Researching children's 'self' constructs and their success at solving word problems: a pilot study

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Few studies have investigated self-constructs on primary school age children's achievement in mathematics. However, studies on secondary and tertiary levels suggest that academic achievement is influenced by a person's self-efficacy/self-confidence, (a belief in their own ability), social comparison, (comparing own performance with others), self-concept, (perceived ability in a particular area) and attitude towards mathematics. In preparation for a research study in the following academic year, twenty-one year 5 pupils took part in a pilot study in which they completed a psychometric inventory which measured social comparison, self-concept and attitude. Additionally pupils rated their confidence in solving a range of mathematical word problems prior to solving them. Analysis suggests that these self-constructs influence primary age pupils' academic performance.

Key Words: self-efficacy, social comparison, self-concept, attitude, word problems.

Background

During the first author's career as a primary school teacher, she was aware of pupils' difficulty in solving mathematical word problems. During this time, the UK Government and mathematics education interest groups were also aware of pupils' difficulties. This was demonstrated in the renewed UK Primary Framework for Mathematics (DfES, 2006) in which one of the aims was to provide children with the skills to accurately and efficiently solve word problems.

Many researchers have indicated that there are a variety of reasons for pupils' difficulties (see for example, Muir and Beswick, 2005; Mamona-Downs and Downs, 2005; Gooding, 2009), with the most common reasons being pupils' uncertainty of the method to use and their lack of confidence in their own ability. These views were supported by the UK Government Review reports, such as the Cockcroft Report (1982), the Williams Report (2008) and the Rose Report (2008). The Cockcroft Report suggested that children needed confidence in the use of mathematics and that mathematically able children are not always good problem solvers, due to lack of confidence. The Williams Report (2008) further emphasised that fostering good attitudes towards mathematics was needed and the Rose Report (2008) concluded that numeracy proficiency involved confidence and competence.

In this paper the idea of self-confidence affecting the way that pupils problem solve is based on Bandura's social cognitive theory (Bandura, 1977; 1986). Social cognitive theory indicates that a pupil's performance is affected by both their environment and their own personal affective/cognitive constructs, such as self-efficacy beliefs (Bandura, 1986). Self confidence is usually the operationalised measurement of self-efficacy (Schunk, 1991). According to Bandura, self-efficacy beliefs, are a pupil's own judgement of their capacity to execute actions to attain a particular performance level. For example, in terms of word problems, self-efficacy will be pupils' judgements of their ability to solve word problems and their performance will be solving the problem correctly. Bandura suggested that pupils who had high self-efficacy were more likely to persevere at solving a problem and trying different methods whilst a pupil with low self-efficacy was more likely to give up. The reasons for giving up may be because pupils lack the skills to solve the problem or they are unsure how to use their skills (Bandura, 1993). Based on Bandura's social cognitive theory, research studies found that there were positive relationships between pupils' self-efficacy and mathematics performance (see for example Linnenbrink and Pintrich, 2003; Pietsch, Walker and Chapman, 2003; Marat, 2005; Williams and Williams, 2010). There is also an indication that pupils feel less confident in solving problems on areas of perceived conceptual difficulty like fractions (Nunes and Bryant, 2009) and time (Monroe, Orme and Erikson 2002). Rittle-Johnson and Schneider, (in press) suggest that children's conceptual knowledge is often fragmented which could explain the lack of self-efficacy.

Besides self-efficacy, there are other affective/cognitive constructs that can influence pupils' problem solving skills such as self-concept, although there are arguments whether the two are essentially different (see Pietsch et al., 2003). According to Marsh, Relich and Smith (1983) self-concept is one's perceived ability in a particular area based on environmental reinforcements. Self-concept was found to be significantly correlated to measures of performance and hence suggests that self-concept and self-efficacy may be related. In fact, Zimmerman (2000) found that there was a correlation between self-concept and self-efficacy. Self-concept is sometimes operationalised as a measurement both from the affective (i.e. attitudes) and cognitive constructs (Pietsch et al., 2003). The affective domain relates to pupils' attitudes. In fact, Singh, Granville and Dika (2002) found that there was a positive relationship between attitude towards mathematics and performance that would be expected if attitudes formed part of pupils' self-concepts. Marsh (1990; 1993) suggests that social comparison may also affect performance and influence pupils' self-concept. Marsh believes social comparison is how pupils evaluate how good they are in comparison to others and may be considered to be both an environmental and personal factor within social cognitive theory framework. These studies were with secondary and university students. Little research, of this type, has been carried out with pupils of primary school age and therefore this research will explore the extent to which social cognitive theory applies to primary school age pupils.

The aim of this study was thus to investigate how these cognitive and affective constructs (social comparison, mathematics attitudes and self-efficacy) relate to each other and influence the mathematical word problem solving performance of primary school age children, in England and to inform and focus the approach for the main programme of research, which was to take place the following year. A Year 5 class was chosen as most research in this area has focused at the secondary and tertiary level with little indication whether these constructs and attitudes influence performance at the primary school level.

Method

After receiving approval from the headteacher, twenty one Year 5 pupils at a primary school were given a written questionnaire. The questionnaire was used to measure the pupils' mathematics social comparison, mathematics self-concept, attitude towards mathematics, mathematics self-efficacy and mathematics performance. The social-comparison and the mathematics self-concept inventory were from Pietsch et al. (2003). The mathematics self-concept inventory consisted of six items and was a mixture of both competence and affective items that were measured on a scale from 1: 'I disagree' to 3: 'I agree'. This scale was adapted to represent limited complexity to a ten year old. The attitudes questionnaire was based on eight items from Pampaka, Wo, Kalambouka and Swanson (2012) and used a similar scale as the self-concept inventory. Only one social comparison item was used and was measured on a four-point scale from 1: 'Not Very Good' to 4: 'Excellent'.

As the pupils were unfamiliar with this type of questionnaire, the researcher took time to read the questions aloud and discuss them with the class, prior to its completion, so that their meanings were correctly understood. There is a problem with questionnaires (Menter, Elliot, Hulme, Lewin and Lowden, 2011) in that the answers to the questions depend on how they are interpreted. This is particularly important where there are 'reverse (score) coded questions' e.g. 'I am more worried about mathematics than any other subject'.

The mathematics self-efficacy and performance were measured following a similar method and survey design to Pampaka, Kleanthous, Hutcheson and Wake. (2011). Pupils were first asked to assess their self-efficacy in solving fifteen word problems and were then asked to solve these problems. Each correct problem was awarded two marks. These word problems were modified from Pampaka et al. (2011) as their questionnaire was based on a Year 6 class. Self-efficacy was measured on a four point scale from 1: 'Not confident at all' to 4: 'Very confident'. This method was used in order to compare perceived performance with actual performance (Pajares and Miller, 1995). The problem solving tasks were related to mathematical problems in the Year 5 curriculum and included tasks related to fractions, time and height (see Figures 1-3 for examples of problems asked). In the problem solving test, questions were read to the class, again where necessary, but no further explanation was given. The researcher ensured that all of the questions had been attempted and that the data set was complete.

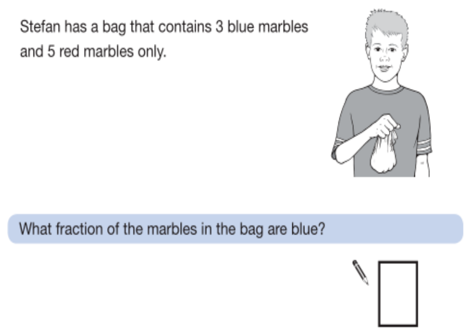

Figure 5: Example of a fraction problem

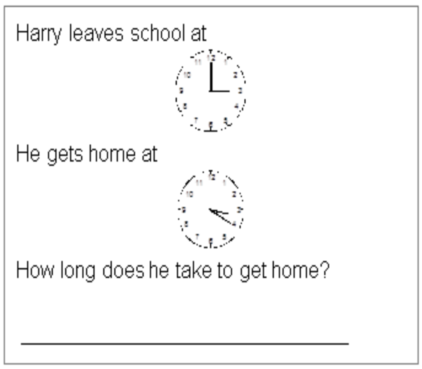

Figure 2: Example of a time problem

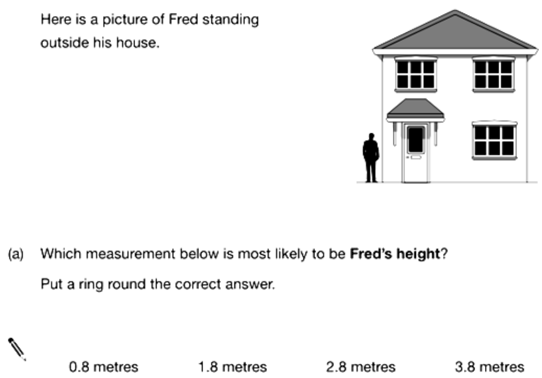

Figure 3: Example of a height problem

Data on pupils' gender and their mathematical level grouping were also collected. Pupils' mathematical level grouping was determined by the teacher, based on the pupil's past performance and on-going assessment. There were two groupings: High and Low level.

Results

Table 1 below shows the make up of the class by attainment and gender.

Table 1: Y5 class make up by level grouping and gender

	Boys	Girls	
High level	8	2	10
Low level	4	7	11
	12	9	21

Pupils were fairly confident in solving each problem, with mean scores on a range of 2.62 to 3.71 (out of 4). The mathematical problems were marked out of 2, and the mean scores for the problems ranged from 0.19 to 2.0. Pupils generally performed lower in problems where their confidence was low. For example, pupils had the lowest confidence in solving the fraction problem in figure 1 (2.62) and also performed poorly (0.57). In the time problem in figure 2, pupils also had low confidence (2.95) and also performed poorly (0.86) and in the height problem in figure 3, whilst pupils were fairly confident of finding the correct solution (3.14) they had the lowest performance of all (0.19).

Using the coding for each of the questionnaire items, the totals for each of the affective/cognitive constructs for the pupils were calculated (see Table 2). Pupils' self-concept and attitudes were quite positive for this class. However, in terms of social comparison, that is, how well the pupils thought they were doing in comparison with their classmates, this was relatively low.

Table 2: The mean totals for the affective//cognitive constructs for the 21 pupils in Year 5

Construct	Mean	Mean as Percentage of Maximum
Performance (out of 30)	15.2	50
Self-Efficacy (out of 60)	46.9	78
Social Comparison (out of 4)	2.5	62
Self-Concept (out of 18)	15.4	85
Attitude (out of 24)	21.9	91

The Cronbach alpha for both the self-efficacy and word problems' performance were within the range required for reliability (0.85 and 0.75 respectively). Although, the pupils had a relatively high self-efficacy (78%) on the word problems their performance was relatively low, that is, pupils only acheived 50% on average.

For each of the variables, the data was found to follow a normal distribution and this allowed the data to be analysed for relationships between the variables, social comparison, self-concept, attitude and self-efficacy in relation to the performance on word problems. A multivariate analysis of variance (MANOVA) was used to determine if there was any difference in the cognitive/affective constructs between the groups by gender and grouping level. Only self-efficacy was found to be significant and this was for gender by the grouping level interaction ($F(1,17) = 5.19$, $p = 0.04$, $\eta_p^2 = 0.23$). The female pupils had similar self-efficacy in both the Low and High level groups (47.9 and 45.0 respectively). However, the boys in the Low level group had a lower self-efficacy score than boys in the High level group (41.8 versus 53.1).

To determine the relationship between the affective/cognitive constructs and the performance in the Year 5 class, a correlation analysis of all the constructs was completed (see Table 3). The results indicate that for the class there is a significant relationship between their self-efficacy, social comparison and their performance. In addition, pupil's self-concept was found to be related to mathematical attitudes. However, this may be because the self-concept inventory included attitudinal items.

Table 3: Pearson's correlation between self-constructs and problem solving

	Social comparison	Self-concept	Attitude	Self-efficacy	Problem solving score
Social comparison	1				
Self-concept	0.42	1			
Attitude	-0.05	0.52*	1		
Self-efficacy	0.56**	0.29	0.21	1	
Problem solving score	0.52*	0.26	0.02	0.48*	1

** 1% level of significance, * 5% level of significance

As there was an interaction with the mathematics level grouping and gender, an exploratory correlational analysis was undertaken. It is exploratory as the sample size is small and hence findings must be taken with caution. The data was first split by gender and a correlational analysis with the affective/cognitive constructs was conducted separately for boys and girls. This was then repeated by splitting the data into the two grouping levels. Interestingly, significant correlations were found between self-efficacy, social comparison and performance only for the boys but not for the girls. Further, when looking at the level groupings, marginal correlations were found between performance and social comparison ($p = 0.06$) and self-efficacy ($p = 0.07$) for the High level group. There were no correlations found for the Low level group for performance. As most of the boys were in the High level group, this may be a contributing factor for the marginal correlations in the level grouping. It is uncertain whether gender or level grouping only is influencing performance or a combination of both.

Discussion

This study found a weak but modest relationship of self-efficacy on problem solving performance which is consistent with analysis of the 2003 PISA survey (Ferla, Valcke and Cai, 2009); other studies such as Zimmerman (2000) have found a stronger relationship between self-efficacy and performance. Whilst Skaalvic and Skaalvic's (2011) longitudinal study found that self-concept was a mediator in performance, no relationship was found in this study. Skaalvic and Skaalvic conducted their study in Norway with pupils' aged 14-16 years. Pupils' age may have an influence on how they view mathematics as Midgley, Feldlaufer and Eccles (1989) noted that pupils' perception of mathematics changes from primary to secondary school. This they found, was due to pupils' perception that they had less support from teachers and so experienced a sharp decline in their perception of the usefulness and importance of mathematics. It may mean that these personal constructs such as self-efficacy with relation to mathematics performance begin to have a stronger impact the older the student is. Perhaps in further studies, which we are conducting with younger pupils (8 to 9 year olds), this relationship between self-efficacy and performance, may be even weaker. Possibly, within the mathematical context, there may be questions about whether social cognitive theory can be applied to younger age groups.

There is also an indication that the primary school pupils' self-efficacy may be dependent on their gender and their level grouping. As pupils' self-evaluation of themselves can be formed by social comparisons (Festinger, 1954), it may be pupils who are in the High level group may perceive themselves as being better than those in the Low level group and hence have a higher self-efficacy. This appeared to be moderated by gender in this study as the girls' self-efficacy did not differ by level grouping, whereas the boys' did. This might be because the girls compared themselves with the other girls and as there were a small number of girls in the High level group, they were not able to socially compare themselves to the same extent as the boys.

Conclusion

The main aim of this study was to investigate how personal affective/cognitive constructs influence the mathematical word problem solving performance of a Year 5 class (9 to 10 year olds), in England. From the analysis it is clear that there is a weak correlation between self-efficacy and success in solving word problems and pupils' social comparison and problem solving success. Self-efficacy and social comparison were also correlated. Self-efficacy in this class was found to be dependent on gender and the level grouping of the pupils.

This was a small scale pilot study and findings must be taken within that context. However, whilst there may be limits in scale, similar results to studies with secondary and tertiary students will confirm that social cognitive theory can be applied to primary school pupils. Although little research of this type has been done with a primary school age group, the effects of self-constructs on problem solving performance will be investigated further as part of a larger study where both qualitative and quantitative data will be used to confirm the findings.

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