Mathematics Education Research Group of Australasia

21 April 2023

**RE: Response from the Mathematics Education Research Group of Australasia (MERGA)[1] to the Teacher Education Expert Panel Discussion Paper**

Dear Members of the Teacher Education Expert Panel,

The Mathematics Education Research Group of Australasia would like to thank the Panel for the opportunity to respond to the Teacher Education Expert Panel Discussion Paper. As experts in mathematics education research, we focus our response on **Reform 1 - Section 1.2.2 *Effective Pedagogical Practices*** (pp. 10-16), which we see as having the most direct impact on the mathematics education of Australia's children.

**Brief summary of our response**

Our response is directed towards the following two issues outlined in Section 1.2.2:

1. The recommended teaching approach (explicit instruction) is overly narrow in scope.
    - *The issue*: Listing explicit instruction as the core strategy limits the range of knowledge and skills needed for deep mathematical understanding and transfer to complex, unfamiliar problems. It does not allow teachers to address the Australian Curriculum: Mathematics (v9.0), which outlines a set of Mathematical Processes: Mathematical modelling, computational thinking, statistical investigations and probability experiments and simulations. These demand new skills not developed by explicit teaching.
    - *Our response*: Multiple teaching approaches are needed in order to prepare students to address the challenging, contemporary problems of the future as promoted in the Australian Curriculum: Mathematics (v9.0).

2. The Discussion Paper recommendations, asserted as being 'evidence-based', are not grounded in quality research from a broad range of research disciplines.
    - *The issue*: The claim that the report recommendations are 'evidence-base' is unsubstantiated. The large majority of evidence claimed by the report is either not provided, out-dated, not based on rigorous methodologies, or overly weighted towards cognitive science. Furthermore, references written by our own members mis-represent their research and infer that they agree with the report's claims and recommendations.
    - *Our response*: Research in education is interdisciplinary in nature and requires a *broad range of evidence* that is discipline-specific and from diverse methodologies and perspectives, including both classic and contemporary research.

[1] *The Mathematics Education Research Group of Australasia (MERGA)* was established in 1977. Its ~250 members consist primarily of mathematics education researchers, as well as teachers, industry professionals and research higher degree students in mathematics education. MERGA is committed to "promote, share and disseminate rigorous research in mathematics education across Australasia" (MERGA website, http://merga.net.au).

**Why does this matter?**

*Teaching approaches*

Research in education, like in science, develops over time as new findings emerge. Contemporary research in mathematics education draws on advances in knowledge of how people learn mathematics, the rise of new technologies, developments from neuroscience, changes in workforce needs, impact of globalisation and greater attention to social justice and diversity. These elements have had a profound influence on what is necessary to prepare students for the demands of the 21st century. In the past 25 years, substantial gains have been made in research on the teaching and learning of mathematics due to developments in all of these areas. The demands of personal, civic and work life require capabilities now require skills in complex problem solving, critical and creative thinking, innovation and flexibility, teamwork and interpersonal skills. The foundations of the Australian Curriculum: Mathematics includes mathematical proficiency, described as a blend of fluency, understanding, reasoning and problem solving. It is not possible for mathematics teacher educators to prepare graduate teachers who can meet the requirements of both the Australian Curriculum: Mathematics (about curriculum) and this discussion paper (about pedagogy).

Teachers need to develop a repertoire that allows them to implement different strategies as needs require. No single teaching approach can address all knowledge and skills needed for deep understanding of mathematics. The assumption underlying explicit teaching is that the goal of education is solely to develop a knowledge base of facts, concepts and procedures. This is only a small part of what we consider to be needed for applying mathematical understanding. It would be akin to only allowing the teaching of grammar and spelling in the English curriculum. We are concerned that focusing too much on explicit instruction will exacerbate the declining enrolments in higher level mathematics (see, for example, Chinofunga et al., 2022).

Finally, teacher education programs are already legislated and verified as using evidence-based teaching approaches through the process of accreditation outlined by the Australian Institute for Teaching and School Leadership (AITSL). We argue that the recommendations in the Discussion Paper, specifically Reform 1 – Section 1.2.2., directly *interfere* with national requirements from the Australian Professional Standards for Teachers and the Australian Curriculum. We contend that it is inappropriate to dictate a specific teaching approach, particularly one that contradicts national requirements already in place.

*Claims about 'evidence-based' teaching*

A hallmark of rigorous research is close attention to the sources of that research. In Reform 1 - Section 1.2.2 *Effective Pedagogical Practices* summarises three strategies reported to have "the highest impact on improvement in student learning outcomes" (p. 10). Support for this claim stems from Barak Rosenshine's (2012/2010) summary of principles of instruction. Rosenshine's report provides few citations to support individual claims, however it does list additional readings (see Table 1, Appendix). The large majority (88%) of these readings are more than 25 years old and neglect contemporary research in education.

The sources of evidence are critical to determining the quality and rigour of research. The Discussion Paper provides a summary of evidence in Table 1.2 in the subsection *What is the evidence?* (p. 11). The presented evidence proports to be a synthesis by AERO of research in three practices: Mastery learning (81 studies), Formative assessment (138 studies) and Explicit instruction (328 studies).

However, the 'evidence' summarised in Table 1.2 links evidence for all three practices to a single blog post from a senior researcher at AERO. The blog post lists one OECD report and no review studies. Looking further, the AERO website does have a section on these three areas that each include a reference list. However, closer investigation affirms many of the same concerns. The evidence is often dated, relies heavily on a single area of research (cognitive science), or mis-represents research intended for a different cohort of learners. For example, one of the key sources of explicit teaching from AERO is from Rosenshine's (1986) synthesis from nearly 40 years ago; many of the articles listed are in the area of learning disabilities and special education, or based on research that has been heavily contested (see Table 2, Appendix). The selection of a brain science perspective, while perfectly respectable in its own right, does not do justice to the breadth of research about what "learning" means.

Finally, we believe that any recommendations about effective and evidence-based teaching practice in mathematics should draw on mathematics education research rather than generic educational research. Furthermore, MERGA members are deeply disappointed that the Discussion Paper mis-represents our research (e.g., Geiger, 2018; Geiger et al., 2015; Goos et al., 2014; 2019; Hurst & Hurrell, 2014; Siemon, 2022; Sullivan, 2011; Tout, 2020). Including these citations implies that the authors broadly agree with recommendations made in the report and their research serves as supporting evidence. We respectfully disagree.

In closing, the Mathematics Education Research Group of Australasia (MERGA) supports a range of teaching strategies in mathematics. We disagree strongly with the Discussion Paper's recommendations for explicit instruction as the core approach to the teaching and learning of mathematics. Further, while we fully support evidence-based approaches to educational practice, we disagree with the selective use of evidence in support of claims in the report. We repeat that any recommendations about effective and evidence-based teaching practice in mathematics should be drawing appropriately on mathematics education research.

Sincerely,

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## Appendix

Table 1: Sources of evidence reported in Rosenshine's (2012/2010) principles of instruction

| Principle | Sources and additional readings |
|---|---|
| 1. Daily review. Daily review can strengthen previous learning and can lead to fluent recall. | Miller, 1956; LaBerge & Samuels, 1974. |
| 2. Present new material using small steps. Only present small amounts of new material at any time, and then assist students as they practise this material | Evertson et al., 1980; Brophy & Good, 1990. |
| 3. Ask questions. Questions help students practise new information and connect new material to their prior learning. | Good and Grouws, 1979; King, 1994; |
| 4. Provide models. Providing students with models and worked examples can help students learn to solve problems faster. | Sweller, 1994; Rosenshine, Chapman & Meister, 1996; Schoenfeld, 1985. |
| 5. Guide student practice. Successful teachers spent more time guiding the students' practice of new material. | Evertson et al., 1980; Kirschner, Sweller & Clark, 2006. |
| 6. Check for student understanding. Checking for student understanding at each point can help students learn the material with fewer errors. | Fisher & Frey, 2007; Dunkin, 1978. |
| 7. Obtain a high success rate. It is important for students to achieve a high success rate during classroom instruction. | Anderson & Burns, 1987; Frederiksen, 1984. |
| 8. Provide scaffolds for difficult tasks. The teacher provides students with temporary supports and scaffolds to assist them when they learn difficult tasks. | Berkowitz, 1986; Pressley et al., 1995; Rosenshine & Meister, 1992 |
| 9. Independent practice. Provide for successful independent practice. | Rosenshine, 2009; Slavin, 1996. |
| 10. Weekly and monthly review. Students need to be involved in extensive practice in order to develop well-connected and automatic knowledge. | Good & Grouws, 1979; Kulik & Kulik, 1979. |
| Additional references provided: | Brophy & Good, 1986; Gage, 1978; Good & Grouws, 1977; Rosenshine, 2009; Rosenshine & Stevens, 1986; Stallings & Kaskowitz, 1974. |
| **Summary of 25 references (median 37 years old)** | **References in the last 25 years: 3**<br>**References greater than 25 years old: 22** |

Table 2: Recommended strategies by AERO related to explicit instruction

| Recommended strategies | Supporting references (see notes below) |
|---|---|
| Break down complex skills and knowledge into smaller instructional tasks | Hughes, Morris, Therrien & Benson, 2017[1]; Sweller, van Merriënboer & Paas, 1998[2]. |
| Use worked examples to demonstrate what your students need to learn | Kirschner, Sweller & Clark, 2006[3]; Martin & Evans, 2018[4]. |
| Provide opportunities for students to practise what they have already learned | Archer & Hughes, 2011[5]; Sweller, van Merriënboer & Paas, 1998[2]; Martin & Evans, 2018[4]. |
| Organise lessons to keep students focused on the learning objective | Ellis & Worthington, 1994[6]; Sweller, van Merriënboer & Paas, 1998[2]. |

Notes:

1. Hughes et al (2017) is published in a journal focused on learning disabilities, with article highlighting the use of explicit instruction effectiveness for students with learning disabilities.
2. Sweller et al (1998) has since been updated (see Sweller et al, 2019). Their article has been directly critiqued by Schmidt et al. (2007, which includes Paas, one of its authors) and Jonassen (2009). See also Tobias (2009), who discusses the relationship between motivation (and persistence) and explicit instruction promoted by Rosenshine; as well as cognitive load in constructivism and explicit instruction, and their different purposes.
3. Kirschner, Sweller, and Clark (2006) has been repeatedly criticised for framing inquiry-based learning as leaving students to figure out mathematics on their own with no support. This is falsely represents inquiry-based practices, which are significantly supported by the teacher (e.g., see Hmelo-Silver, Duncan, & Chinn, 2007).
4. Martin & Evans (2018) is an individual study that introduces the Load Reduction Instruction framework, which seeks to reduce difficulty, provide support, practice, feedback and independence. In fact, "reduction of cognitive load can sometimes impair learning rather than enhancing it" (Schnotz & Kürschner, 2007, p. 469).
5. Archer and Hughes (2011) is published by Guilford Press, which publishes professional and self-help books; it is not known for publishing academic research.
6. Ellis & Worthington (1994) is a research report from special education for a centre that no longer exists.

Limitations to explicit instruction include the following (Ryan et al, 2017; Schnotz & Kürschner, 2007)

- *Lack of engagement*. Explicit instruction may lead to disengagement. Students may be enculturated to become passive learners, simply receiving information rather than actively engaging with it.
- *Limited transfer*. Explicit instruction may limit transfer of knowledge to new situations and not give students the disposition or skills to use their knowledge in complex or real-world situations.
- *Overemphasis on rote learning*. Explicit instruction can promote rote learning, limiting deeper understanding. For example, students may memorize information without understanding its meaning or significance, limiting their ability to think critically and creatively.
- *Limited opportunities for student autonomy*. Explicit instruction may limit opportunities for student autonomy and independence if students are not given opportunities to explore their own interests or to engage in self-directed learning.

## References

*Excluding those cited in the Discussion Paper, Rosenshine (2010) and AERO's website*


Chinofunga, M. D., Chigeza, P., & Taylor, S. (2022). Senior high school mathematics subjects in Queensland: Options and trends of student participation. *PRISM: Casting New Light on Learning, Theory and Practice, 4*(1), 72-85.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: a response to Kirschner, Sweller, and Clark. *Educational Psychologist, 42*(2), 99-107.

Jonassen, D. (2009). Reconciling a human cognitive architecture. In S. Tobias and T. M Duffy (Eds.), *Constructivist instruction: Success or failure?* (pp. 25-45). Routledge.

Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: basic psychological needs in motivation, development, and wellness.* NY: The Guilford Press.

Schmidt, H. G., Loyens, S. M., Van Gog, T., & Paas, F. (2007). Problem-based learning is compatible with human cognitive architecture: Commentary on Kirschner, Sweller, and Clark. *Educational Psychologist, 42*(2), 91-97.

Schnotz, W. & Kürschner, C. (2007). A reconsideration of cognitive load theory. *Educational Psychology Review, 19*(4), 469-508.

Sweller, J., van Merriënboer, J. J., & Paas, F. (2019). Cognitive architecture and instructional design: 20 years later. *Educational Psychology Review, 31*, 261-292.

Tobias, S. (2009). An eclectic appraisal of the success or failure of constructivist instruction. In S. Tobias and T. M Duffy (Eds.), *Constructivist instruction: Success or failure?* (pp. 335-350). Routledge


## Further reading


Munter, C., Stein, M. K., & Smith, M. S. (2015). Dialogic and direct instruction: Two distinct models of mathematics instruction and the debate (s) surrounding them. *Teachers College Record, 117*(11), 1-32.

Thanheiser, E. (2023). What is the Mathematics in Mathematics Education? *The Journal of Mathematical Behavior, 70*, 101033.

Webb, N. M., Franke, M. L., Ing, M., Turrou, A. C., Johnson, N. C., & Zimmerman, J. (2019). Teacher practices that promote productive dialogue and learning in mathematics classrooms. *International Journal of Educational Research, 97*, 176-186.