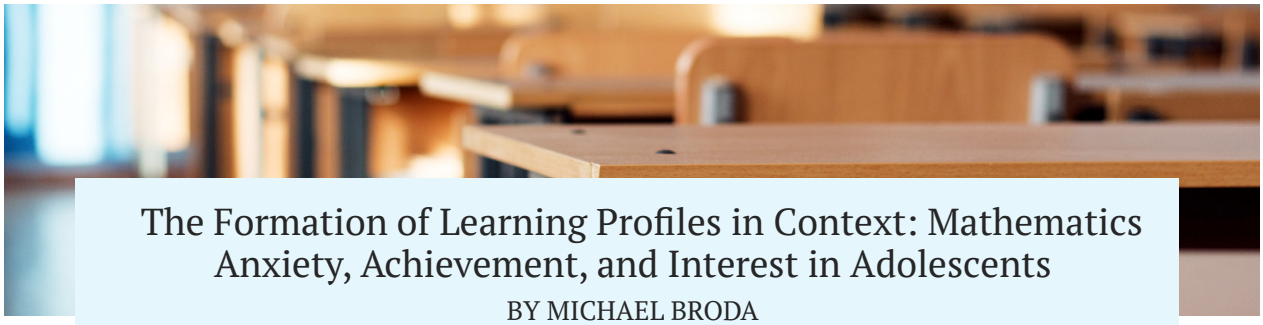

The Formation of Learning Profiles in Context: Mathematics Anxiety, Achievement, and Interest in Adolescents

BY MICHAEL BRODA

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Recent research has begun to uncover the complex relationships between the cognitive components (e.g. problem solving, conceptual development) and affective components (e.g., attitudes, emotions) of mathematics learning.[1] For example, many affective components, including interest, anxiety, and self-efficacy, have all been found to have significant associations with one another and with mathematics achievement.[2]

While traditional research methods have focused on the traits and perceptions of individuals and the aggregate correlations between these factors and individuals' outcomes (e.g., GPA), these methods are limited. They cannot capture complex interactions among related, but distinct, mathematics learning constructs and they cannot capture aspects of the environment (in this case, the teacher and the classroom context) that may be "hidden" from individuals (in that individuals may not be consciously aware of how they are influenced by these factors) but that matter for big picture outcomes. In turn, these correlational methods have often produced inconsistent findings (see, e.g. De Smedt et al., 2013).

Newer methods of classification and analysis, such as multilevel latent profile analysis (MLPA),[3] can identify distinct subgroups, or clusters, within a larger population based on a series of indicators, while also accounting for the influence of higher-level contextual variables. This study used data from the National Study of Learning Mindsets (NSLM) to examine whether students could be grouped into distinct profiles based on their levels of mathematics interest, anxiety, and achievement, and whether these profiles might be shaped by students' teachers and their own mindsets about mathematics.

Study Design

This study used multilevel latent profile analysis (MLPA) to find distinct subgroups of students within the full population of students that participated in the National Study of Learning Mindsets and to investigate the extent to which membership in a given subgroup was influenced by classroom-level factors, such as teacher beliefs about mathematics.

While not widely applied in the context of mathematics learning, scholars in other fields have used MLPA to obtain critical insights

Key Findings

- The study identified eight distinct clusters of students (i.e., learning profiles), each with a distinct pattern of anxiety, achievement, and interest in mathematics.
- The eight identified profiles demonstrated a variety of patterns and levels across the three indicators, suggesting a number of different within-person relationships between achievement, interest, and anxiety.
- Students who were in classrooms with teachers who had a more procedural (vs. conceptual) view of mathematics were more likely to be in the profiles with lower interest and higher anxiety.

Research Team

- **Early Career Fellow:** Michael Broda, Virginia Commonwealth University
- Eric Ekholm, Virginia Department of Education

Areas of expertise: psychology, education, mathematics learning, quantitative research methods

Sample

This study leverages data from the National Study of Learning Mindsets (NSLM), the largest- ever randomized controlled trial of a growth mindset program in the U.S. in K-12 settings, in which a brief online growth mindset program was administered to 9th grade students during the 2015-2016 academic year. The NSLM features a nationally representative probability sample of regular U.S. public high schools. Additional information about the NSLM sample of schools and students can be accessed here. This study includes all 16,630 students who completed a questionnaire in the fall of 9th grade as part of the growth mindset program.

MINDSET SCHOLARS NETWORK

The National Study of Learning Mindsets Early Career Fellowship is a project of the Mindset Scholars Network and the University of Texas at Austin Population Research Center. The Mindset Scholars Network is a group of leading social scientists dedicated to improving student outcomes and expanding educational opportunity by advancing our scientific understanding of students' mindsets about learning and school. The University of Texas at Austin Population Research Center aims to provide outstanding infrastructure resources and sustain a dynamic interdisciplinary culture geared toward facilitating the highest level of population-related research among its faculty members and graduate and undergraduate trainees.

TEXAS PRC POPULATION RESEARCH CENTER

This snapshot was published at the close of the National Study of Learning Mindsets Early Career Fellowship and captures in-progress work.

about how individuals' profiles are shaped by their context. For example, Van Eck et al., 2017 examined patterns in student perceptions of school climate, and found that a student's profile membership was significantly associated with the chronic absence rate at their school. In other words, students who perceived a more negative climate in their schools were also more likely to attend schools with higher chronic absence rates than students who reported more positive climate. The goal of the current project was to explore similar questions in the context of mathematics learning.

The main variables of interest were mathematics achievement, as measured by students' 8th grade mathematics GPA, and mathematics anxiety and mathematics interest, both self-reported by students in a survey. These three indicators were the basis for determining the optimal number of student clusters, as they represent distinct but interrelated components of students' cognitive and affective experiences in mathematics. Several teacher measures were also included to assess the extent to which they might influence cluster membership. These included teachers' own levels of mathematics anxiety and their beliefs about the nature of mathematics instruction, both self-reported by teachers in a survey.

Key Findings

The study identified eight clusters of students (i.e., learning profiles), each with a distinct pattern of anxiety, achievement, and interest in mathematics.

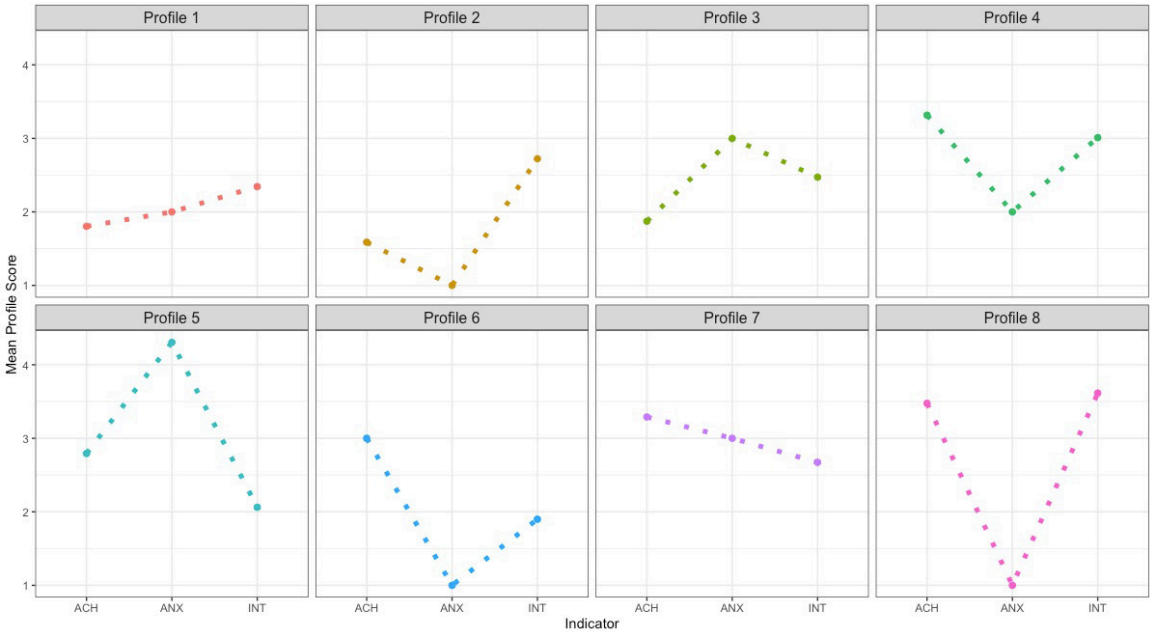
Eight distinct mathematics learning profiles were created based on students' 8th grade mathematics GPA and their survey responses, as seen in the figure below. The profiles revealed a complex set of interactions between each of the indicators, with several important trends. The clearest differentiator among profiles appeared to be anxiety. Students in profiles 2, 6, and 8 all were characterized as having very low anxiety (a mean of 1 on a 1-5 scale), but markedly different levels of achievement and interest in mathematics. Students in profiles 1 and 4 demonstrated medium-low anxiety (a mean of 2 on a 1-5 scale), with students in profile 4 having significantly higher levels of achievement and interest compared to students in profile 1. Students in profiles 3 and 7 demonstrated medium-high anxiety (a mean of 3 on a 1-5 scale), with students in profile 7 having significantly higher levels of achievement compared to students in profile 3. Finally, students in profile 5 demonstrated high anxiety (a mean of 4.70 on a 1-5 scale), medium-high achievement, and low interest.

The eight profiles vary in size from about 4% of the sample for profile 6 (about 700 students) to 24% of the sample for profile 4 (about 4,000 students). The profiles represent subgroups of students that are statistically distinct from one another in terms of their levels of mathematics anxiety, interest, and achievement.

Overall, the results align with previous research that has found positive relationships between mathematics achievement and interest, and negative relationships between mathematics anxiety and achievement/interest, with some notable differences. For example, students in profile 1 (1,200 students) and profile 7 (3,000 students) exhibited patterns that tend to differ from prior research. Profile 1 was characterized by lower achievement, medium-low anxiety, and medium-low interest, and Profile 7 was characterized by high achievement, medium-high anxiety, and medium-high interest.

Given that this is the first research to find that these three constructs form multidimensional profiles that are distinct from one another in a generalizable sample, it is possible that these profiles may have been previously unobserved due to sampling bias or sample size/variability. Table 1 below summarizes the profiles by level (e.g. low, medium, high) and sample size.

Mathematics Learning Profile by Achievement (ACH), Anxiety (ANX), and Interest (INT)



The eight identified profiles demonstrated a variety of patterns and levels across the three indicators, suggesting a number of different within-person relationships between achievement, interest, and anxiety.
MLPA allows for examination of patterns driven by both shape (the relative comparison between each indicator) and level (the sample mean for each indicator). The 8-profile solution found a number of both shape and level differences, suggesting a significant amount of within-person complexity in the relationship between these indicators.

Students who were in classrooms with teachers who had a more procedural (vs. conceptual) view of mathematics were more likely to be in the profiles with lower interest and higher anxiety.
Teachers appear to play a role in students' profile membership. When teachers had a more procedural view of mathematics (indicated by strong agreement to statements such as, "There is usually only one correct way to solve a math problem"), their students were more likely to be in the profiles with lower interest and higher anxiety than students of teachers who had a more conceptual view of mathematics (indicated by strong disagreement to statements like the one above). Teachers' mathematics anxiety was not found to be significantly associated with students' profile membership.

These profiles were also validated by several measures collected six months after the original data collection, including mathematics self-concept and challenge seeking behavior. Students in profiles with lower anxiety and higher interest and achievement also had higher levels of mathematics self-concept and chose more complex mathematics practice problems (and fewer simple problems) when provided the opportunity.

Table 1.
Summary of Mathematics Learning Profiles, by Level of Response

Profile No.	Ach.	Anxiety	Insight	% of Sample	% Female	% CSB	Math Sc Mean
1	Low	Med-Low	Med-Low	7%	35%	29%	4.62
2	Low	Low	Med-High	5%	78%	36%	6.43
3	Low	Med-High	Med-Low	9%	37%	39%	4.45
4	High	Med-Low	Med-High	24%	81%	30%	4.39
5	High	High	Low	19%	0%	57%	5.67
6	High	Low	Low	4%	100%	48%	5.39
7	High	Med-High	Med-High	19%	67%	23%	4.65
8	High	Low	High	12%	44%	60%	5.3

Notes. CSB = Challenge Seeking Behavior, Math SC = Mathematics Self-Concept. N = 16,609. Mathematics self-concept is a self-report measure on a 1-7 scale, with higher values indicating higher mathematics self-concept. Challenge seeking behavior here represents the percentage of students in a profile who chose more challenging mathematics practice items compared to less challenging ones

Insights and Future Directions

This study offers a number of unique insights that may be of future use to education practice and policy. First, this study is the first of its kind to provide evidence on a national, generalizable scale of unique cognitive and affective learning profiles among U.S. high school students. Leveraging the sampling design and scope of the NSLM data, this work is able to confirm other smaller-scale evidence that has suggested that distinct profiles may exist. Our results suggest that overall, most students are at least somewhat anxious about mathematics; we also find that interest seems to be much more highly variable across profiles. Thus, interest may be a construct that is more open to change than anxiety and perhaps could be a useful focus of further instructional intervention.

Second, this study adds to early large-scale evidence on the role of teachers' beliefs about mathematics in shaping their students' learning. Prior research has found that teachers' mathematics anxiety can, in some situations, be associated with their students' mathematics achievement).[4] This study did not find a significant relationship between teacher anxiety and profile membership, but it did find a relationship between teachers' views of mathematics as a discipline and their students' interest and anxiety in mathematics. This could be another possible pathway by which teachers' beliefs about their subject shape their students' cognitive and affective experiences in their classes.

References

[1] Honicke & Broadbent, 2015; Usher & Pajares, 2009; Wang et al., 2017
[2] Hart et al., 2016
[3] Henry & Muthén, 2010; Vermunt, 2003
[4] Beilock et al. 2010; Ramirez et al. 2018

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