Predicting Middle School Students' Self-Efficacy in Computer Programming Using Linear Mixed Models

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Introduction

- Self-efficacy (SE): individual's beliefs regarding their performance and capacity in a particular domain
  - According to Social Cognitive Career Theory (SCCT), SE promotes career interests and goals[1]
- Curated Pathways to Innovation (CPI): web app providing a collection of STEM and computer science (STEM+C) activities for middle school students[3]
  - Aims to boost self-efficacy and career aspirations in STEM+C, particularly among female and URM students (Black/African-American, Hispanic/ Latino, American Indian, Alaska Native)[2]
  - Ultimate goal is to expand diversity in STEM+C education and employment
  - Students complete activities to earn badges; after each badge they fill out a survey asking about task-specific self-efficacy (specific to badge) and global self-efficacy (computer programming in general)

Research Questions

- **RQ1)** Does task-specific SE predict global SE?
- **RQ2)** Are there differences in students' task-specific and global SE on the basis of gender, URM-status, or the interaction of these two demographic variables?
- **RQ3)** Does gender, URM-status, or the interaction of these two variables predict global SE after accounting for variation explained by task-specific SE?

Sample

- 869 middle school students (mean age = 11.2, 42.8% female, 55.9% URM)
- 6082 survey responses
- 122 badges total

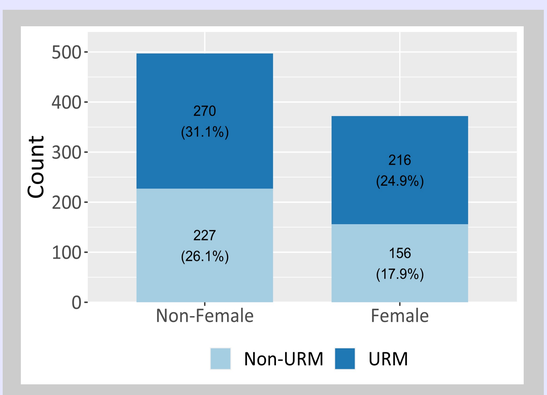

Figure 1: Student demographics by gender and URM-status

Materials

- Self-efficacy survey items are answered using a 5-point Likert scale (1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree)
- Only including responses in which both self-efficacy items were answered

Task-specific SE	"I am good at the kinds of activities that were in this badge"
Global SE	"I am good at computer programming"

Table 1: Items corresponding to task-specific and global SE

	Mean	SD	Median	Range
Task-Specific SE	3.88	1.16	4	4
Global SE	3.57	1.26	4	4

Table 2: Descriptive statistics for task-specific and global SE

Analysis

- Survey responses are nested under both student and badge → non-independence within clusters
  - Responses completed by the same student are non-independent
  - Responses corresponding to the same badge are non-independent

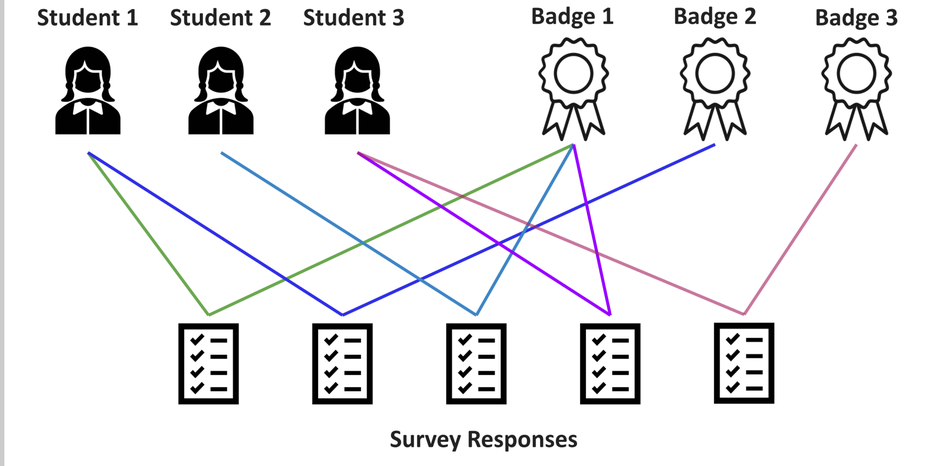

Figure 2: Nested data structure with clusters of survey responses at the student and badge level

- Implemented linear mixed-effects models with lme4 package in R to account for nested data
- Random effects: student and badge
  - Chi-squared test to determine which random effects significantly improved model fit
  - Task-specific self-efficacy
    - Both student-ID ($p < 0.001$) and badge ($p < 0.001$) significantly improved model fit
  - Global self-efficacy
    - Both student-ID ($p < 0.001$) and badge ($p = 0.019$) significantly improved model fit
- Computed t-values and corresponding p-values for each fixed effect

Linear Mixed-Effects Models	
RQ1	gse ~ tse + (1|id) + (1|badge)
RQ2	tse ~ female1*urm1 + (1|id) + (1|badge) gse ~ female1*urm1 + (1|id) + (1|badge)
RQ3	gse ~ tse + female1*urm1 + (1|id) + (1|badge)

Table 3: Linear mixed-effects models of task-specific self-efficacy (tse) and global self-efficacy (gse)

Results

- RQ1: Task-specific SE was significantly and positively predictive of global SE ($\beta = 0.49$, $p < 0.001$)
- RQ2: Gender was a significant predictor of task-specific SE, but not global SE
  - Female students had lower task-specific self-efficacy ($\beta = -0.20$, $p = 0.048$)
  - Neither URM-status nor the gender-URM interaction were significant predictors of task-specific or global SE
- RQ3: After accounting for variation due to task-specific SE, neither gender, URM-status, nor the interaction of the two were significantly associated with global SE
  - Task-specific SE was the only significant predictor ($\beta = 0.49$, $p < 0.001$)

Discussion

- Limitations
  - Dichotomous coding of gender
  - Homogeneous term "URM" to categorize a heterogeneous group
  - Findings are all correlational
- Student and badge random effects both significantly explain variation in self-efficacy ratings
  - Individual differences in self-efficacy
  - Perhaps harder badges lead to diminished self-efficacy (area for future research)
- Boosting confidence through specific activities corresponds to higher general self-efficacy in STEM+C
- Reinforces importance of CPI and other resources to encourage students to pursue STEM+C and combat gendered and racialized stereotypes, in line with Social Cognitive Career Theory[2]

References

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