Thinking Skills and Creativity 20 (2016) 17–28

Contents lists available at ScienceDirect

Thinking Skills and Creativity

journal homepage: http://www.elsevier.com/locate/tsc

Students' beliefs about themselves as mathematics learners

Linda Bonne[a,*], Michael Johnston[b]

[a] New Zealand Council for Educational Research, 178-182 Willis Street, P.O. Box 3237, Wellington 6140, New Zealand
[b] Victoria University of Wellington, Faculty of Education, Donald Street, P.O. Box 17-310, Karori, Wellington 6147, New Zealand

ARTICLE INFO

Article history:
Received 22 March 2015
Received in revised form
15 December 2015
Accepted 1 February 2016
Available online 3 February 2016

Keywords:
Mathematics
Self-efficacy
Primary or elementary
Beliefs
Intervention

ABSTRACT

Key aims of this study were to identify relationships between students' domain-general theory-of-intelligence, task-specific mathematics self-efficacy, and mathematics achievement, and the effects on these variables of teacher-implemented micro-interventions. The dimensionality of theory-of-intelligence was also investigated. Participants were 7–9-year-olds in four New Zealand primary schools, two of which formed the intervention group ($n = 41$) and the remaining two, the comparison group ($n = 50$). Three waves of data were collected in a quasi-experimental, longitudinal design, using a questionnaire designed to measure students' domain-general beliefs about their capacity to increase their intelligence and task-specific beliefs about their mathematics capability, and a mathematics achievement test. In their regular mathematics lessons, intervention group teachers incorporated micro-interventions in the form of particular pedagogical strategies, as they judged appropriate. Many of these strategies focused on making students' progress explicit, and all aimed at increasing students' mathematics self-efficacy. Results showed that students' beliefs about intelligence comprised two distinct dimensions, one corresponding to entity beliefs and the other to incremental beliefs. The intervention group showed a significantly greater increase in mathematics achievement, incremental belief and self-efficacy than the comparison group. While mathematics achievement and self-efficacy were consistently correlated, there was no significant correlation between mathematics achievement and incremental belief. Two main implications of the findings were that, first, teachers' micro-interventions can be effective in building students' learning dispositions and achievement. Secondly, relationships between students' metacognition and achievement are less straightforward than has been represented in the relevant research literature.

1. Introduction

The New Zealand government made a significant financial investment in the Numeracy Development Projects (e.g., New Zealand Parliament, 2006) over the first decade of this century, aiming to build teachers' professional capability and thereby, raise student achievement. During that period, teachers in over 90% of schools worked to implement changes in their mathematics teaching. But after an initial improvement in student achievement overall, further gains proved elusive and many students continued to fall short of reaching the curriculum expectations for their year level (see, for example, Young-Loveridge, 2010). From 2010, the additional imperative for schools with students in Years 1–8 to implement

* Corresponding author.
E-mail addresses: linda.bonne@nzcer.org.nz (L. Bonne), michael.johnston@vuw.ac.nz (M. Johnston).

http://dx.doi.org/10.1016/j.tsc.2016.02.001

national standards for reading, writing, and mathematics (Ministry of Education, 2009) has reinforced an emphasis on raising achievement.

Recent findings from the PISA study showed a decline in the mathematics self-efficacy and achievement of 15-year-old New Zealanders, between 2003 and 2012 (Ministry of Education, 2015). An increasing body of research and theory suggests that a focus on strengthening students' self-efficacy (e.g., Bandura & Schunk, 1981; Bandura, 1986; Ramdass & Zimmerman, 2008) and theory-of-intelligence (e.g., Dweck & Leggett, 1988; Dweck, 2000) might be at least as effective as content-focussed initiatives in improving students' achievement.

While both theory-of-intelligence and self-efficacy can be broadly characterised as psychological orientations to learning, there are a number of differences between them. First, a person's self-efficacy reflects confidence in his or her own capability, whereas theory-of-intelligence is focussed on intelligence in the abstract; a theory-of-intelligence belief is a belief about the construct of intelligence itself. Second, theory-of-intelligence is concerned with the potential for improvement over time, whereas self-efficacy is concerned with present capability. Third, in keeping with everyday understanding of the term, it is probable that most research participants have interpreted *intelligence* as a domain-general construct, whereas under Bandura's original (1986) theory, *self-efficacy* is conceptualised in relation to particular tasks within a domain (such as mathematics). While there is some divergence in the research literature from these conceptualisations (e.g., Jones, Wilkins, Long, & Wang, 2012; Kung, 2009; Ziegler & Stoeger, 2010), in the present work we operationalised both constructs in a way that preserved these distinctions, in order to facilitate a comparison of the relationship of each with mathematics achievement.

1.1. Theory-of-intelligence

In this paper, we conceptualise intelligence as a construct comprising three dimensions: one, the complexity of knowledge and skill that can be learned; two, the capacity for learning; and three, the rate at which knowledge and skill can be acquired. This working definition is compatible with Gardner's (1983) multiple intelligences, and with the knowledge acquisition component of Sternberg's (1985) triarchic theory of intelligence.

Dweck and Leggett (1988) described the belief that intelligence can be increased through effort as an *incremental theory-of-intelligence*, and a belief that intelligence is fixed, as an *entity theory-of-intelligence*. The two beliefs have been characterised as opposite ends of the same uni-dimensional construct. Whether research participants have interpreted intelligence as uni-dimensional or comprising multiple dimensions, as described above, is largely unexamined.

Theory-of-intelligence is important because of its association with achievement. Weak but significant and positive correlations between having an incremental theory-of-intelligence and academic achievement have typically been reported for research participants ranging from 10-year-olds to undergraduate students (e.g., Aronson, Fried, & Good, 2002; Blackwell, Trzesniewski, & Dweck, 2007; Braasch, Bråten, Strømsø, & Anmarkrud, 2014; Cury, Elliot, Da Fonseca, & Moller, 2006). Dweck and colleagues have conducted a number of studies that have included assessment of theory-of-intelligence with participants from kindergarten through to adults (e.g., Blackwell et al., 2007; Cain & Dweck, 1995; Hong, Chiu, Dweck, Lin, & Wan, 1999).

Several intervention studies (Blackwell et al., 2007; Donohoe, Topping, & Hannah, 2012; Sciarretta & Cacciamani, 2012) have included interventions that comprised a series of lessons aimed at strengthening students' incremental theory-of-intelligence. Two of these (Blackwell et al., 2007; Sciarretta & Cacciamani, 2012) were quasi-experimental designs in which post-intervention measures showed an increase in incremental theory-of-intelligence, and in the case of Blackwell et al., in achievement, for the intervention group relative to the control group. Donohoe et al. (2012) investigated the effects on incremental theory-of-intelligence, resilience and sense-of-mastery, of an on-line interactive intervention programme, *Brainology* (Mindset Works Inc., 2008). Although their intervention group showed a significant increase in incremental beliefs relative to their control group, a follow-up measure showed that this effect did not endure. No follow-up measures were taken by Blackwell et al., or by Sciarretta and Cacciamani, so the durability of their intervention effects is unknown. Participants in each of these studies were all at least 10 years old. Each of the interventions in these three studies comprised a series of one-off lessons, delivered either by researchers or, in the case of Donohoe et al. (2012), via digital technology. None of them involved teachers making pedagogical changes, which have the potential to exert influence on students' learning over time.

For measuring the theory-of-intelligence of children 10 years and older, Dweck (2000) recommended the six items shown in Table 1. Endorsement of the first three is taken to indicate an entity belief, and endorsement of the remaining three, an incremental belief—represented as the two extremes of the same construct. The entity-belief items have been presented in questionnaires in a number of other studies, conducted in a variety of academic settings (e.g., Ablard, 2002; Gonida, Kiosseoglou, & Leonardi, 2006; Shih, 2007), with students aged from 9 to 15 years, typically using 6-point ordinal scales. In the latter studies, the incremental-belief items were not used; it was assumed that rejection of an entity belief equated with having an incremental belief. A corollary of this assumption is that theory-of-intelligence is a uni-dimensional construct.

Levy and Dweck (1999) explicitly characterised theory-of-intelligence as being not only uni-dimensional, but also as *dichotomous*, asserting that "once an individual has indicated agreement with a particular theory, the degree of agreement typically does not provide additional information" (p. 1167). They described their participants as having *either* an incremental *or* entity belief. However, in Ablard and Mills's (1996) study, which used a single item on a 6-point ordinal scale ranging from