Gendered Career Choices in Adolescence and their Links to Academic Outcomes: A Longitudinal Examination of Career Choices using NEPS data

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National Education Panel Study (NEPS) Projects

• Here at TU Dortmund, there are many projects with NEPS, e.g.,:
  • Self-concept as a mediator for risk factors on academic development (DeVries et al., 2021)
  • Differential effects of instructional methods based on subject, student ability, and student background (DeVries et al., 2020)
  • IFS is part of NEPS excellence network (in charge of collecting some of the data)

• Already, 60 publications this year with NEPS
  • Inequality in home education during the first COVID-19 lockdown (Sari et al., 2021)
  • Migration background impacts the effect of early institutional childcare upon children’s prosocial behavior and peer problems (Konrad-Ristau & Burghardt, 2021)

• But, hardly any of the 1000+ NEPS publications use advanced data science techniques

• Our focus today:
  • Gender typicality of career choices and links to self-concept and ability (in prep)
Gender Differences in STEM/MINT Domains

• Men are overrepresented in STEM fields in Germany and other western countries (e.g., the United States; Bundesagentur für Arbeit, 2019; U.S. Census Bueau, 2019)

• Girls are less likely to aspire to STEM fields (Parker et al., 2012) even when achievement differences are accounted for (Lauermann et al., 2015, 2017)
Gender Differences in STEM/MINT Domains

• Girls are more likely to have high achievement in both math and reading, and a greater discrepancy between math achievement and self-concept of ability (Lauermann et al., 2015; Wang et al., 2013)
  • Higher ability in the verbal domain may direct girls away from math careers (Breda & Napp, 2019)
  • Motivational factors (e.g., self-concept) may push girls away from STEM fields

• How does career choice relate to the gender typicality of that career, and does this change over schooling?
  • How does gender-typicality relate to STEM careers?
  • How does gender-typicality relate to math and reading achievement and self-concept, as well as gender?
Methods – Intro to NEPS

• Started in 2008 to study education in Germany
  • Permanently funded since 2014

• Multi-cohort longitudinal study of German pupils, students, and adults

• Data from many perspectives & sources
ADMINISTRATION AND CENTRAL COORDINATING DEPARTMENT OF THE NEPS
AT THE LEIBNIZ INSTITUTE FOR EDUCATIONAL TRAJECTORIES

COMPETENCE DEVELOPMENT
LEARNING ENVIRONMENTS
EDUCATIONAL DECISIONS
MIGRATION BACKGROUND
RETURNS TO EDUCATION
PERSONALITY & MOTIVATION

STAGE 8
ADULT EDUCATION AND LIFELONG LEARNING

STAGE 7
FROM HIGHER EDUCATION TO THE LABOR MARKET

STAGE 6
FROM VOCATIONAL TRAINING TO THE LABOR MARKET

STAGE 5
FROM UPPER SEC. SCHOOL TO HIGHER ED./VOC. TRAINING/LABOR MARKET

STAGE 4
FROM LOWER TO UPPER SECONDARY SCHOOL

STAGE 3
FROM ELEMENTARY SCHOOL TO LOWER SECONDARY SCHOOL

STAGE 2
FROM KINDERGARTEN TO ELEMENTARY SCHOOL

STAGE 1
NEWBORNS AND EARLY CHILDHOOD EDUCATION

RESEARCH DATA CENTER AND METHOD DEVELOPMENT
| Stage 1 | Newborns and Early Childhood Education |
| Stage 2 | From Kindergarten to Elementary School |
| Stage 3 | From Elementary School to Lower Secondary School |
| Stage 4 | From Lower to Upper Secondary School |
| Stage 5 | From Upper Sec. School to Higher Ed./Voc. Training/Labor Market |
| Stage 6 | From Vocational Training to the Labor Market |
| Stage 7 | From Higher Education to the Labor Market |
| Stage 8 | Adult Education and Lifelong Learning |

**administration and central coordinating department of the NEPS**

**at the Leibniz Institute for Educational Trajectories**

- Competence Development
- Learning Environments
- Educational Decisions
- Migration Background
- Returns to Education
- Personality & Motivation

**research data center and method development**
Methods – Measures

• Data from Starting Cohort 4 (SC4)
  • Began data collection in grade 9
  • 4759 Gymnasium students
  • Data from students and their parents

• Career preference (open-ended)
  • Concurrent census data about the gender proportion of chosen job category
  • Measured in 9th, 10th, 11th, and 12th year (Gymnasium only in our study)

• Math and German self-concept
• Math and reading competence

<table>
<thead>
<tr>
<th>MATH</th>
<th>GERMAN</th>
</tr>
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<td>I get Good Grades</td>
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<td>I’m a hopeless case (Reversed)</td>
</tr>
</tbody>
</table>
Methods – Growth Mixture Modeling

• A latent growth model is fitted to the proportion of women in career choice data from 9th-12th grade

• Mixture modeling to identify the number of different trajectories of career choice development

• 5-class model had the best fit (via AIC and BIC)
The Trajectories:

- Blue: Female Jobs (F)
  - 20.7%, N=983
- Purple: gender-neutral jobs (N)
  - 47.8%, N=2276
- Teal: Male Jobs (M)
  - 19.3%, N=920
- Red: Neutral to Male Jobs (NtM)
  - 6.3%, N=300
- Green: Male to Female jobs (MtF)
  - 5.9%, N=280
Math Achievement and Self-Concept by Gender and Trajectory
Male Pupils – only significant paths shown

Dummy-coded Gendered Career Trajectory
Male Trajectory used as reference
Male Pupils – only significant paths shown

Math Self-Concept
Math Achievement
Reading Self-Concept
German Achievement
Parents’ Educ.

Neutral to Male
Female
Neutral
Male to Female

Positive Pathway
Negative Pathway

Dummy-coded Gendered Career Trajectory
Male Trajectory used as reference
Math Self-Concept → Math Achievement → Reading Self-Concept → German Achievement → Parents’ Educat. → Male to Female

Negative Pathway:
- Math Self-Concept → Math Achievement
- Math Achievement → Reading Self-Concept
- Reading Self-Concept → German Achievement
- German Achievement → Parents’ Educat.

Positive Pathway:
- Male to Female → Math Self-Concept
- Male to Female → Math Achievement
- Male to Female → Reading Self-Concept
- Male to Female → German Achievement

Dummy-coded Gendered Career Trajectory
Male Trajectory used as reference
Male Pupils – only significant paths shown

Grade 9

Math Self-Concept

Math Achievement

Reading Self-Concept

German Achievement

Parents’ Educat.

Neutral to Male

Female

Neutral

Male to Female

Grade 12

Math Self-Concept

Math Achievement

German Self-Concept

Reading Achievement

Positive Pathway

Dummy-coded Gendered Career Trajectory
Male Trajectory used as reference

Neutral to Male

Female

Neutral

Male to Female

Negative Pathway

Positive Pathway

Dummy-coded Gendered Career Trajectory
Male Trajectory used as reference
Results Summary

• Identified 5 career choice trajectories across late secondary school based on gender proportions of preferred careers
  • 3 stable trajectories: male dominated, female dominated, and neutral
  • 2 transition trajectories: male to female dominated and neutral to male dominated

• In contrast to girls, boys’ career choice trajectories relate to corresponding changes in academic beliefs and competence across both math and German

• For girls, switching to a male-dominated career choice relates to gains in math achievement, but not self-concept
Outlook

• NEPS has over 1000 publications since 2008, only one publication and one working paper use machine learning:
  • A double machine learning approach to estimate the effects of musical practice on student’s skills (Knaus, 2021)
  • Early identification of college dropouts using machine-learning: Conceptual considerations and an empirical example (Isphording & Raabe, 2019)

• NEPS is a rich dataset which tracks many important variables as well as later life outcomes

• The planned research profile FAIR will expand upon this work by bringing together research groups from data science, statistics, and social sciences (e.g., education)
References


Thank you!

• Questions?

• Comments?
Extra Slides
Verbal Achievement and Self-Concept by Gender and Trajectory

![Diagram showing Grade 12 reading competency by class membership and gender](image1)

![Diagram showing Grade 12 German self-concept by class membership and gender](image2)
Grade 12 Reading and Math Self-Concepts and Achievement by Class Membership and Gender

<table>
<thead>
<tr>
<th>Class Membership</th>
<th>Reading Achievement</th>
<th>Reading Self-concept</th>
<th>Math Achievement</th>
<th>Math Self-concept</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys (SE)</td>
<td>Girls (SE)</td>
<td>Boys (SE)</td>
<td>Girls (SE)</td>
</tr>
<tr>
<td>Neutral-to-Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0.82 (0.07)</td>
<td>1.17 (0.09)</td>
<td>2.71 (0.06)</td>
<td>3.05 (0.09)</td>
</tr>
<tr>
<td>Female</td>
<td>0.78 (0.10)</td>
<td>1.04 (0.03)</td>
<td>2.99 (0.07)</td>
<td>3.12 (0.02)</td>
</tr>
<tr>
<td>Neutral</td>
<td>0.92 (0.04)</td>
<td>1.04 (0.03)</td>
<td>2.90 (0.03)</td>
<td>3.17 (0.02)</td>
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<tr>
<td>Male-to-Female</td>
<td>0.87 (0.08)</td>
<td>1.04 (0.10)</td>
<td>2.75 (0.07)</td>
<td>3.15 (0.07)</td>
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<tr>
<td>Male</td>
<td>0.84 (0.04)</td>
<td>1.08 (0.09)</td>
<td>2.61 (0.03)</td>
<td>3.04 (0.06)</td>
</tr>
<tr>
<td></td>
<td>1.69 (0.08)</td>
<td>1.64 (0.14)</td>
<td>2.82 (0.07)</td>
<td>2.89 (0.10)</td>
</tr>
<tr>
<td></td>
<td>1.46 (0.10)</td>
<td>1.06 (0.04)</td>
<td>2.36 (0.09)</td>
<td>2.26 (0.04)</td>
</tr>
<tr>
<td></td>
<td>1.67 (0.04)</td>
<td>1.09 (0.03)</td>
<td>2.58 (0.04)</td>
<td>2.33 (0.03)</td>
</tr>
<tr>
<td></td>
<td>1.63 (0.07)</td>
<td>1.24 (0.10)</td>
<td>2.50 (0.08)</td>
<td>2.26 (0.11)</td>
</tr>
<tr>
<td></td>
<td>1.95 (0.05)</td>
<td>1.32 (0.10)</td>
<td>2.94 (0.04)</td>
<td>2.48 (0.10)</td>
</tr>
</tbody>
</table>

Note: Self-concepts are on a 1-4 Likert scale. Achievement is given by weighted likelihood estimates (WLE).
Standardized path loadings for gendered-career trajectory type predicting self-concept and achievement in grade 12.

<table>
<thead>
<tr>
<th>Grade 9 Values</th>
<th>G12 Reading Achieve</th>
<th>G12 Reading Self-Concept</th>
<th>G12 Math Achieve</th>
<th>G12 Math Self-Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading Achieve</td>
<td>boys (SE)</td>
<td>girls (SE)</td>
<td>boys (SE)</td>
<td>girls (SE)</td>
</tr>
<tr>
<td>Reading Achieve</td>
<td>.35*** (.04)</td>
<td>.37*** (.03)</td>
<td>.14*** (.03)</td>
<td>.14*** (.03)</td>
</tr>
<tr>
<td>German self-concept</td>
<td>boys (SE)</td>
<td>girls (SE)</td>
<td>boys (SE)</td>
<td>girls (SE)</td>
</tr>
<tr>
<td>German self-concept</td>
<td>.09** (.03)</td>
<td>.10** (.03)</td>
<td>.46*** (.03)</td>
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</tr>
<tr>
<td>Math Achieve</td>
<td>boys (SE)</td>
<td>girls (SE)</td>
<td>boys (SE)</td>
<td>girls (SE)</td>
</tr>
<tr>
<td>Math Achieve</td>
<td>.25*** (.03)</td>
<td>.30*** (.03)</td>
<td>-.09** (.03)</td>
<td>-.02 (.03)</td>
</tr>
<tr>
<td>Math self-concept</td>
<td>boys (SE)</td>
<td>girls (SE)</td>
<td>boys (SE)</td>
<td>girls (SE)</td>
</tr>
<tr>
<td>Math self-concept</td>
<td>-.04 (.03)</td>
<td>-.08** (.03)</td>
<td>.02 (.03)</td>
<td>-.05 (.03)</td>
</tr>
<tr>
<td>Parental Education</td>
<td>boys (SE)</td>
<td>girls (SE)</td>
<td>boys (SE)</td>
<td>girls (SE)</td>
</tr>
<tr>
<td>Parental Education</td>
<td>.03 (.03)</td>
<td>.03 (.03)</td>
<td>.00 (.03)</td>
<td>.02 (.03)</td>
</tr>
<tr>
<td>Career Choice Trajectory</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutral-to-male</td>
<td>boys (SE)</td>
<td>girls (SE)</td>
<td>boys (SE)</td>
<td>girls (SE)</td>
</tr>
<tr>
<td>Neutral-to-male</td>
<td>.04 (.03)</td>
<td>.02 (.03)</td>
<td>.01 (.03)</td>
<td>.01 (.04)</td>
</tr>
<tr>
<td>Female</td>
<td>boys (SE)</td>
<td>girls (SE)</td>
<td>boys (SE)</td>
<td>girls (SE)</td>
</tr>
<tr>
<td>Female</td>
<td>-.01 (.02)</td>
<td>-.07 (.06)</td>
<td>.13*** (.03)</td>
<td>.01 (.06)</td>
</tr>
<tr>
<td>Neutral</td>
<td>boys (SE)</td>
<td>girls (SE)</td>
<td>boys (SE)</td>
<td>girls (SE)</td>
</tr>
<tr>
<td>Neutral</td>
<td>.07* (.03)</td>
<td>-.08 (.07)</td>
<td>.14*** (.03)</td>
<td>.05 (.06)</td>
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<tr>
<td>Male-to-Female</td>
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<td>.01 (.03)</td>
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</tr>
</tbody>
</table>

26
# Model Selection

<table>
<thead>
<tr>
<th># of Classes</th>
<th>AIC</th>
<th>BIC</th>
<th>Adjusted BIC</th>
<th>Entropy</th>
<th>Size of Smallest Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>127,936</td>
<td>128,022</td>
<td>127,980</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>2</td>
<td>115,915</td>
<td>115,992</td>
<td>115,954</td>
<td>0.647</td>
<td>1207</td>
</tr>
<tr>
<td>3</td>
<td>115,407</td>
<td>115,504</td>
<td>115,457</td>
<td>0.735</td>
<td>964</td>
</tr>
<tr>
<td>4</td>
<td>115,283</td>
<td>115,400</td>
<td>115,342</td>
<td>0.740</td>
<td>231</td>
</tr>
<tr>
<td>5</td>
<td>115,186</td>
<td>115,322</td>
<td>115,255</td>
<td>0.697</td>
<td>280</td>
</tr>
</tbody>
</table>

Models above 6 starts produced invalid results, and thus were excluded from consideration.

Note: AIC refers to adjusted information criteria. BIC refers to Bayesian information criteria.
Latent Class Separation

- Classes are well defined by intercept and slopes of career-choice trajectories
Latent Class Separation – Gender
• And by Gender
Methods – Measures (2 of 2)

• Math and German Self-concept
  • Self-Report, 4 pt. Likert scale
  • Mean scores
  • 9th & 12th Grade
• Math and Reading Competence
  • Achievement testing
  • 9th & 12th Grade
  • 0-centered WLE values (for 9th Grade value)
• SES
  • Monthly household income
  • Parental Education level (University degree vs. no degree).

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</table>
Class Membership, Gender and SES

- Gender dictates class membership
- But so does SES
Class Membership and SES

- Splits by top and bottom income deciles
- Class F shrinks dramatically – particularly for boys
- Higher proportion of girls in M and MtF classes
- Smaller proportion of girls in NtM class
Development and Career Choice from Gottfredson

• Career Choices go through stages of “circumscription”

• Late Childhood/preadolescence
  • Opposite gendered jobs are excluded

• Early Adolescence
  • Jobs outside of own perceived SES are excluded

• Late Adolescence/Teens
  • Compromise period based on personal interests/values/abilities

Grade 9 and 12 Competencies by trajectory
Self Concept by Trajectory

Grade 9 math self-concept by class membership and gender

Grade 12 math self-concept by class membership and gender

Grade 9 German self-concept by class membership and gender

Grade 12 German self-concept by class membership and gender