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“When a number moves across, it changes its sign” – Investigating Teachers' Conceptual Understanding of Algebra

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Background to the Study

Algebra has long been identified as an area of difficulty in the teaching and learning of mathematics. In Ireland such difficulties have traditionally been attributed to an over reliance on transformational-based activities when teaching the domain. These activities place a high emphasis on manipulating expressions and equations in a rote fashion, without a sound conceptual understanding of algebraic concepts. Bale (1999) describes conceptual understanding as an associative or connected body of knowledge, rather than a procedurally based knowledge, which can be applied to a variety of diverse contexts. To address this issue a reformed algebra strand was introduced to all post-primary schools in September 2011. In a shift from the transformational-based approach, the reformed strand followed the lead of several countries and advocated a functions-based approach to teaching the domain. This functions-based approach involves understanding the notion of change and making generalizations about how two or more varying quantities such as patterns of number sequences are related (Tanışlı, 2011). However, a study by Prendergast and Treacy (2018) found that not all teachers had successfully adopted the functions-based approach in their own teaching. As well as a reluctance to deviate from the transformational-based approach, teachers identified a lack of uniformity in the teaching and learning of algebra, particularly between primary and post-primary education. With such findings in mind, this study follows on from that research and focuses on teachers’ insights into their teaching of algebra, particularly during the transition from primary to post-primary school. Data generated in this research specifically investigates upper primary and lower post-primary school teachers’ conceptual understanding of algebra and, more particularly, linear equations.

Methodology

The study was qualitative in nature and involved two phases of semi-structured interviews with a cohort of upper primary (10 – 12 years) and lower post-primary (12 – 15 years) school teachers. Participants were recruited through a purposive sample method from one local education authority in Ireland. The first phase of interviews took place in January 2018 and involved 15 teachers (9 primary [P1-P9] and 6 post-primary [S1-S6]) from 8 different schools (6 primary and 3 post

primary). The second phase of interviews took place in May 2018 and involved 13 of the same teachers from Phase 1 (8 primary and 5 post-primary). For the purpose of this submission, the authors investigate teachers' conceptual understanding of linear equations. This proposal focuses on one question asked of teachers in Phase 1 and the related follow up question posed in Phase 2:

Phase 1 Question: Take a look at the following equation: $2x + 6 = 10$. How would you typically explain to your students how to solve this equation?

Phase 2 Question: In the pre-interview, a number of teachers indicated that they would instruct their students to bring the six across the equals sign and it would change sign to become a minus. Are there any issues that you see with such an explanation? What changes (if any) would you make to the explanation?

Preliminary Findings

Preliminary analysis conducted utilising the domain of expressions and equations as an organising framework (Bush & Karp, 2013), indicates a lack of conceptual understanding of linear equations on behalf of participating teachers and a prevailing over-reliance on 'rules without reason' when teaching algebra. For the Phase 1 Question, four out of the fifteen post-primary teachers effectively demonstrated conceptual knowledge of solving such a linear equation (S4: *So what I would start here is gain the notion of equality. Whatever we do to the left-hand side must be done to the right hand side*). Four of the primary teachers were either unable to generate a response or gave an inappropriate response (P5: *Let's see. Right well I would explain to them we need to find what x is... we haven't done these yet so...*). The other seven teachers' responses (five primary and two post-primary) were procedural in nature and all focused on the notion of numbers moving across the equals sign and then changing signs. (P1: *If it is a plus it becomes a minus and if it's a minus it becomes a plus*). The issue of moving across the equals sign and changing sign was probed further in Phase 2 and there were a variety of responses from the eleven teachers (8 primary and 5 post-primary). Three of the primary teachers did not see any issue with such an explanation (P6: *no I don't see anything wrong with it*). Four of the primary teachers could see where issues might arise but were unable to give an appropriate suggestion on how they would change the explanation (P2: *the biggest thing for me would be how is the +6 changing to a -6?*). While these findings are preliminary, the initial results raise concerns about participating teachers' conceptual understanding of algebra and, more specifically, linear equations. This research is intended to inform mathematics teacher education programmes in Ireland, particularly in the transition from primary to post-primary mathematics.

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