just 29% of applicants will be women. [5, 6]
- In Scotland, a large number of females graduate in STEM subjects but fail to move onto a STEM career compared to that of men. According to The Royal Society of Edinburgh, this represents a **£170 million per annum loss to Scotland's national income**. [7]

A supply of IT professionals doesn't meet a growing demand.

Why is this a problem? II

- A number of studies show, that diverse teams perform better. [8]
- Diversity could be seen as antidote to so-called groupthink.

Women can actually
make computer
science better!



Why is this a problem? III

- 34% higher return investment when women are in leadership positions. [6]
- 40% higher citation for patents with women co-inventors vs. those with men only inventors. [6]

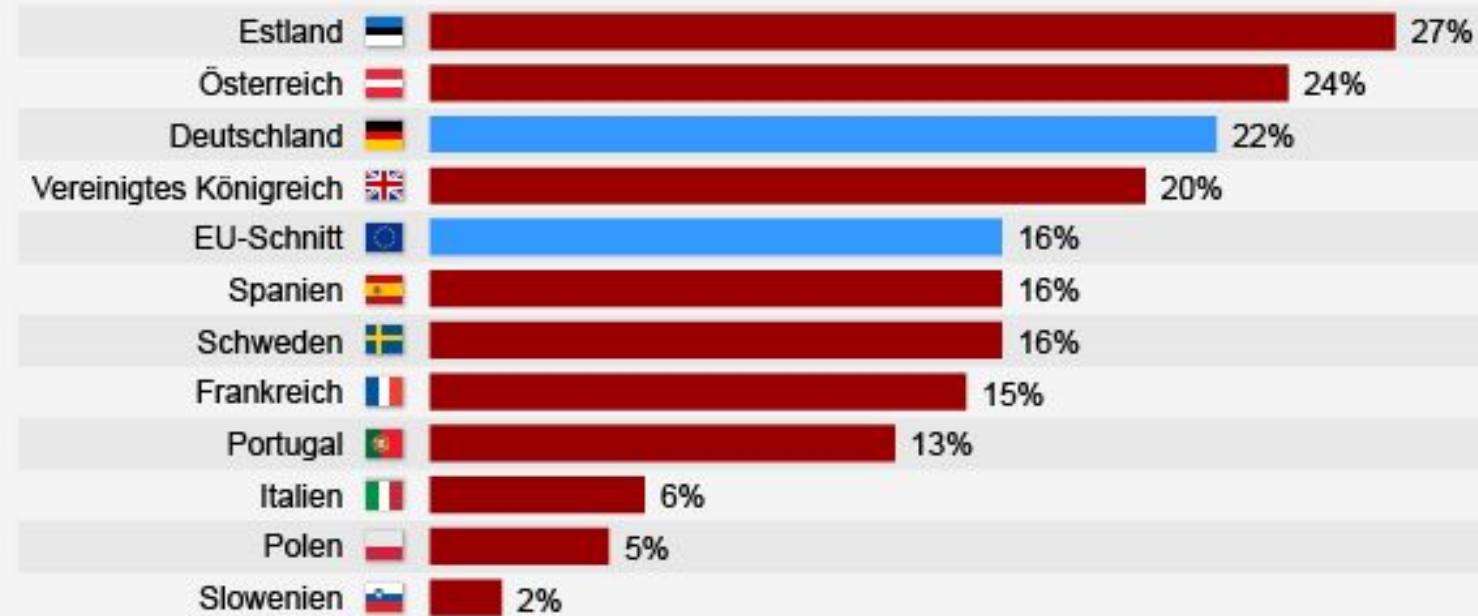
What are the ethical implications? I

- **Social inequality**
- STEM fields provide a great number of good jobs, including highly prestigious and well-paid
- In the future, a huge shortage is predicted:
- E.g., a 2012 report from the President's Council of Advisors on Science and Technology indicates that training scientists and engineers at current rates will result in a deficit of 1,000,000 workers to meet United States workforce demands over the next decade. [9]

The pay gap

Gehaltsunterschiede zw. Männern und Frauen in Deutschland hoch

Unbereinigter "Gender Pay Gap" in der EU 2011 in Prozent



Quelle: Statistisches Bundesamt

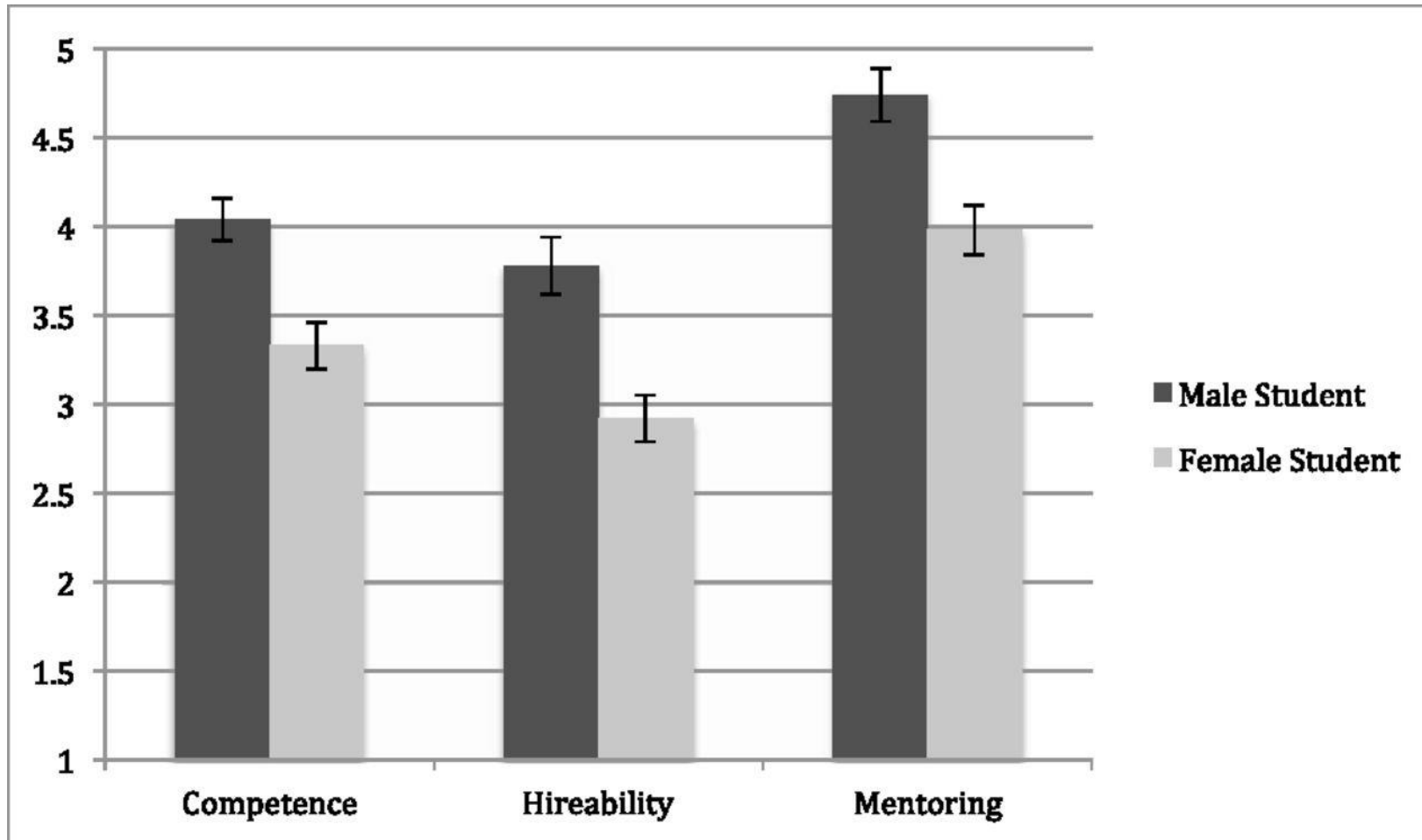
statista ZEITUNG ONLINE

- Germany: > 3,000 euro gap in annual salary in IT field

What are the ethical implications? II

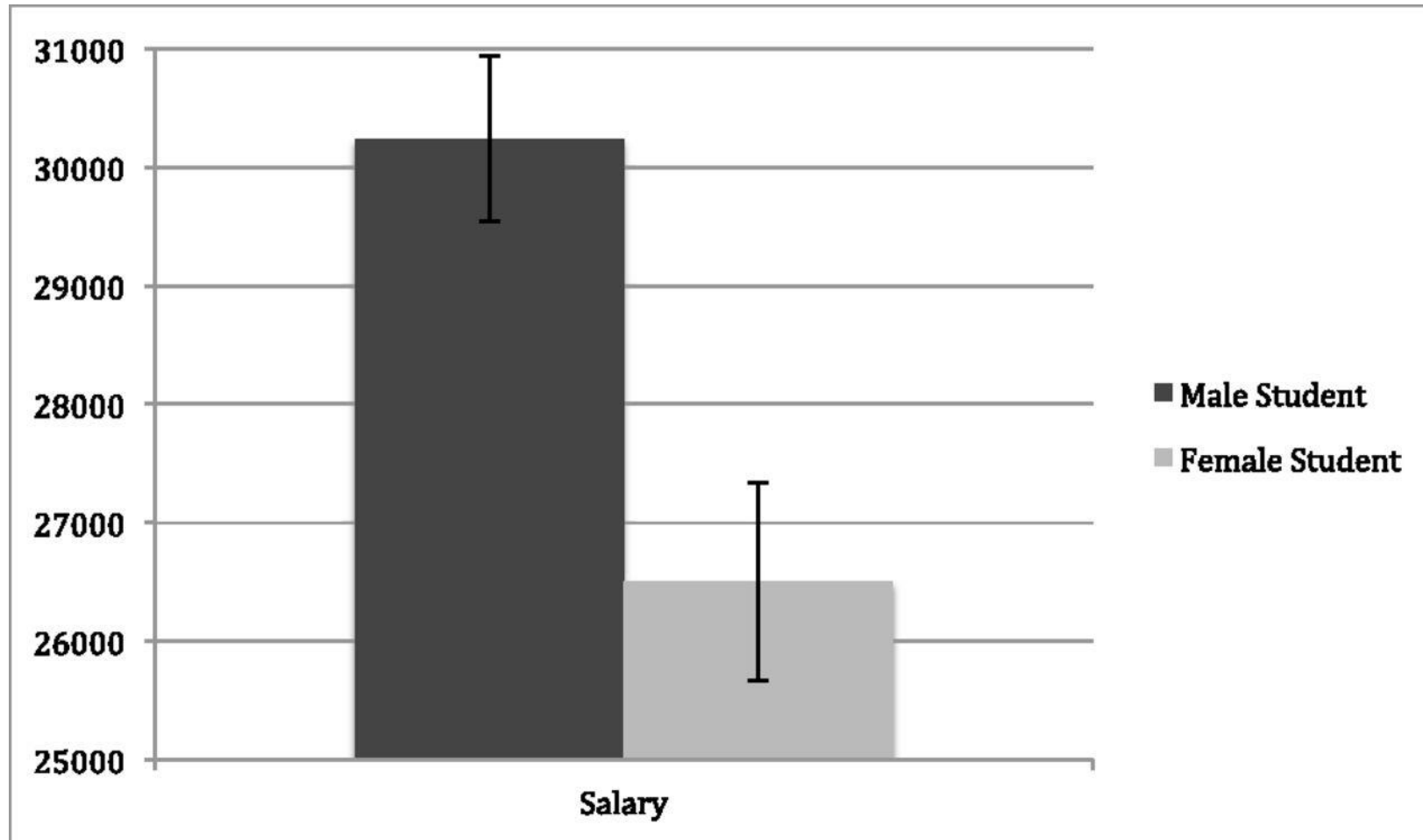
- The pay gap and overall low representation of women in higher levels in the hierarchy of many professions may also be a consequence of discrimination.
- Example:
- In one study (2012) the researchers asked 127 faculty members of reputable research-intensive American universities to evaluate an application of a student. All respondents received the same documents, except that student's name was randomly assigned to be either male or female. [9]

Competence, hireability, and mentoring by student gender condition (collapsed across faculty gender).



Corinne A. Moss-Racusin et al. PNAS 2012;109:16474-16479

Salary conferral by student gender condition (collapsed across faculty gender).



Corinne A. Moss-Racusin et al. PNAS 2012;109:16474-16479

What are the ethical implications? III

- Social inequality:
 - Lower wages
 - Lower influence in society
- Introduction of suffering:
 - Hindrances on the way of unlocking potential of women
 - Obstacles towards living out plans or dreams of women
 - Lower self-esteem
 - Increased anxiety

What are the reasons which drive women away from computer science (and STEM)?

- Psychological phenomena like self-fulfilling prophecy and stereotype threat, which could contribute to lesser attractiveness of computing for women, employ **stereotypes**.
- A stereotype is a widely held but fixed and oversimplified image or idea of a particular type of person or thing. [Google Dictionary]
- People use stereotypes as heuristics (i.e. cognitive shortcuts) when making decisions in social situations.

Stereotypes: may originate from childhood



Stereotypes: may originate from childhood

- Girls are more expected to stay at home, speaking with adults and reading books
- Boys are more expected to do outdoor activities, in particular play games in teams



Girls want to be gorgeous, boys want to be clever



Boy will become a doctor, girl will be a nurse

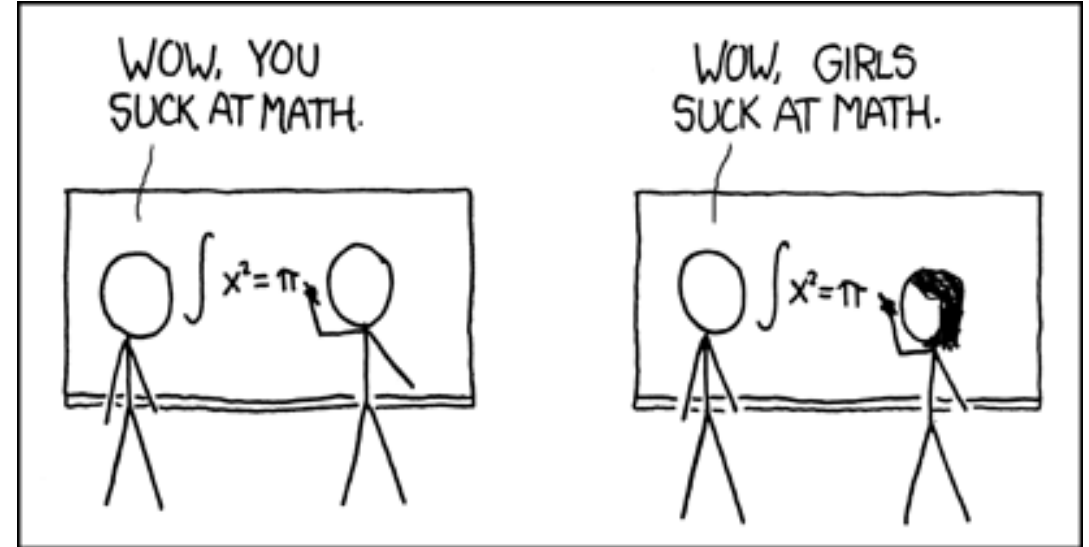


Stereotypes against women: interests

- Men prefer working with things, women prefer working with people.
- When interests were classified by RIASEC type (Realistic, Investigative, Artistic, Social, Enterprising, Conventional), men showed stronger Realistic and Investigative interests, and women showed stronger Artistic, Social, and Conventional interests.
- Sex differences favoring men were also found for more specific measures of engineering, science, and mathematics interests. [10]

Stereotypes against women: abilities

- Women have less intrinsic aptitude for mathematics, science, programming, etc.
- Whereas boys' successes in math are attributed to ability, girls' successes are attributed to effort; conversely, boys' failures in math are attributed to a lack of effort and girls' failures to a lack of ability. [link]



- Women are less competent professionally. (E.g., learned from the study about discrimination.)

Stereotypes against women: behavior

- Women should be quiet and obedient.
- Teachers are more likely to accept questions from boys while telling girls to wait for their turns. [\[link\]](#)

Stereotypes: how close to the reality? I

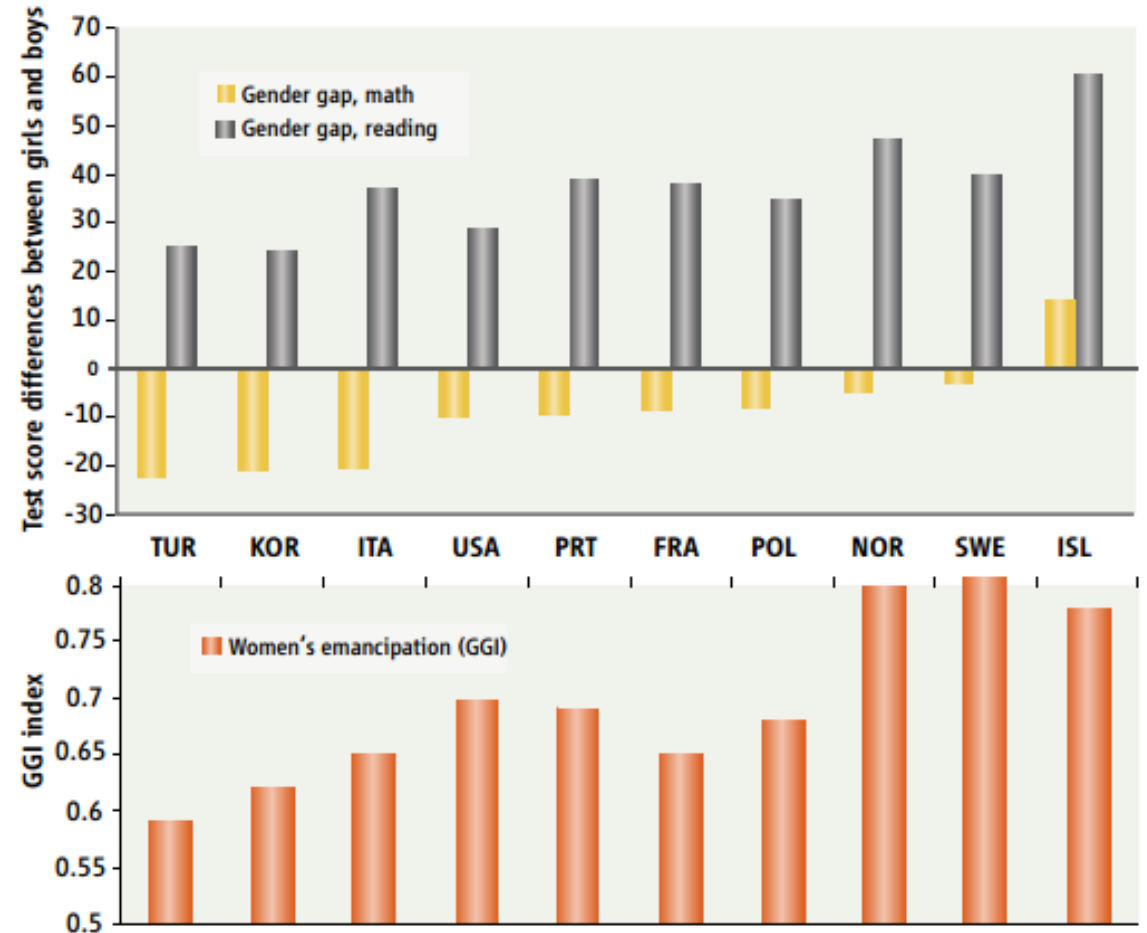
- Biological differences were the most popular explanation for decreased participation of women in science, medicine, etc. before 20th century. [link]
- **Female and male brains are indeed different.**
- In particular, in weight number of cells, quantity of grey matter in different areas in brain. [link]
- **However, scientists cannot yet say much about how that differences affect intellectual abilities (or preferences).**

Stereotypes: how close to the reality? II

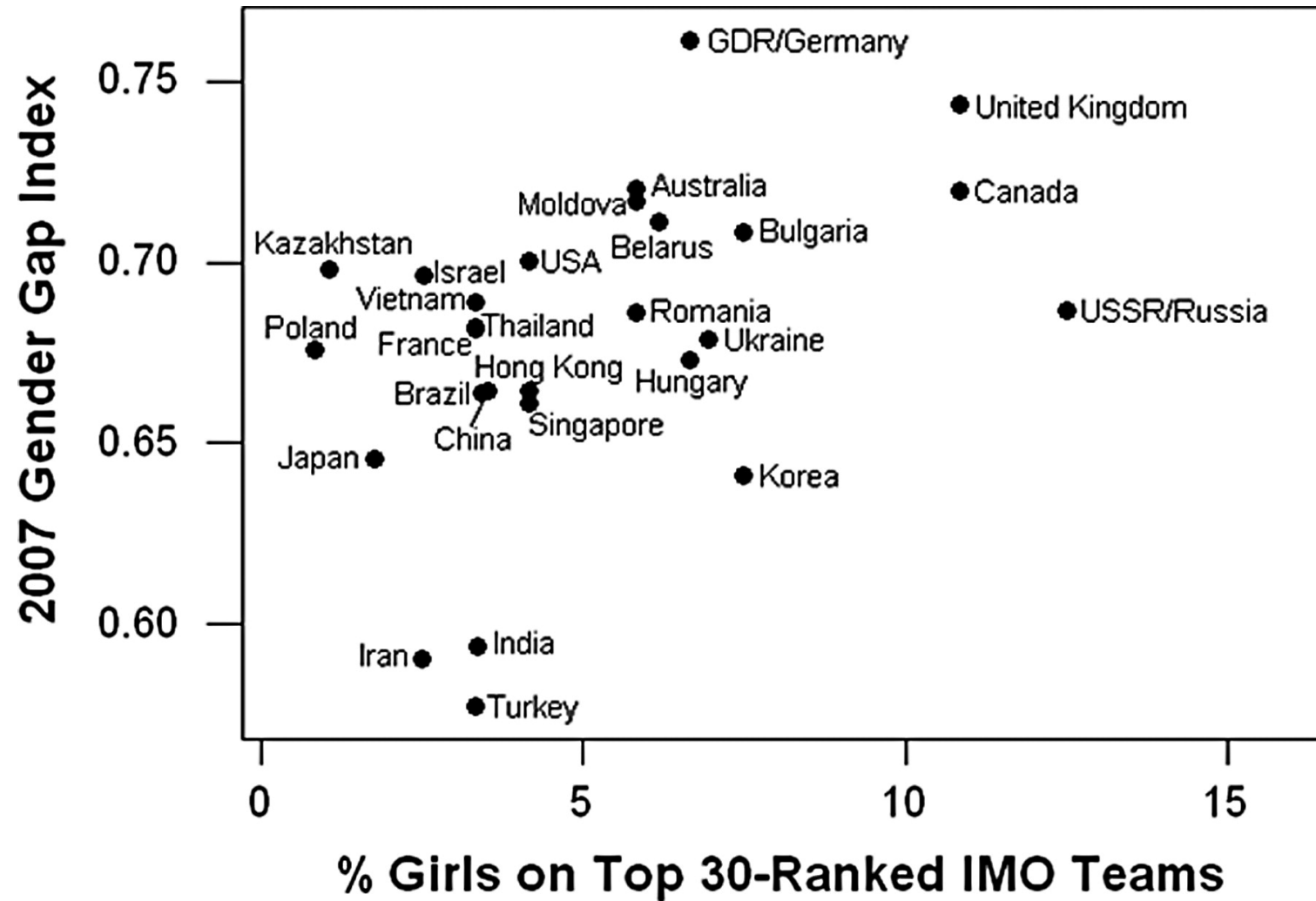
- Experiments with infants:
- Research didn't confirm that male infants are more interested in objects, and female infants are more interested in people. [\[link\]](#)
- Meta-analyses of tests on various abilities:
- No large overall differences in mathematical skills, verbal ability or visuospatial skills found.
- However, many studies show, that girls score slightly higher in verbal ability and boys in spatial ability tests. [\[links\]](#)

Stereotypes: how close to the reality? III

- Some researchers claim that differences in aptitude for certain tasks between sexes has genetic basis. [link]
- But there is a good argument against this claim: some studies show, that gender differences in test performance change from country to country and correlate well with such measures of women emancipation as GGI (Gender Gap Index). [link]



Presence of females on top 30-ranked IMO teams strongly correlates ($r = 0.44$, $P < 0.05$) with measures of gender equity within countries.



Janet S. Hyde, and Janet E. Mertz PNAS 2009;106:8801-8807

What are the reasons which drive women away from computer science (and STEM)?

- Lack of interest
- Socio-psychological reasons:
 - Low perceived ability in computing/science/mathematics [\[link\]](#)
 - Low representation of women in these fields [\[8\]](#)
 - Lack of role models
 - Self-fulfilling prophecy
 - Stereotype threat

Self-fulfilling prophecy

- Expectancies people have towards others may lead to a behavior confirming these expectancies.
- Classical experiment of Rosenthal & Jacobson (1968):
- The researchers gave an IQ test to elementary school children
- They gave to the teachers of the school a list of “high-scorers”, which were, however, chosen **randomly**, rather than on the basis of test results
- Year after these children really showed significantly better improvement in comparison with “average” children

How these expectancies are transmitted?

- People can subconsciously behave in a way to trigger the behavior they expect from the other person.
- If you think I'm talkative, you may behave in a way that encourages me to speak more.
- If students think their teacher is mean, they may act in a way to cause him/her to be mean.
- If parents of a girl think she is reluctant to use computer, they may act in a way to cause her feeling reluctance when facing computer.

In which ways teachers treat girls differently?

- Teachers often give boys more opportunity to figure out the solution to a problem by themselves while telling the girls to follow the rules.
[link]
- Teachers address boys more questions and comment more on their work.

Stereotype threat

- Stereotype threat is a situational predicament in which people are or feel themselves to be at risk of confirming negative stereotypes about their social group. [Wikipedia]
- Example:
- In a study of Ilan Dar-Nimrod and Steven Heine, a group of women were given a GRE-like test; a verbal reasoning section contained a manipulation in a form of reading comprehension essay, one of four kinds: claiming that 1) no differences between sexes in math performance found; 2) there is a difference; 3) there is a difference and it has genetic basis; 4) there is a difference and it has experiential basis. The performance in math section was measured.

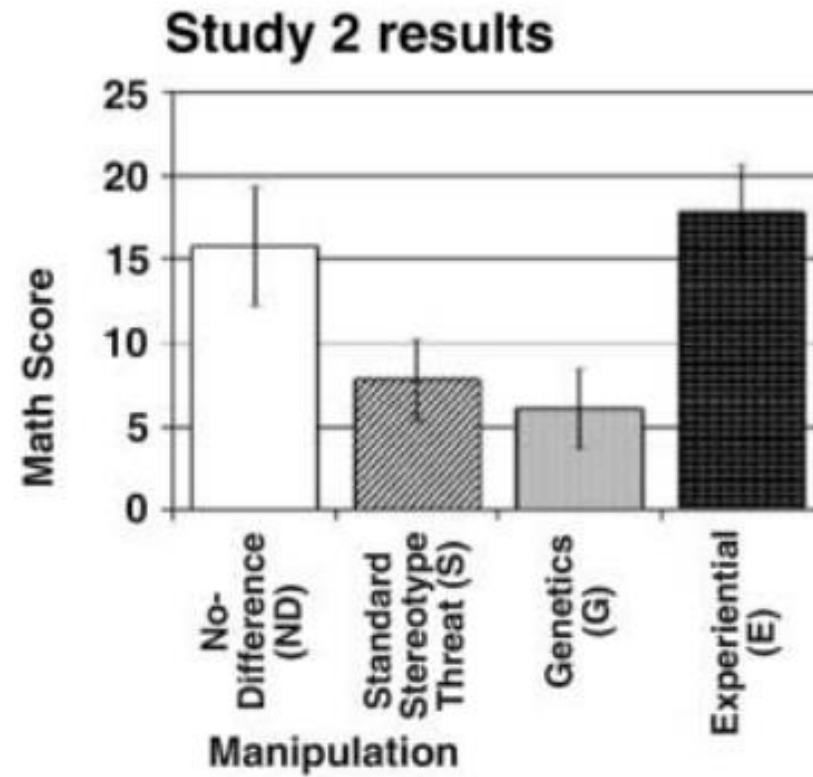
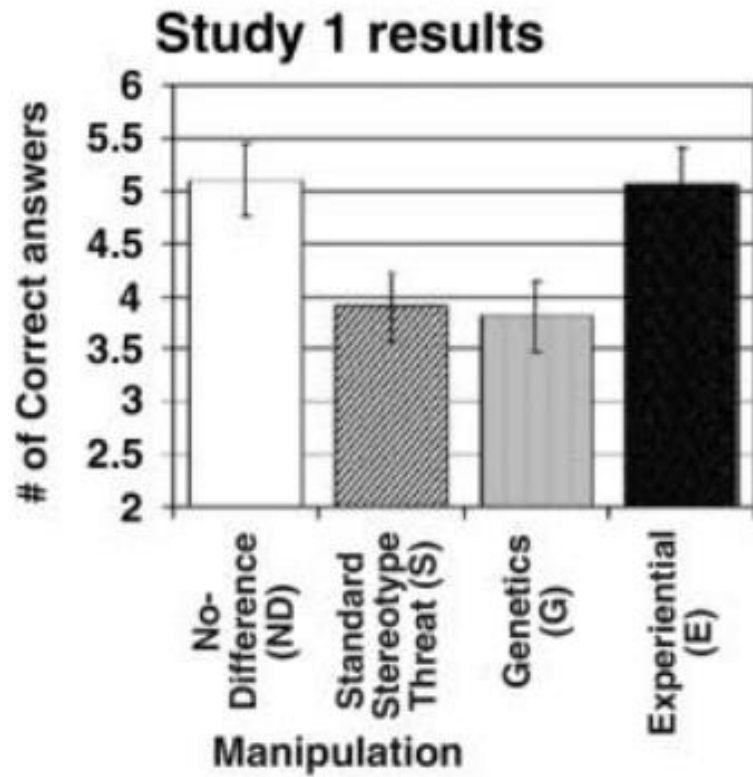


Fig. 1. (Left) Study 1 results. Scores on second math test (controlling for scores on first test) after reading essays. **(Right)** Study 2 results. Scores on math test after hearing manipulation.

What could be the solutions?

- Teaching about stereotype threat has shown to increase the performance of women. [\[link\]](#)
- There are many examples of successful single sex schools (classes). [\[link\]](#)
- Redesigning introductory computing courses in a way that they are more accessible to newcomers. Separating students into groups with accordance to their previous experience with computing. [\[link\]](#)
- Organizing workshops for young women to teach them to code (e.g., Rails Girls) in a calm, non-pressuring atmosphere. [\[link\]](#)

Thank you for your attention!
You are welcome to ask questions.