Measuring student experiences in mathematics:

Insights from the experience sampling method on enjoyment, efficacy, and anxiety in the Excellent Math program

LEARN! Learning sciences

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1. Excellent Math, a **mastery approach** to elementary mathematics education
2. Measuring **Student Experiences** in Mathematics
3. Exploring the **Threshold for Mastery**: 75% or 100%?
4. Conditions for **Conceptual Change** in Teacher Professional Development
5. Assessing Educational **Effects** in Elementary Schools

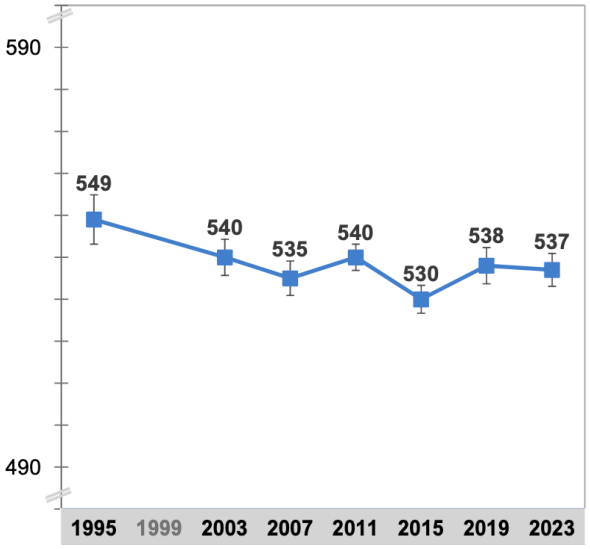
- Case study: Shedding some light on **shadow education**
- Higher ambitions in math education: **standards and trends**
- Insights from **first-year secondary students** on mastery learning
- **Monoculture** in math education at teacher training colleges
- Mastery learning as a **promising English approach** for better math education
- Math intervention as **an equalizer in VMBO**
- Effect of math intervention on teacher training students (**PABO students**)
- Relationship between math intervention and performance in **economics and STEM**
- **Stagnation of School Performance** in Mathematics in Dutch Elementary Education

Background (1): Declining math performance in elementary education

1. Stagnating and declining trends in international studies PISA and TIMSS (OECD, 2023; Von Davier et al., 2024)

Grade 4 Students (groep 6)

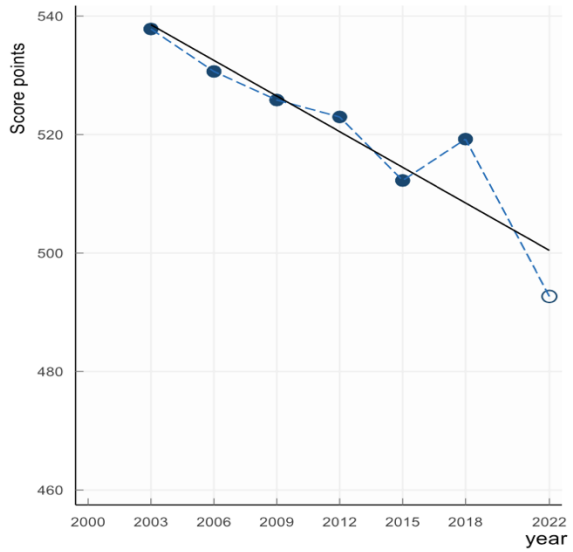
The high score from 1995 has not been achieved again



TIMSS: 2024

Grade 9 Students (3e klas)

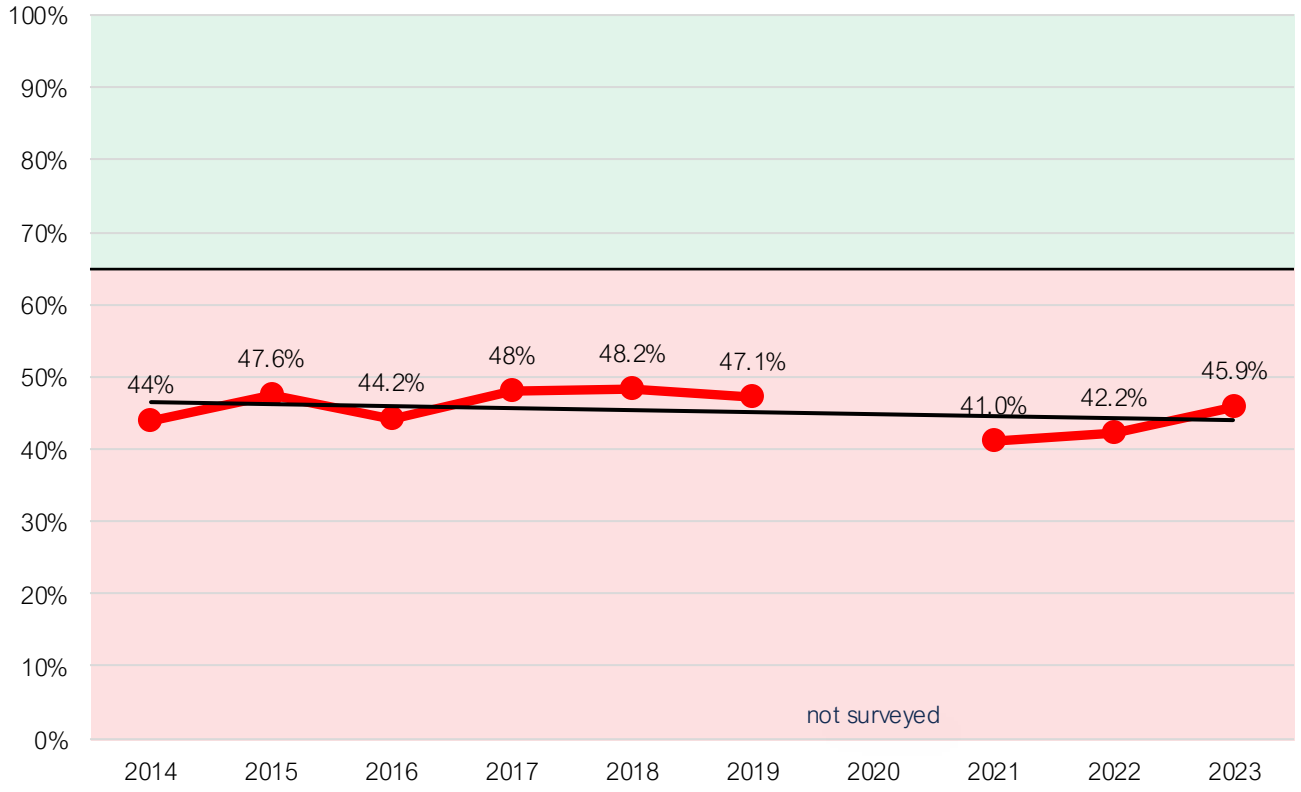
Declining trend remains steadily negative



PISA: OECD, 2023

Background (1): Declining math performance in elementary education

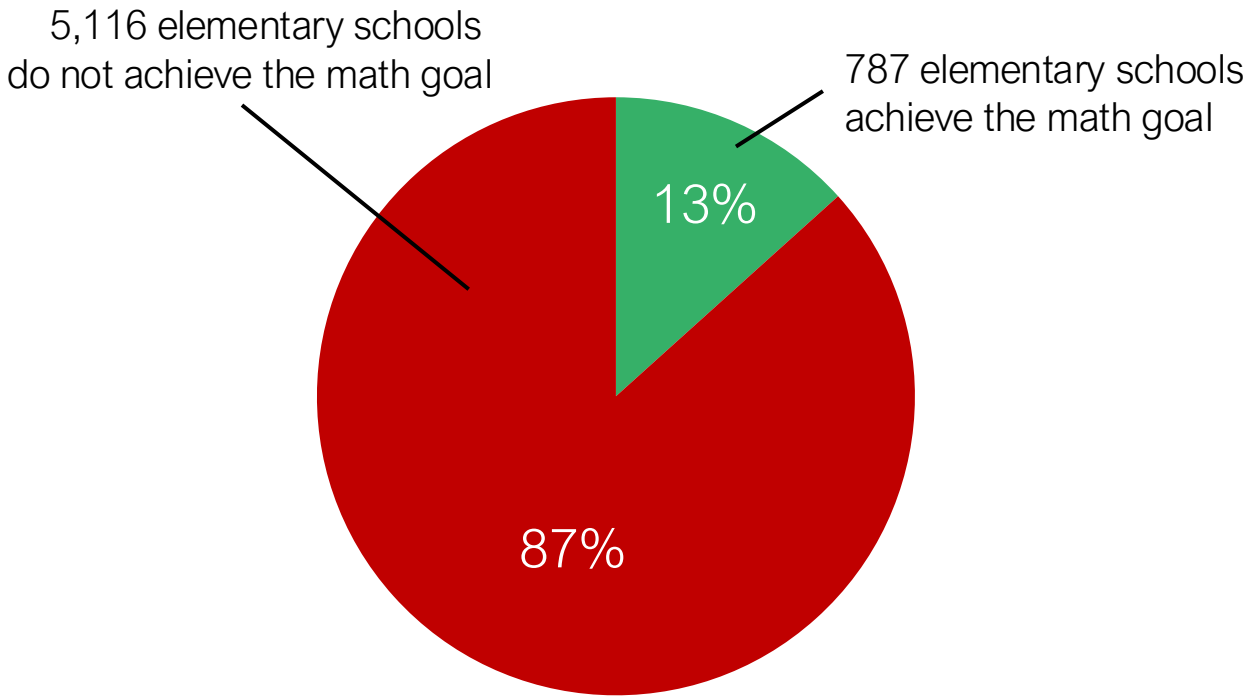
2. Persistent low proficiency in math provides insufficient preparation for secondary education (Inspectorate, 2024a, 2024b)

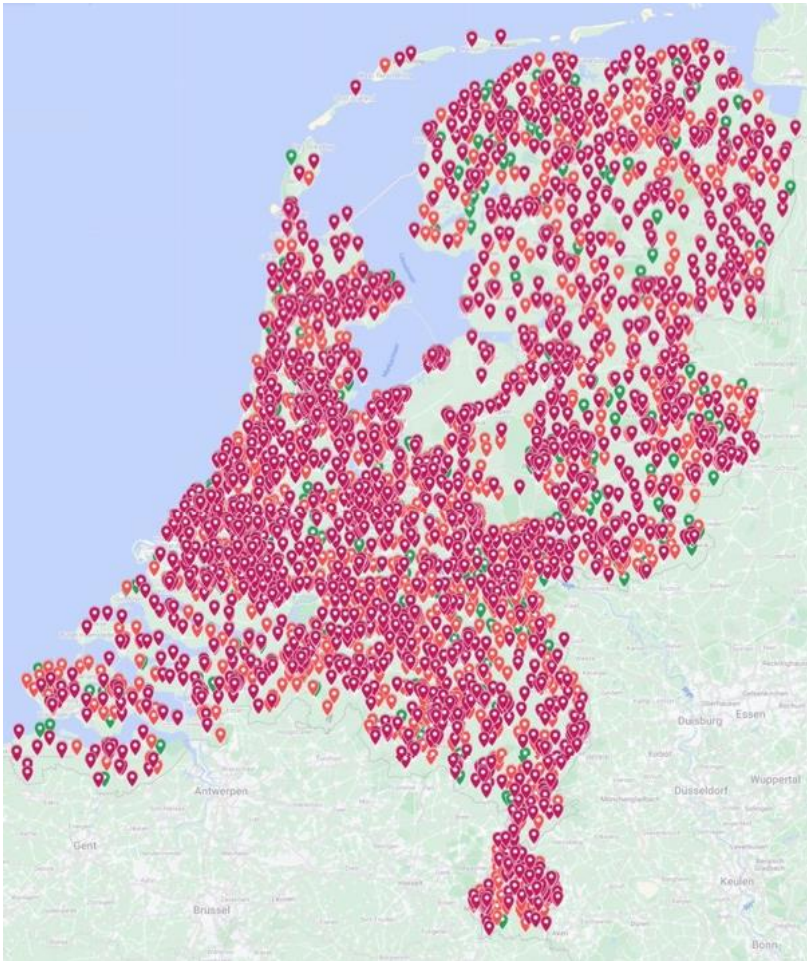


The national ambition (>65% of students at the 1S level) has never been achieved (Education Inspectorate, DUO education data)

Background (1): Declining math performance in elementary education

3. Elementary schools underperforming with school math trends stagnating (Langerak, 2025)





Background (1): Declining math performance in elementary education

1. **Stagnating and declining** trends in international studies PISA and TIMSS (OECD, 2023; Von Davier et al., 2024)

2. Persistent **low proficiency** in math provides insufficient preparation for secondary education (Inspectorate, 2024a, 2024b)

3. Elementary schools **underperforming** with school math trends stagnating (Langerak, 2025)

4. Concerns have been raised about the **type of pedagogy** in math education (e.g., Van de Craats, 2007; KNAW, 2009; Kirschner, 2022)

Background (2): Exploring an alternative approach to math education

Excellent Math ('Foutloos Rekenen')

Institution:	Netherlands Mathematical Institute (shadow education)
Type:	accelerated learning, 12 weeks
Students:	grades 4, 5, 6 (groep 6, 7, 8)
Group size:	6-8 students
Materials:	textbook, online LMS, paper, pencil, eraser
Content:	23 maths procedures (algorithms that always work)
Pedagogy:	mastery learning: sequenced curriculum, structured group instruction, frequent assessments, mastery through intensive practice

Previous study

Previous study has explored key features of the EM program and its impact on student performance (Langerak, Meeter, Cornelisz, under review)

Initial findings indicate:

- significant improvement in standardized math test scores
- positive parental feedback on children's emotional development and attitude towards math

However, the children themselves were not surveyed

Social-emotional aspects: academic emotions (Pekrun et al., 2002)

Students experience a range of 'academic emotions' influenced by the learning context, classroom instructions, and achievement (e.g., joy, hope, anger, boredom, anxiety).

- These emotions affect behavior and performance, while performance, in turn, shapes emotions.
- Reflects a reciprocal relationship between experience and outcome (Pekrun & Stephens, 2012).

Three constructs (Ashcraft & Rudig, 2012; Ashcraft, 2002).

1. **Math enjoyment**: positive emotion relating to either the task itself or performance
2. **Self-efficacy in math**: a person's own belief in their ability to succeed at math
3. **Math anxiety**: feeling of tension, apprehension or fear that interferes with math performance

Research questions

How does the EM program impact social-emotional constructs, as measured by **student** questionnaires before, during, and after the program?

How does the EM program impact social-emotional constructs, as measured by **parent** questionnaires before and after the program?

How do students **perform** in the EM program, as measured by the Pace-to-Mastery Index (PTM), a quantitative measure of learning pace based on time points of passed assessments?

Variables

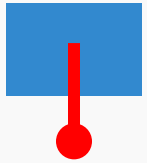
- General student characteristics (e.g., age, gender)

Additional variables:

- Household socio-economic status (SES-WOA) (low, medium, high)
- School-level SES (‘schoolweging’) (low, medium, high)
- School performance: based on the percentage of students achieving the ‘1S level’ in the past four years (low, average, good)

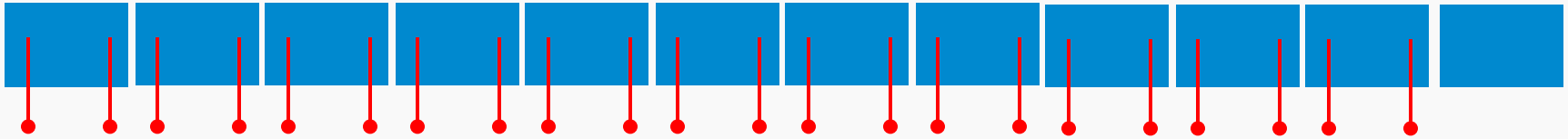
Measuring social-emotional constructs among students

PRE



online questionnaire

Experience sampling



during online homework on the second and last day of the week (first day is the instruction lesson)

subset of 6 statements (2 per construct)
+ 3 filler items total (22 time points)

POST

online questionnaire

29 statements measuring three constructs (Questionnaire: PEIL, 2021, 2024)

1. Math enjoyment: *"I like learning math."*
2. Self-efficacy in math: *"I think I am going to do well on the coming math test."*
3. Math anxiety: *"During math lessons, I am afraid to make mistakes."*

Response Format - 4-point Likert scale : "I strongly agree" to "I strongly disagree"

Experience Sampling Method (Myin-Germeys & Kuppens, 2022)

Real-time and real-world assessment, captures experiences as they occur in daily life, reducing recall bias (retrospective recall)

High ecological validity, data is collected in **natural settings**, reflecting authentic behavior and experiences

Structured self-reporting, participants answer pre-defined questions at scheduled moments, ensuring **systematic data collection**

Repeated measurements, multiple assessments track patterns and fluctuations in emotions, behaviors, and context over time

Preliminary results of subset of data

- Pre and post comparison of n=121 students who filled in questionnaires **before** and **after** the program

- Subset of n=608 students (raw data) who filled in questionnaires **during** the program
  > The two statements per construct averaged per student
  > All students averaged per time point

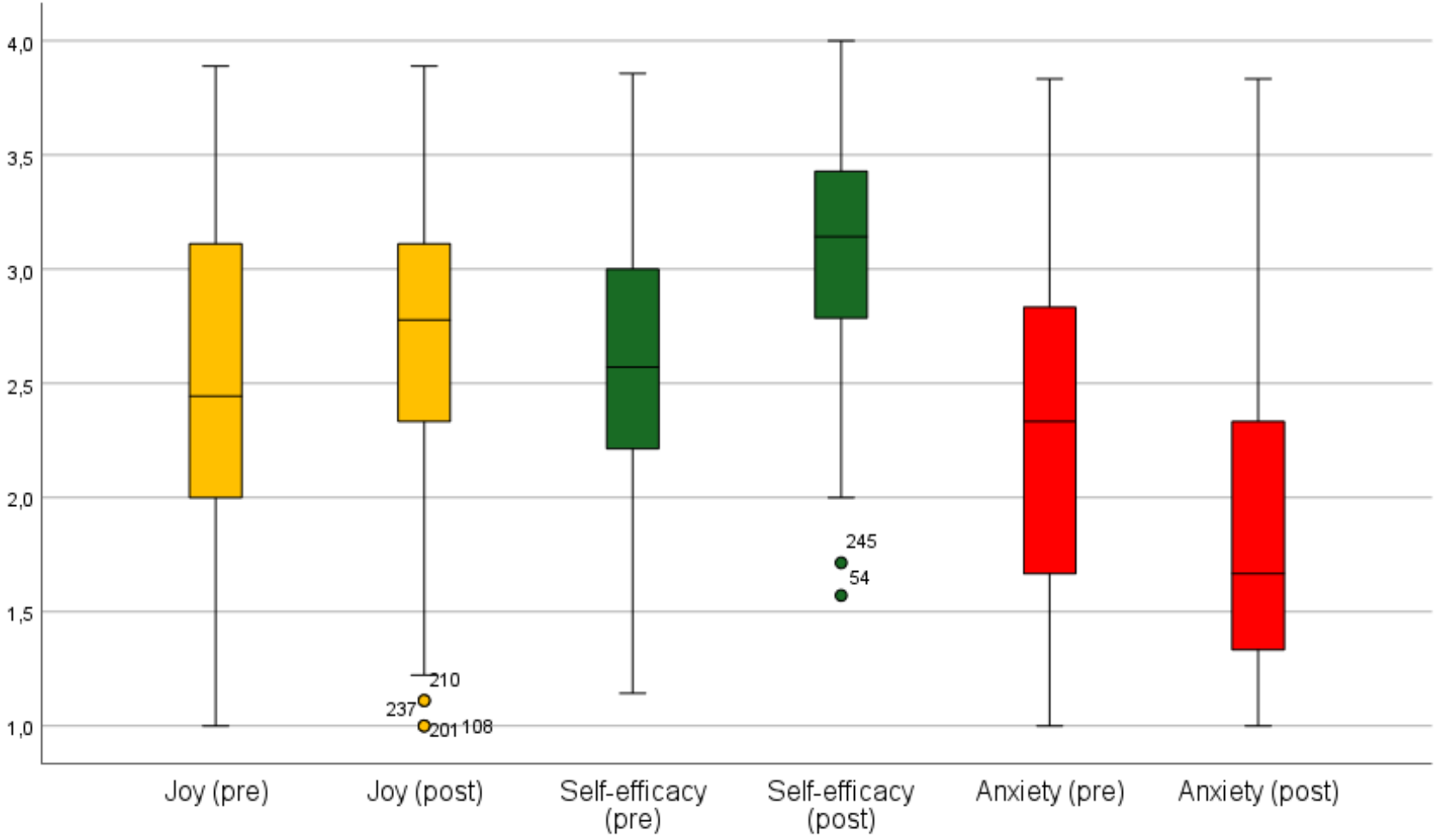
Preliminary Pre and Post

Significant improvements across constructs

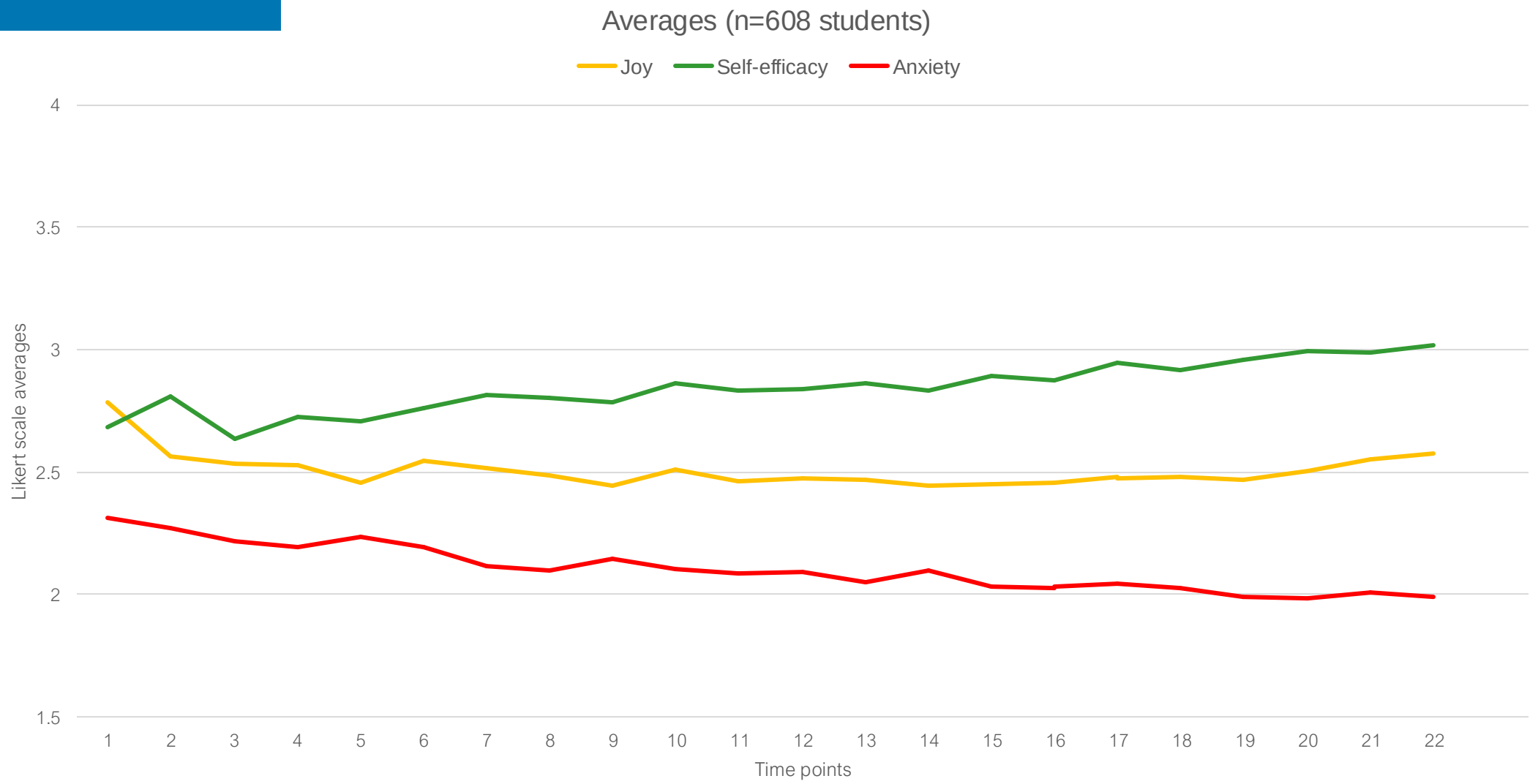
Math enjoyment: t(120) = -2.61, p = .010 Cohen's d = 0.237, small

Self-efficacy: t(120) = -10.02, p<.001 Cohen's d = 0.911, large

Math Anxiety: t(120) = 6.47, p<.001 Cohen's d = 0.588, medium



During the program



Discussion

In ESM research with repeated measures per participant, **data is nested** within individuals.
A t-test does not account for this dependency and ignores within-subject correlations.
Consider using multilevel modeling, consider adding control variables.

- multilevel modeling - account for within-subject dependencies by adding random intercepts and slopes so that individual differences in baseline levels and response patterns over time are properly modeled

- repeated measures ANOVA - considers within-subject variation to account for dependencies in repeated measurements

- control variables - include covariates (e.g., age, gender, household-SES, school-level SES) to control for confounding effects, ensuring that observed relationships reflect true effects rather than external influences

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Vrije Universiteit Amsterdam partners with the Netherlands Mathematical Institute in this project

Nederlands Mathematisch Instituut

VU VRIJE UNIVERSITEIT AMSTERDAM

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External PhD-candidate

Educational Sciences

Nederlands Mathematisch Instituut

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Comparison with national PEIL-data (2019 & 2023)

Comparison with national PEIL-data on mathematics scores show mixed results

Math enjoyment scores are no different from national averages in 2019 or 2023
(2023: $t(120) = 0.872$, $p = .385$)

Self-efficacy scores are higher than the national average in 2019 and 2023
(2023: $t(120) = 4.28$, $p < .001$, Cohen's d = 0.389, medium)

Anxiety scores have reduced but still higher than the national averages in 2019
($t(120) = 2.10$, $p = .037$, Cohen's d = 0.191, small)

However PEIL-data is based on year 6 (groep 8); this study investigated years 4-5-6 (groep 6, 7, 8)
PEIL-data for anxiety scores only available for 2019

Discussion: Is this comparison with national data valid?