

# Preparation for Future Learning in Physics: The Importance of Overlap in Prior Knowledge

**Other Conference Item****Author(s):**

[Thurn, Christian Maximilian](#) ; [Edelsbrunner, Peter](#) ; Schumacher, Ralph; Stern, Elsbeth

**Publication date:**

2023-08-23

**Permanent link:**

<https://doi.org/10.3929/ethz-b-000649170>

**Rights / license:**

[Creative Commons Attribution 4.0 International](#)

# Preparation for Future Learning in Physics: The Importance of Overlap in Prior Knowledge

**Christian M. Thurn; Peter A. Edelsbrunner;  
Ralph Schumacher; Elsbeth Stern**

**Link to slides: [t.ly/9eaRh](https://t.ly/9eaRh)**



**To which extent is prior  
knowledge in physics  
beneficial for future  
learning?**

# Prior knowledge and preparation for future learning

- Prior knowledge about the specific learning content is the single best predictor of knowledge and achievement
- Prior knowledge can be transferred most likely if it is similar to
  - the new knowledge
  - the physical, temporal, functional and social contexts
  - the modality of testing

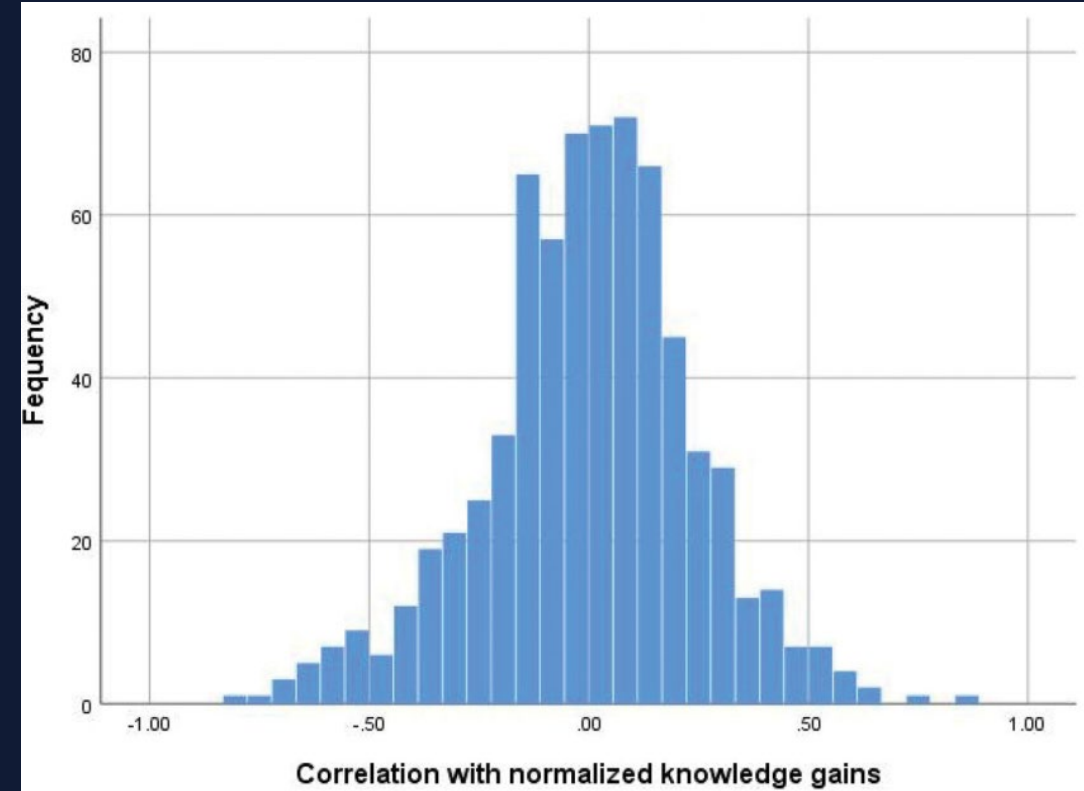
→ Preparation for Future Learning

# Effects of prior knowledge

Prior knowledge can support future learning if it is:

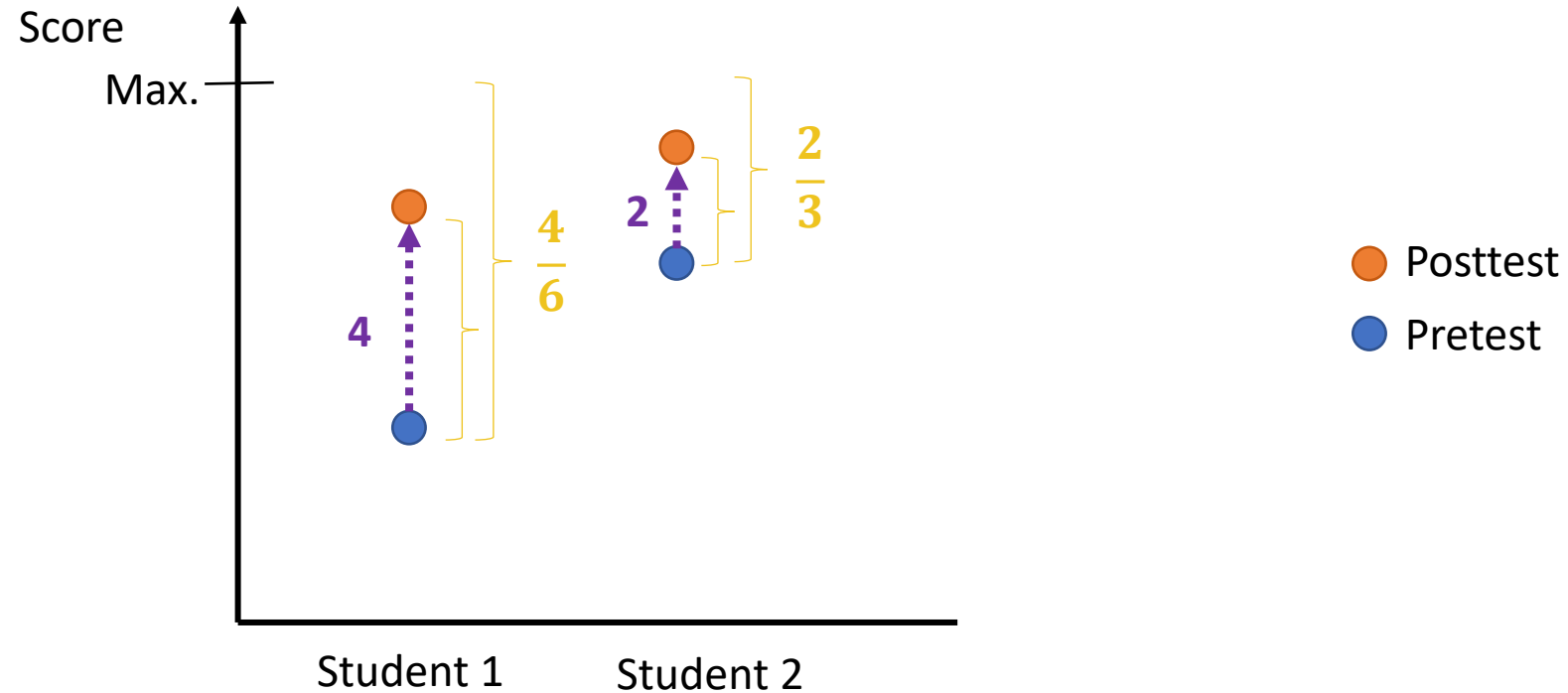
- activated
- relevant for the new knowledge
- congruent with the new knowledge

BUT: prior knowledge **not** always positively related to learning gains



Prior knowledge can cause negative transfer in some contexts, whereas it supports learning in others

# Posttest vs. absolute vs. normalized gain

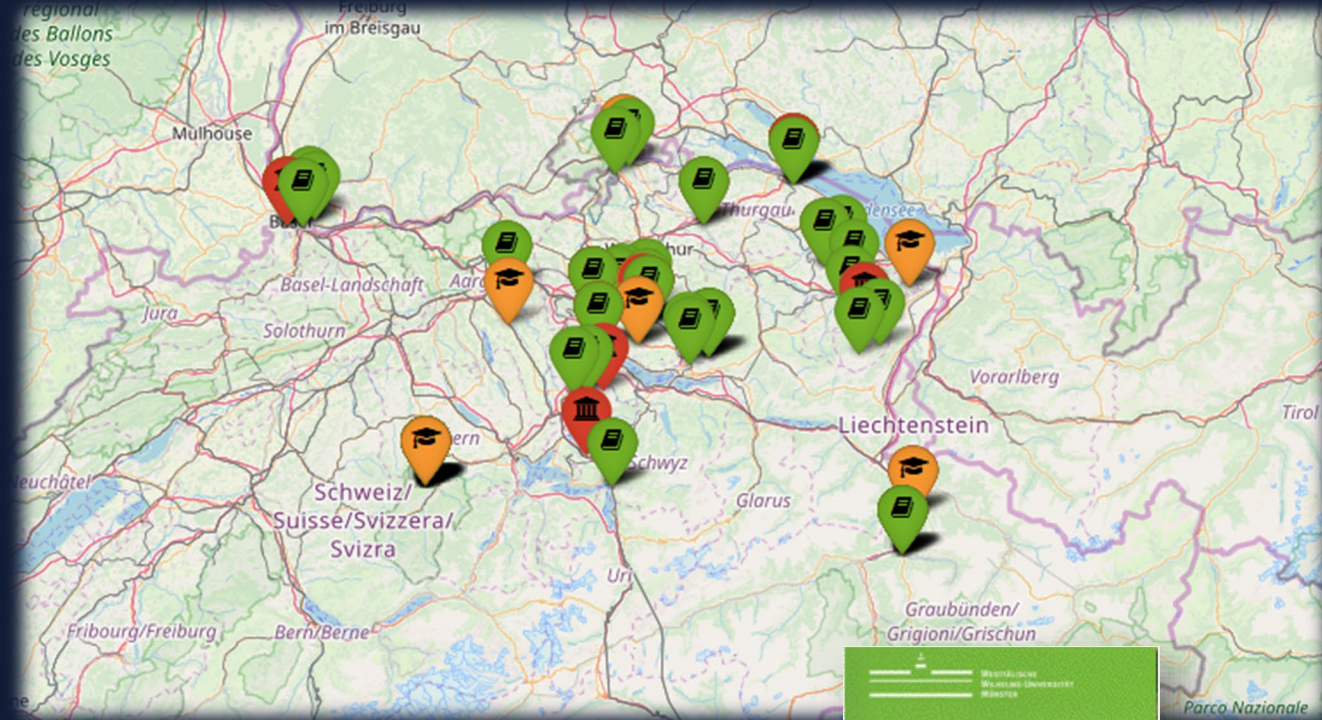


- Absolute gain = Posttest - Pretest
- Normalized gain =  $(\text{Posttest} - \text{Pretest}) / (\text{Max.} - \text{Pretest})$

...systematic research on the conditions under which prior knowledge has positive, negative, or negligible effects on learning

# Swiss MINT Study

- Over 17000 students from 1<sup>st</sup>-6<sup>th</sup> grade
- Around 600 classes in 130 schools in the North and West of Switzerland



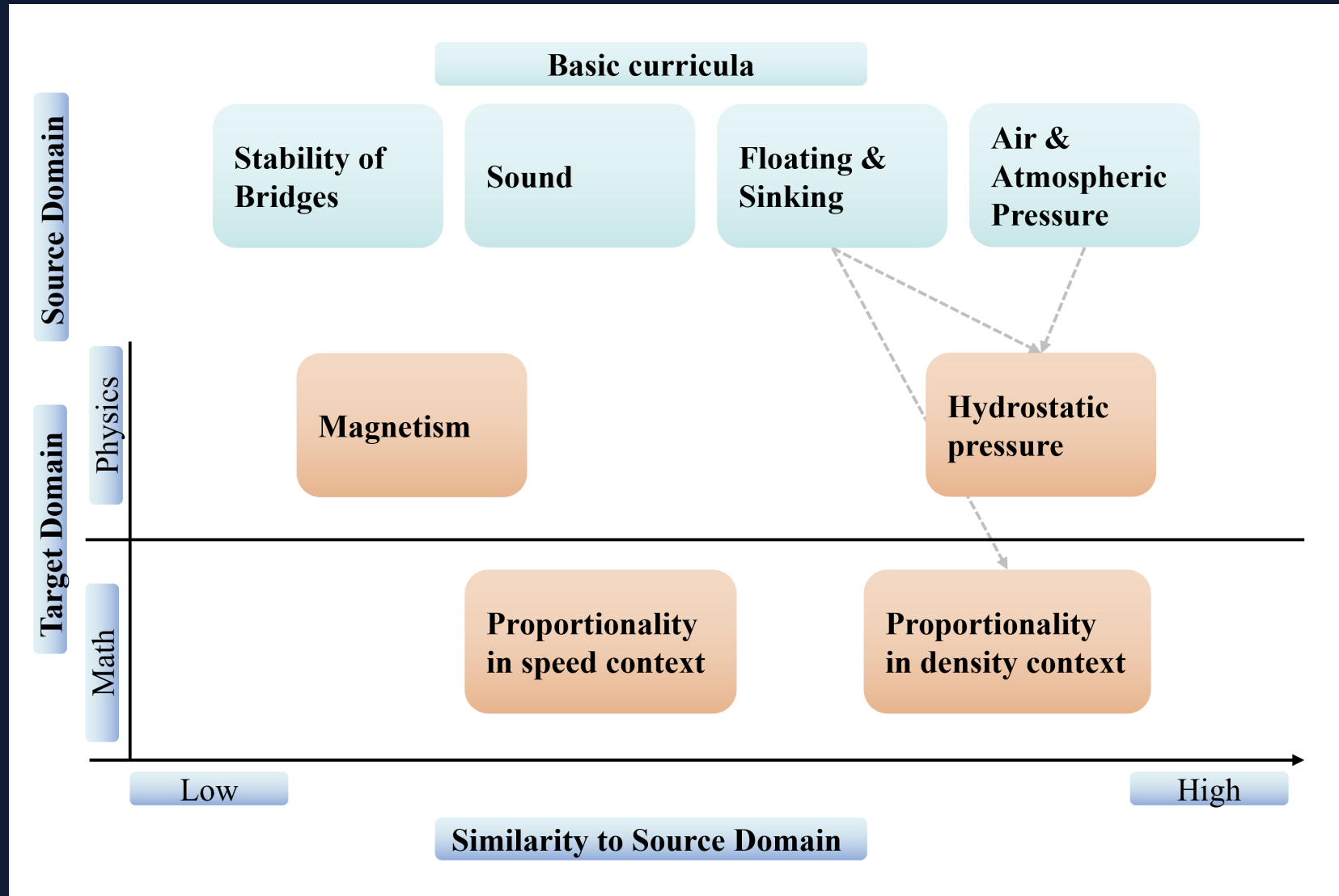
- Teaching material from University of Münster, Germany (Möller, 2005)
- 15 teacher-guided lectures on the topics:
  - Air & Air-pressure
  - Bridges & Stability
  - Floating & Sinking
  - Sound & Spreading of Sound

} Basic curricula





# Design



# Samples

- Magnetism Study ( $n = 1840$ ,  $M_{\text{age}} = 12.12$  years)
- Proportionality Study ( $n = 566$ ,  $M_{\text{age}} = 11.24$  years)
- Hydrostatic Pressure Study ( $n = 1375$ ,  $M_{\text{age}} = 13.64$  years)

# Research Questions

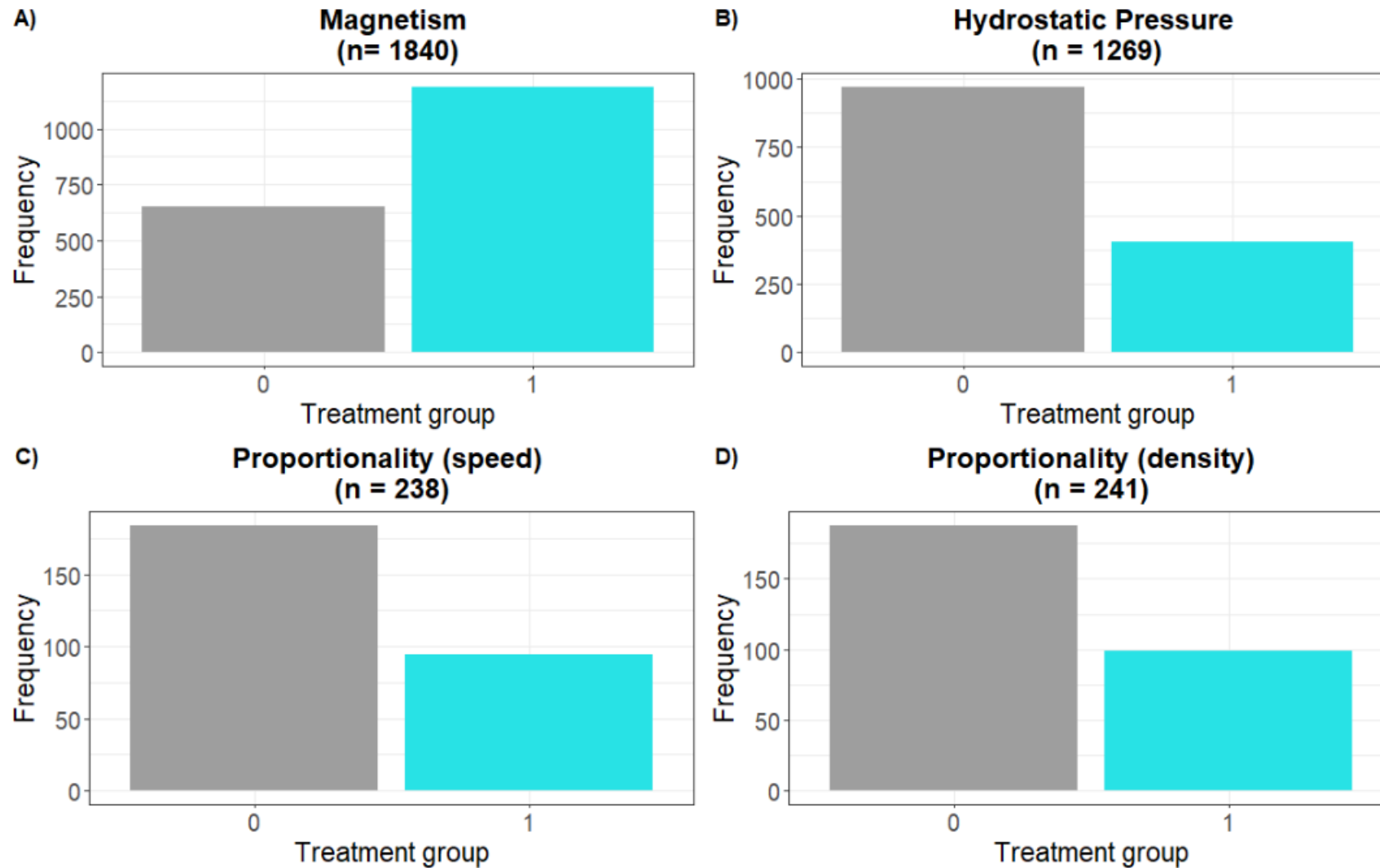
Is there an effect on normalized learning gains...

1) ...of the intervention group?

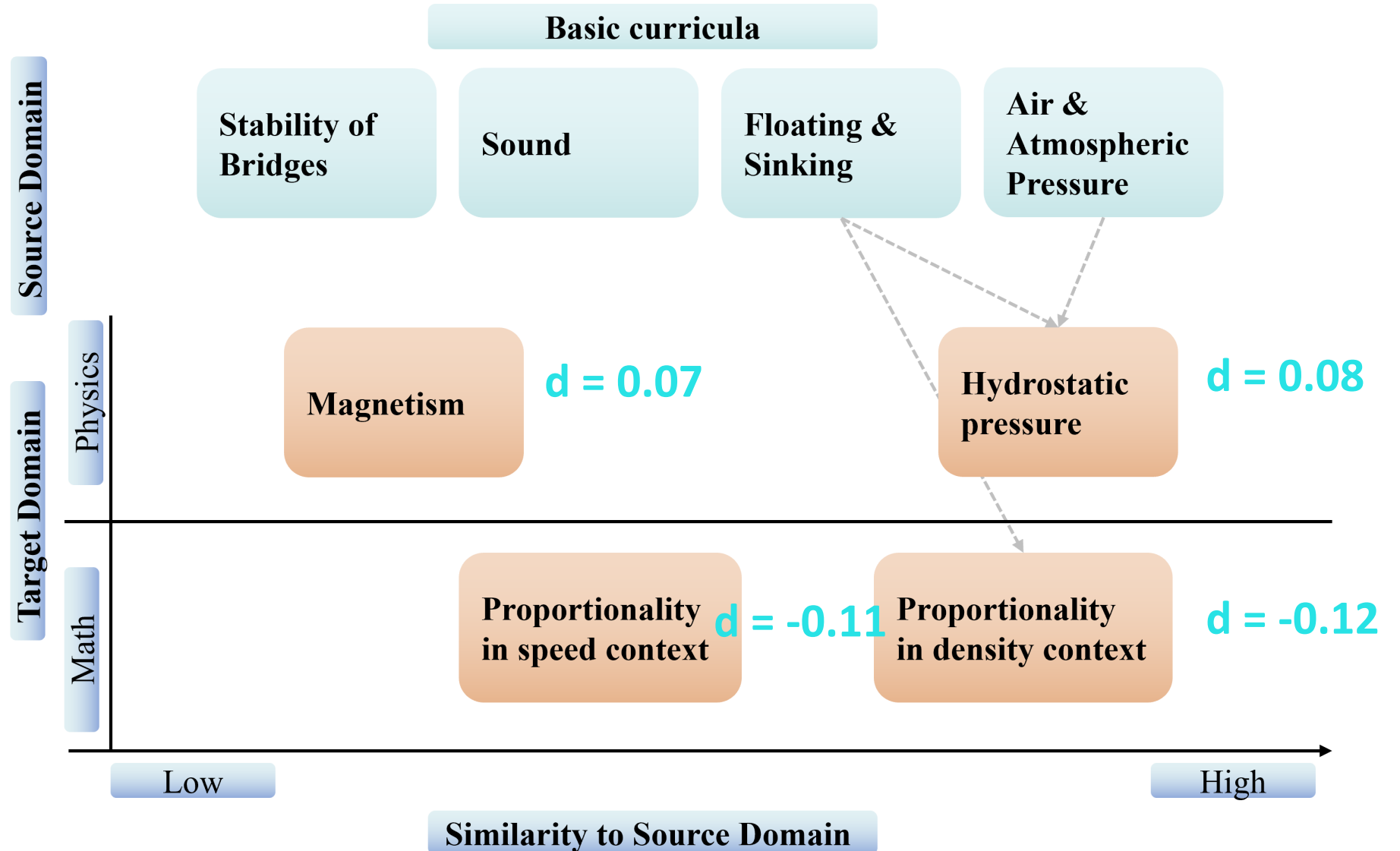
2) ...of the number of physics units (dosage effect)?

3) ...of the posttest score of each physics unit?

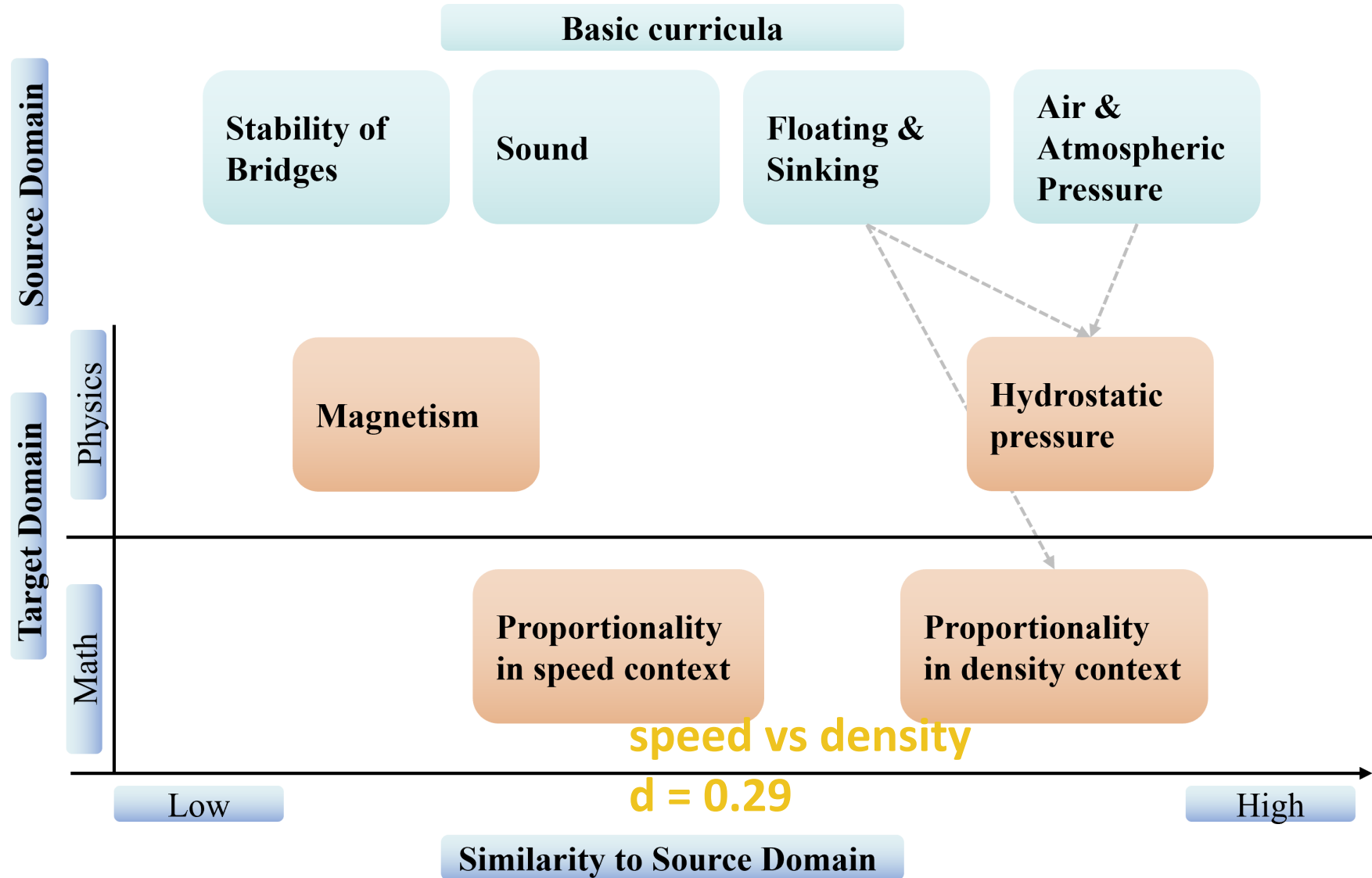
# Intervention vs. control



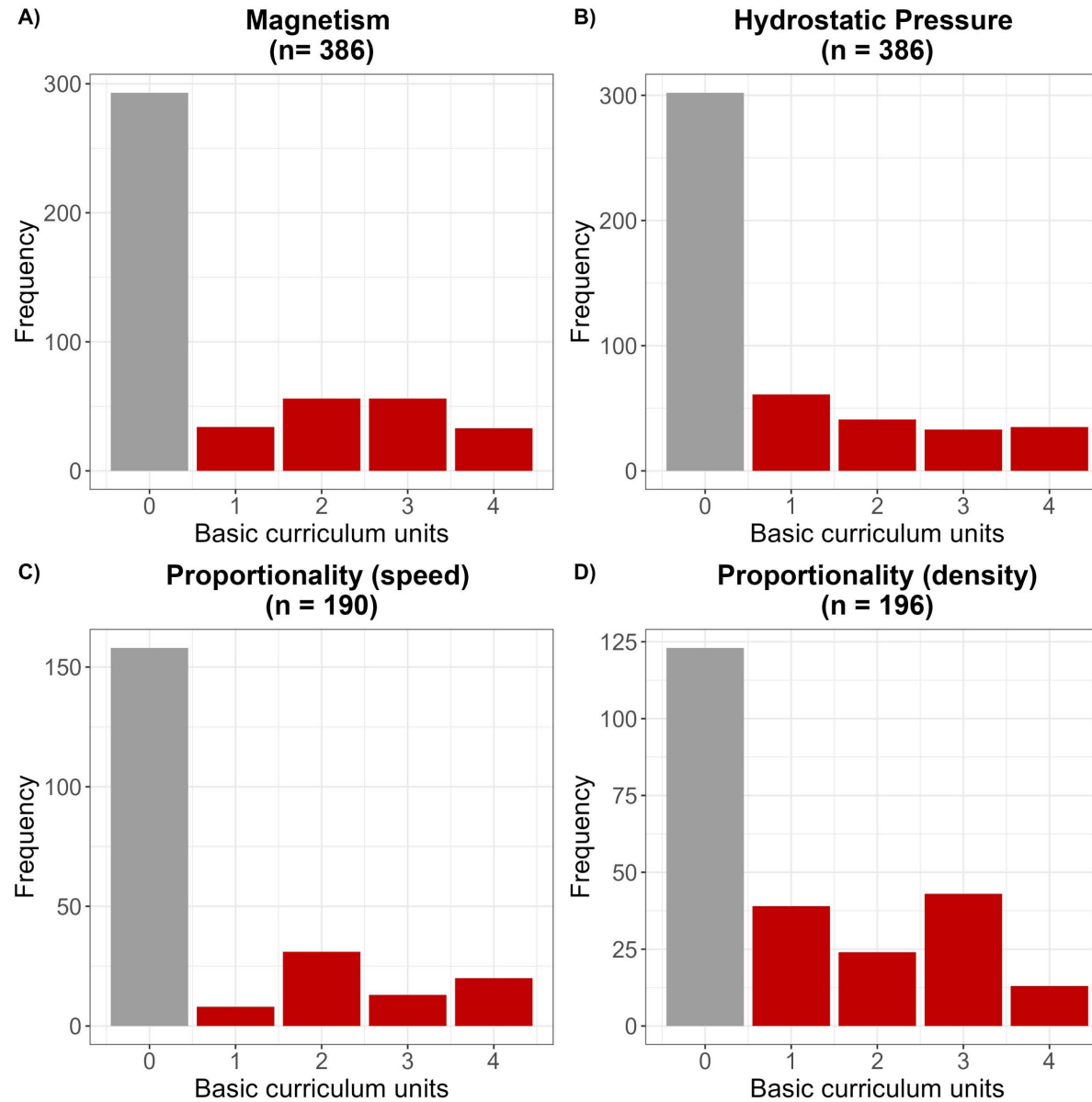
# Intervention vs. control



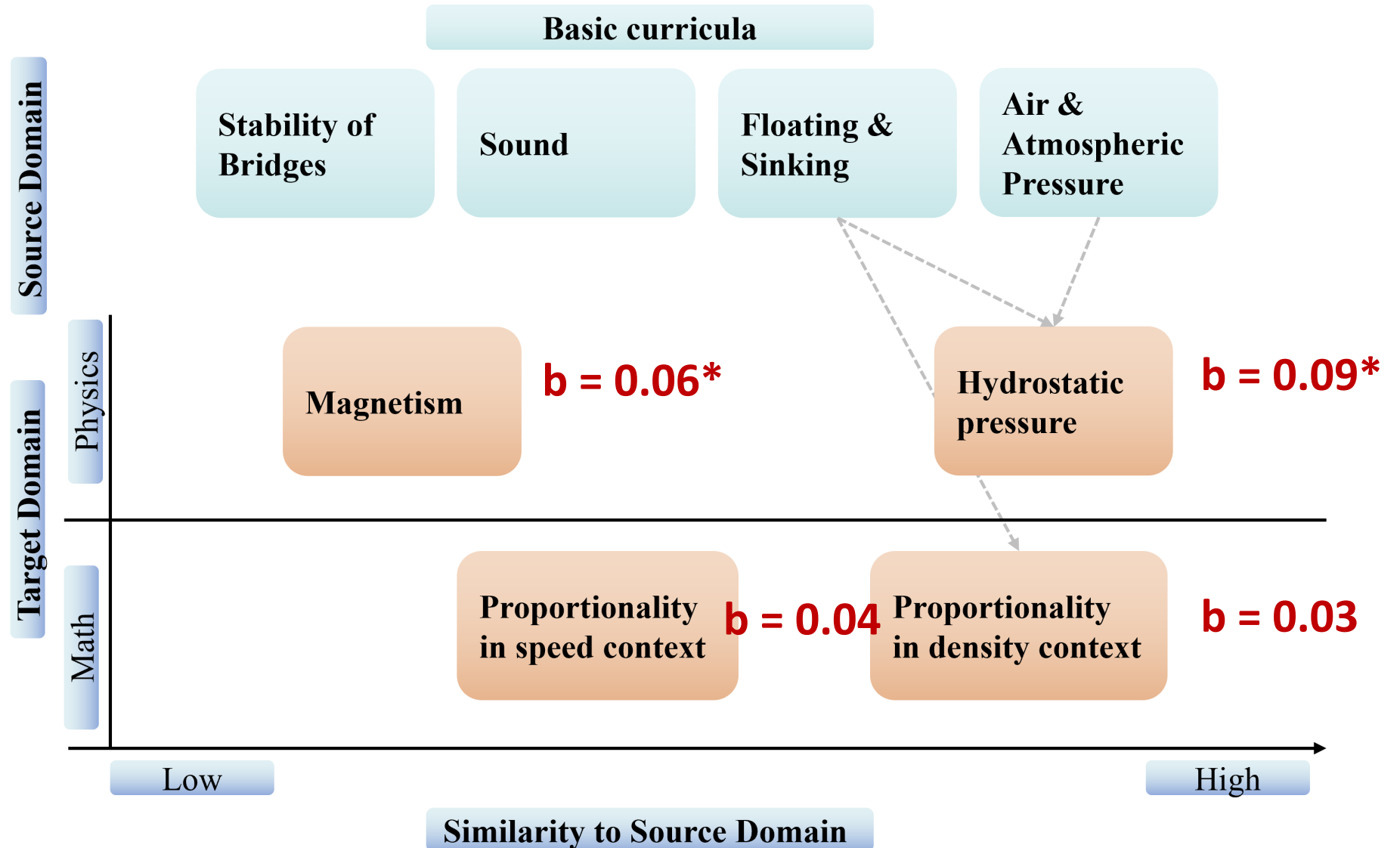
# Important



# Dosage effect

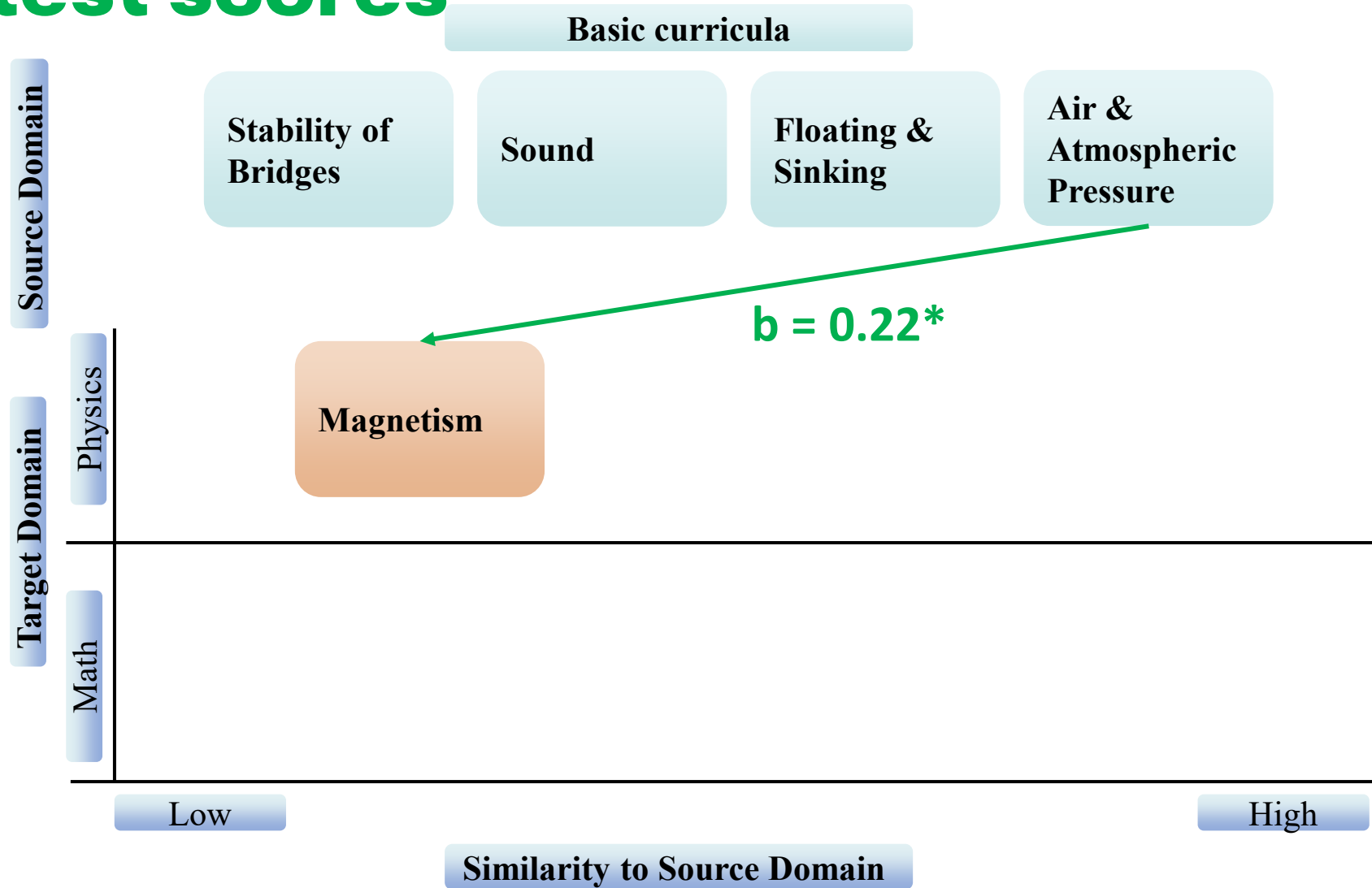


# Dosage effect

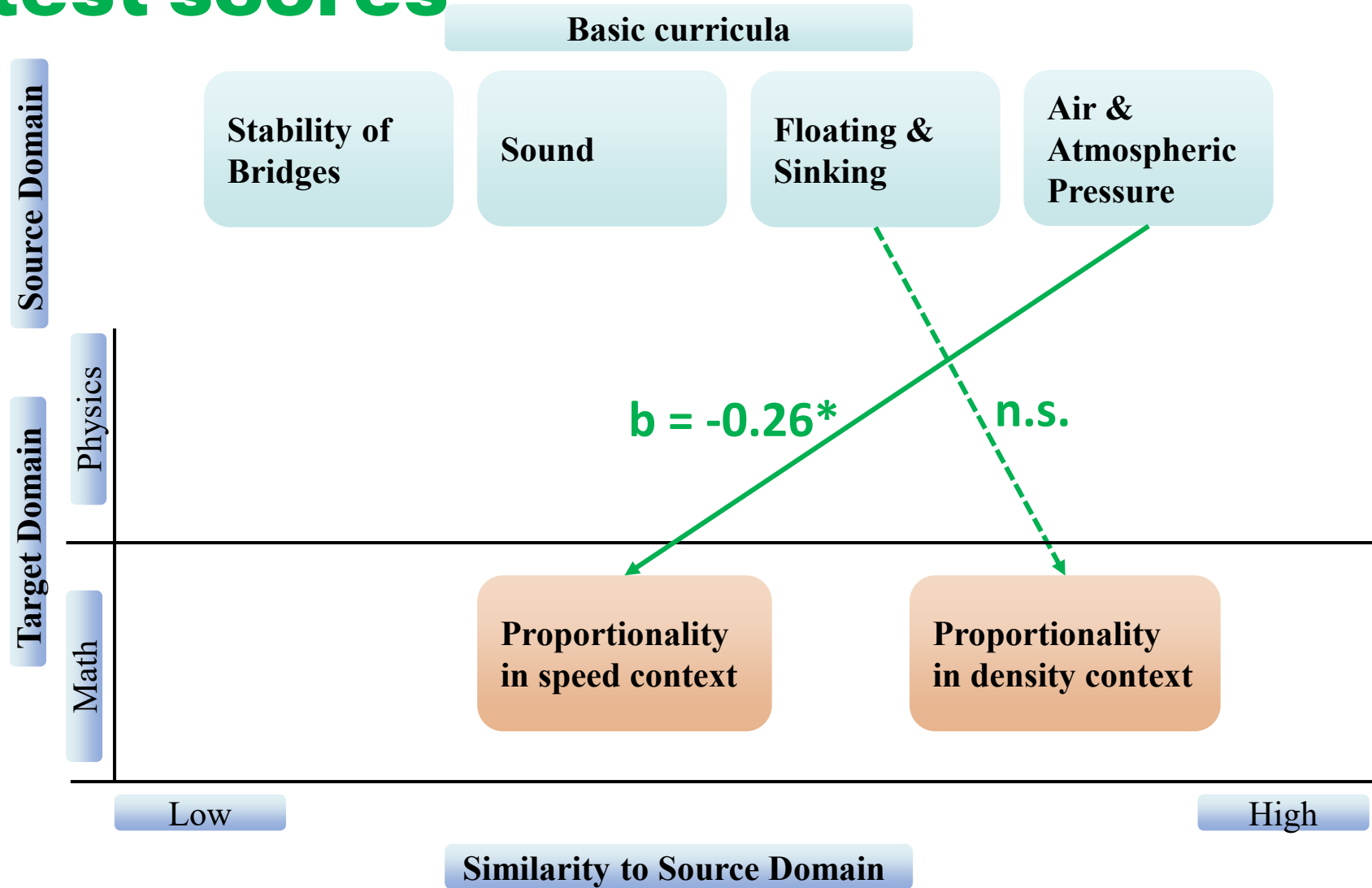




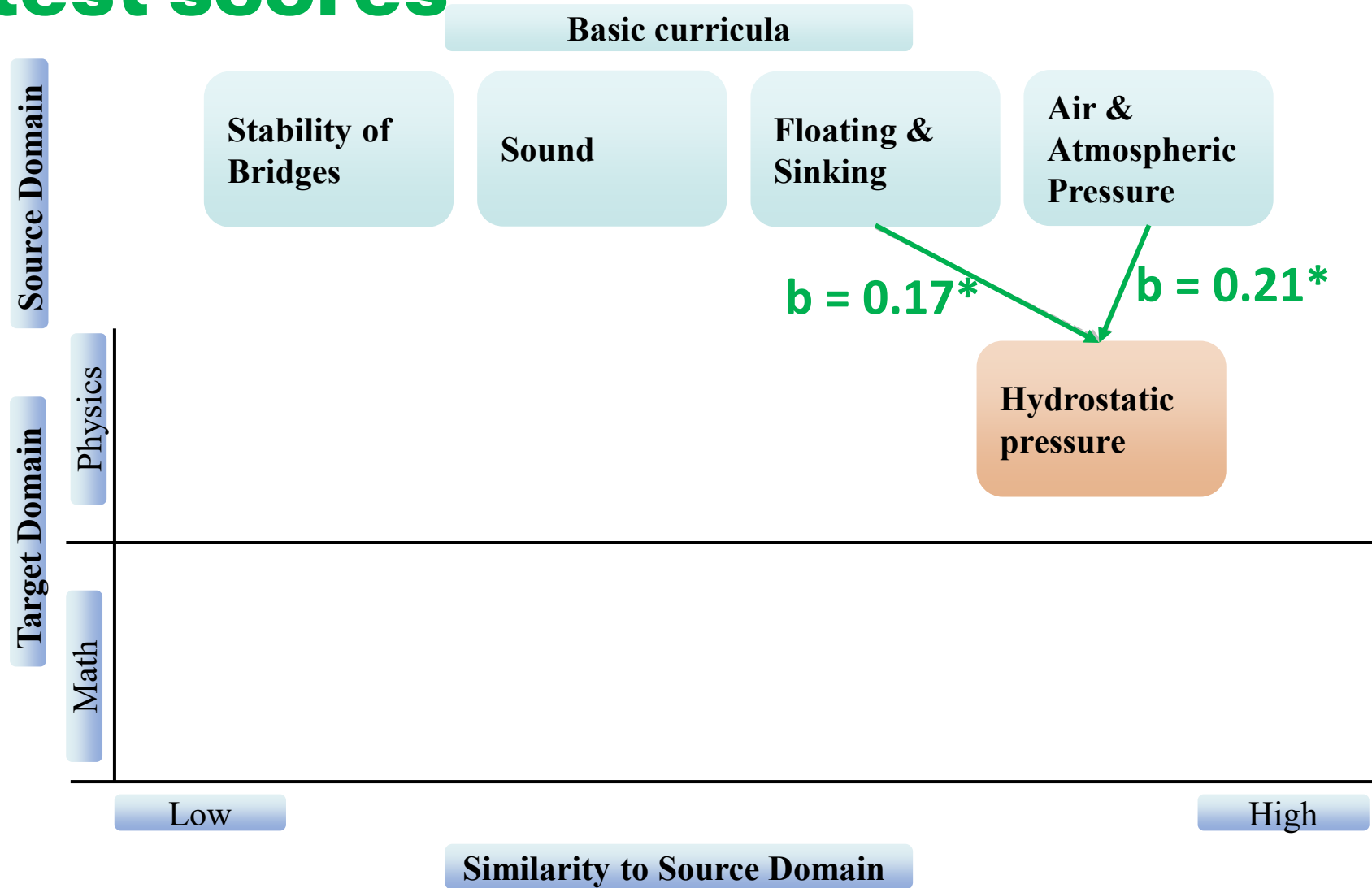
# Posttest scores



# Posttest scores




# Posttest scores



# Discussion

- Large-scale evaluation of the idea of preparation for future learning
- Overlap in relevant and congruent knowledge is theoretically important; our results specify this theory:
  - **Prior knowledge is important when learning happens in the same target domain (e.g., magnetism, hydrostatic pressure)**
  - **Transfer of prior knowledge to a different domain is difficult**
  - **General knowledge seemed more predictive than specific knowledge**

**Thank you for your  
attention, I am  
looking forward to  
the discussion** 

**Link to slides: [t.ly/9eaRh](https://t.ly/9eaRh)**

- Ackerman, P. L. (2007). New developments in understanding skilled performance. *Current Directions in Psychological Science*, 16(5), 235-239.
- Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn?: A taxonomy for far transfer. *Psychological bulletin*, 128(4), 612.
- Bransford, J. D., & Schwartz, D. L. (1999). Chapter 3: Rethinking transfer: A simple proposal with multiple implications. *Review of Research in Education*, 24(1), 61-100.
- Brod, G. (2021). Toward an understanding of when prior knowledge helps or hinders learning. *npj Science of Learning*, 6(1), 1-3.
- Hambrick, D. Z., & Meinz, E. J. (2011). Limits on the predictive power of domain-specific experience and knowledge in skilled performance. *Current Directions in Psychological Science*, 20(5), 275-279.
- Schalk, L., Edelsbrunner, P., Deiglmayr, A., Schumacher, R., Stern, E. (2019). Improved Application of the Control-of-Variables Strategy as a Collateral Benefit of Inquiry-Based Physics Education in Elementary School. *Learning and Instruction*, 59, 34-45.
- Schneider, W., Körkel, J., & Weinert, F. E. (1989). Domain-specific knowledge and memory performance: A comparison of high- and low-aptitude children. *Journal of educational psychology*, 81(3), 306-312.
- Simonsmeier, B. A., Flaig, M., Deiglmayr, A., Schalk, L., & Schneider, M. (2021). Domain-specific prior knowledge and learning: A meta-analysis. *Educational Psychologist*, 57(1), 31-54.
- Staub, F. C., & Stern, E. (2002). The nature of teachers' pedagogical content beliefs matters for students' achievement gains: Quasi-experimental evidence from elementary mathematics. *Journal of educational psychology*, 94(2), 344-355.
- Stern, E. (2005). Knowledge restructuring as a powerful mechanism of cognitive development: How to lay an early foundation for conceptual understanding in formal domains. In P. D. Tomlinson, J. Dockrell & P. Winne (Eds.), *Pedagogy – teaching for learning* (pp. 153–169). Leicester: British Psychological Society.
- Stern, E. (2015). Intelligence, prior knowledge, and learning. In D. Wright (Ed.), *International Encyclopedia of the Social and Behavioral Sciences* (2nd ed, Vol. 12, pp. 323–328). Elsevier.
- Tricot, A., & Sweller, J. (2014). Domain-specific knowledge and why teaching generic skills does not work. *Educational psychology review*, 26(2), 265-283.
- Weinert, F. E., Helmke, A., & Schneider, W. C. (1989). Individual differences in learning performance and in school achievement: Plausible parallels and unexplained discrepancies. In H. Mandl, E. De Corte, N. Bennet, & H. F. Friedrich (Eds.), *Learning and instruction* (pp. 461–479). Pergamon Press.

**Backup slides**

**School  
Subjects**



**Interdisciplinary  
knowledge**

