Western Norway
University of
Applied Sciences

Self-Efficacy in Mathematics Education:

Using questionnaires to investigate students' self-efficacy for tasks of different levels of perceived difficulty

Karin Street
Hafslo
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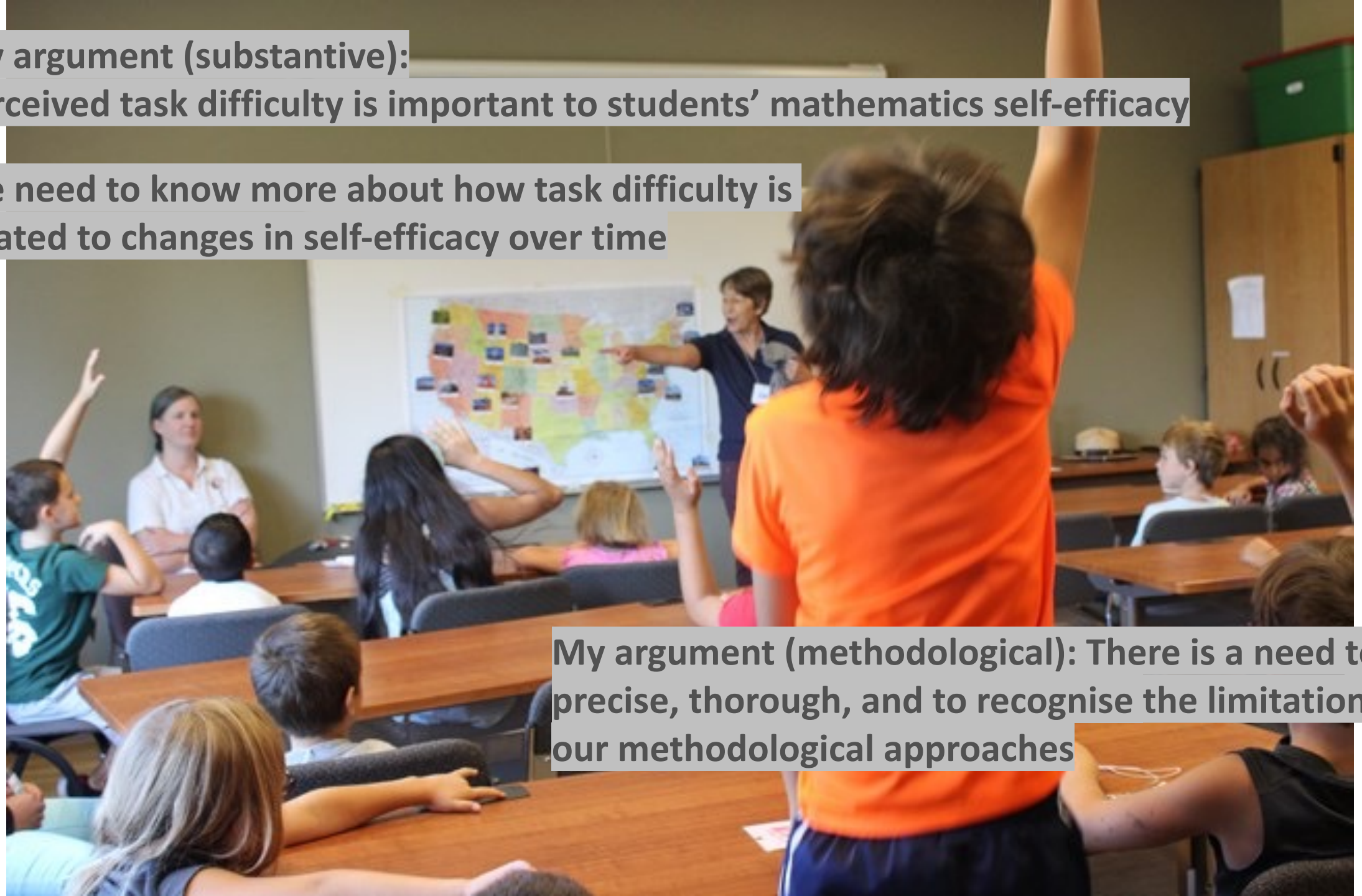
Overview

- Quick introduction to self-efficacy – *what* and *why*
- The meaning of self-efficacy – how I have approached and operationalised self-efficacy in my research
- Applying my approach to measuring self-efficacy for substantive purposes – Investigating students' self-efficacy for different levels of difficulty
    - *Please ask clarifying questions as we go, and make a note of other questions for the discussion at the end*



My argument (substantive):
Perceived task difficulty is important to students' mathematics self-efficacy

We need to know more about how task difficulty is related to changes in self-efficacy over time

My argument (methodological): There is a need to be precise, thorough, and to recognise the limitations of our methodological approaches

What is self-efficacy?

- Self-efficacy: *beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments* (Bandura, 1997, p. 3).
- Differs from, e.g., self-concept, self-esteem, and self-worth: Self-efficacy appraisal is (relatively) *specific* and connected to *mastery* of *prospective* (future) tasks
- In my work I have focused on students'
  - *self-efficacy for mathematics test performance*
  - and
  - *self-efficacy for learning mathematics*

Why is self-efficacy important?

- Self-efficacy is related to study and career choices, experiences of anxiety or motivation / engagement, and adaptive learning behaviours such as effort, goal-setting and self-regulation (e.g., Klassen, 2010)
- Self-efficacy is related to performance (e.g., Talsma et al., 2018)

- *An expanded view of learning and agency*.

> "[t]here is a marked difference between possessing knowledge and skills and being able to use them well under diverse circumstances, many of which contain ambiguous, unpredictable, and stressful elements" (Bandura, 2012, p. 24).

- The need to consider the «whole» learner – not just their knowledge

Self-efficacy questionnaires - variations in practice:

- From general*, via domain, to specific task self-efficacy
- Some problematic practice, e.g., inconsistent operationalisation:
  - «Mathematics is an easy subject» (low face validity)
  - «Were you succeeding at what you were doing?» (retrospective)
- Some simply different, e.g.:
  - “How confident are you that you could solve a math question like this one in the future?” (single item – needs to be unambiguous)
  - Differences in scales: Unipolar / bipolar (Likert), different anchors
  - *Perceived* versus *objective* level of difficulty (e.g., what % of students answered the task correctly)

* uniform scale for general self-efficacy is not recommended (e.g., Bandura, 2012; Pajares & Miller, 1995)

Research gap: Self-efficacy and *level of (perceived) difficulty*

- Self-efficacy is conceptualised as a *multidimensional construct* *(Bandura, 1997)*:
  - Degree of s*pecificity/generality* (e.g., general?, academic, domain, task-specific)
  - *Strength* of self-efficacy (e.g., scale from 0-10)
  - *Level of difficulty* (e.g., self-efficacy for easy or hard tasks)
- Measurement approach recommended by Bandura (1997):

Sample Items From the Memory Self-Efficacy Questionnaire (MSEQ)

(Berry et al., 1989)

Grocery

If I heard it twice, I could remember 12 items from a friend's grocery list of 12 items, without taking any list with me to the store.

No Yes 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

If I heard it twice, I could remember 10 items from a friend's grocery list of 12 items, without taking any list with me to the store.

No Yes 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

If I heard it twice, I could remember 8 items from a friend's grocery list of 12 items, without taking any list with me to the store.

No Yes 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

If I heard it twice, I could remember 5 items from a friend's grocery list of 12 items, without taking any list with me to the store.

No Yes 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

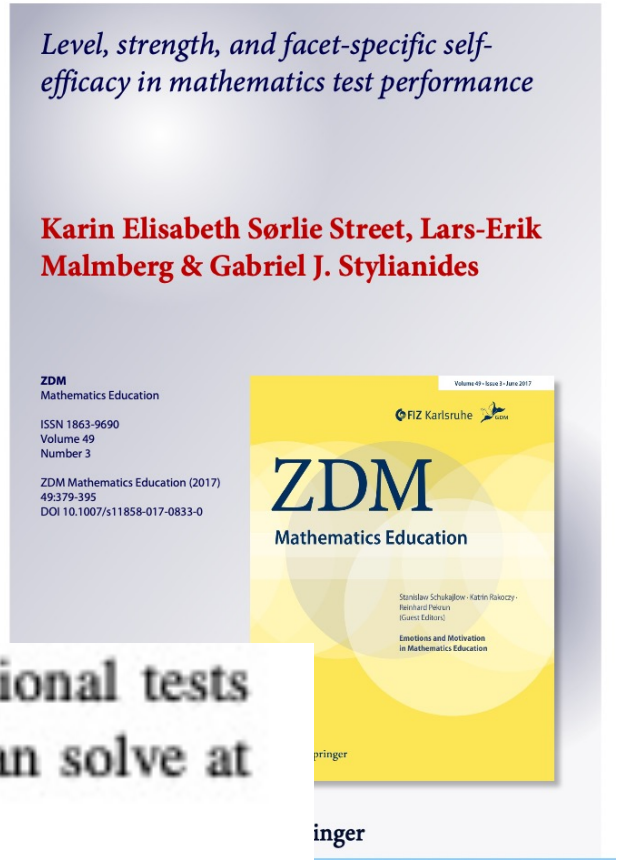
If I heard it twice, I could remember 2 items from a friend's grocery list of 12 items, without taking any list with me to the store.

No Yes 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Self-efficacy for mathematics test performance, ***study 1***

Street et al., 2017

- We developed the *Self-Efficacy Gradations of Difficulty Questionnaire* (SEGD).
- Four facets of test-taking (*specificity*), each with varying *levels of difficulty, on a 0-10 scale (strength)*



- Example item:

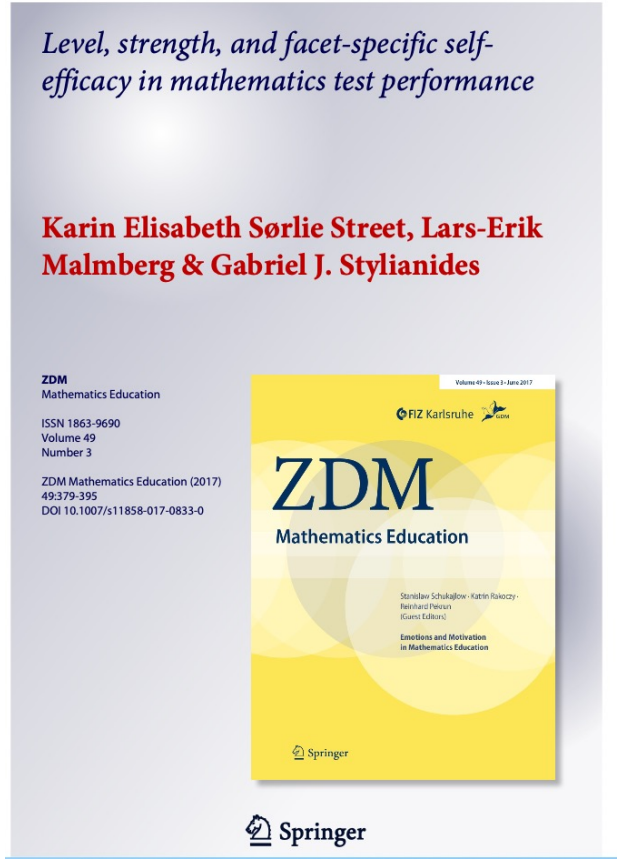
There are more than 50 problems on the national tests in mathematics. How certain are you that you can solve at least a certain number of them?

During the national tests this year I can solve:

1: at least 5 of the problems
2: at least 10 of the problems
3: at least 25 of the problems
4: at least 40 of the problems
5: all the problems

Self-efficacy for mathematics test performance, ***study 1***

- *RQ1: What is the structural validity of the proposed self-efficacy constructs, which include facets and levels of self-efficacy expectations?*
- *RQ2: How are facet-specific and level-specific self-efficacy expectations associated with performance on national tests in mathematics?*



› Participants were Norwegian grade 5, 8 and 9 students (N=756), who filled out questionnaires prior to a national test

Validity – do we measure what we want to measure?

Face validity (interpretability, operationalisation according to theoretical stance?)

During the national test this year I can solve at least < x > of the problems

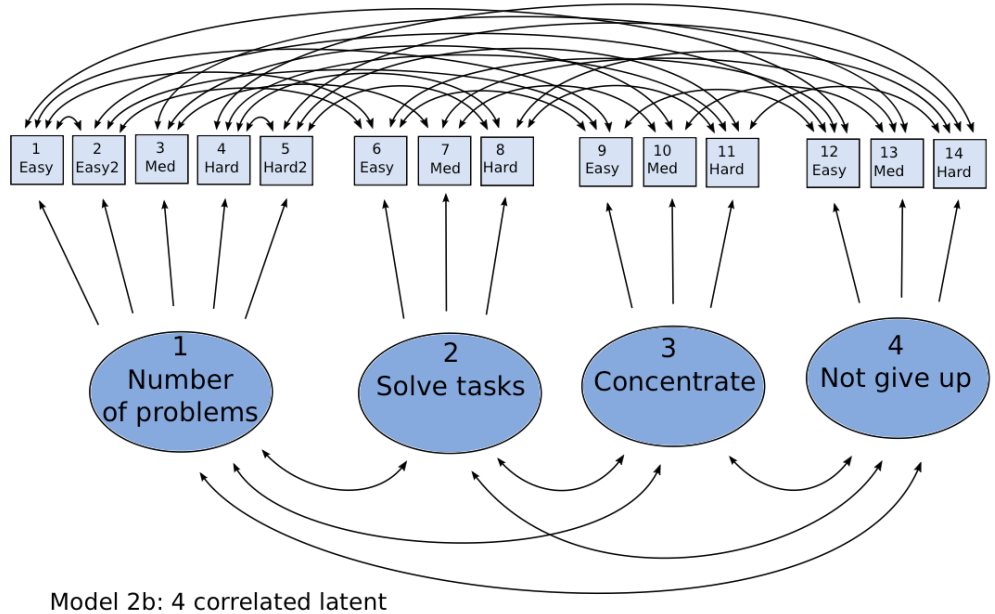
vs, e.g.,

I am better at mathematics than my classmates

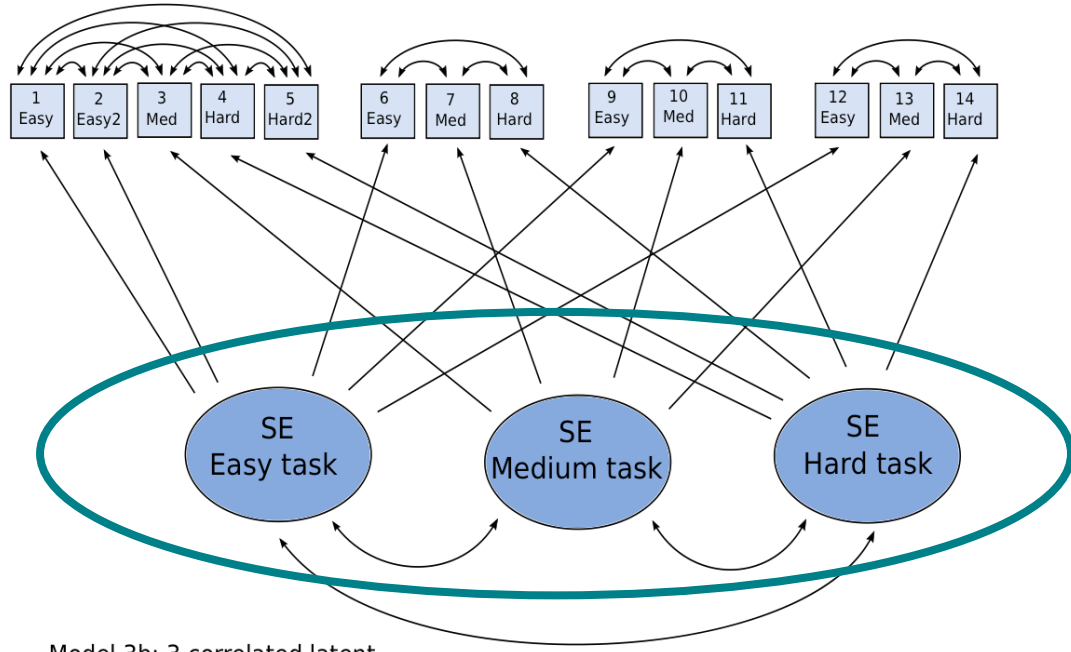
Validity – do we measure what we want to measure?

Face validity (interpretability, operationalisation according to theoretical stance?)

Structural validity (does the theoretically proposed factor structure fit the data?)



Model 2b: 4 correlated latent facets w/ CUs* for 3 levels



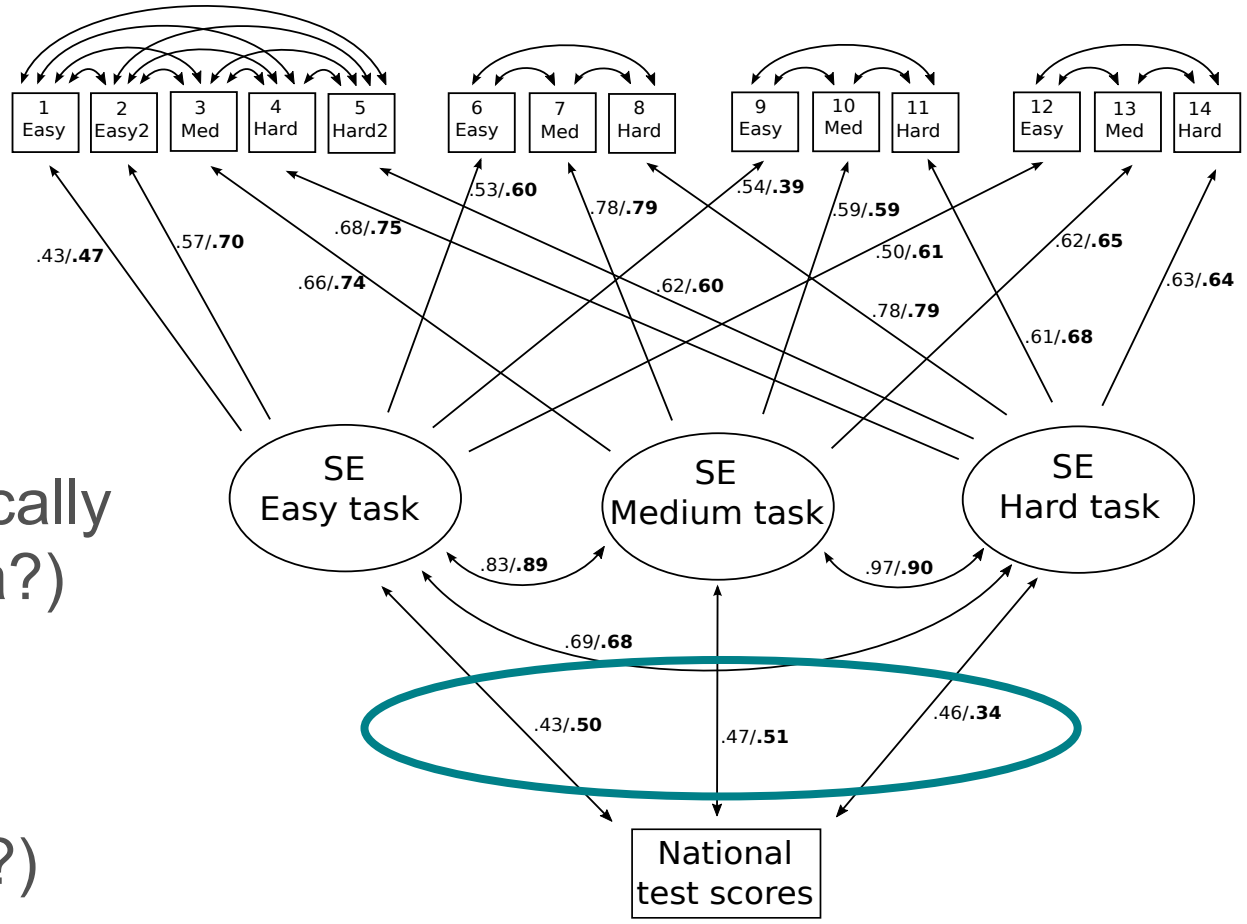
Model 3b: 3 correlated latent levels w/ CUs* for 4 facets

Validity – do we measure what we want to measure?

Face validity (interpretability, operationalisation according to theoretical stance?)

Structural validity (does the theoretically proposed factor structure fit the data?)

Convergent validity (do we find theoretically predicted relationships?)



Note: Estimates before "/" are Grade 5 results, after "/", in **bold**, are grade 8/9 results. All estimates are standardized (STYX) estimates from Mplus (Muthén & Muthén 2012). Estimates for CUs are not given due to space limitations.

*Self-efficacy for mathematics test performance – **study 2***

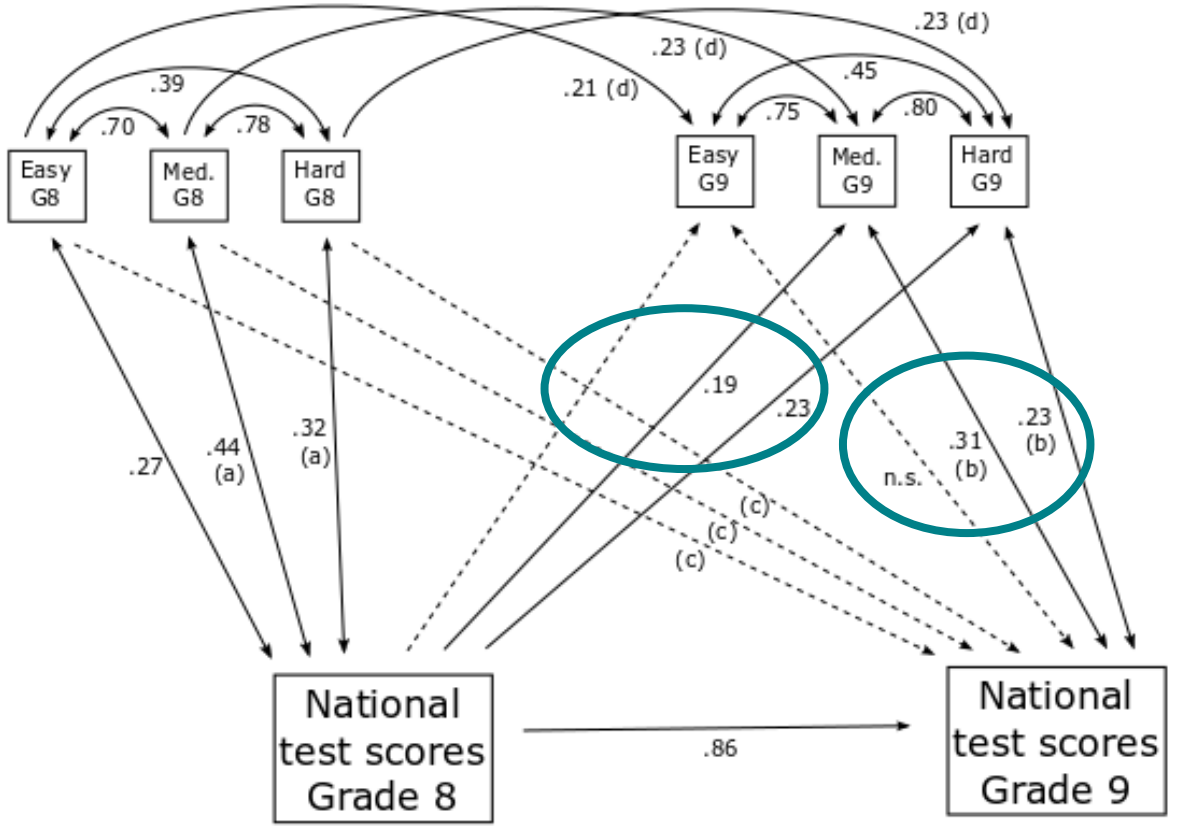
(Street et al., in review)

Followed students (N=95) across one year

Overall research question: What is the reciprocal relationship between students' mathematics self-efficacy and national test performance in grade 8 and grade 9?

Key findings: Differential relationships according to levels of difficulty

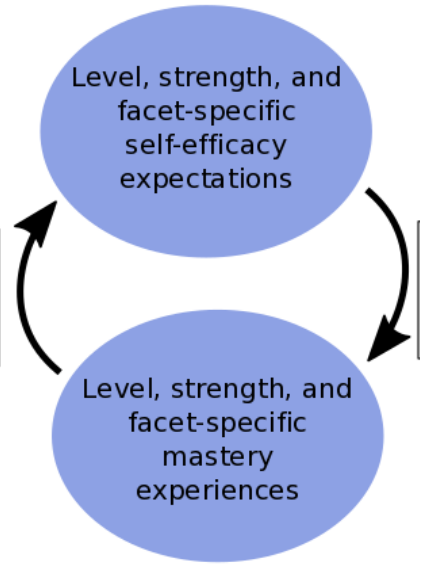
Stronger relationships between self-efficacy for medium difficulty /hard tasks and performance, as compared with self-efficacy for easy tasks and performance



Note: "Easy", "Med.", and "Hard" refer to self-efficacy for easy, medium difficulty and hard tasks. "G8" and "G9" refer to Grade 8 and Grade 9.
All estimates are standardized (STYX) estimates from Mplus (Muthén & Muthén 2012).
Paths are significant at the $p<.05$ level. Dotted paths are nonsignificant.
(a), (b), (c), and (d) indicate equality constraints..

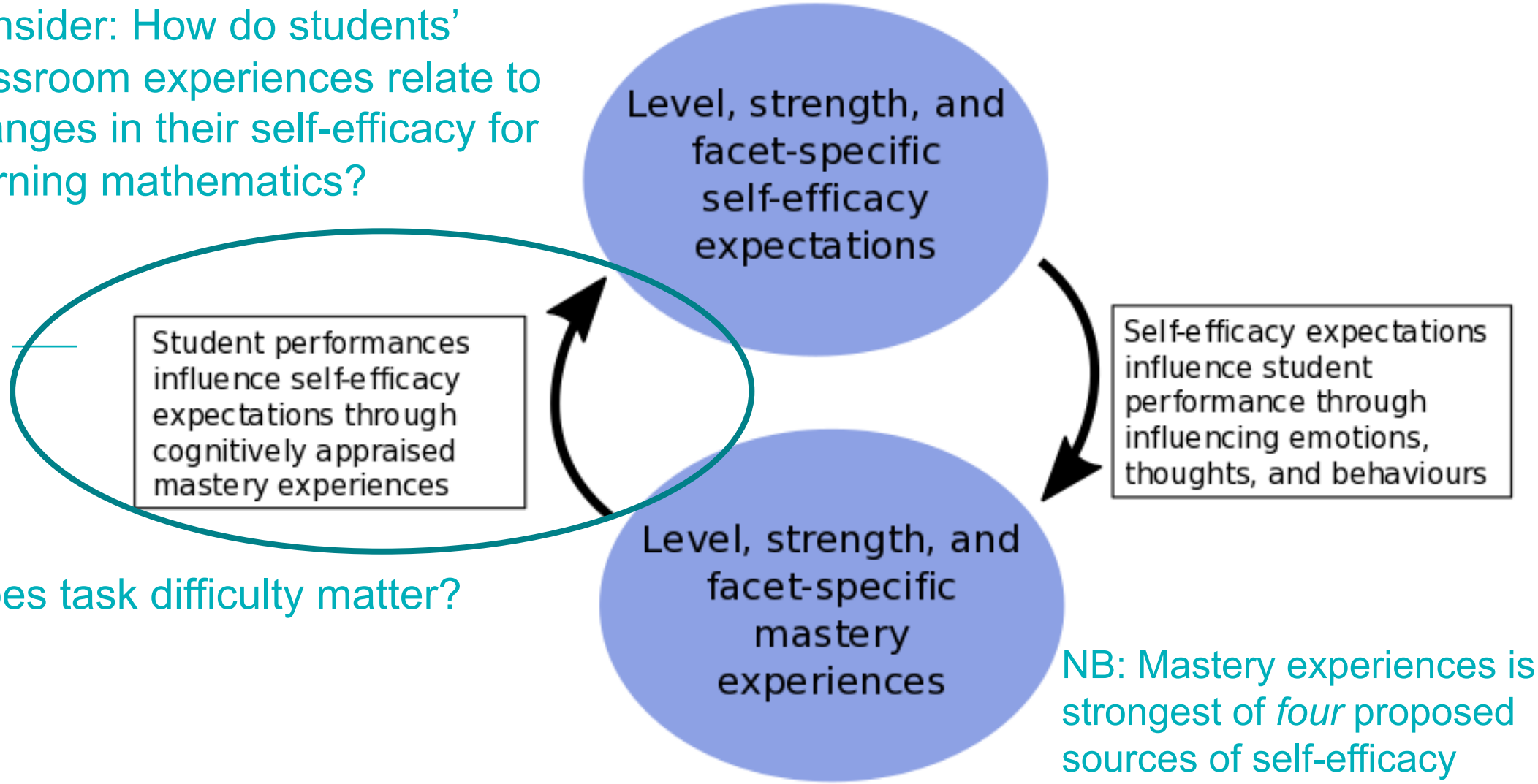
Summary of *self-efficacy for mathematics test performance*

- It was meaningful to include levels of difficulty when measuring students' self-efficacy for mathematics test performance
- Differential relationships between students' mathematics self-efficacy and test performance according to levels of (perceived) task difficulty
- *What role does level of difficulty play for changes to students' self-efficacy over time (process of self-efficacy change)?*



Theoretical model for process of self-efficacy change:

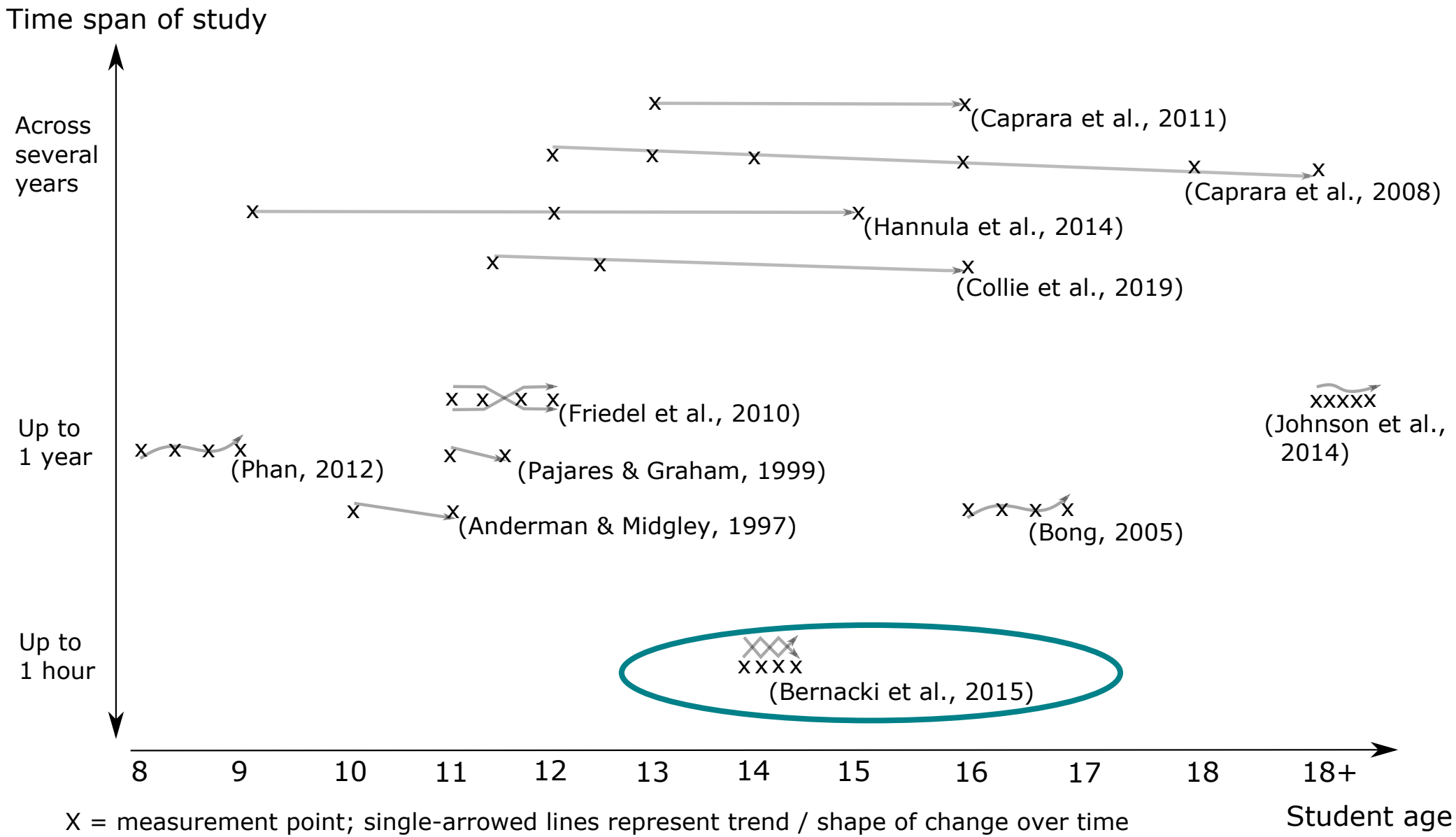
Consider: How do students' classroom experiences relate to changes in their self-efficacy for learning mathematics?



Does task difficulty matter?

NB: Mastery experiences is the strongest of *four* proposed sources of self-efficacy

Research gap: Lack of investigations including *process* data



*Self-efficacy for learning mathematics– **study 3***

(Street et al., in preparation)

We followed grade 6 & 10 students (N=181) as they were introduced to a new topic

What is the stability and change of students' mathematics self-efficacy across a sequence of classroom lessons?

Adapted the SEGD;

Example item:

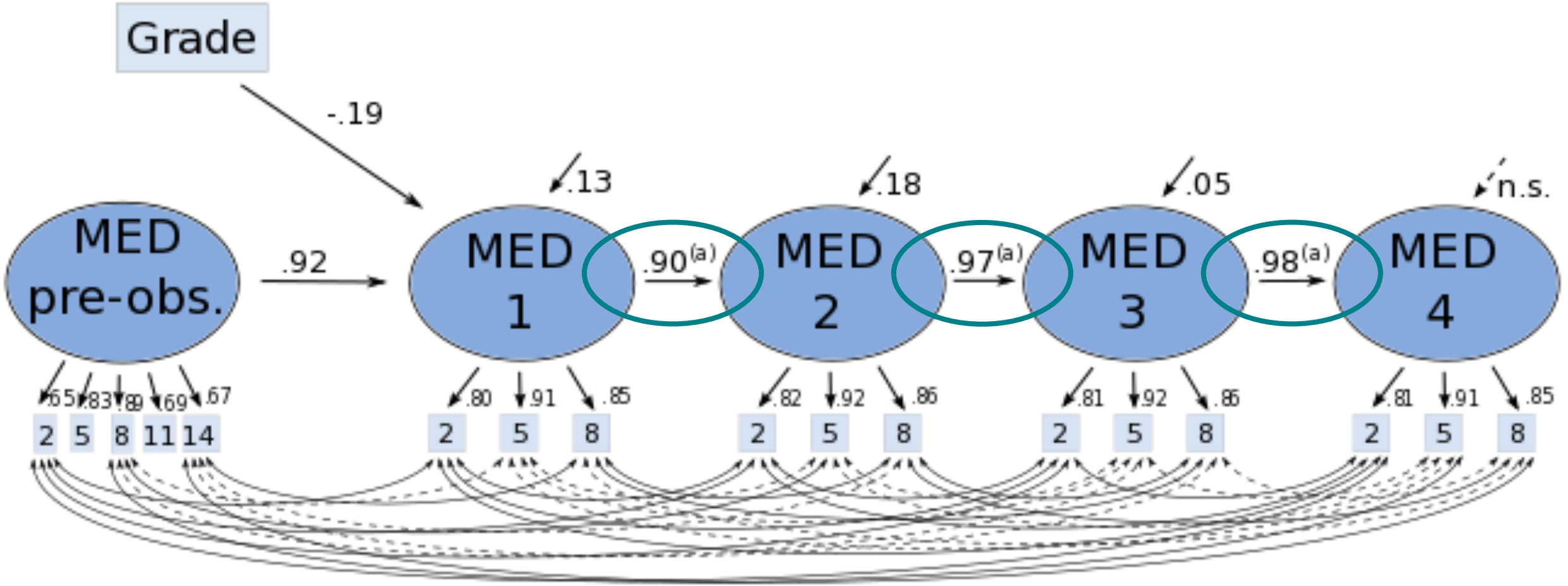
For each of these questions, think about the lesson on <algebra> which is just about to start.

1: In the next lesson in mathematics you will learn about <algebra>. How certain are you that you can learn <algebra> with a certain amount of help from the teacher?

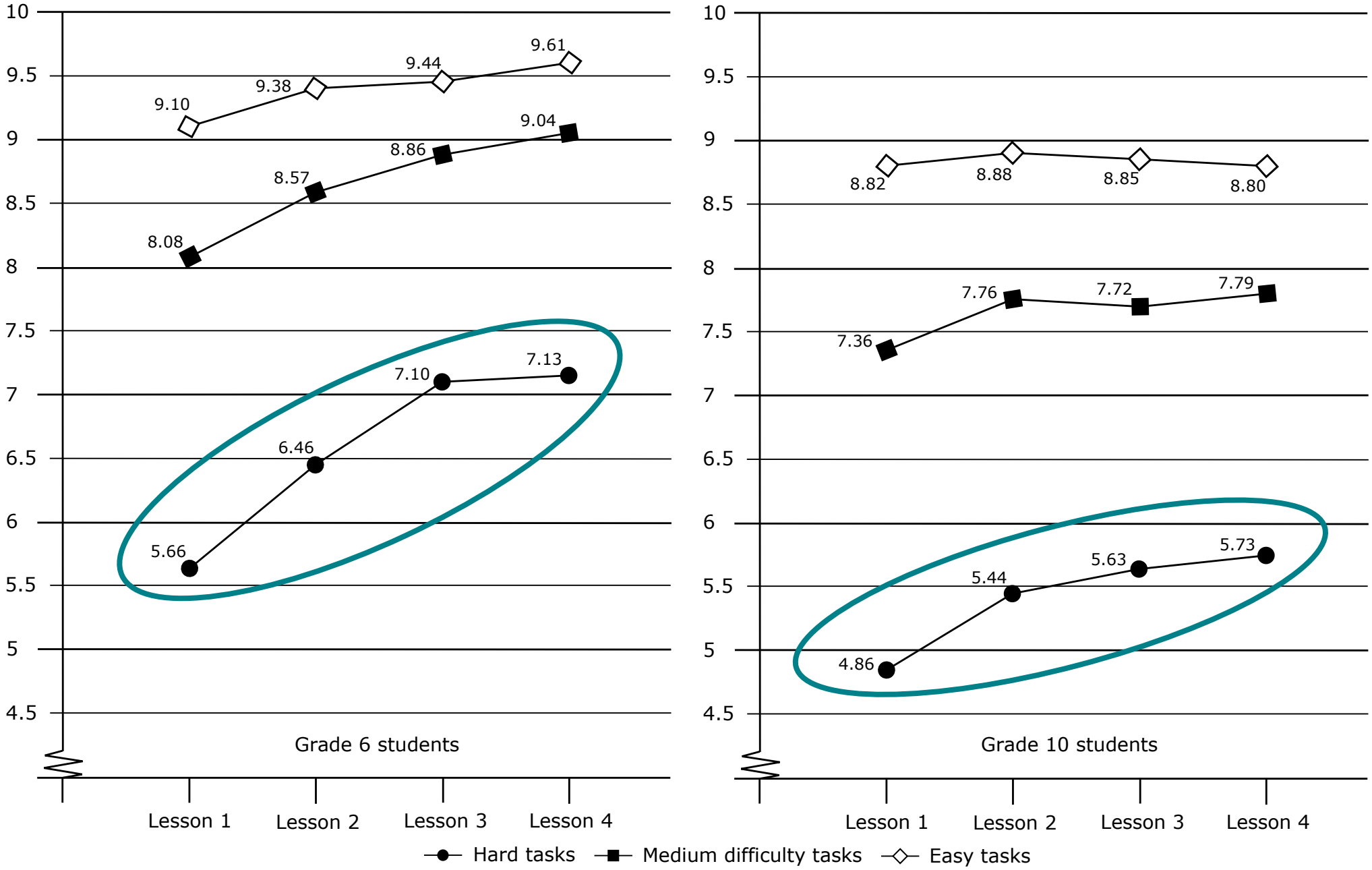
In the next lesson in maths I can learn <algebra>:

	0 Not at all certain	1	2	3	4	5 Moderately certain	6	7	8	9	10 Completely certain
if I get a lot of help from the teacher											
if I get some help from the teacher											
without any help from the teacher at all											

Key finding 1: *Rank order* of students' self-efficacy highly stable:



Key finding 2: Steeper changes in association with *harder tasks* and *younger students*



Summary of *self-efficacy for learning mathematics*

- Rank order of students' self-efficacy *highly stable*
  - Students' self-perceptions as learners and doers of mathematics
  - What about maladaptive belief cycles?
- Steepness of growth curves (mean change) differed according to perceived task difficulty
- *Task difficulty as an opportunity to create memorable / influential mastery experiences?* (e.g., Bobis et al., 2021; Warshauer, 2015)
  - The difference between *learning* in the sense of schema building /automation (might require repetition of procedure, not-too-difficult tasks etc)
  - Process of self-efficacy change (might require disruption and disequilibrium to create influential event)
  - The importance of students' cognitive appraisals (filters through which they understand classroom experiences)

A note on affordances and limitations

- *Measurement* is not meaningful unless there is a standard / point of comparison: E.g., differences between individuals/groups, changes over time...
- *Measurement invariance is* a pre-requisite to make comparisons (to not compare apples and pears), however...
- Simple *face validity* should not be overlooked amidst the more advanced statistical procedures (we might be comparing apples and avocados)
- Mixed-methods research – e.g., classroom observations and interviews – to complement and challenge findings, direct analyses

Future directions

- What characterises the main developmental trajectories (profiles) of student self-efficacy growth?
- What are the individual and classroom factors associated with students' developmental trajectories?
- Develop and test new instruments for classroom observations, e.g.,
  - Nature of Task (Street et al., in preparation)
  - a novel, dyadic, instrument for instructional and emotional support
- What is the relationship between classroom interactions (dyadic and whole-class) and students' mathematics self-efficacy changes?

Thank you!

References:

- Anderman, E. M., & Midgley, C. (1997). Changes in achievement goal orientations, perceived academic competence, and grades across the transition to middle-level schools. *Contemporary Educational Psychology*, *22*(3), 269–298. https://doi.org/10.1006/ceps.1996.0926
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman and Co.
- Bandura, A. (2012). On the Functional Properties of Perceived Self-Efficacy Revisited. *Journal of Management*, *38*(1), 9–44. https://doi.org/10.1177/0149206311410606
- Bernacki, M. L., Nokes-Malach, T. J., & Aleven, V. (2015). Examining self-efficacy during learning: variability and relations to behavior, performance, and learning. *Metacognition and Learning*, *10*(1). https://doi.org/10.1007/s11409-014-9127-x
- Berry, J. M., West, R. L., & Dennehey, D. M. (1989). Reliability and validity of the Memory Self-Efficacy Questionnaire. *Developmental Psychology*, *25*(5), 701–713. https://doi.org/10.1037/0012-1649.25.5.701
- Bobis, J., Russo, J., Downton, A., Feng, M., Livy, S., McCormick, M., & Sullivan, P. (2021). Instructional moves that increase chances of engaging all students in learning mathematics. *Mathematics*, *9*(6), 1–19. https://doi.org/10.3390/MATH9060582
- Bong, M. (2005). Within-grade changes in Korean girls' motivation and perceptions of the learning environment across domains and achievement levels. *Journal of Educational Psychology*, *97*(4), 656–672. https://doi.org/10.1037/0022-0663.97.4.656
- Caprara, G. V., Fida, R., Vecchione, M., Del Bove, G., Vecchio, G. M., Barbaranelli, C., & Bandura, A. (2008). Longitudinal analysis of the role of perceived self-efficacy for self-regulated learning in academic continuance and achievement. *Journal of Educational Psychology*, *100*(3), 525–534. http://search.proquest.com/docview/614483692?accountid=38978
- Caprara, G. V., Vecchione, M., Alessandri, G., Gerbino, M., & Barbaranelli, C. (2011). The contribution of personality traits and self-efficacy beliefs to academic achievement: A longitudinal study. *British Journal of Educational Psychology*, *81*(1), 78–96. https://doi.org/10.1348/2044-8279.002004

References:

- Collie, R. J., Martin, A. J., Bobis, J., Way, J., & Anderson, J. (2019). How students switch on and switch off in mathematics: exploring patterns and predictors of (dis)engagement across middle school and high school. *Educational Psychology*, *39*(4), 489–509. https://doi.org/10.1080/01443410.2018.1537480
- Friedel, J. M., Cortina, K. S., Turner, J. C., & Midgley, C. (2010). Changes in efficacy beliefs in mathematics across the transition to middle school: Examining the effects of perceived teacher and parent goal emphases. *Journal of Educational Psychology*, *102*(1), 102–114. http://search.proquest.com/docview/614511223?accountid=38978
- Hannula, M. S., Bofah, E. A., Tuohilampi, L., & Metsämuuronen, J. (2014). A longitudinal analysis of the relationship between mathematics-related affect and achievement in Finland. *Proceedings of the Joint Meeting of PME 38 and PME-NA 36*, *38*, 249–256.
- Johnson, M. L., Edwards, O. V, & Dai, T. (2014). Growth Trajectories of Task Value and Self-efficacy Across an Academic Semester. *Universal Journal of Educational Research*, *2*(1), 10–18. https://doi.org/10.13189/ujer.2014.020102
- Klassen, R. M., & Usher, E. L. (2010). Self-efficacy in educational settings: Recent research and emerging directions. In T. C. Urdan & S. A. Karabenick (Eds.), *Advances in Motivation and Achievement* (Vol. 16, pp. 1–33). Emerald Group Publishing. https://doi.org/10.1108/S0749-7423(2010)000016A004
- Pajares, F., & Graham, L. (1999). Self-Efficacy, Motivation Constructs, and Mathematics Performance of Entering Middle School Students. *Contemporary Educational Psychology*, *24*(2), 124–139. https://doi.org/10.1006/ceps.1998.0991
- Pajares, F., & Miller, M. D. (1995). Mathematics self-efficacy and mathematics performances: The need for specificity of assessment. *Journal of Counseling Psychology*, *42*(2), 190–198.
- Phan, H. P. (2012). The Development of English and Mathematics Self-Efficacy: A Latent Growth Curve Analysis. *The Journal of Educational Research*, *105*(3), 196–209. https://doi.org/10.1080/00220671.2011.552132

References:

- Street, K. E. S., Malmberg, L.-E., & Stylianides, G. J. (2017). Level, strength, and facet-specific self-efficacy in mathematics test performance. *ZDM - Mathematics Education*, *49*(3), 379–395. https://doi.org/10.1007/s11858-017-0833-0
- Street, K. E. S., Stylianides, G. J., & Malmberg, L.-E. (n.d.). Reciprocal relaitonships between mathematics self-efficacy and national test performance. *Manuscript Submitted for Publication*.
- Talsma, K., Schüz, B., Schwarzer, R., & Norris, K. (2018). I believe, therefore I achieve (and vice versa): A meta-analytic cross-lagged panel analysis of self-efficacy and academic performance. *Learning and Individual Differences*, *61*(January), 136–150. https://doi.org/10.1016/j.lindif.2017.11.015
- Warshauer, H. K. (2015). Productive struggle in middle school mathematics classrooms. *Journal of Mathematics Teacher Education*, *18*(4), 375–400. https://doi.org/10.1007/s10857-014-9286-3