International Journal of Educational Research 62 (2013) 21–35

Contents lists available at SciVerse ScienceDirect

International Journal of Educational Research

journal homepage: www.elsevier.com/locate/ijedures

The role of reading comprehension in maths achievement growth: Investigating the magnitude and mechanism of the mediating effect on maths achievement in Australian classrooms

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ARTICLE INFO

Article history:
Received 13 May 2013
Received in revised form 7 June 2013
Accepted 21 June 2013
Available online

Keywords:
Mediation
Reading comprehension
Group differences
Mathematics achievement
Structural equations modelling
Language background

ABSTRACT

This study examined the role of reading comprehension skill in the relationship between problem solving ability and growth in maths achievement. Within this analysis framework, group differences based on language background were also examined. The participants for this study are government school students ($N = 5886$) in grades 3–8 in Victoria, Australia.

Results showed no evidence of moderation by language background, implying that language background does not have an effect on how RC skill mediates the relationship between PS ability and growth in maths achievement.

Partial mediation is confirmed in more focussed tests of mediation using regression analysis. Two datasets using independent measures provide corroborating evidence that RC skill may be partially mediating the relationship between PS ability and growth in maths. In addition, findings show that these mechanisms hold uniformly regardless of language background, and that with no evidence of group differences with respect to the partial mediation model, the results have better generalisability to the student population. These findings have important implications for future system-wide implementation of large scale interventions on Australia's linguistically diverse classrooms.

1. Introduction

1.1. Language and mathematics

The main aim of this paper is to investigate the mechanism of the mediating effect of reading comprehension (RC) on the relationship between reasoning ability and growth in maths achievement, and develop a model to assess the magnitude of this effect, all within the context of linguistically diverse Australian classrooms. The effect of English RC skill on the relationship between maths ability and other cognitive abilities (such as fluid intelligence) has not been studied using large Australian datasets. There had been international studies that focused on how phonological decoding, processing speed, concept formation, and other language skills influence maths ability (Fuchs et al., 2006; Seethaler & Fuchs, 2006). Hart, Petrill, Thompson, and Plomin (2009) found that certain maths skills that are dependent on school learning have greater shared environmental influences (environmental factors that account for the similarities), while greater environmental overlap (i.e., variability is accounted for by environmental rather than innate factors) between reading and maths ability was

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http://dx.doi.org/10.1016/j.ijer.2013.06.009

found for skills that involve reading, such as problem solving (PS) ability. Because their study involved twins, shared environmental influences can be interpreted as variability between families and across schools. Thus, it appears that performance on maths items is not uniformly dependent on general cognitive abilities but rather influenced by either genetic or environmental factors depending on specific maths skills involved (Hart et al., 2009). This implies that some maths items are more influenced by the variability in skills due to environment (e.g., differences in school and background) than general cognitive ability, suggesting that the interrelationship between PS and reading skills is significant whether accounted for by genetic or environmental factors.

This interrelationship between PS and reading skills is supported by results from Vilenius-Tuohimaa, Aunola, and Nurmi (2008). Their study looked at how gender (genetic) and parental education (environmental) influence RC and mathematical PS ability; with results showing that even if both factors are controlled, reading and PS skills are still significantly interrelated. Vilenius-Tuohimaa et al. (2008) suggest that the covariance between RC and mathematical PS could imply that a reasoning component common to both may be at play. Unfortunately, it is not clear from their path models the role that RC skills play in predicting PS performance – whether RC moderates or mediates the relationship between mathematical PS and either genetic or environmental factors.

Given that important language skills (e.g., decoding and comprehension, word efficiency, phonological processing) either directly predict maths performance (Fuchs et al., 2006; Seethaler & Fuchs, 2006) or at least covary with it (Hart et al., 2009; Vilenius-Tuohimaa et al., 2008), the language used to measure maths performance has direct implications for non-native speakers of this language. This effect of test language on maths performance of non-native speakers may not be simple (or uniform) due to the differences in language loadings depending on types of maths skills being measured (for example, arithmetic calculation may have less language loads compared with more complex word problems) (see for example findings in Fuchs et al., 2005, 2006). But regardless of differential effects that depend on skills being measured and type of test items, it can be argued that skills in the test language would have some influence on the performance in these tests, just as reading skills overlap with general cognitive ability in its loading on maths ability (Hart et al., 2009).

The effect of language background as a moderator of language proficiency is apparent in studies that focus on performance of two linguistic groups in tests that are predominantly in the language of only one of the groups. A study by Alderman (1981) examines the effect of language proficiency in the performance of students whose first language is either English or Spanish on a test of academic aptitude and findings showed that language proficiency in a second language moderates the relationship between performance on an aptitude test given in a second language (English, SAT) and performance on a similar aptitude test given in a first language (Spanish, PAA). This shows that the language used in a test is an additional and significant hurdle for students in order to demonstrate the abilities that such particular test aims to measure, regardless of whether language ability itself is relevant to the abilities being measured. For example, in Alderman's (1981) study, the moderating effect of English language proficiency is significant whether the outcome variable being measured is aptitude scores in verbal ability (SAT-verbal) or maths ability (SAT-maths) and thus "proficiency in a second language has theoretical and empirical relevance for interpreting the results of tests given in that language" (Alderman, 1981, p. 17). This is in line with valid concerns that, when applied to non-native speakers, certain tests invariably become a test of language proficiency (Solano-Flores & Trumbull, 2003). In this context, the test language becomes a factor that contributes to measurement error while being in itself irrelevant to the construct being measured, hence detracting from the valid interpretation of test results (Solano-Flores & Trumbull, 2003). Group difference between NESB and ESB students cannot be solely attributed to language factors because other sociocultural factors may come into play (Carstairs, Myors, Shores, & Fogarty, 2006). Nevertheless, there is evidence that from a testing perspective, verbal load is a major determinant of group differences – even when the groups may not be based strictly on language backgrounds or language skills.

It is not difficult to hypothesise a link between language proficiency and performance in maths. Yet research on this area, particularly on the relationship between language proficiency and trends in maths achievement, is rare (Tate, 1997). Tate's review, spanning some 15 years, focused on trends in maths achievement in the US and found only one study that looked at language proficiency as predictor. In Australia, there is similar scarcity in studies on the predictors of maths achievement and even more so on the predictors of maths achievement growth (Hemmings, Grootenboer, & Kay, 2011). The comparative lack of research activity on the effects of language proficiency on maths growth is worsened by confusion on the conceptual definition of language proficiency in its use as a demographic variable for research on group differences (Tate, 1997), where some terms are used more interchangeably,[1] while others less so. Beyond the labelling issues, the construct attributed to a grouping variable based on language proficiency needs to be defined clearly to minimise the impact of construct-irrelevant variance in the analyses later on (Hauger & Sireci, 2008). It is therefore important to examine the effects of RC skill separately for NESB and ESB students so that language proficiency is not confounded with language background.

1.2. General reasoning ability and mathematics achievement

Although research on the interrelation of reading and PS skills using Australian data is relatively rare, Carstairs et al. (2006) found differences between NESB and ESB in tests of fluid intelligence (MUNNS, based on a battery of intelligence tests,

[1] In this study, the term LBOTE is maintained as a demographic status variable as defined by the Australian Bureau of Statistics. ESB and NESB are terms used as the group names resulting from the dichotomy based on LBOTE status.