Gendered Career Choices in Adolescence and their Links to Academic Outcomes:

A Longitudinal Examination of Career Choices using NEPS data

Dr. Jeffrey M. DeVries
Prof. Dr. Fani Lauermann
Institut für Schulentwicklungsforschung (**IFS**) ● TU Dortmund University

IFS Center for Research on Education and School Development

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)

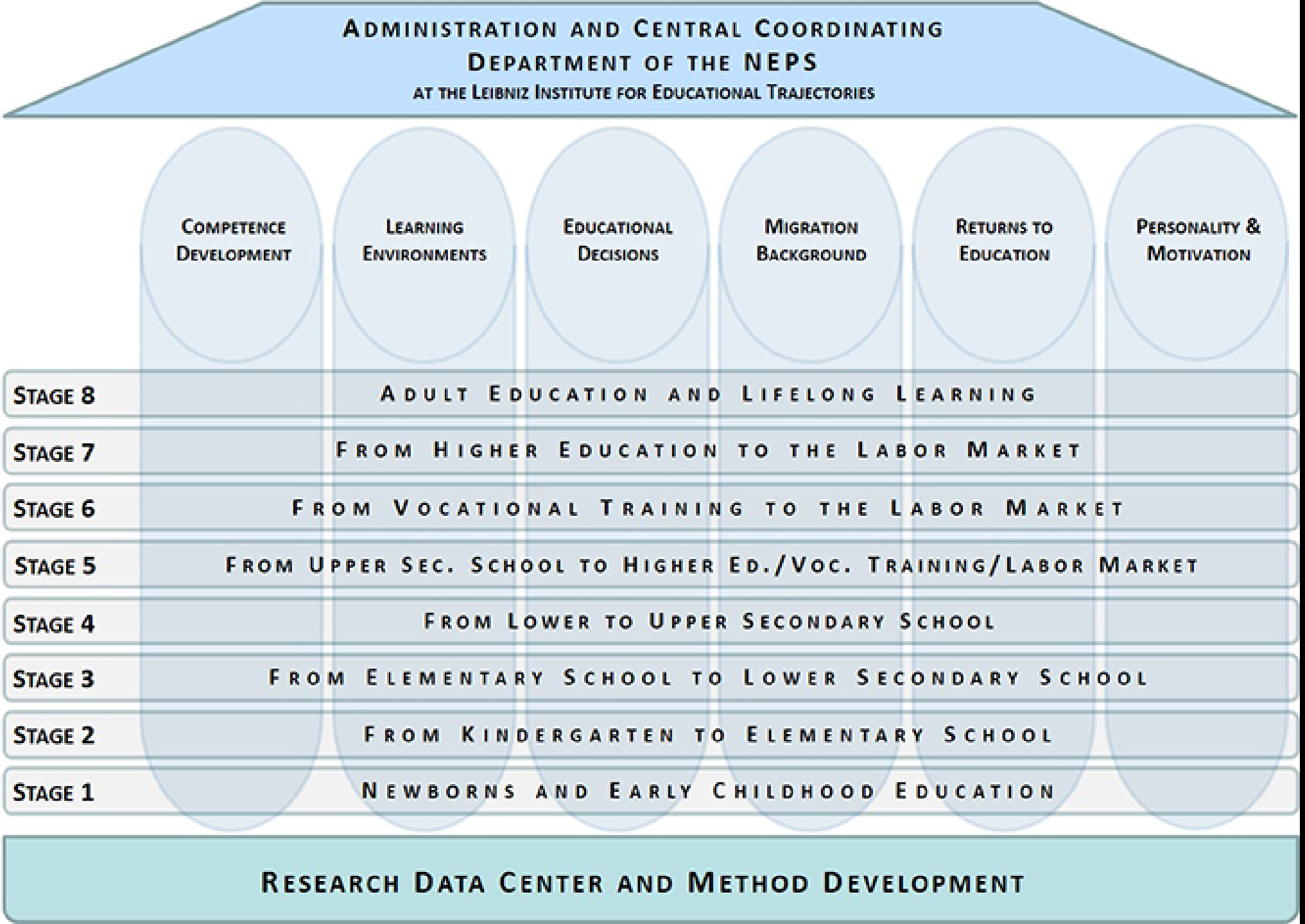
Gender Differences in STEM/MINT Domains

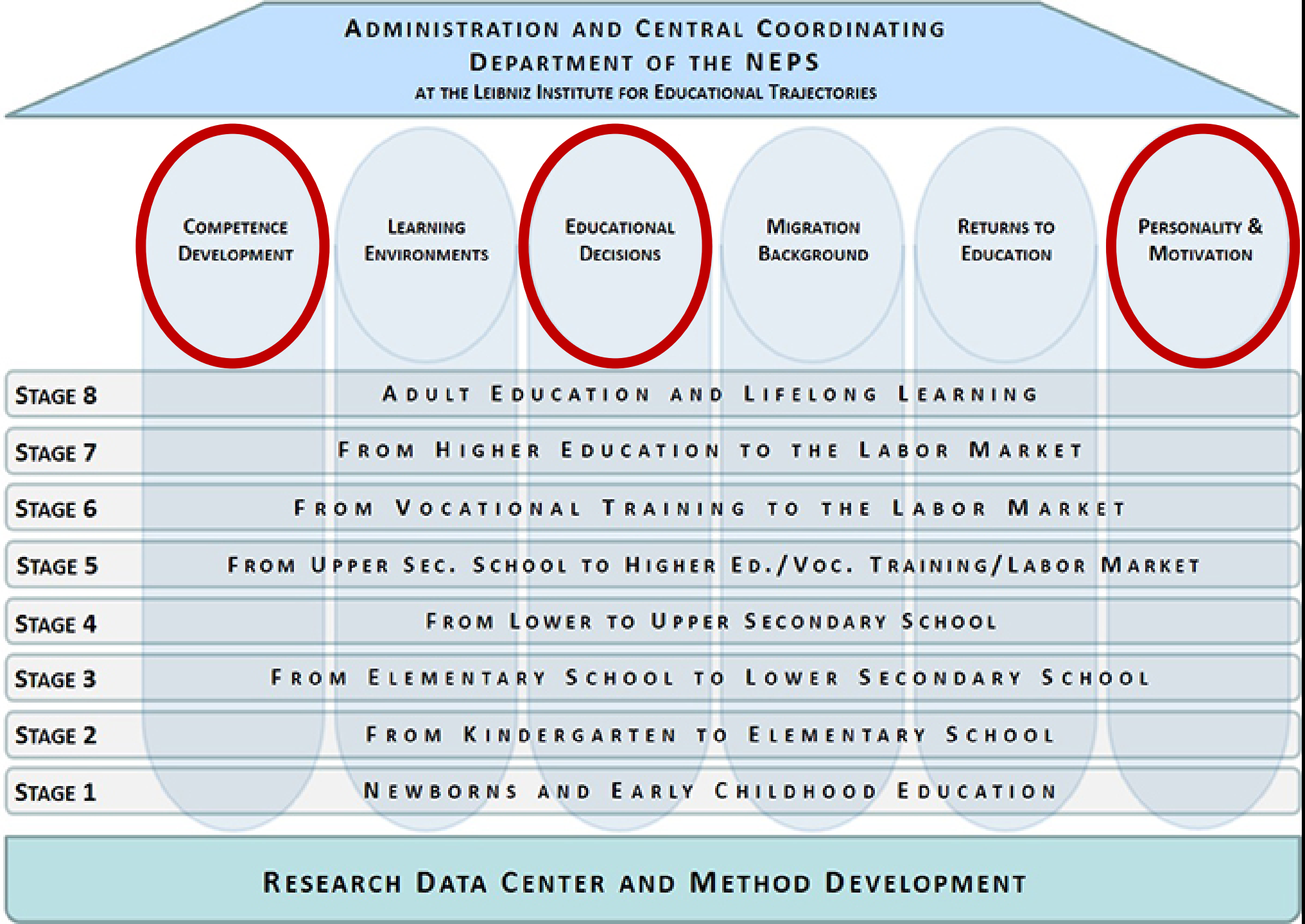
- Girls are more likely to have high achievement in **both** math and reading, and a greater discrepancy between math achievement and self-concept of ability (Lauermann et al., 2015; Wang et al., 2013)
  - Higher ability in the verbal domain may direct girls away from math careers (Breda & Napp, 2019)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


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

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

MATH	GERMAN
I get Good Grades	I get good grades
It's one of my best subjects	I learn fast
I've always been good at it	I'm a hopeless case (Reversed)

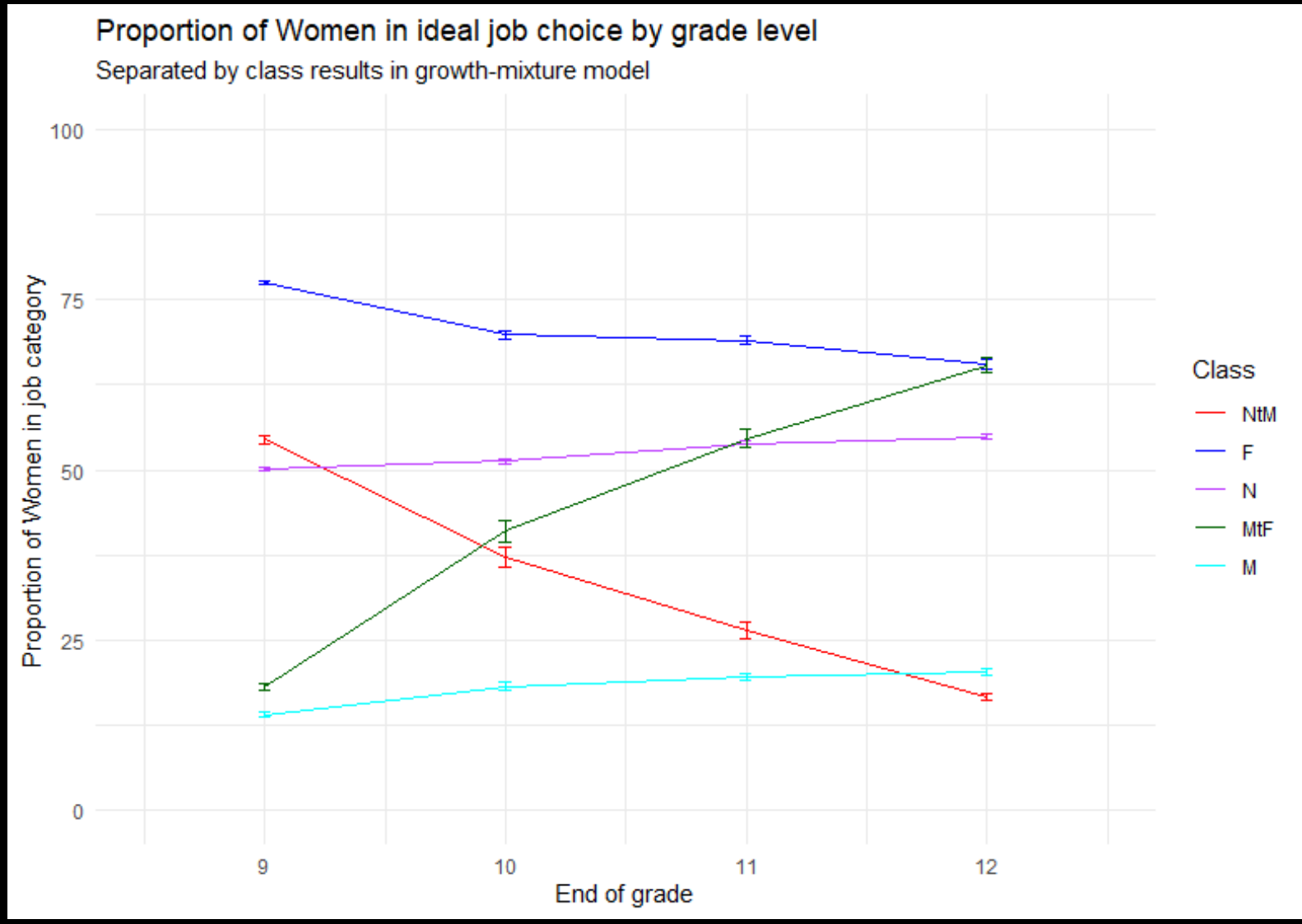
Methods – Growth Mixture Modeling

- A latent growth model is fitted to the proportion of women in career choice data from 9^{th}-12^{th} 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)

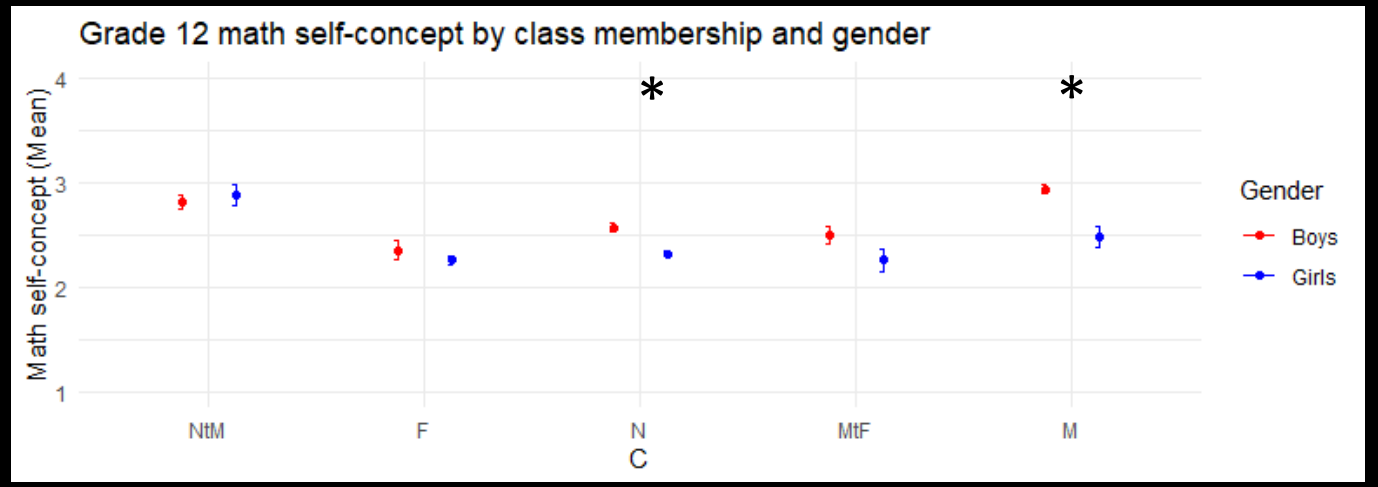
The Trajectories:

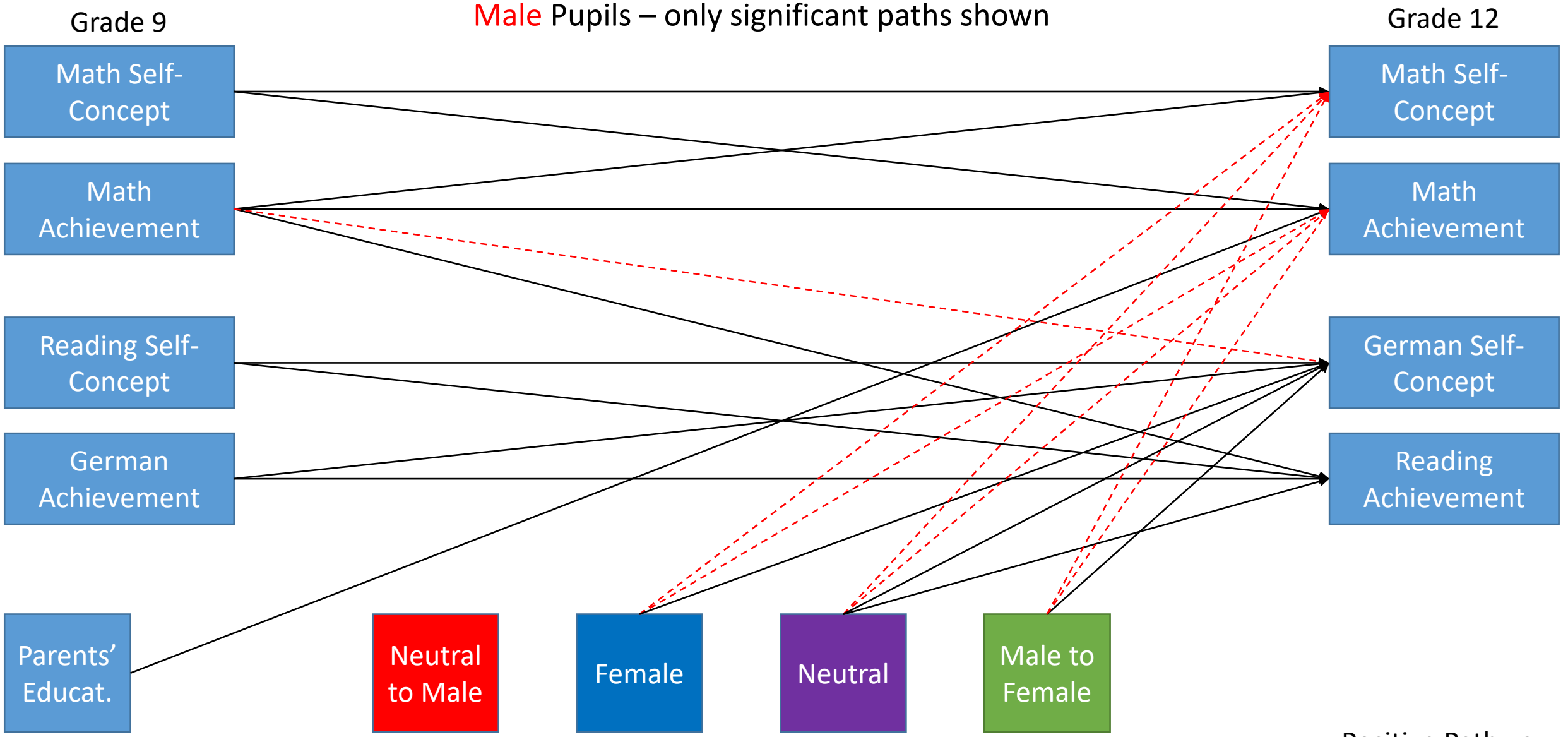
- Blue: Female Jobs (**F**)
  - 20.7%, N=983
- Purple: gender-neutral jobs (**N**)
  - 47.8%, N=2276
- Teal: Male Jobs (**M**)
  - 19.3%, N=920

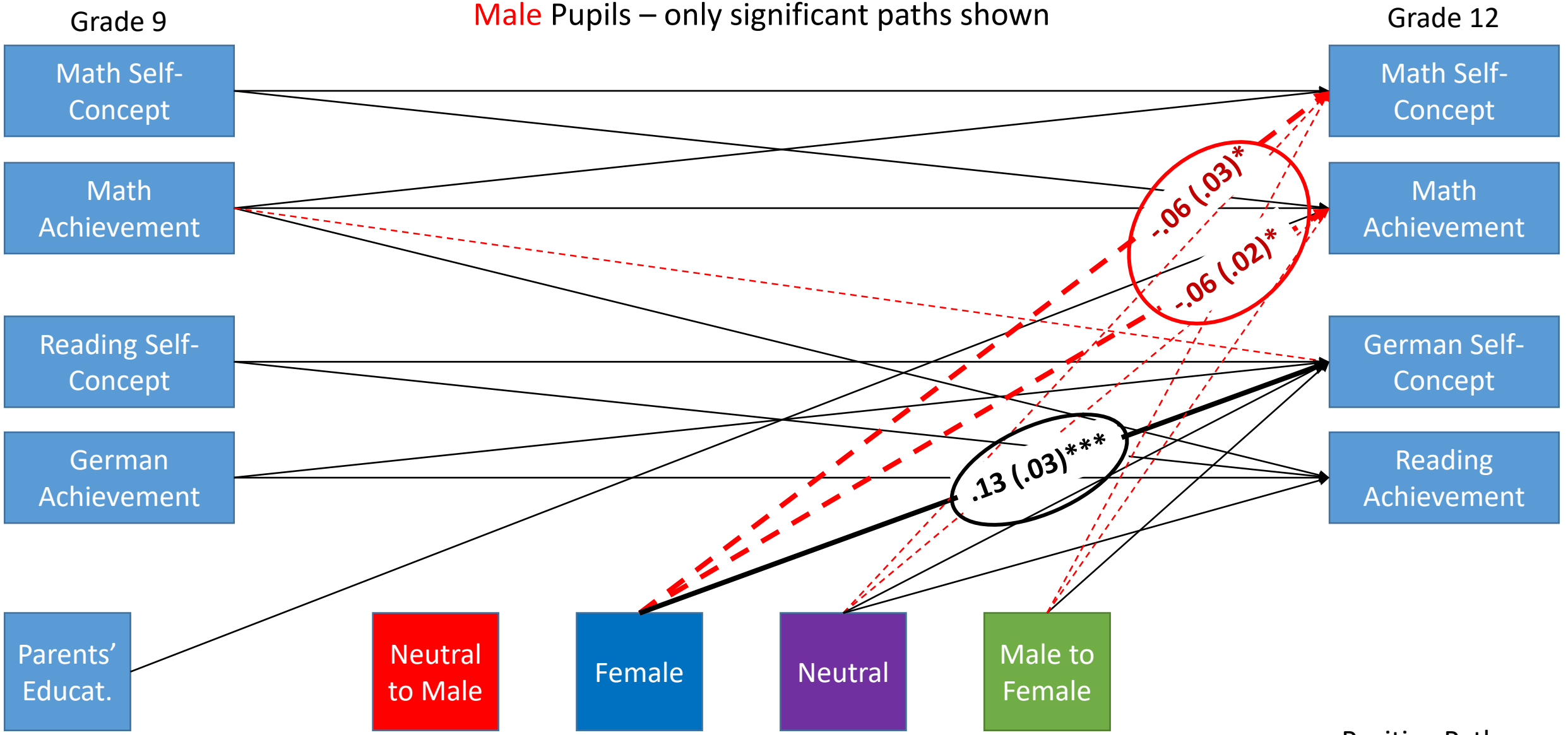
- Red: Neutral to Male Jobs (**NtM**)
  - 6.3%, N=300
- Green: Male to Female jobs (**MtF**)
  - 5.9%, N=280



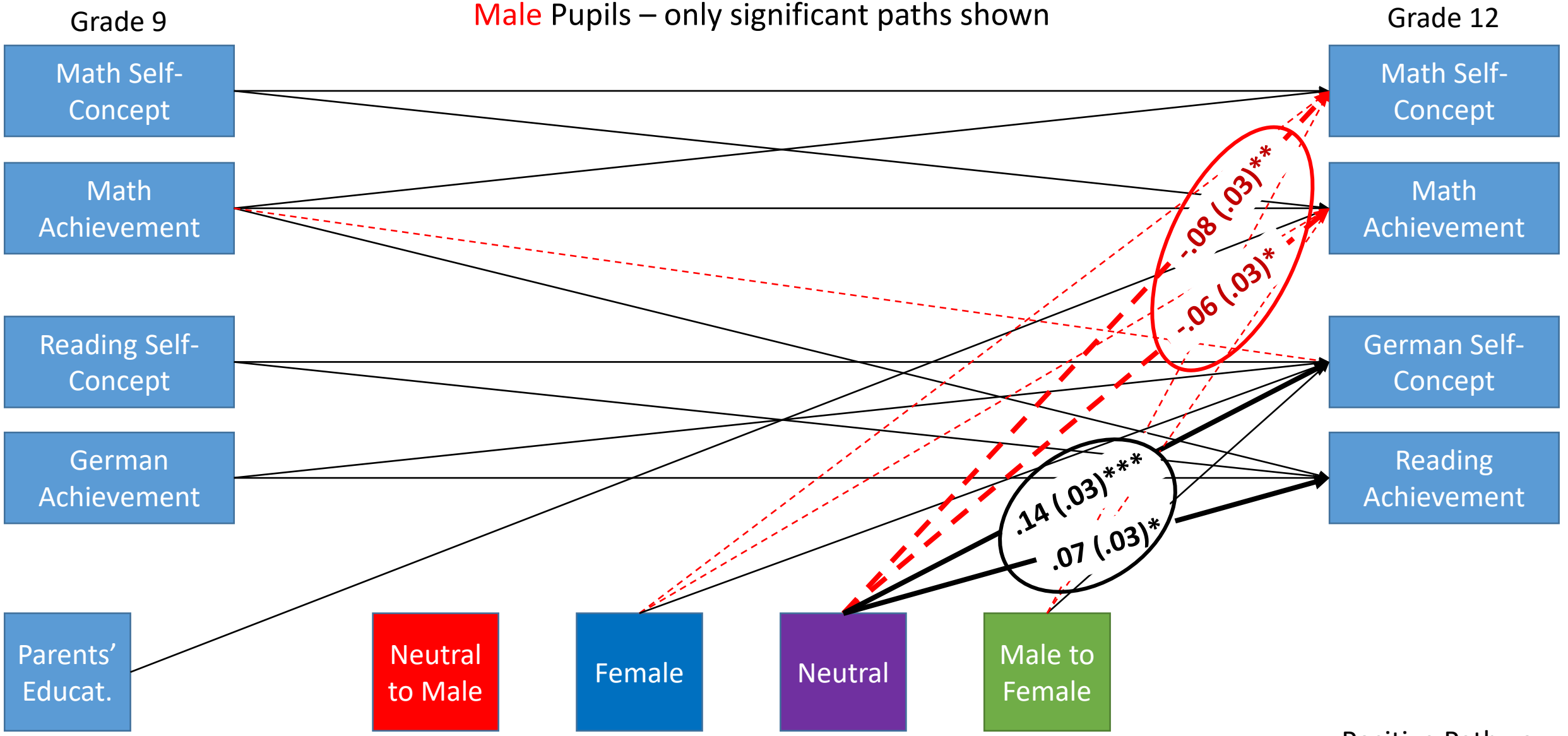
Math Achievement and Self-Concept by Gender and Trajectory



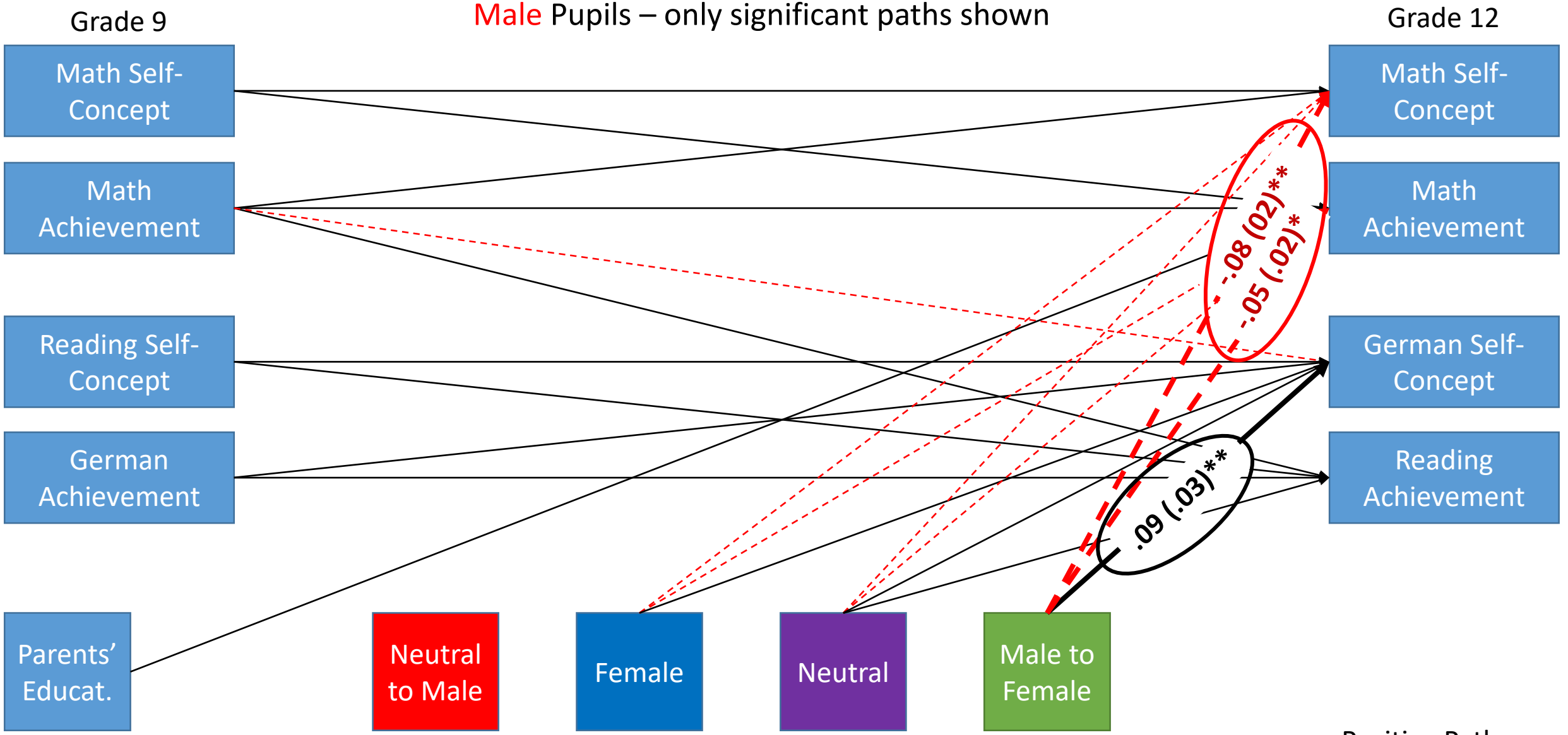

Male Pupils – only significant paths shown
Grade 9
Grade 12
Math Self-Concept
Math Achievement
Reading Self-Concept
German Achievement
Parents' Educat.
Math Self-Concept
Math Achievement
German Self-Concept
Reading Achievement
Neutral to Male
Female
Neutral
Male to Female
Positive Pathway
Negative Pathway
Dummy-coded Gendered Career Trajectory
Male Trajectory used as reference



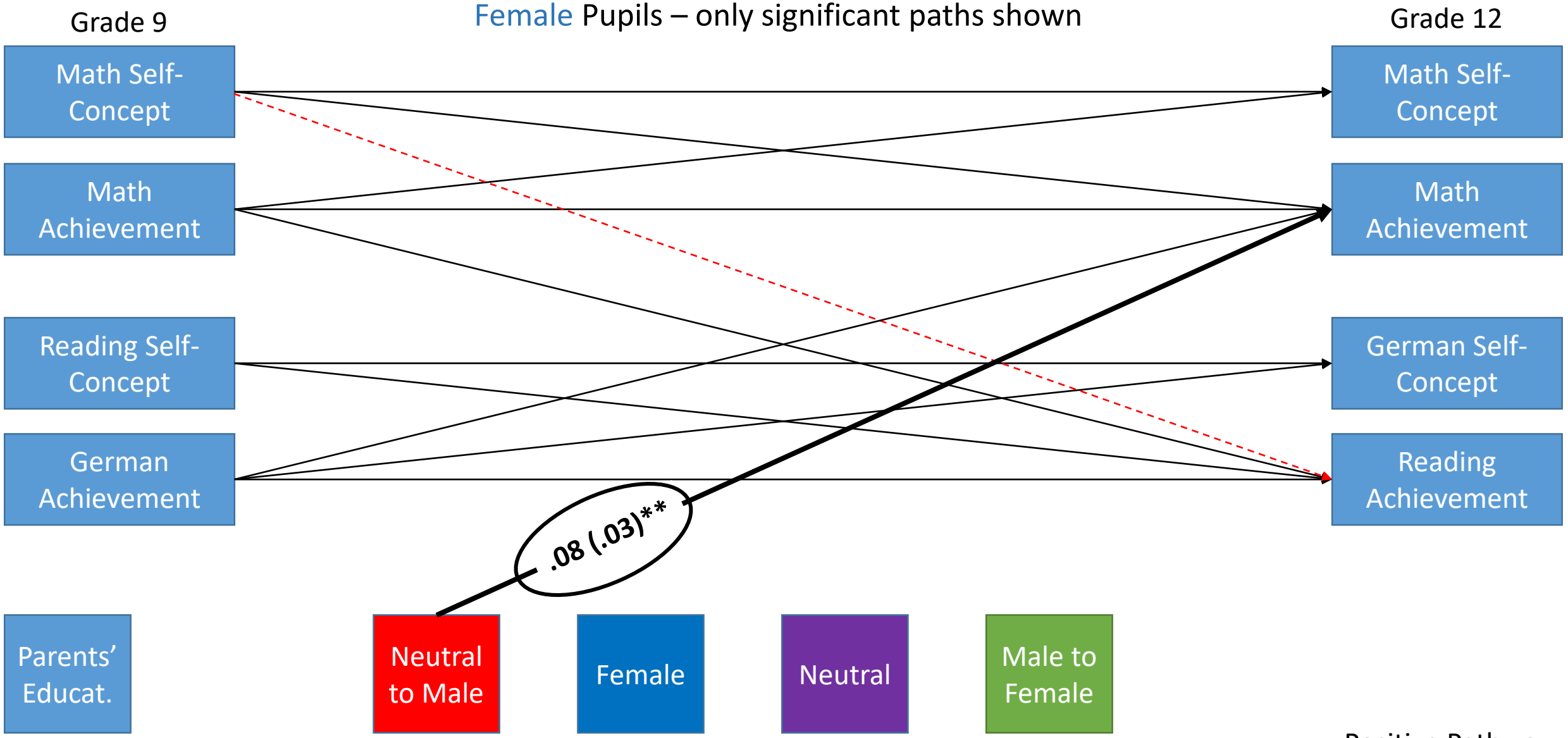
Dummy-coded Gendered Career Trajectory
Male Trajectory used as reference



Dummy-coded Gendered Career Trajectory
Male Trajectory used as reference



Dummy-coded Gendered Career Trajectory
Male Trajectory used as reference



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)

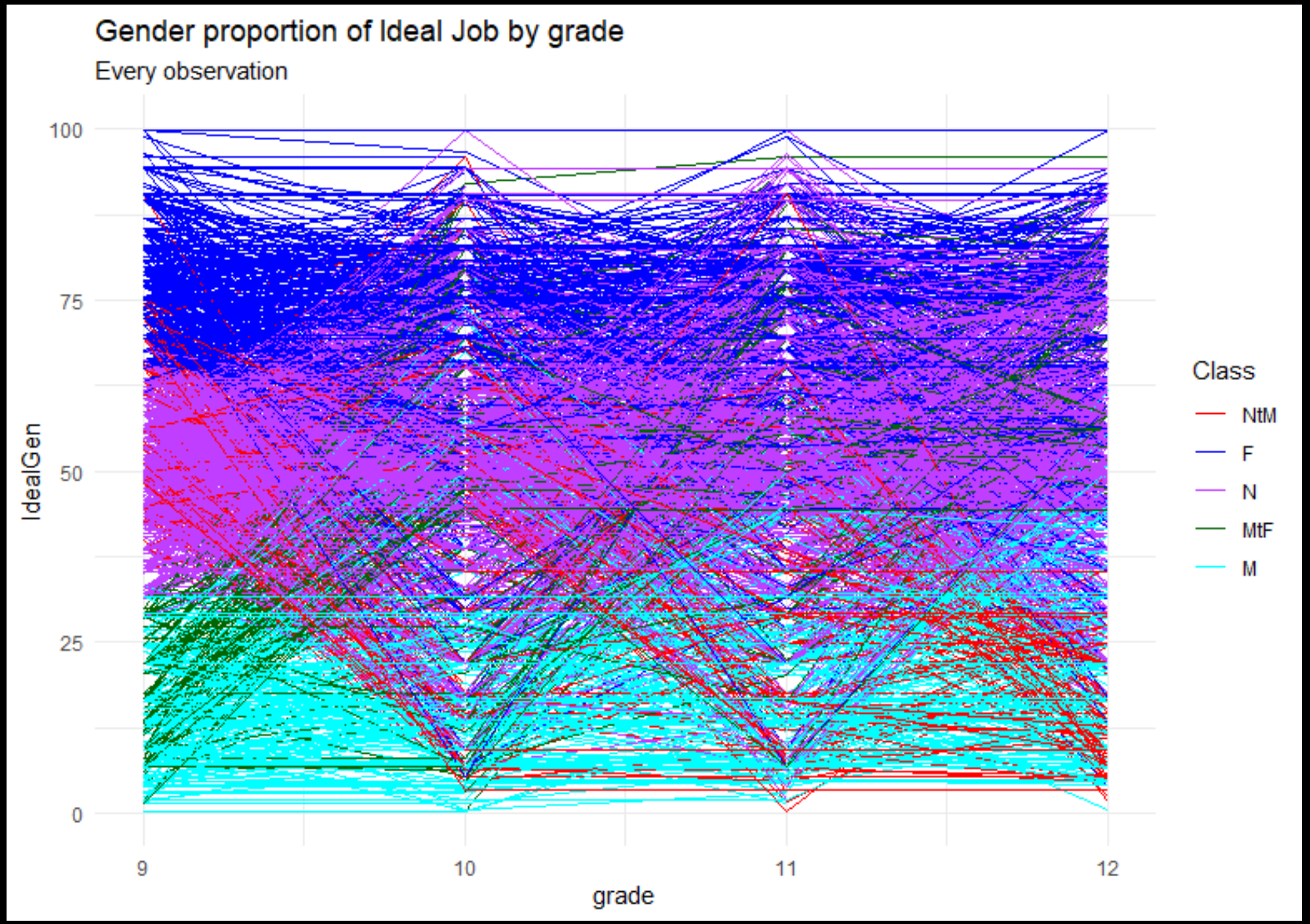
References

- Breda, T & Napp, C (2019). Girls' comparative advantage in reading can largely explain the gender gap in math-related fields. *Proceedings of the National Academy of Sciences of the United States of America (PNAS), 116, 31,* 15435-15440. https://doi.org/10.1073/pnas.1905779116
- Bundesagentur für Arbeit. (2019). *MINT – Berufe [STEM Careers]*. https://statistik.arbeitsagentur.de/DE/Statischer-Content/Statistiken/Themen-im-Fokus/Berufe/Generische-Publikationen/Broschuere-MINT.pdf?__blob=publicationFile&v=6
- DeVries, Jeffrey M., Carsten Szardenings, Philipp Doebler, and Markus Gebhardt. 2021. Subject-Specific Self-Concept and Global Self-Esteem Mediate Risk Factors for Lower Competency in Mathematics and Reading. *Social Sciences 10: 11*. https://doi.org/10.3390/socsci10010011
- DeVries, J. M., Szardenings C., Doebler P. & Gebhardt M. (2020) Individualized Assignments, Group Work and Discussions: How They Interact With Class Size, Low Socioeconomic Status, and Second Language Learners. *Front. Educ. 5:65*. doi: 10.3389/feduc.2020.00065
- Konrad-Ristau, K., & Burghardt, L. (2021). Differences in children's social development: How migration background impacts the effect of early institutional childcare upon children's prosocial behavior and peer problems. *Frontiers in Psychology, 12,* Article 614844. https://doi.org/10.3389/fpsyg.2021.614844
- Lauermann, F. (2015). Teacher motivation and its implications for the instructional process: Technical report and recommendations for an international large-scale assessment of teachers' knowledge and professional competencies. Technical paper prepared for the OECD Innovative Teaching for Effective Learning (ITEL) – Phase II Project: A Survey to Profile the Pedagogical Knowledge in the Teaching Profession (ITEL Teacher Knowledge Survey). OECD: Paris.
- Lauermann, F. (2017). Teacher motivation, responsibility, pedagogical knowledge and professionalism: A new era for research. In *Organisation for Economic Co-Operation and Development [OECD]* (Eds.) Teachers' pedagogical knowledge and the teaching profession. OECD: Paris.
- Lauermann, F., Chow, A., & Eccles, J. S. (2015). Differential Effects of Adolescents' Expectancy and Value Beliefs about Math and English on Math/Science-Related and Human-Services-Related Career Plans. *International Journal of Gender, Science and Technology*, *7*(2), 205–228. http://genderandset.open.ac.uk/index.php/genderandset/article/view/393/674
- Parker, P. D., Schoon, I., Tsai, Y.-M., Nagy, G., Trautwein, U., & Eccles, J. S. (2012). Achievement, agency, gender, and socioeconomic background as predictors of postschool choices: A multicontext study. *Developmental Psychology*, 1629–1642. https://doi.org/10.1037/a0029167
- Sari, E., Bittmann, F., & Homuth, C. (2021). Explaining inequalities of homeschooling in Germany during the first COVID-19 lockdown. *SocArXiv.* Advance online publication. https://doi.org/10.31235/osf.io/vsdq4
- U.S. Census Bueau. (2019). *STEM and STEM-Related Occupations by Sex and Median Earnings: ACS 2019*. https://www.census.gov/data/tables/time-series/demo/income-poverty/stem-occ-sex-med-earnings.html
- Wang, M.-T., Eccles, J. S., & Kenny, S. (2013). Not lack of ability but more choice: Individual and gender differences in choice of careers in science, technology, engineering, and mathematics. *Psychological Science*, *24*(5), 770–775. https://doi.org/10.1177/0956797612458937

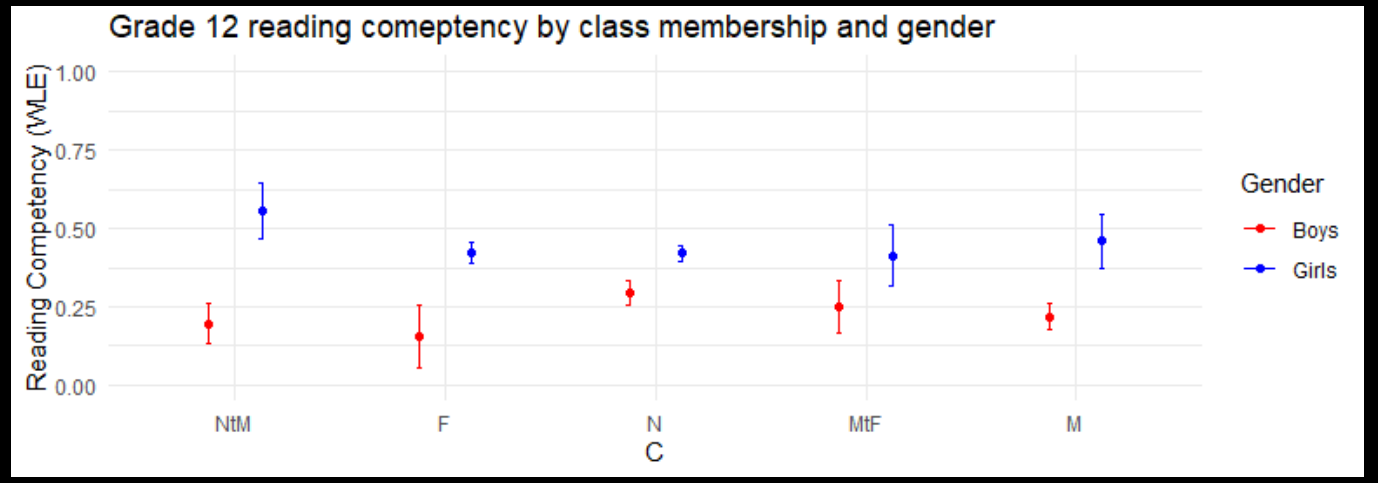
Thank you!

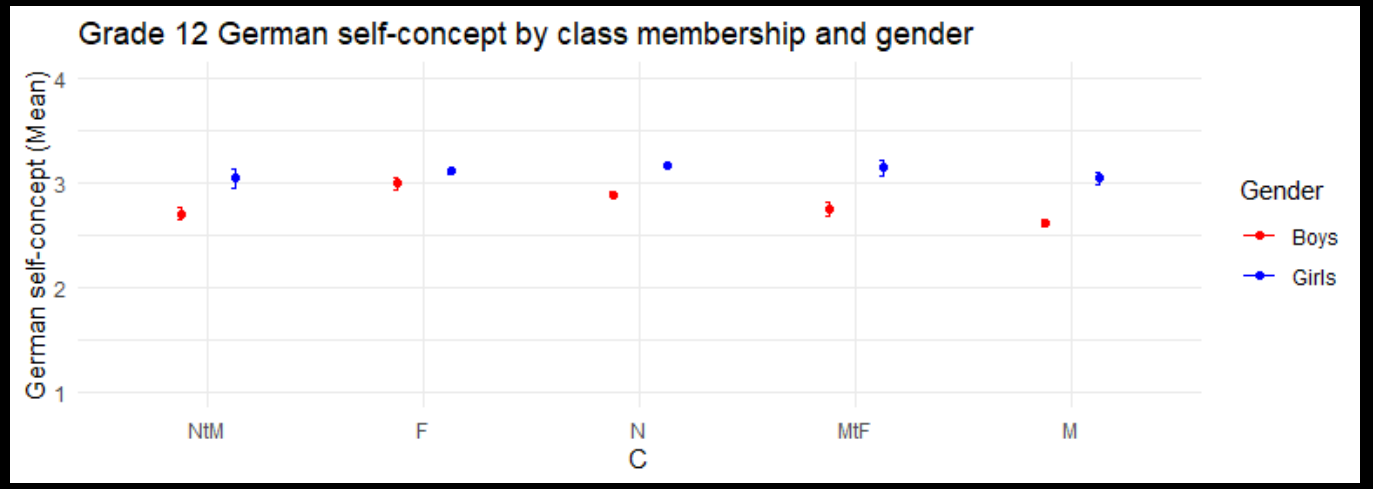
- Questions?
- Comments?

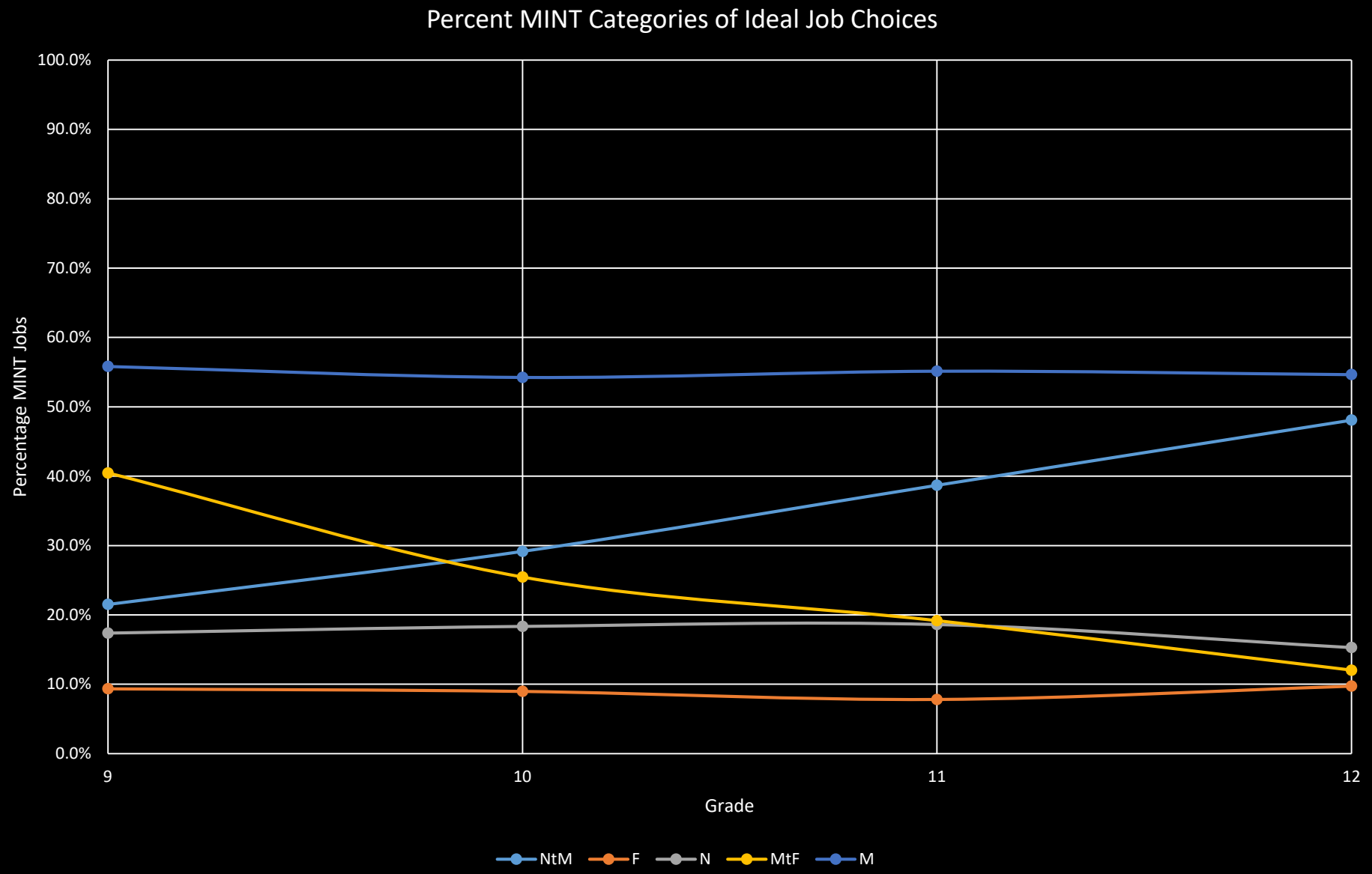
Extra Slides


Gender proportion of Ideal Job by grade
Every observation
100
75
50
25
0
IdealGen
9
10
11
12
grade
Class
NtM
F
N
MtF
M

Verbal Achievement and Self-Concept by Gender and Trajectory






Percent MINT Categories of Ideal Job Choices
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Percentage MINT Jobs
9
10
11
12
Grade
NtM
F
N
MtF
M

Grade 12 Reading and Math Self-Concepts and Achievement by Class Membership and Gender

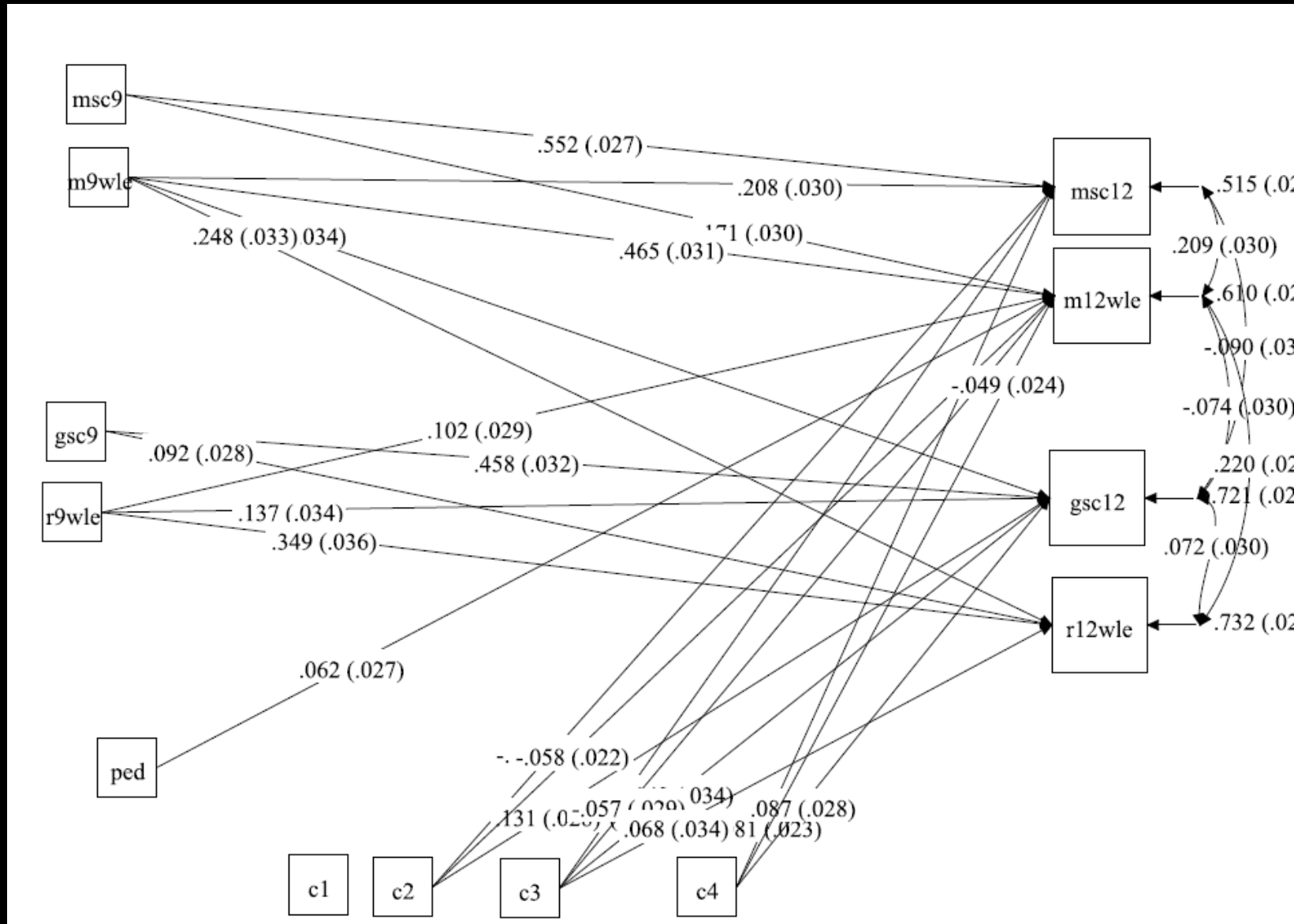
		Reading Achievement		Reading Self-concept		Math Achievement		Math Self-concept	
		Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Neutral-to-Male	M (SE)	0.82 (0.07)	1.17 (0.09)	2.71 (0.06)	3.05 (0.09)	1.69 (0.08)	1.64 (0.14)	2.82 (0.07)	2.89 (0.10)
Female	M (SE)	0.78 (0.10)	1.04 (0.03)	(2.99 (0.07)	3.12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

Note: Self-concepts are on a 1-4 Likert scale. Achievement is given by weighted likelihood estimates (WLE).

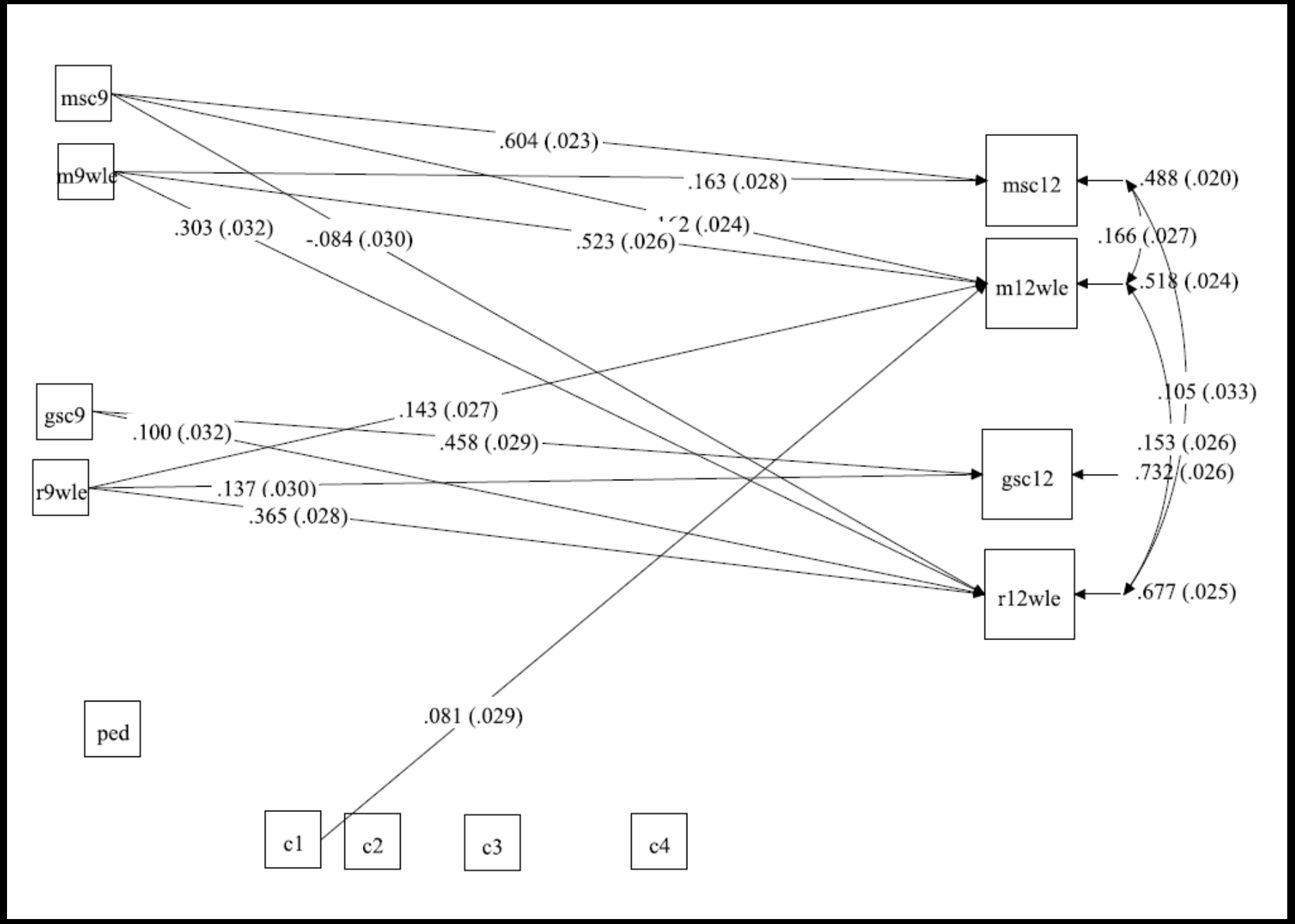
Standardized path loadings for gendered-career trajectory type predicting self-concept and achievement in grade 12.

		G12 Reading Achieve		G12 Reading Self-Concept		G12 Math Achieve		G12 Math Self-Concept	
Grade 9 Values		boys	girls	boys	girls	boys	girls	boys	girls
Reading Achieve	(SE)	.35*** (.04)	.37*** (.03)	.14*** (.03)	.14*** (.03)	.10*** (.03)	.14*** (.03)	-.02 (.02)	.04 (.03)
German self-concept	(SE)	.09** (.03)	.10** (.03)	.46*** (.03)	.46*** (.03)	-.00 (.03)	-.04 (.03)	-.01 (.03)	-.02 (.02)
Math Achieve	(SE)	.25*** (.03)	.30*** (.03)	-.09** (.03)	-.02 (.03)	.47*** (.03)	.52*** (.03)	.21*** (.03)	.16*** (.03)
Math self-concept	(SE)	-.04 (.03)	-.08** (.03)	.02 (.03)	-.05 (.03)	.17*** (.03)	.162*** (.02)	.55*** (.03)	.60*** (.02)
Parental Education	(SE)	.03 (.03)	.03 (.03)	.00 (.03)	.02 (.03)	.06* (.03)	.04 (.02)	.05 (.03)	.03 (.02)
Career Choice Trajectory									
Neutral-to-male	(SE)	.04 (.03)	.02 (.03)	.01 (.03)	.01 (.04)	-.01 (.03)	.08** (.03)	.02 (.03)	.02 (.02)
Female	(SE)	-.01 (.02)	-.07 (.06)	.13*** (.03)	.01 (.06)	-.06** (.02)	-.02 (.05)	-.06* (.03)	-.01 (.04)
Neutral	(SE)	.07* (.03)	-.08 (.07)	.14*** (.03)	.05 (.06)	-.06* (.03)	-.03 (.05)	-.08** (.03)	.01 (.04)
Male-to-Female	(SE)	.01 (.03)	-.06 (.04)	.09** (.03)	.04 (.03)	-.05* (.02)	.01 (.03)	-.08** (.02)	-.04 (.02)

Boys


msc9
m9wle
gsc9
r9wle
ped
c1
c2
c3
c4
msc12
m12wle
gsc12
r12wle
.552 (.027)
.208 (.030)
.248 (.033) 034)
.465 (.031)
171 (.030)
.102 (.029)
.092 (.028)
.458 (.032)
.137 (.034)
.349 (.036)
.062 (.027)
-.049 (.024)
-. -.058 (.022)
131 (.02
.057 (.029) 034)
.068 (.034) 81 (.023)
.087 (.028)
.515 (.02
.209 (.030)
.610 (.02
-.090 (.03
-.074 (.030)
.220 (.02
.721 (.02
.072 (.030)
.732 (.02

Girls


msc9
m9wle
gsc9
r9wle
ped
c1
c2
c3
c4
msc12
m12wle
gsc12
r12wle
.604 (.023)
.163 (.028)
.303 (.032)
-.084 (.030)
.523 (.026)
.143 (.027)
.100 (.032)
.458 (.029)
.137 (.030)
.365 (.028)
.081 (.029)
.488 (.020)
.166 (.027)
.518 (.024)
.105 (.033)
.153 (.026)
.732 (.026)
.677 (.025)

Model Selection

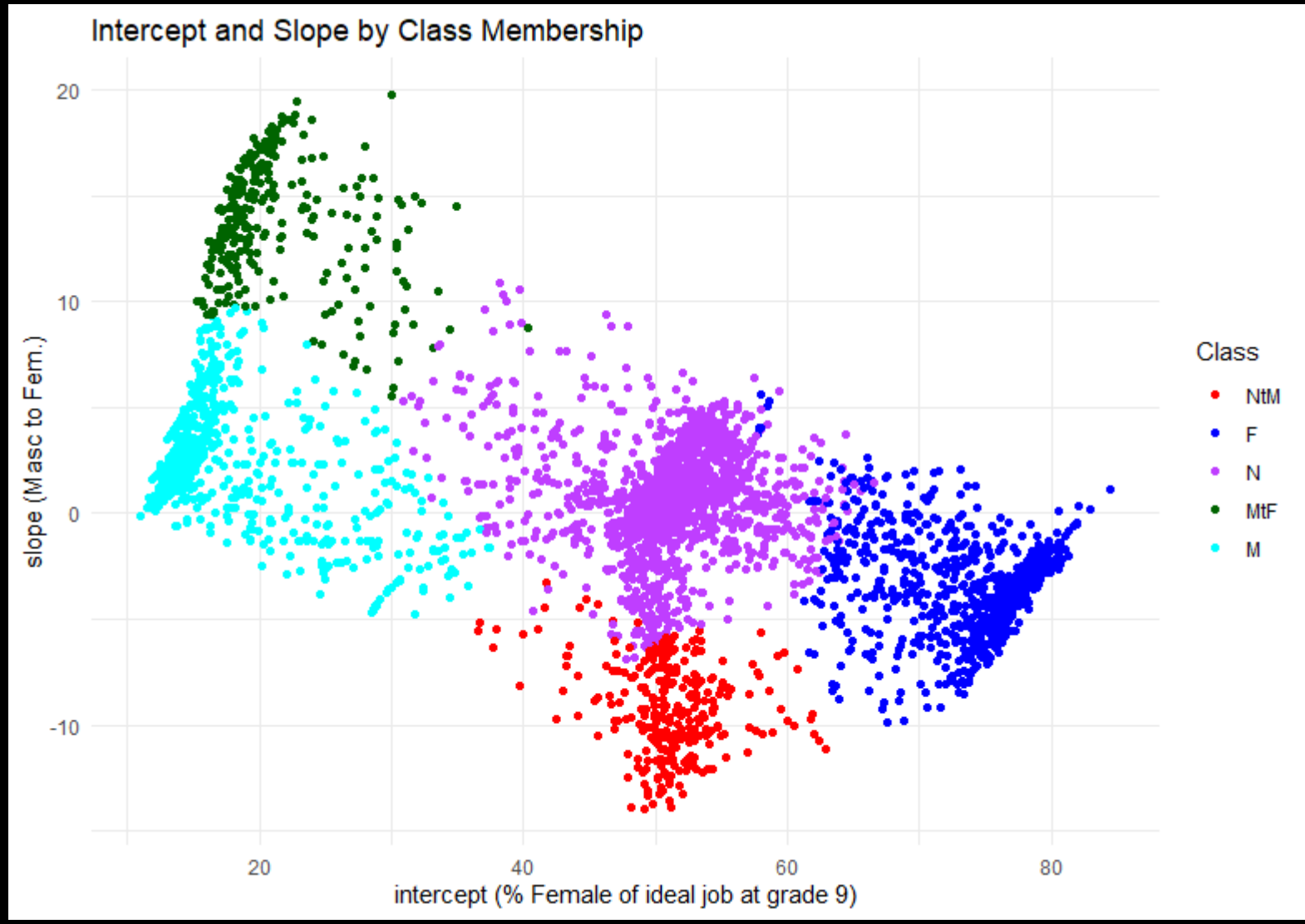
# of Classes	AIC	BIC	Adjusted BIC	Entropy	Size of Smallest Class
1	127,936	128,022	127,980	*n.a.*	*n.a.*
2	115,915	115,992	115,954	0.647	1207
3	115,407	115,504	115,457	0.735	964
4	115,283	115,400	115,342	0.740	231
5	**115,186**	**115,322**	**115,255**	**0.697**	**280**

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.

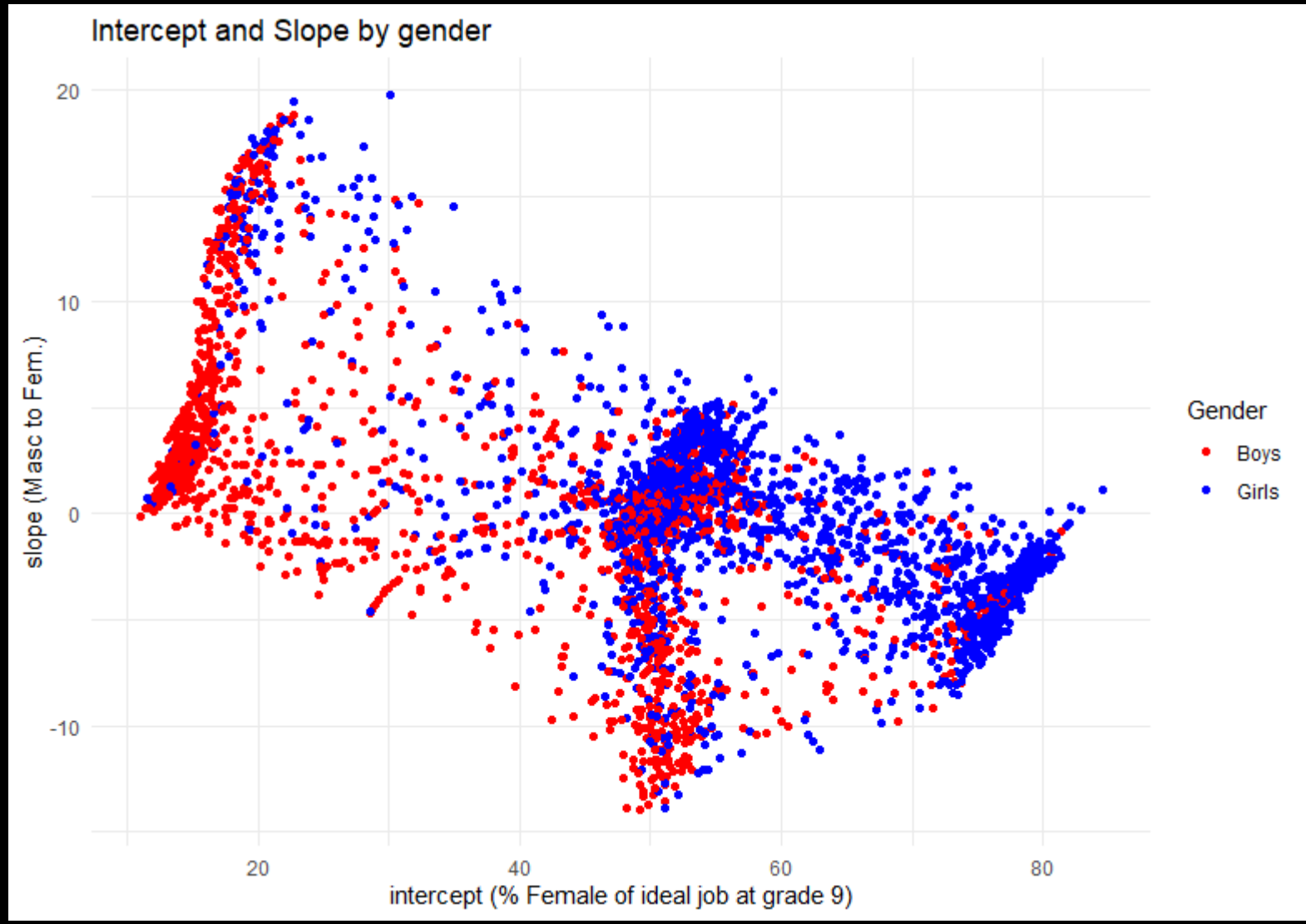
Latent Class Separation

- Classes are well defined by intercept and slopes of career-choice trajectories



Latent Class Separation – Gender

- And by Gender



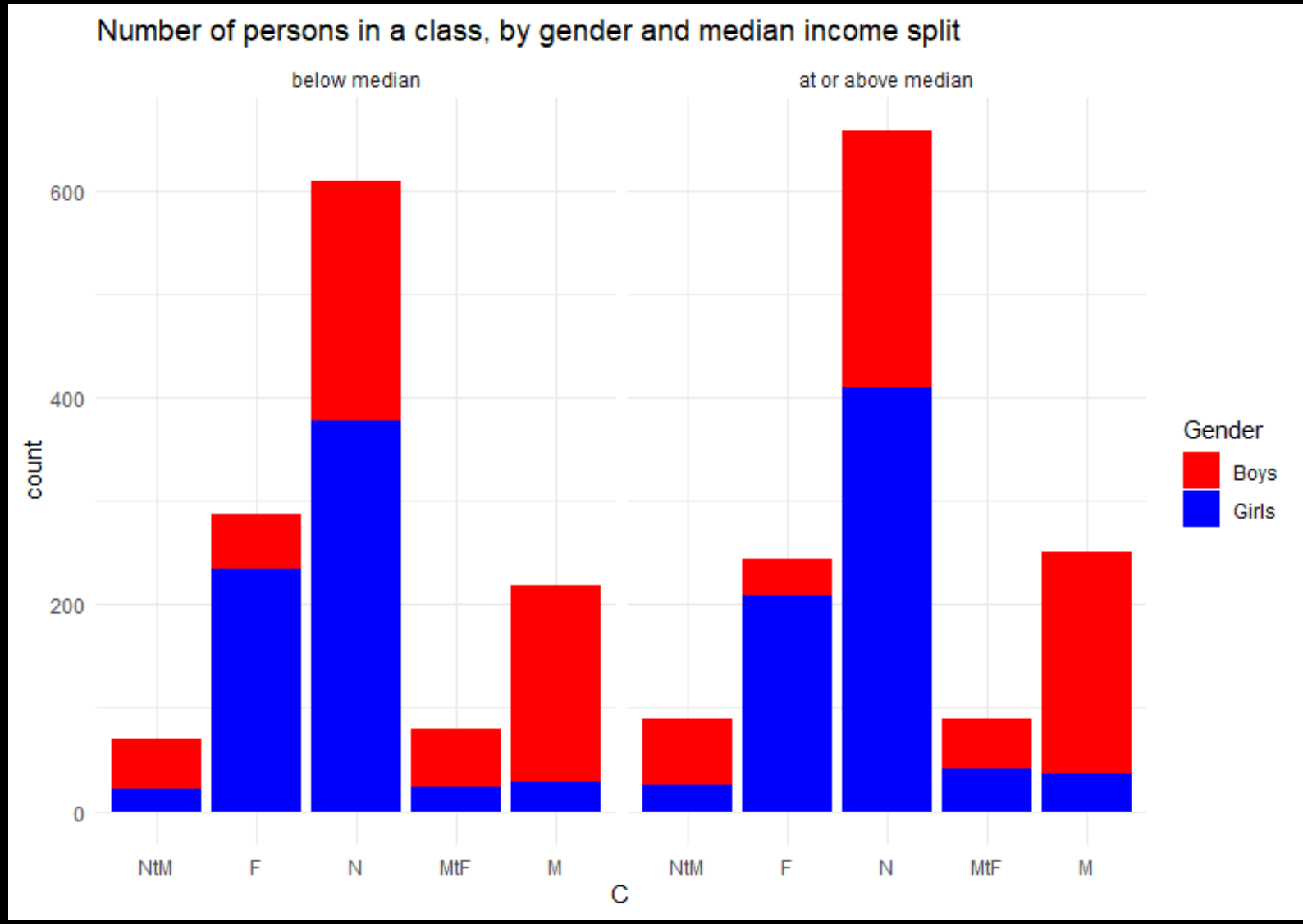
Methods – Measures (2 of 2)

- 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).

MATH	GERMAN
I get Good Grades	I get good grades
It's one of my best subjects	I learn fast
I've always been good at it	I'm a hopeless case (Reversed)

Class Membership, Gender and SES

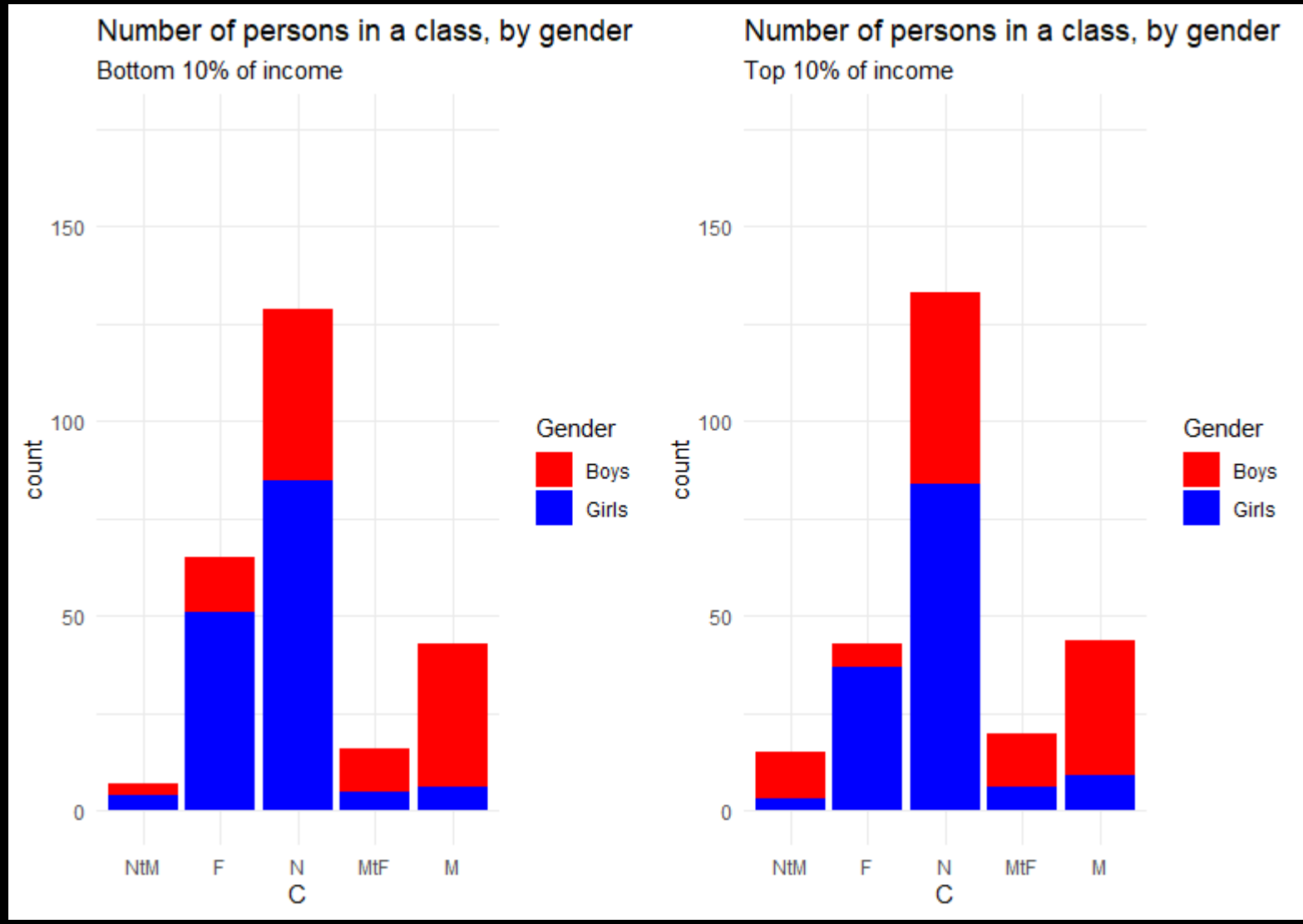
- Gender dictates class membership
- But so does SES



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

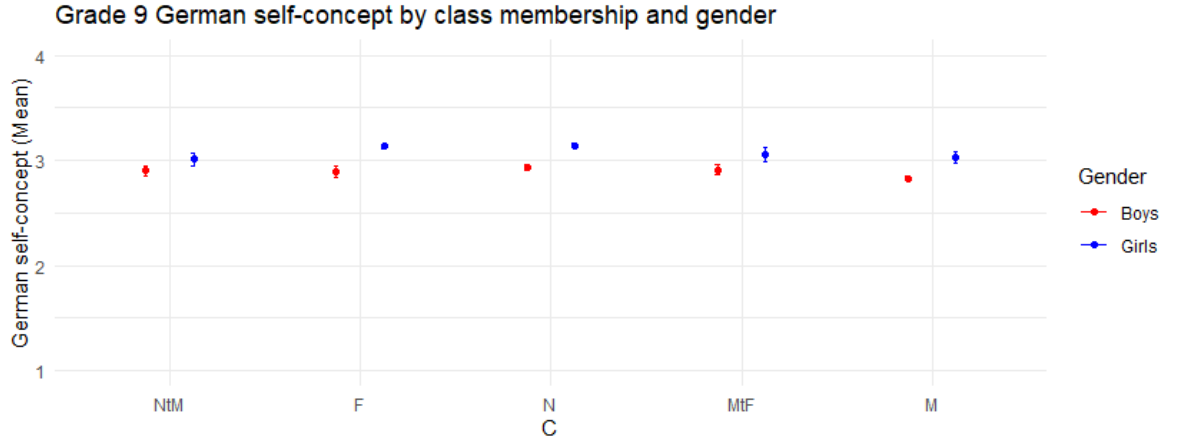


Development and Career Choice from Gottfredson

- 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

Gottfredson, 1981; 1996; Gottfredson & Lapan, 1997

Grade 9 and 12 Competencies by trajectory

Self Concept by Trajectory