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Exploring the Complexity of Students' Inconsistent Relational Understanding of the Equal Sign

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Understanding the equal sign is essential for moving from arithmetic to algebra. Rather than recognising, with a *relational understanding*, that the equal sign indicates both sides are equivalent, many students interpret it as a symbol of "putting the answer here." (e.g. fill 7 for 1 + 6 = __ + 2). This *operational understanding* often causes later struggles in algebra. Some pedagogies, such as exposing students to various forms of number sentences (e.g. $a = a$, $b = a + c$ and $a + b = c + d$), can effectively challenge students' operational view and elicit relational understanding. However, recent studies have highlighted a previously overlooked stage in which students, while moving on to a full relational understanding, hold inconsistent and contradictory conceptions of the equal sign. For instance, students fill 5 for 3 + 6 = 4 + __, but fill 7 for 2 + 5 = __ + 1. Another example is that students may consider 3 + 2 = 5 + 1 = 6 and 3 + 2 + 1 = 5 + 1 = 6 both correctly. This study aimed to provide further insights into this stage to help teachers to better support students' progress towards full relational understanding.

This study applied Rasch modelling (a statistical approach for aligning students' abilities with item difficulties) to analyse assessments of Grade 1 Chinese students' understanding of the equal sign (N = 1008). We found that about 30% of tested students exhibited inconsistent understanding of the equal sign, indicating this phenomenon is both common and important to address. We identified a few key barriers for these students' thinking. First, many students can correctly evaluate True/False to item '$a + b = c + d$' but were struggling to solve the items with forms '$a + b = c +$ __' and '$a + b =$ __ $+ c$'. Second, more students were comfortable solving the form '$a + b = c +$ __', but slipped back into operational understanding when solving form '$a + b =$ __ $+ c$'. Finally, while majority of students can correctly respond to all the items above, they consider both ' 4 + 2 = 6 + 3 = 9' and '4 + 2 + 3 = 6 + 3 = 9' to be both correct.

These findings, together with the interview data, provide the following implications for classroom teachers. First, the number sentences have different discriminative powers to assess students' understanding of the equal sign. Compared to number sentences where a number followed the equal sign (e.g., True/False items or $a + b = c +$ __), items with a blank placed immediately after the equal sign (e.g., $a + b =$ __ $+ c$) were more likely to expose students' operational interpretation. Furthermore, the multi-equals expression ($a + b = c + d = e$) requires the most robust relational understanding to address. Teachers can use these items to pinpoint students' stages of understanding of the equal sign and provide targeted support. Second, students' inconsistent reasoning shows that their emerging relational conceptions can still be undermined by routine arithmetic drills: when faced with familiar structures (e.g., filling a blank after the equal sign), their operational view may resurface. This reminds us that students' progression toward a full relational understanding is not spontaneous, and teachers need to continually reinforce the relational meaning of the equal sign in daily practice and to address critical misconceptions, such as the forms $a + b = c + d = e$, with care.

For more information, please refer to the following paper presented at the 47th Annual Conference of MERGA in July 2025.
Sun (2025). Exploring the complexity of students' inconsistent relational understanding of the equal sign. In S. M. Patahuddin, L. Gaunt, D. Harris & K. Tripet (Eds.), *Unlocking minds in mathematics education. Proceedings of the 47th annual conference of the Mathematics Education Research Group of Australasia* (pp. 35-42). Canberra: MERGA.