Examining Gender Differences in the Mathematical Literacy of 15-Year-Olds and the Numeracy Skills of the Age Cohorts as Adults

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Gender and STEM

- Importance of STEM
- Gender Disparities in STEM
  - Mathematics achievement
  - STEM credits
  - Bachelor's and doctorate degrees
  - STEM occupations
  - "Leaky Pipeline"
- Gender differences in attitudes

What are PISA and PIAAC?

- Large-scale, international assessments conducted by OECD
- PISA
  - Students aged between 15 years 3 months and 16 years 2 months at grade 7 or above, regardless of the type of institution in which they are enrolled and whether they are in full-time or part-time education
  - 2003 direct assessment measures reading, mathematics (focus of 2003), science, and problem solving
- PIAAC
  - Adults aged 16 to 65 non-institutionalized, residing in the country, irrespective of nationality, and citizenship
  - 2012 direct assessment measures literacy, numeracy, and digital problem solving skills

How do PISA and PIAAC Compare?

Populations

- Several "PISA cohorts" are included in the population assessed in the PIAAC but there are differences in coverage of these cohorts in PISA and PIAAC
  - Fifteen-year-olds who were not enrolled at an educational institution were not tested as part of PISA, while the target population for the PIAAC is the entire resident populations

Mathematics and Numeracy Assessments

- The concepts of numeracy in PIAAC and mathematical literacy in PISA are closely related
  - However, the measurement scales are not the same, so effect size is used to compare results across the two assessments

Focus of the Current Study

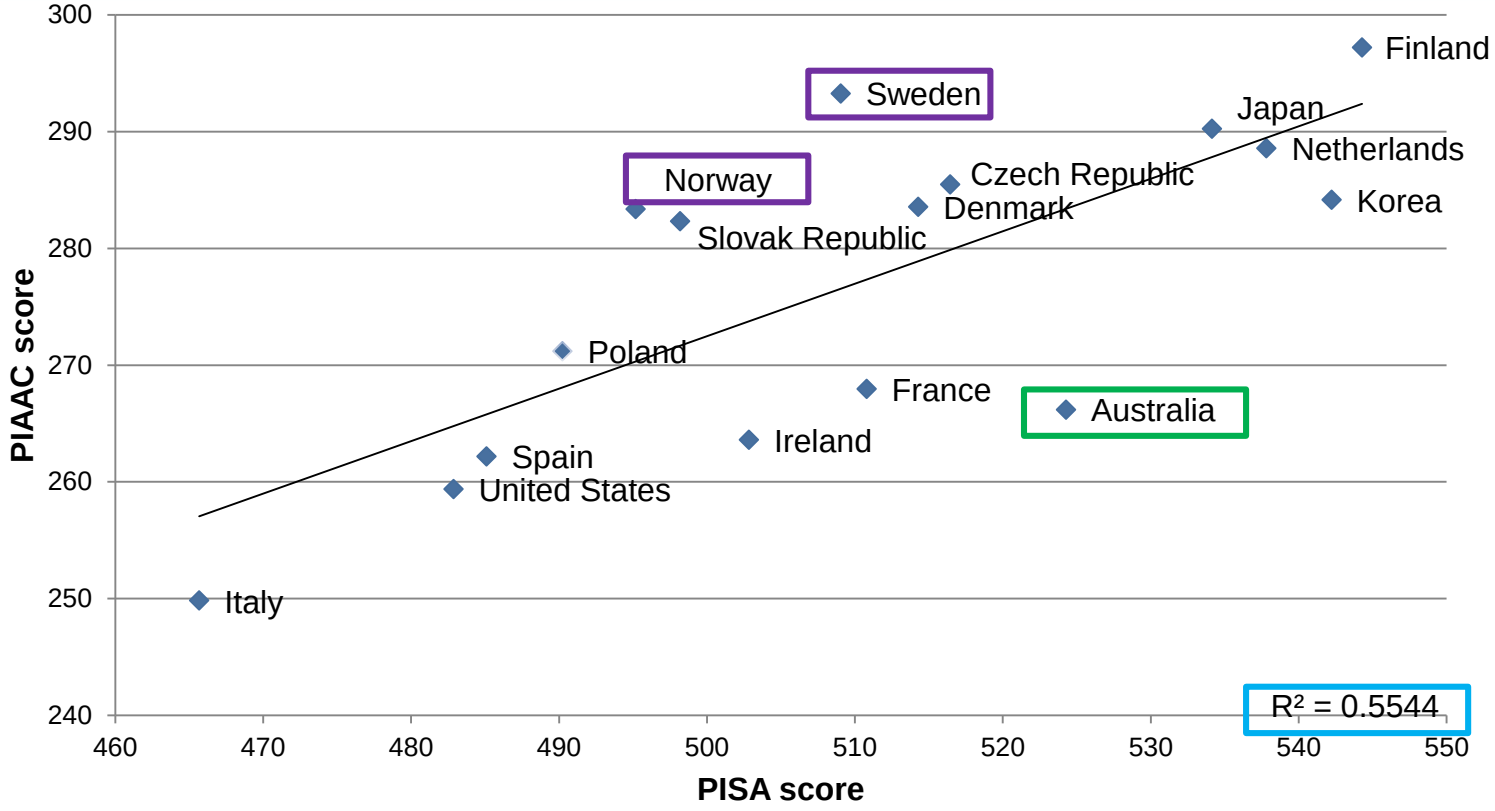
- The cohort that took PISA 2003 is compared with the cohort aged 23-25 that took PIAAC 2012, looking at mathematical literacy in the PISA assessment and numeracy results in PIAAC assessment.
  - A three year age band is used in PIAAC to increase size and reliability of estimates.
- The study looks at the 16 countries that had comparable, publicly available data for both assessments.
  - Australia, Czech Republic, Denmark, Finland, France, Ireland, Italy, Japan, Republic of Korea, Netherlands, Norway, Poland, Slovak Republic, Spain, Sweden, United States

Results

Research Question 1

- How similar or different are the performance of countries in PISA and PIAAC?
  - Compared the overall average mathematics scores in PISA 2003 and the average numeracy scores of the cohort in PIAAC

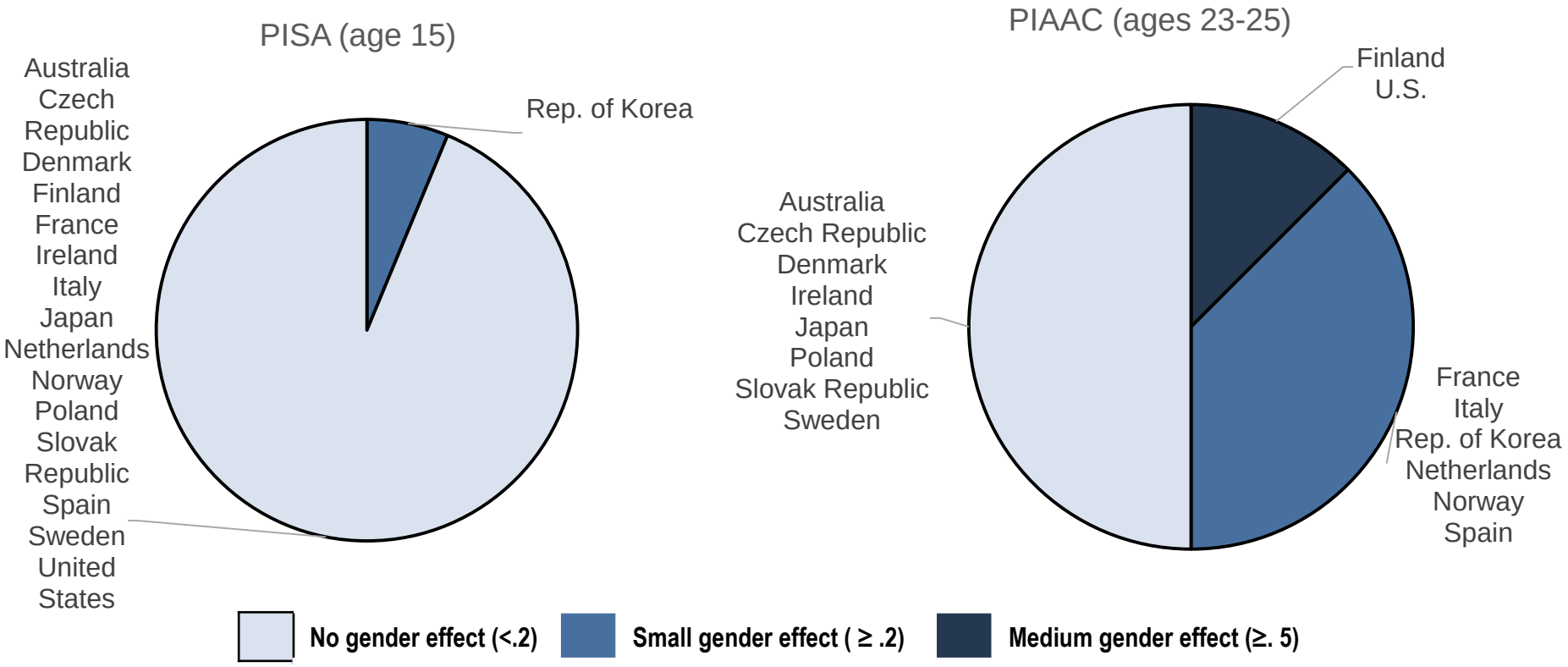
Average mathematics scores of 15-year-olds in PISA 2003 and numeracy scores of 23- to 25-year-olds in PIAAC 2012



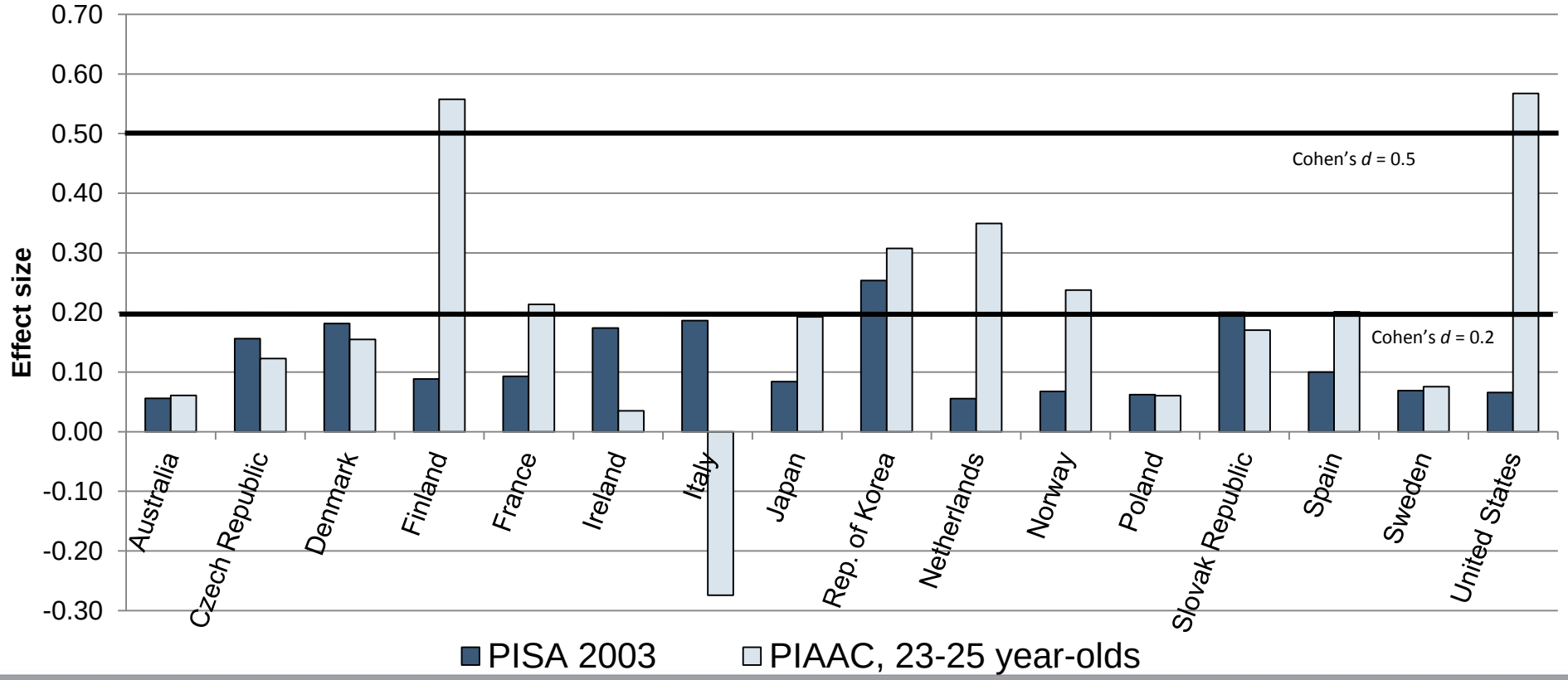
Research Questions 2 and 3

- Are there any significant differences in performance by gender across the participating countries in the two assessments?
- How are these gender differences in performance different among students in PISA and adults in PIAAC?
  - Effect sizes (Cohen's *d*) were calculated to compare gender differences while accounting for the different scales of PISA and PIAAC
  - The gender differences in average numeracy scores were examined in the total PIAAC population (16-65) by 10-year age band

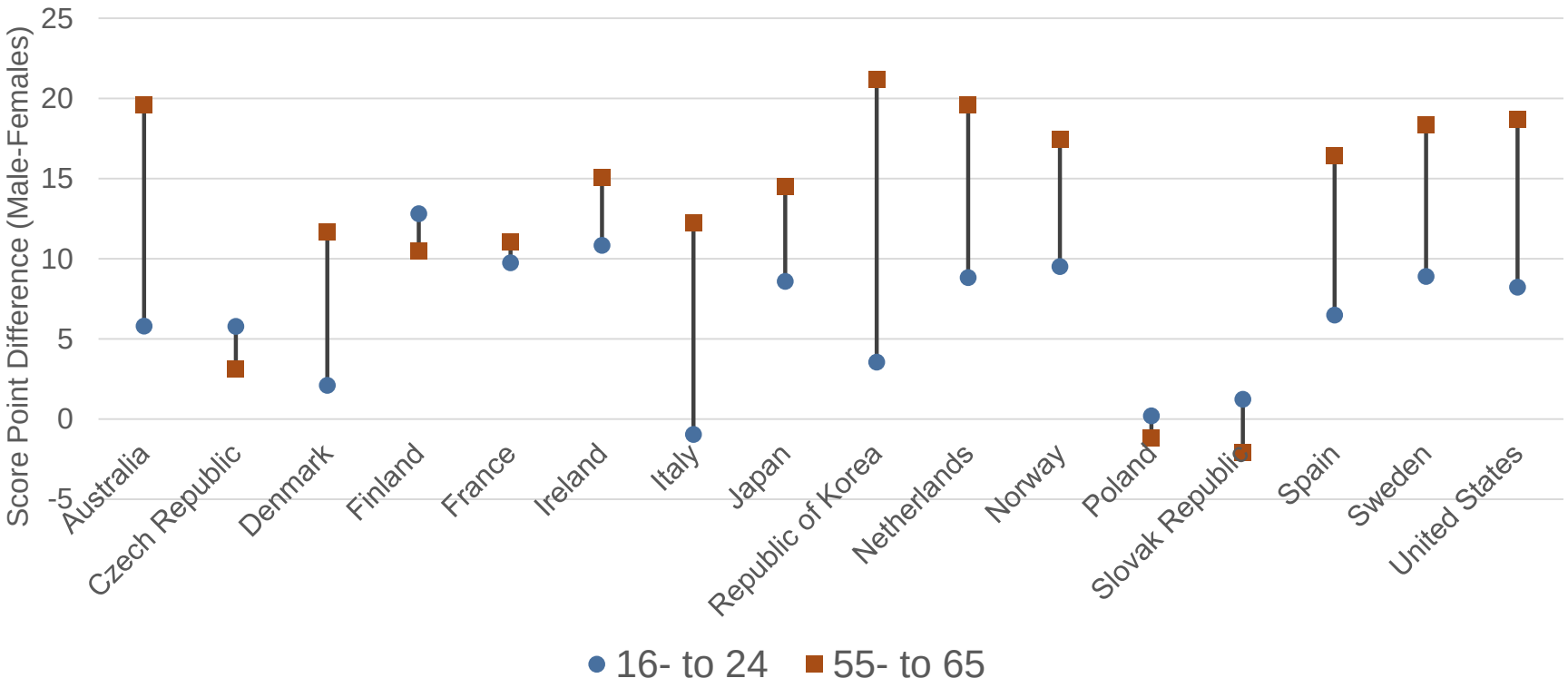
Gender Differences in PISA and PIAAC



Gender Differences in PISA and PIAAC



Gender differences in PIAAC by age



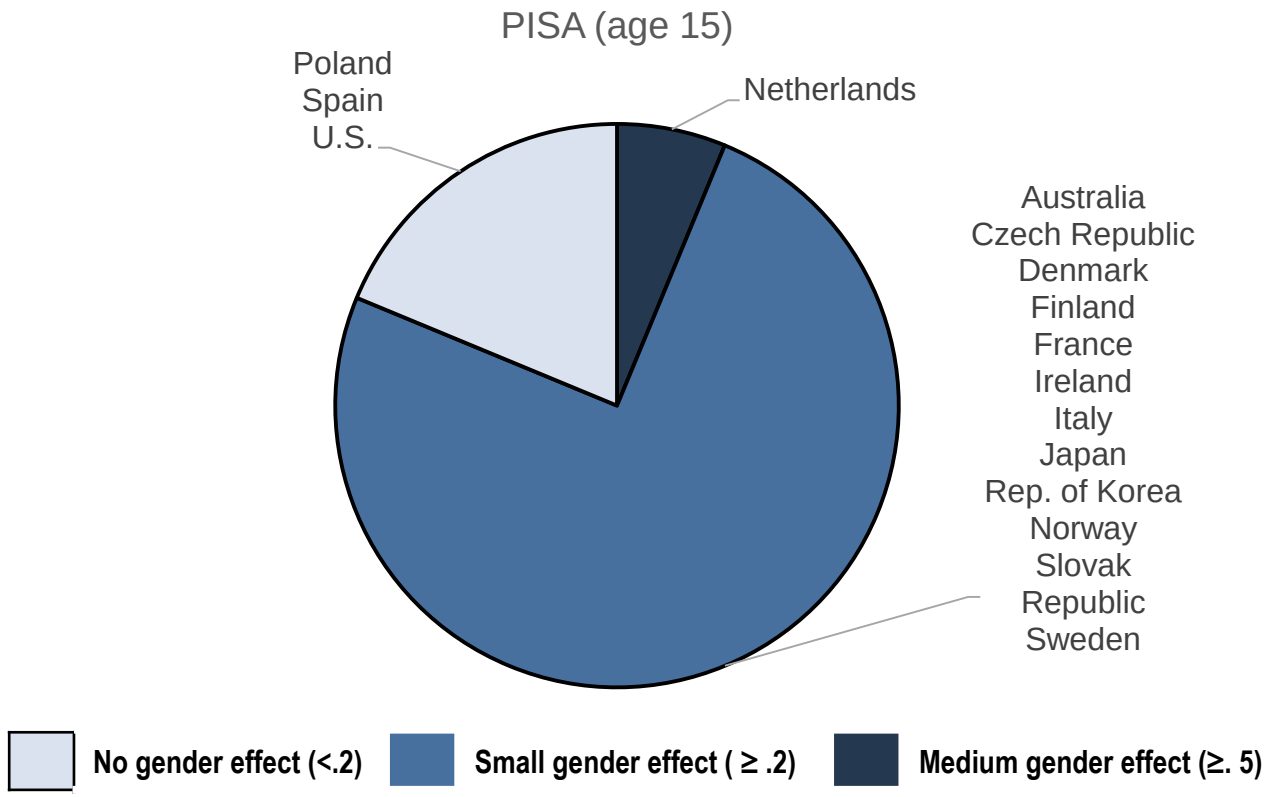
Summary of Results: PISA and PIAAC

- There is a fairly close correlation between countries' mathematics performance in PISA 2003 and in numeracy in PIAAC 2012
- Several countries showed an increased gender effect on numeracy from PISA to PIAAC
  - Finland and United States are the only two countries which had a medium size gender effect on numeracy performance
- In general, the size of the gender gap in numeracy increases as age increases

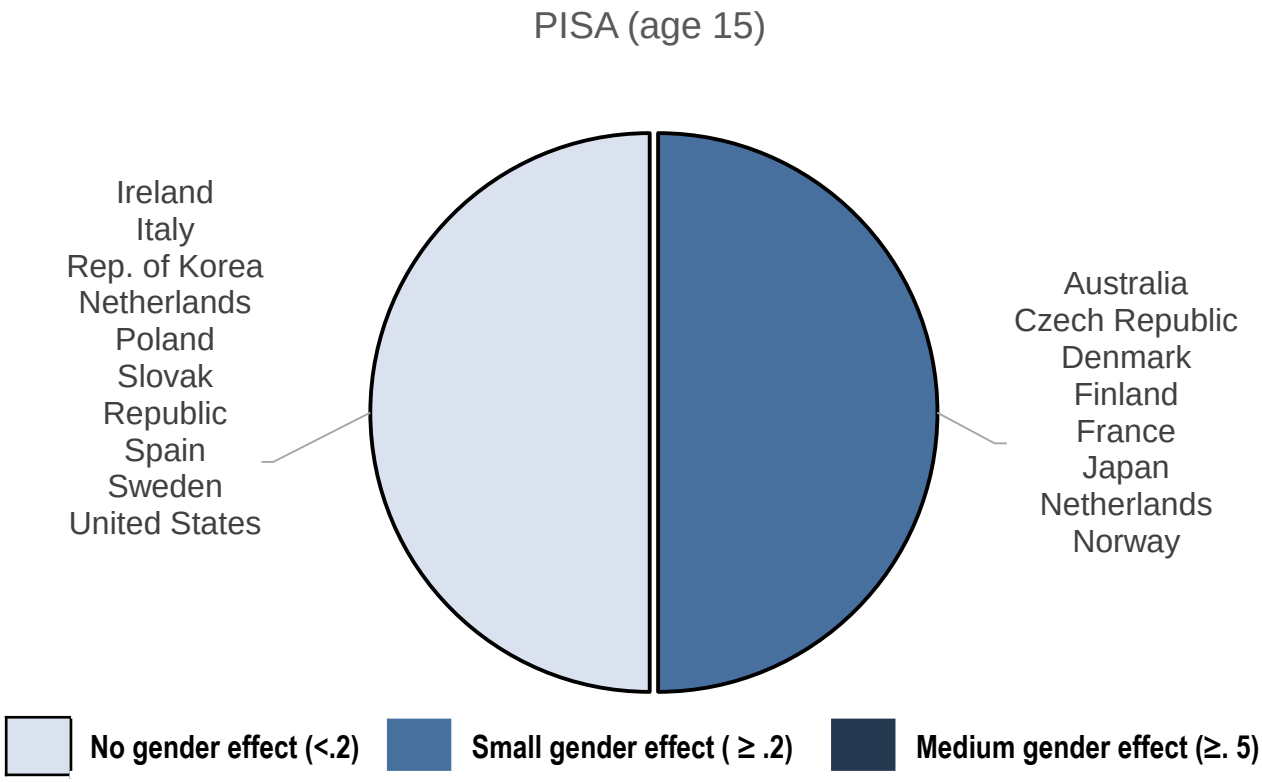
Research Question 4

- Are there any gender differences in attitude and engagement toward learning mathematics among students in PISA?
  - Effect sizes (Cohen's *d*) were calculated to compare gender differences while accounting for these different indices

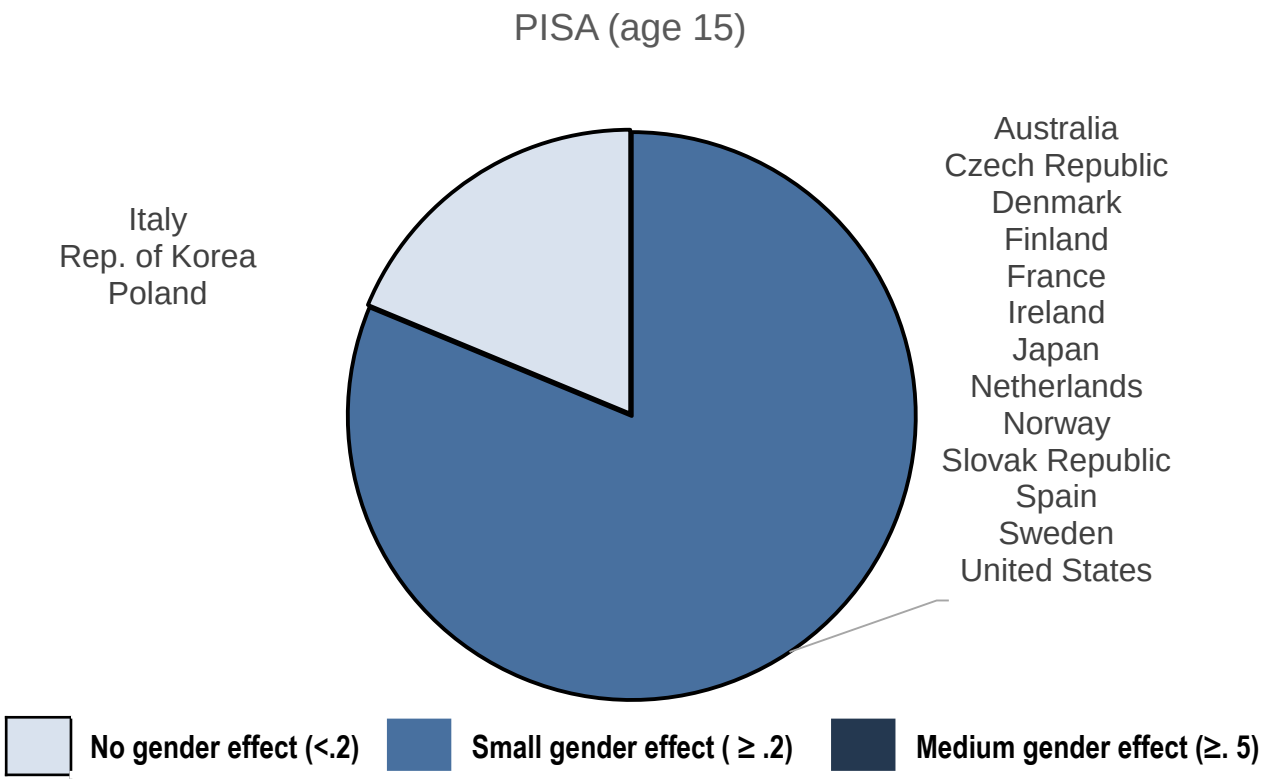
PISA Index of Instrumental Motivation in Mathematics



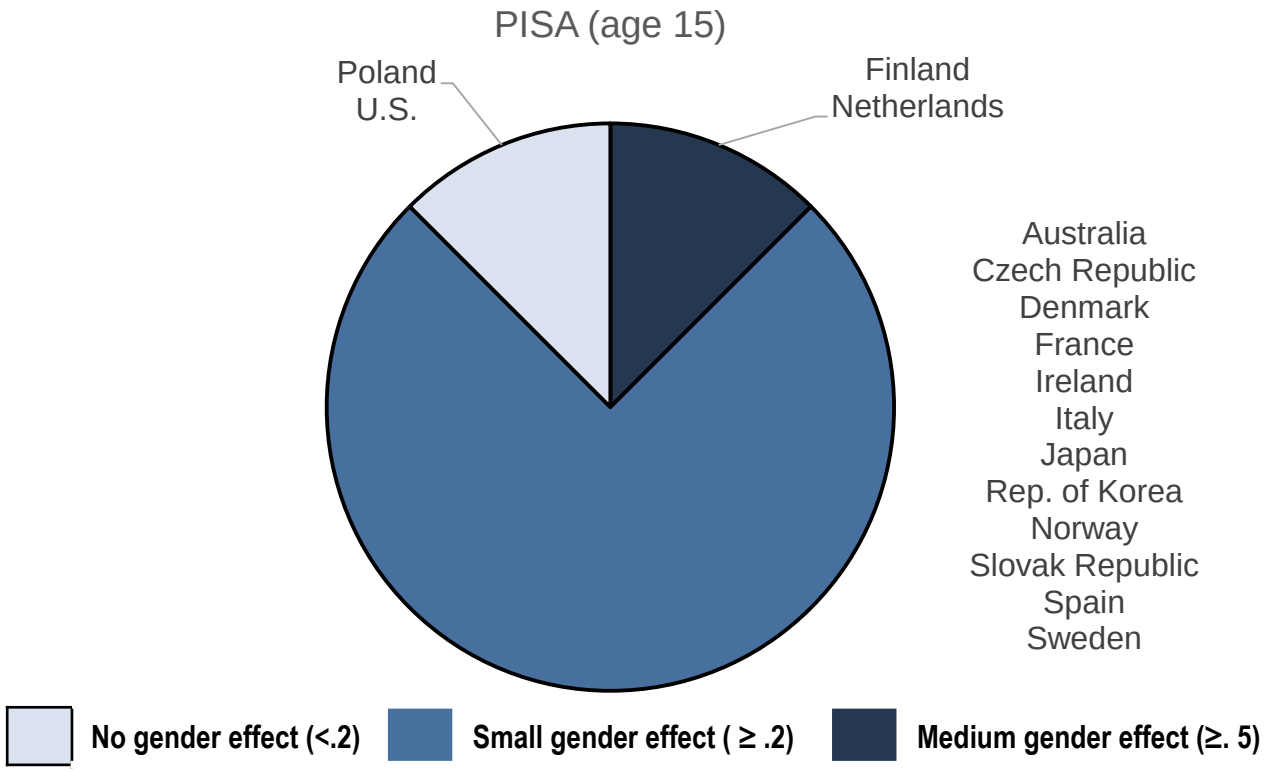
PISA Index of Interest in and Enjoyment of Mathematics



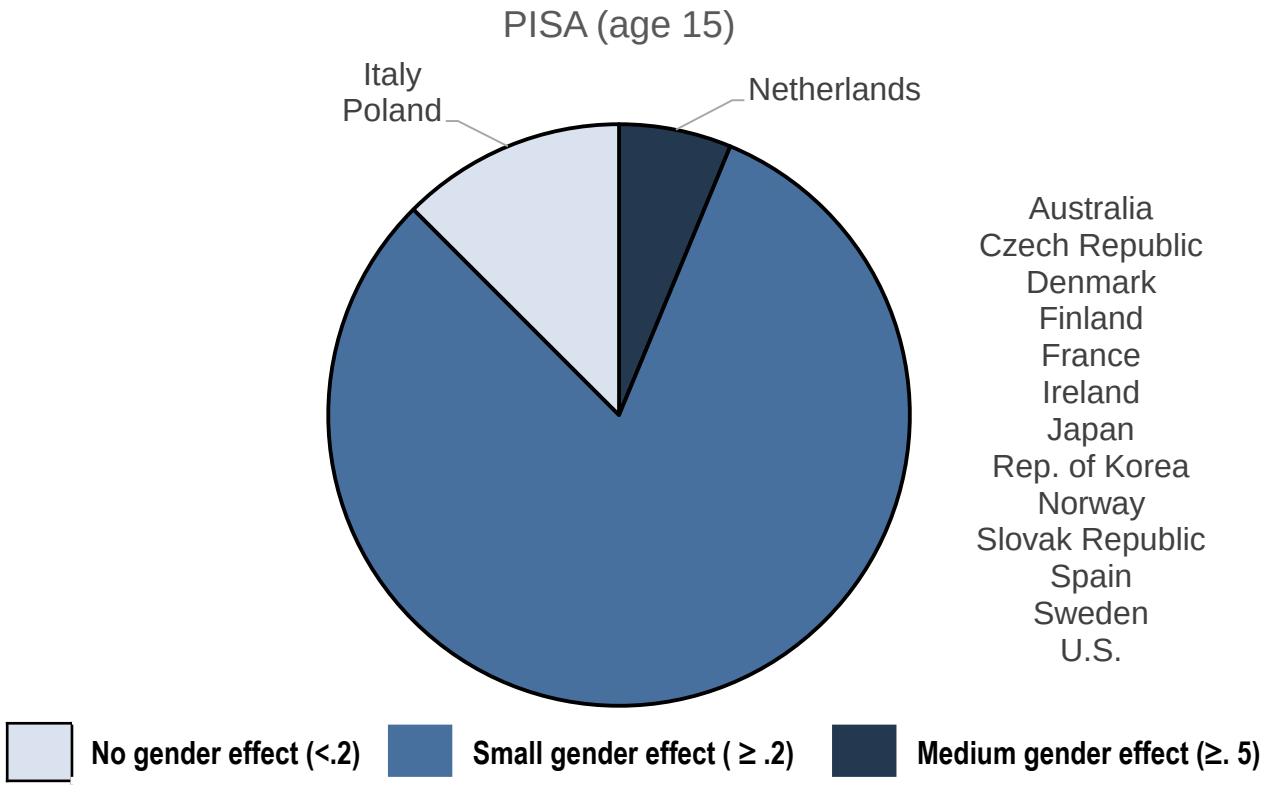
PISA Index of Anxiety in Mathematics



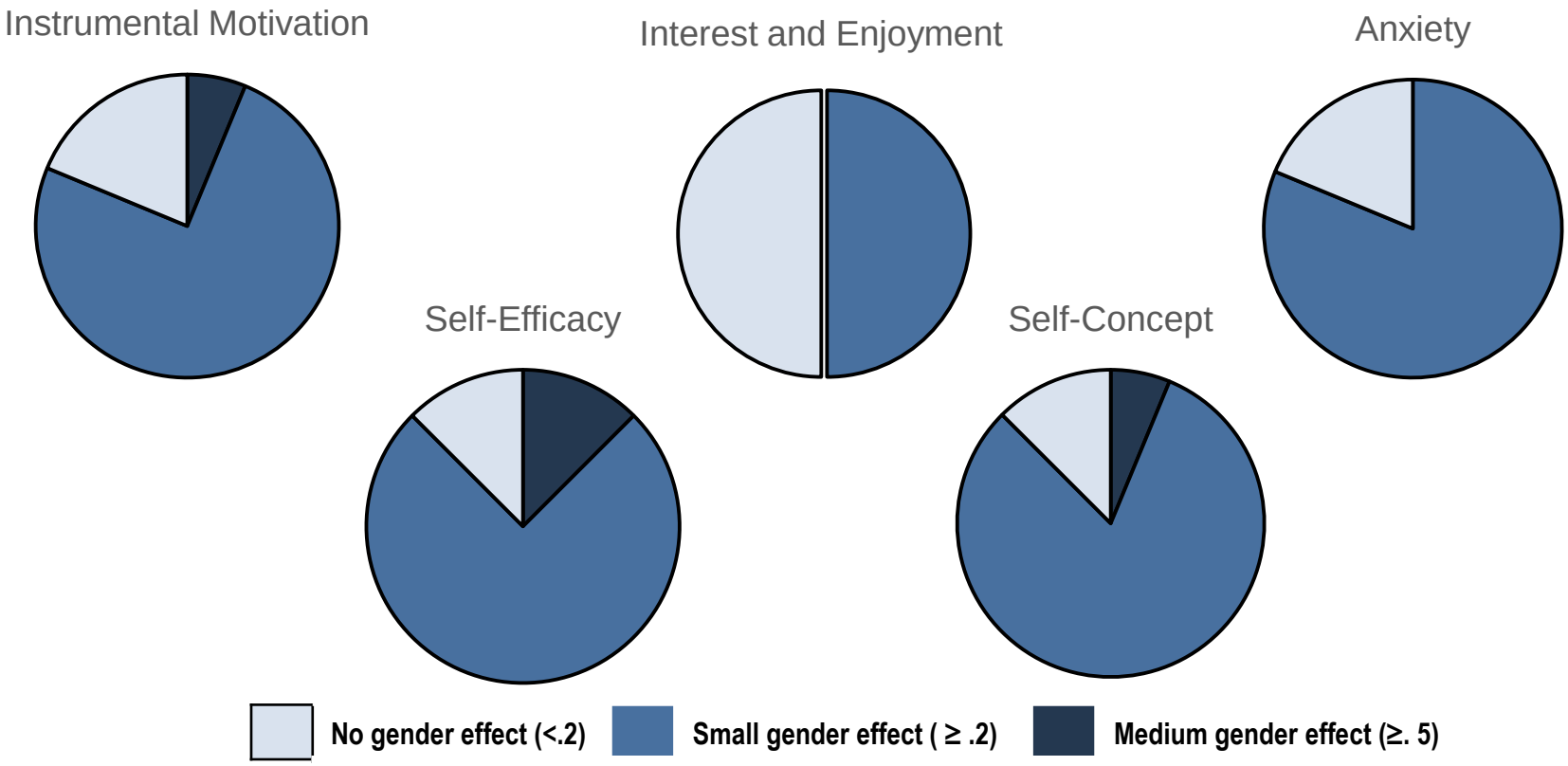
PISA Index of Self-Efficacy in Mathematics



PISA Index of Self-Concept in Mathematics



PISA Indices of Mathematics Attitudes



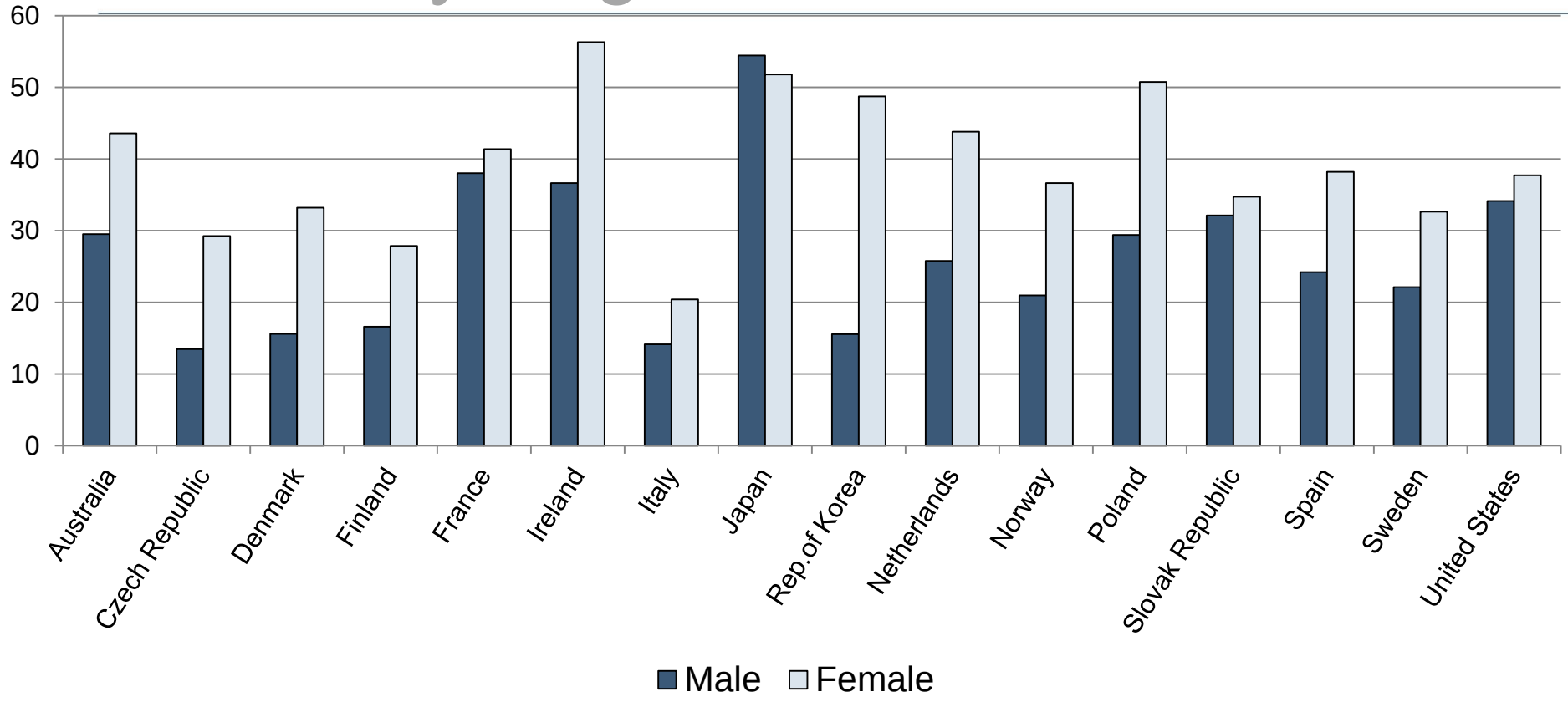
Summary of Results: PISA

- In 4 out of 5 indices we studied, around three-fourth or more countries show a small gender effect
  - Instrumental motivation in mathematics
  - Self-efficacy in mathematics
  - Self-concept in mathematics
  - Anxiety in mathematics
- 3 out of these 4 indices (except anxiety in mathematics) also show 1 or 2 countries with medium size gender effect
- Only 1 index (Interest in and enjoyment in mathematics) show half of the countries with no gender effect and half with small gender effect.

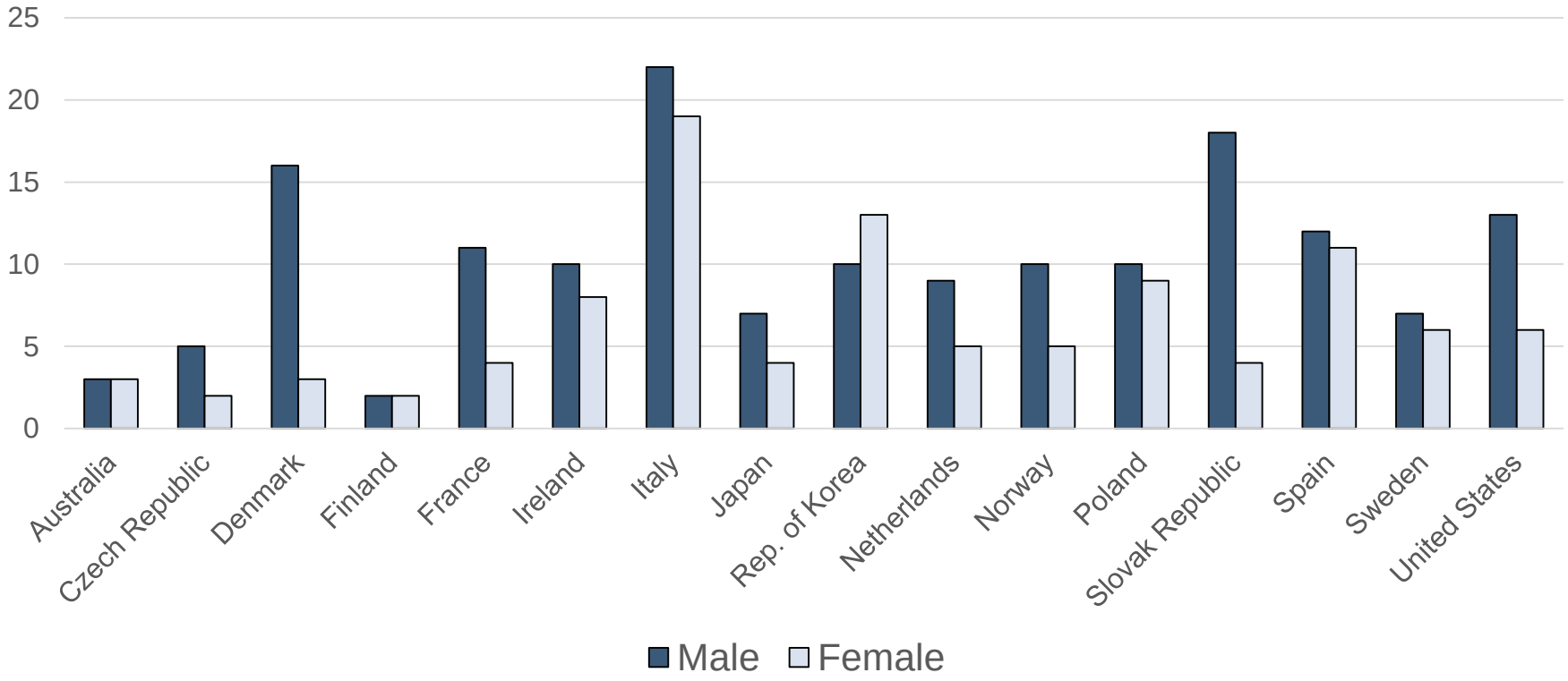
Research Question 5

- Are there any gender differences in highest level of education and major area of study among adults in PIAAC?
  - Percentage distributions of characteristics of PIAAC cohort by gender

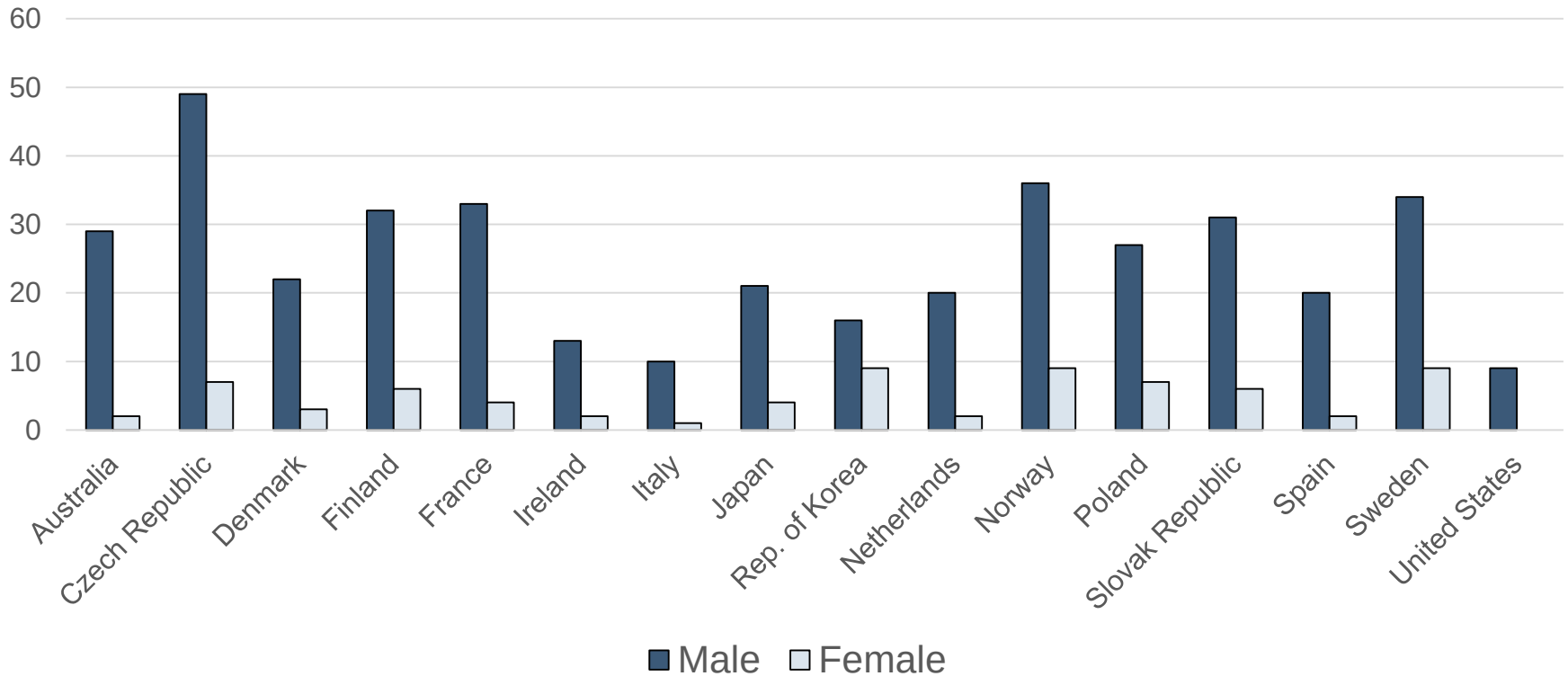
Percentage in PIAAC attaining a university degree



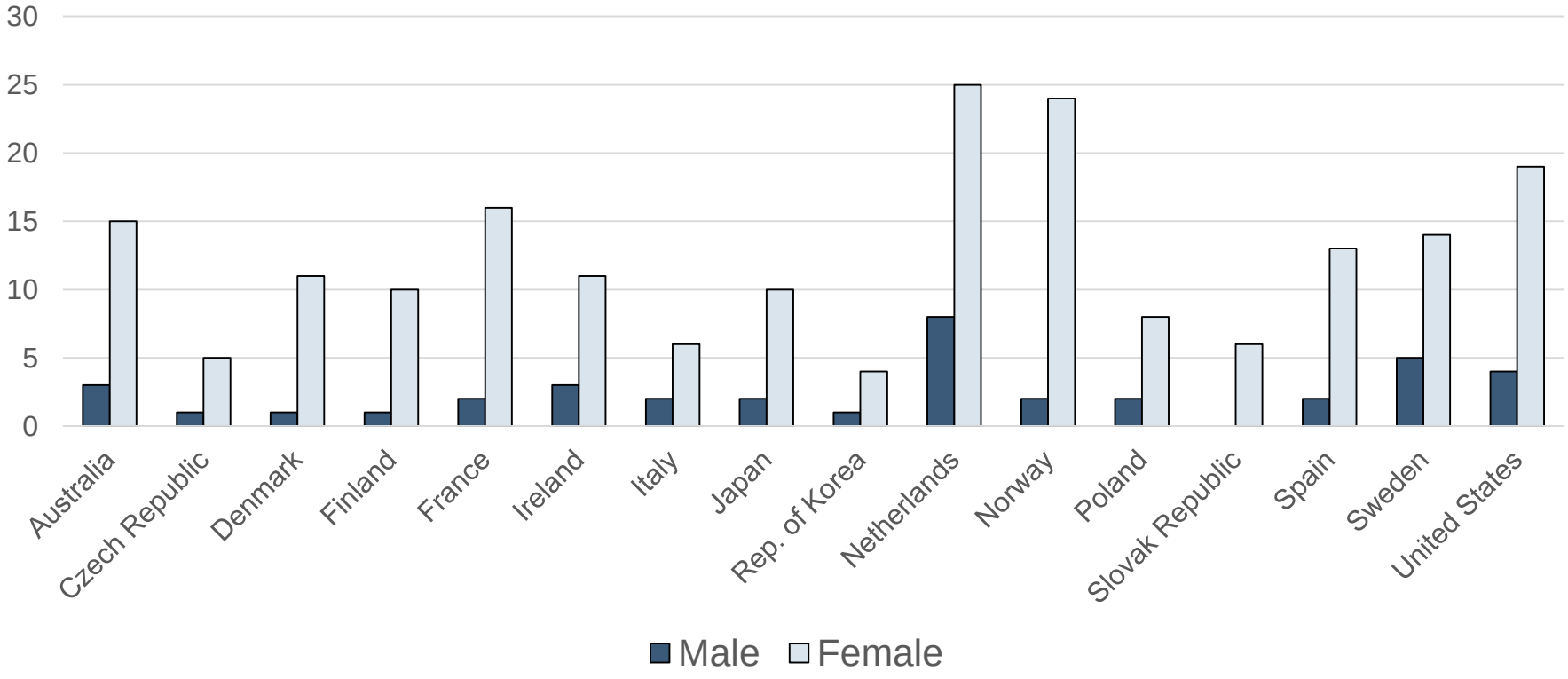
Percentage in PIAAC with area of study in science, mathematics, and computing



Percentage in PIAAC with area of study in engineering, manufacturing and construction



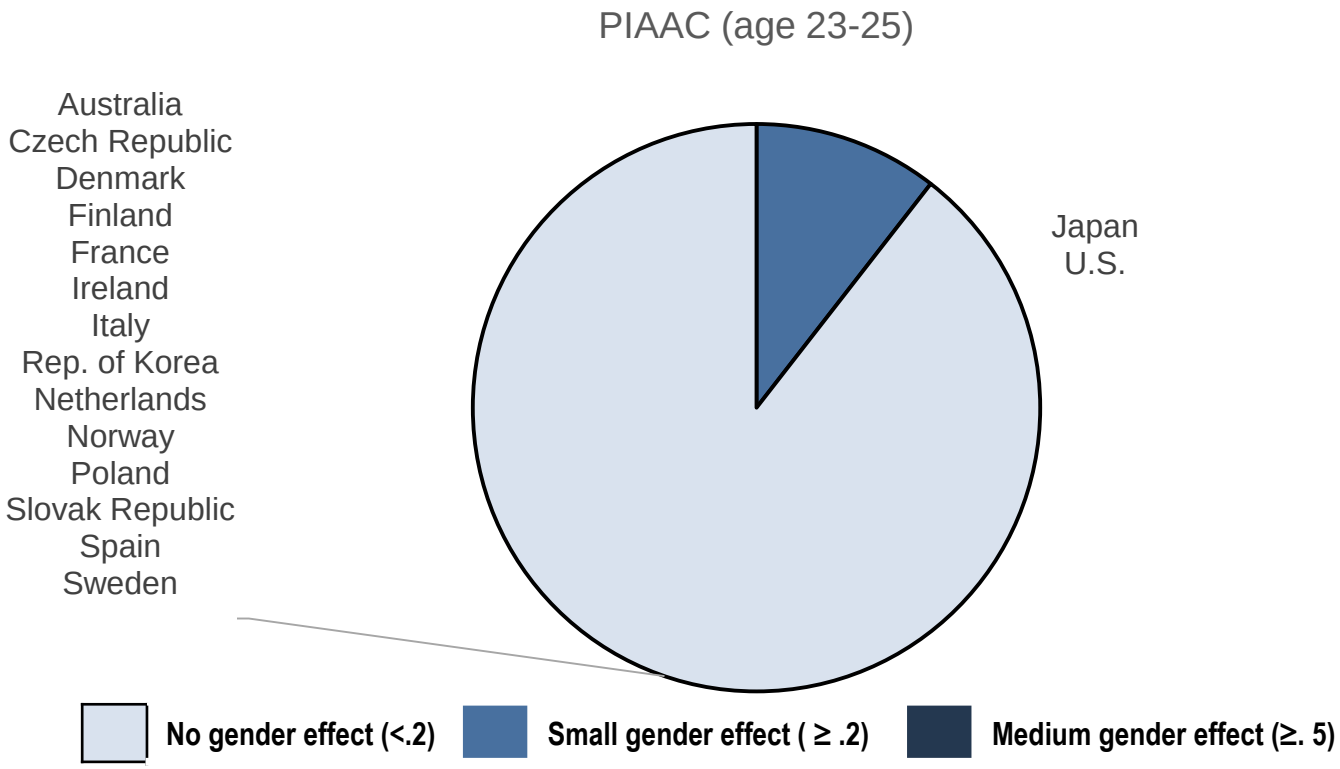
Percentage in PIAAC with area of study in health and welfare



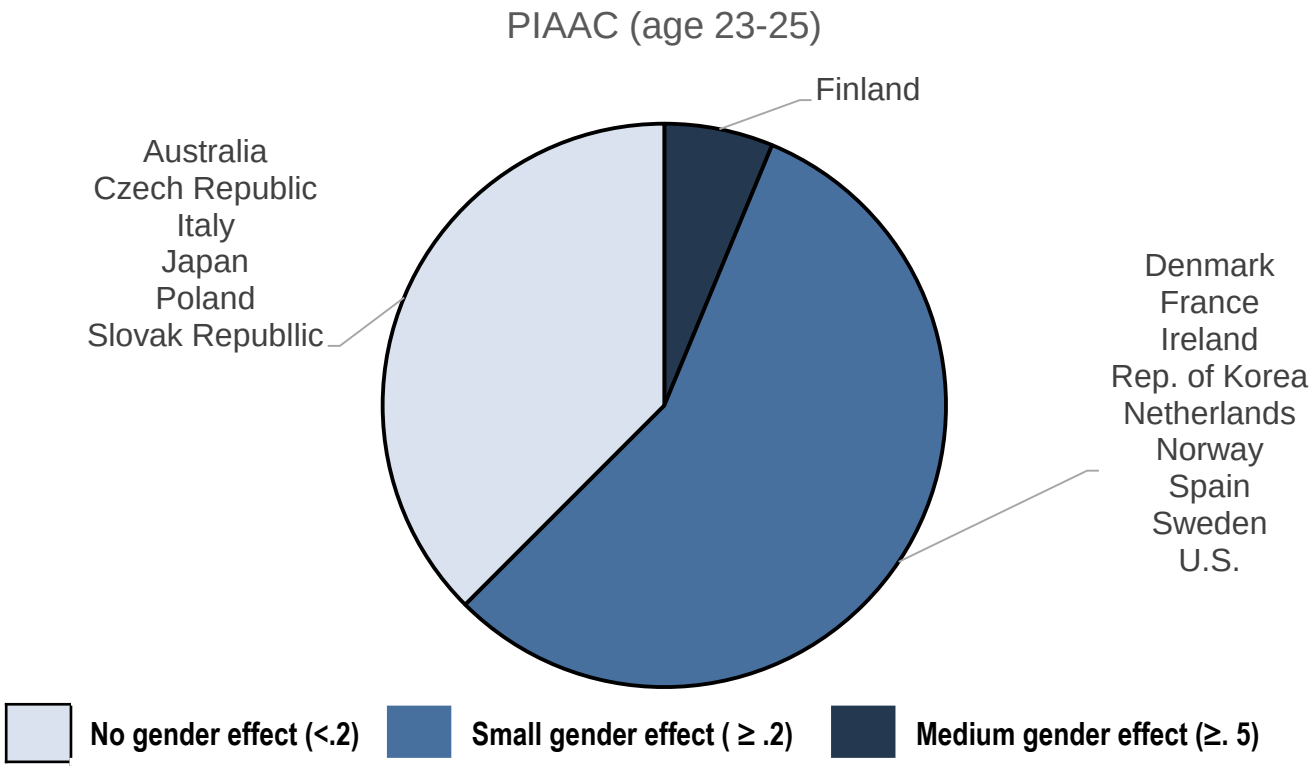
Research Questions 6 and 7

- Are there any gender differences in usage of numeracy skills at home and at work among adults in PIAAC?
- Are there any significant gender differences in readiness to learn new ideas/information among adults in PIAAC?
  - Effect sizes (Cohen's d) were calculated to compare gender differences while accounting for these different indices

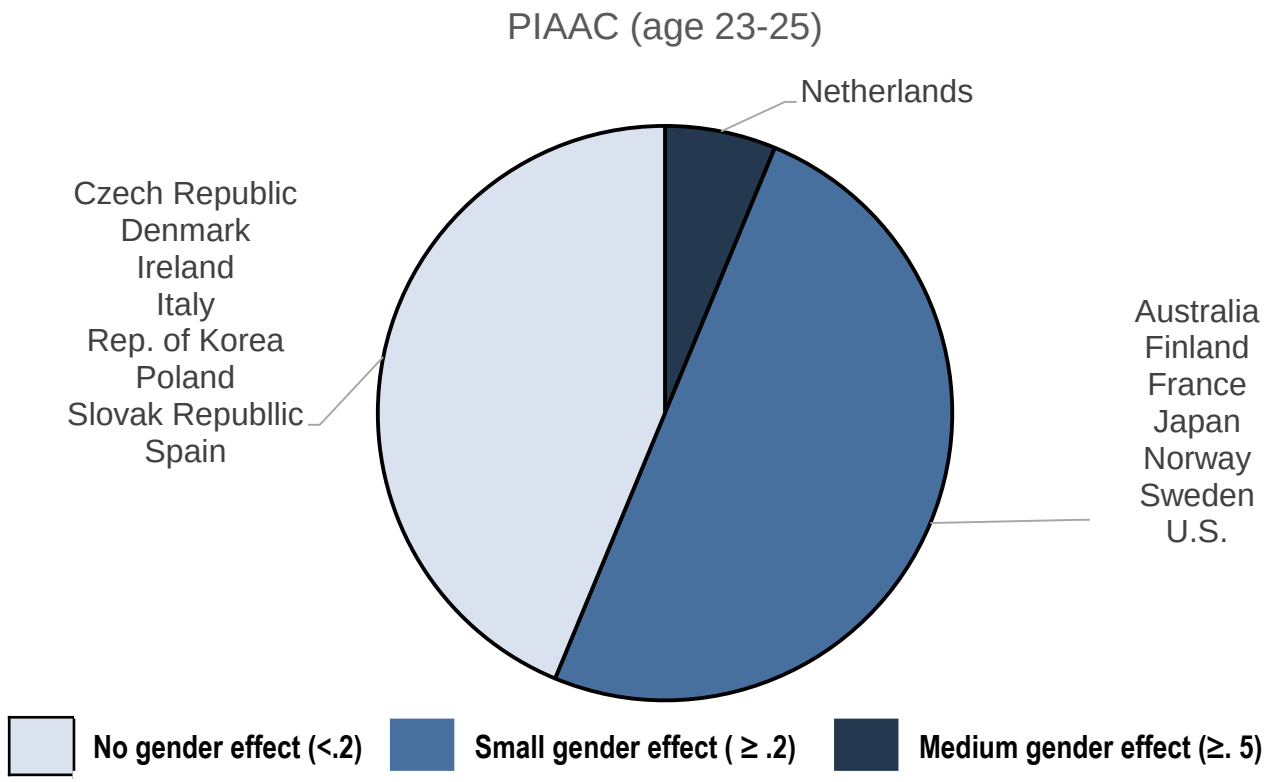
PIAAC Index of Readiness to Learn



PIAAC Index of Numeracy Skill Use at Home

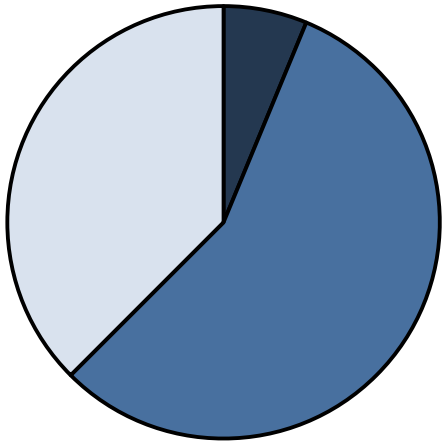


PIAAC Index of Numeracy Skill Use at Work

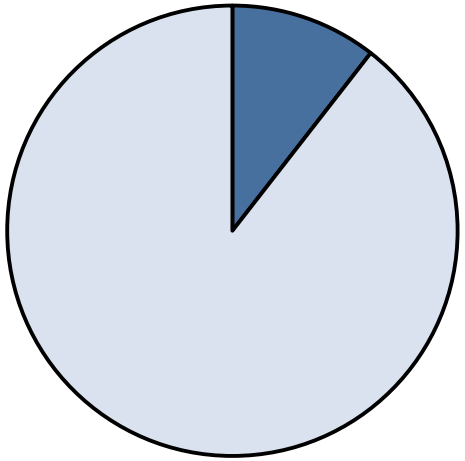


PIAAC Indices

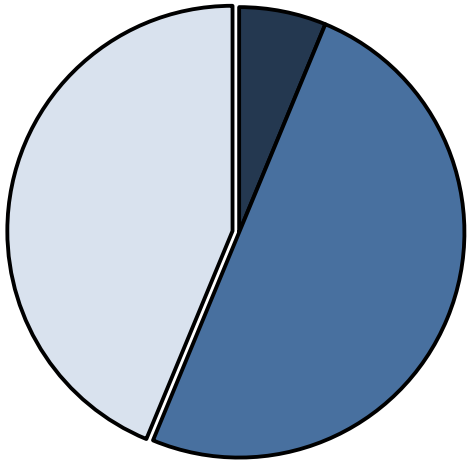
Numeracy Skill Use at Home



Readiness to Learn



Numeracy Skill Use at Work



No gender effect (<.2) Small gender effect (≥ .2) Medium gender effect (≥. 5)

Summary of Results: PIAAC

- In most countries, a higher or equal percent of females have attained college education
- On average more females chose non-STEM areas of education
- Within STEM areas, more females chose health and welfare than engineering, computing, and construction
- For most countries, except U.S. and Japan, there is no gender effect for readiness to learn index
- On average, more men use their numeracy skill both at home and at work

Major Findings of the Study

- The gender effect in the cohort of 15-year-olds in PISA 2003 either stayed the same in PIAAC 2012 (when those in the cohort were 23 to 25 years old) or increased
- 15-year-old male students were more engaged in and had more positive attitudes toward learning mathematics than females
- More females than males ages 23-25 had completed a university degree although many more males than females earned a degree in STEM-related areas

Major Findings of the Study (cont.)

- On average, more males ages 23-25 use their numeracy skill both at home and at work, while there is no gender effect for readiness to learn index for most countries
- Poland did not show gender effect on any variables in the study

Policy Implications

- Improving the attitudes of females students by recognizing and addressing adults' (parents, teachers) biases.
- Providing positive reinforcement
- Creating polices and resources to encourage female students
  - Strengthen career services
- Providing polices useful to promote retention and advancement in STEM occupations
  - Financial support
  - Mentorship
  - Work-life balance

Further Research

- Study education systems in Poland, Finland and the U.S. that have very different patterns in gender effect
- Look at the additional cohorts that were included in PISA and PIAAC
- Study the gender differences in performances using other large scale assessment and/or other domains in PISA and PIAAC
- Study the mathematics literacy items in PISA and Numeracy items in PIAAC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