Gender, Motivation and Mathematics Participation: 
A comparison of samples from Australia, Canada and the USA

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STEM Participation: Individual motivations, perceptions, and cultural values

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Background

- Declines in advanced math and science participation in many Western countries, and a paucity of qualified individuals entering “STEM” careers.

- Across OECD countries, women attain 30% of STEM degrees.
  (OECD, 2004)

- Researchers have considered pathways into STEM as a “leaky pipeline”, to identify patterns of leakage and contributing factors.

- Studies of gendered motivational and ability-based beliefs that influence educational and career decisions have often drawn on the Eccles et al. Expectancy-value (EV) model
  (Eccles et al., 1983; Eccles, 2005, 2009)
The Present Study

- Using EV framework, we explored longitudinally relationships between math-related motivations, high school math participation, future educational and occupational aspirations, for male and female adolescents.

- Despite similar achievement, boys and girls differ in their mathematical self-concepts and values.

- (How) Does this impact their mathematical (and non-mathematical) educational and occupational decisions?
  - Senior high math enrolments, and aspired level of education.
  - Is it possible that girls choose careers that are equally prestigious, but less math-related? eg, Lawyer
  - For girls who do aspire to mathematical careers, are they of equal status to boys’ math-related plans?

- How relevant is degree of choice and early specialisation across cultural settings?
Objectives

- to contrast the **roles of expectancies and kinds of values** (intrinsic, importance) for girls and boys in schooling contexts providing varying degrees of choice;

- to test evidence for the **pipeline** metaphor, wherein degree of mathematical preparation has flow-on effects to educational/occupational outcomes;

- to examine possible **non-mathematical outcomes** (aspired level of education, job prestige).

- Understanding the relationship between motivational beliefs and outcomes for male and female adolescents is critical to understanding potential gendered mechanisms that lead to math participation or disengagement.
Eccles et al. Expectancy-value Model

Figure 1. The current form of the Expectancy-Value model. Adapted from Wigfield, A. & Eccles, J.S. (2000). Expectancy-value theory of achievement motivation. Contemporary Educational Psychology, 25, 68-81.
Samples & Settings

- 3 opportune samples from different (similar) contexts:
  - Australian grades 9→11, \( N = 358 \) (98% retention)
  - U.S. grades 10→12, \( N = 418 \) (67% retention)
  - Canadian grades 9/10→11/12, \( N = 471 \) (98% retention)

- Different systems allowed us to examine robustness of patterns – both in identification of gender differences, and the ways motivational beliefs are implicated in educational and occupational choices.

- Systems differ in interesting ways.
Math Choice Contexts across Settings

- **Australian (Sydney):**
  - English was the only compulsory subject when data were collected.
  - Students could choose one of 5 math courses, ranging from the least to most difficult; each spanning two years of study.
  - The middle difficulty course was prerequisite to certain university degrees (e.g., engineering, medicine, accounting, aviation, several science specialisations).

- **U.S. (Michigan):**
  - Most universities require algebra I, geometry, algebra II (or trigonometry, calculus) for admission; as well as 4 years of language arts, 2 years foreign language, 3 years science, and 3 years social science.

- **Canadian (Ontario):**
  - Students required to take language arts and at least 6 advanced courses.
  - To enter university, one of these had to be math in grade 11; those wishing to enter scientific degree programs additionally needed advanced math in grade 12.

In both North American settings, less difficult math courses, such as applied math or personal banking could satisfy high school graduation requirements but not university admission requirements.
EV Motivations Measures T1

- **ABILEXP**: beliefs about how well one will perform on an impending task and subjective ability beliefs
- **INTRIN**: Intrinsic value, likened to interest
- **ATTUTIL**: Attainment value taps the importance of doing well on a task to confirm aspects on an individual’s identity. Utility value, taps more extrinsic and instrumental values. Frequently combined and termed “Importance value”.
- **Slight differences across samples, the 3 factors emerged reliably in each.**
<table>
<thead>
<tr>
<th>Construct</th>
<th>Sample</th>
<th>Ex. Item</th>
<th>Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ABILEXP</strong></td>
<td>Australian</td>
<td>How talented do you think you are at maths?</td>
<td>.89</td>
</tr>
<tr>
<td><em>Ability/expectancy</em></td>
<td>Canadian</td>
<td>How good at math are you?</td>
<td>.93</td>
</tr>
<tr>
<td></td>
<td>U.S.</td>
<td>How good at math are you?</td>
<td>.92</td>
</tr>
<tr>
<td><strong>INTRIN</strong></td>
<td>Australian</td>
<td>How interesting do you find maths?</td>
<td>.94</td>
</tr>
<tr>
<td><em>Intrinsic value</em></td>
<td>Canadian</td>
<td>I have had quite a few interesting math assignments to do at school</td>
<td>.89</td>
</tr>
<tr>
<td></td>
<td>U.S.</td>
<td>In general, I find working on math assignments: (very boring – very interesting)</td>
<td>.88</td>
</tr>
<tr>
<td><strong>ATTUTIL</strong></td>
<td>Australian</td>
<td>How important is doing well in maths to you?</td>
<td>.89</td>
</tr>
<tr>
<td><em>Attainment/Utility value</em></td>
<td>Canadian</td>
<td>Math is a worthwhile and necessary subject</td>
<td>.77</td>
</tr>
<tr>
<td></td>
<td>U.S.</td>
<td>For me, being good at math is: (not at all important – very important)</td>
<td>.80</td>
</tr>
</tbody>
</table>
Educational & Occupational Choices T2

- **Senior high math:**
  - Australian: Level of math
  - Canadian: Number of advanced math courses (averaged for elder cohort)
  - U.S.: Total number of math courses (missing data, 204 valid cases)

- **Aspired education level:**
  - 1 (high school) – 4 (graduate or professional degree)

- **Aspired career:** math-relatedness & prestige (O*NET, 1998)
  - “no”, “any”, “average”, to “high” math
  - 1 (lowest) – 5 (highest) prestige based on estimated wage and education required
Hypotheses

- Boys would have higher self-concepts and intrinsic value, no gender differences on attainment/utility (“importance”) value. (Fredricks & Eccles, 2002; Frenzel et al., 2010; Jacobs et al., 2002; Nagy et al., 2010; Watt, 2004)
- Gender differences in high school math to be more pronounced for Australian, than U.S. or Canadian samples, when college-bound students should perceive more negative consequences of opting out of math (Watt, Eccles, & Durik, 2006).
- Intrinsic value would play a greater role in Australian high school math courses, due to course selection structure and university admissions.
- Attainment/utility (“importance”) value would play a greater role for girls in career choice, with girls attracted to careers they regard as personally meaningful.
- High school math courses would predict math-related career plans, in line with the “pipeline” metaphor.
- Math-related career plans would relate to aspired career prestige; perhaps more strongly for boys \( \leftarrow \text{does the leaky pipeline have a glass ceiling?} \)
- No firm hypotheses concerning gender differences for aspired level of education and career prestige plans; or, whether math motivations and courses would predict “non-mathematical” outcomes.
Analyses

- MANOVAs to check gender differences in educational and occupational choices (single-item indicators)
- Multigroup SEMs (FIML) including means and covariances to test:
  - strong factorial invariance (partial scalar invariance)
  - latent mean differences in motivations for boys vs. girls, and
  - gendered patterns of prediction to choices.
Findings: Gender Differences

- **Australian:**
  - high school math courses
  - aspired career math-relatedness
  - intrinsic value

- **U.S. & Canadian:**
  - self-concept (ability/expectancy)

- **Interpretations:**
  - comparative testing regime in N. America focuses attention on ability/expectancy,
  - degree of choice in Australia focuses attention on interests,
  - earlier specialisation amplifies gender differences in math participation?,
  - with flow-on effects to math-related career choices.
Gendered relationships

FINDINGS (II)
$\chi^2 = 533.44 \text{ df} = 239, \text{ RMSEA} = .059, \text{ NFI} = .87, \text{ TLI} = .90, \text{ CFI} = .92$

Models: Australian

Girls

Boys

sig. diff. intrinsic value $\rightarrow$ educational aspirations
Australian:

- Prior math motivation directly impacted senior high level math enrollments and aspired level of education; indirectly impacted aspired career prestige.

- For girls, motivation additionally impacted planned math-related career. For boys, influences were indirect.

- Intrinsic and Attainment/utility values exerted direct influences.

- Ability/expectancy influences were indirect.
$\chi^2 = 609.11 \text{ df} = 273, \text{ RMSEA} = .051, \text{ NFI} = .87, \text{ TLI} = .90, \text{ CFI} = .92$

Models: Canadian

Girls

Boys

sig. diff. attainment/utility value $\rightarrow$ math participation
Canadian:

- Ability/expectancy emerged as a key motivational influence on advanced math enrollments,
- Intrinsic value had no direct effects (unlike Australian).
- Attainment/utility value predicted math-related career plans for girls and advanced math enrollments for boys, and these relationships differed significantly by gender.
Models: United States

Girls

Boys

Note high latent correlations among US predictors.

sig. diff. attainment/utility value \rightarrow \text{math participation}
U.S.:

- Ability/expectancy again emerged as a key motivational influence, for number of math courses, and aspired level of education.

- Intrinsic value had no direct effects.

- Attainment/utility value predicted number of math enrollments only for girls.

- High latent correlations may produce collinearities.
Discussion

- Effects of expectancy-value math motivations on high school boys’ and girls’ subsequent math- and non-math-related dimensions of educational and occupational aspirations, based on longitudinal data across 3 country samples.
- Motivational beliefs were predictive for boys and girls across settings.
- How do these findings advance our understanding of when and why girls (and boys) “leak” from the math pipeline, and what are the implications for non-mathematical outcomes?
- In general our hypotheses were supported, with illuminating particularities in each country.
Influences across Contexts?

- Different structures appear to activate different choice processes:
  - ability/expectancy beliefs important predictor in N. American samples,
  - intrinsic value in Australian,
  - how to enhance both?

- Attainment/utility (“importance”) value:
  - played a greater role for girls in career choices: implications for making links to math social uses and purposes in school,
  - boys’ choices may be more constrained.

- Math motivations impacted non-mathematical educational aspirations, and (indirectly) career prestige:
  - Australian: intrinsic and importance values more relevant,
  - U.S.: ability/expectancy beliefs,
  - Canada somewhere in between,
valuing of individual freedom, self-expression, imagination
High school math as a “pipeline” to particular careers:
- Yes, in Australian and Canadian,
- No, in U.S. “broken pipeline” (measurement differences? lack of variance?).

Career math-relatedness should relate to career prestige:
- moderately related, often assumed but not directly tested,
- n.s. gender differences (“leaky pipeline” does not have a “glass ceiling”).

Contributions from applying same analysis across samples from separate settings.
Limitations

- Different measures of senior high math participation:
  - may under-estimate for younger Canadian cohort,
  - missing data for U.S. cohort.

- Sample homogeneity (Anglo-European, upper middle-class):
  - limits ability to generalise,
  - gender divide could be greater from less socio-economically advantaged families,
  - motivational processes could vary greatly across cultural settings.

- Limited time-span: seeds for math disengagement are likely sown early.

- Limitations of reliance on aspirations as outcome measures.
Outlook & Future Directions

- Process and outcomes beyond career intentions
- “Choice” degrees of freedom
- Long-term longitudinal studies
- Multiple domains of choice and functioning
- Person-centred analyses, “off diagonals”
- Contextual influences and measurement
- Cross-cultural comparisons
- Lower male participation in female-typed domains and implications for wellbeing

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General Discussion

- What is the role of girls’ and women’s own motivations and self-beliefs?
- Are these self-beliefs accurate?
- What gender discrimination is encountered or perceived?
- How do different cultural values play a role?