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Students' images of mathematics: The role of parents' occupation

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A questionnaire survey was conducted as part of a study investigating post-primary students' images of mathematics in Ireland. A definition of 'image of mathematics' was adopted from Lim (1999) and Wilson (2011). Students' images of mathematics were proposed to include attitudes, beliefs, motivation, self-concept, emotions and past experiences regarding mathematics. This paper focuses on one aspect of the study; the relationship between students' images of mathematics and parents' occupation. Some emergent findings regarding this relationship are presented and discussed.

Keywords: Image of mathematics, affect, parents' occupation.

Introduction

Mathematics education researchers have come to realise in recent decades the significance of mathematics-related affect, with consequential effects on mathematical engagement and performance (Hannula, 2016; Hannula, Ryans, Philippou & Zan, 2004; Lane, O'Donoghue & Stynes, 2014, 2016; Lim, 1999; McLeod, 1994, OECD, 2016). Affect in mathematics education has also been seen to be influenced by various factors including, but not limited to, gender, teachers, parents, peers, society and prior achievement (Frenzel, Goetz, Pekrun & Watt 2010; Hannula et al, 2004; Lane et al, 2014, 2016; Lim, 1999; Morgan, Thornton & McCrory, 2016, OECD, 2016).

There are various constructs investigated by mathematics education researchers in the field of affect. In this study, we focus on the construct 'image of mathematics'.

Although there is no universal definition of 'image of mathematics', there appears to be a general consensus that the term comprises several affective constructs such as: attitudes, beliefs, emotions, self-concept and past experiences regarding mathematics (Brown, 1995; Ernest, 2004; Lane et al., 2014; Lim, 1999). This paper derives from the author's PhD study that examined the image of mathematics held by post-primary students in Ireland (Lane et al., 2014; 2016). No previous research in Ireland had extensively examined second-level students' mathematics-related affect, although studies such as the Programme for International Student Assessment (PISA) have reported on particular aspects such as students' attitudes and confidence (Perkins, Shiel & Merriman, 2013). Lane et al. (2016) found that, similarly to the international context, statistically significant differences occurred for Irish students' images of mathematics with regards to gender, prior achievement and past experiences. Students' image formation was also reported to be influenced by their teachers, parents and peers (Lane et al., 2014). In this paper, one particular aspect of parental influence is examined, with the aim to establishing whether there exists a relationship between parents' occupation and students' images of mathematics. In particular, the author highlights parents' occupations with a strong mathematics base as a distinct occupation category, hypothesizing that these parents would hold positive views of mathematics e.g. in terms of value, and this paper aims to examine whether this positivity would appear to manifest itself in their children.

Theoretical framework

In her study on the public image of mathematics in the UK, Lim (1999) examined the influences on a person's image of mathematics. She found that images were influenced by four external factors, namely: teachers, parents, peers and society (listed in descending order of reported influence). While the relationship between students' mathematics-related affect and their teachers/the way in which they are taught, as well as the importance of peers and peer-learning in relation to affective issues, is evident in the literature (Dweck, 1986; Frenzel et al., 2010; Hill, 2008; OECD, 2016; Pantziara, 2016), the relationship between students' mathematics-related affect and parents/family is less visible.

Parents' occupation

The role of parents as an influence on students' mathematics-related affect and achievement has received some attention in the literature (Fennema & Sherman, 1976; Frenzel et al., 2010; Lane et al., 2014; Lim, 1999; OECD, 2014). Parents' influence can be explained by three underlying mechanisms according to Bosco & Bianco (2005), these being: socialization, modelling and resources. As part of these mechanisms, it is suggested that parents' values, attitudes etc. can be passed to their children, with obvious connotations with regards to students' images of mathematics. Lim (1999) and Lane et al. (2014) found parents to be the second most common influence in forming an image of mathematics. This influence occurs chiefly in the form of support and encouragement, but also indirectly from parents' own images of mathematics. In Frenzel et al. (2010), students' 'interest' in mathematics was found to be higher when his/her parents expressed higher levels of mathematics values. Similarly, ASPIRES (2013) found that a key factor affecting young people's science-career aspirations was the amount of 'Science Capital' a family has. Which includes science-related qualifications, understanding, knowledge, interest and social contacts.

With regards to the role of parents' occupations, this aspect has been found to indirectly impact on children's occupational choices, through their interests and skills (Lawson et al., 2015). The influence of parents' occupation on students' mathematical performance was examined in PISA 2012. Results indicated that across most countries, children whose parents worked as *professionals* (in health, teaching, science, business or administration) had the best results in mathematics (OECD, 2014) indicating a relationship between students' socio-economic background and their mathematics achievement. Furthermore, PISA results indicate that students from disadvantaged backgrounds tend to have a more negative mathematical self-concept than advantaged students, likely linked to lower mathematical achievement (OECD, 2016). Given the influence of parents in terms of students' mathematics-related affect (Frenzel et al., 2010; Lane et al., 2014; Lim, 1999) and also the relationship between affect and achievement in mathematics (OECD, 2016), parents' occupations may impact on student achievement not only in terms of students' socio-economic background, but also in terms of students' images of mathematics.

In this paper, we adapt the definitions of Lim (1999) and Wilson (2011) for her study, with 'image of mathematics' conceptualized as follows: a mental representation or view of mathematics, presumably constructed as a result of past experiences, mediated through school, parents, peers or society. This term is also understood broadly to include three domains:

- The affective domain dealing with attitudes, emotions, and self-concept regarding mathematics and mathematics learning experiences.
- The cognitive domain dealing with beliefs regarding mathematics and mathematics learning experiences.
- The conative domain dealing with motivation regarding mathematics and mathematics learning.

The theoretical framework for the author's study is outlined in more detail in Lane et al. (2014).

Methodology

A mixed-methodology was employed to investigate the image of mathematics held by 5th-year ordinary level mathematics students in second level education in Ireland. The main method used to examine students' images of mathematics was a questionnaire survey. The questionnaire contained both quantitative fixed-response items and qualitative open-ended questions. The quantitative aspect incorporated eight pre-established Likert scales, with a total of 84 items, to examine students' attitudes, beliefs, emotions, self-concept and motivation regarding mathematics – see Table 1. As no single scale existed to measure image of mathematics, the scales were selected that most closely resembled the elements comprising our 'image of mathematics' construct and also that fit with the other scales concisely in terms of length and layout. The five open-ended questions sought to gain further insight into students' images in terms of their influences, prior experience, use of mathematics in everyday life and their causal attributions for success/failure in mathematics. However, this paper aims to address only one aspect of the study with the following research question:

Is there a relationship between image of mathematics and parents' occupation for 5th year, ordinary level mathematics students in Ireland?

In order to address this question, we focus on the quantitative data, with students' scores on the eight Likert-type scales examined with respect to parents' occupation.

Author	Scale	Image of Mathematics Element
Aiken (1974)	Enjoyment of Mathematics	Attitude
Aiken (1974)	Value of Mathematics	Attitude
Fennema & Sherman (1976)	Attitude Toward Success in Mathematics	Attitude
Fennema & Sherman (1976)	Effectance Motivation in Mathematics	Motivation
Fennema & Sherman (1976)	Anxiety about Mathematics	Emotions
Fennema & Sherman (1976)	Mathematics as a Male Domain	Beliefs
Gourgey (1982)	Mathematical Self-Concept	Self-concept
Schoenfeld (1989)	Beliefs about Mathematics	Beliefs

Table 1: Image of Mathematics Scales

A random stratified sample of 60 schools was selected for this study, although only 23 of these agreed to participate. A total of 356 students completed the questionnaire survey. The students were aged

between 15 and 18 years and were all studying ordinary level (intermediate level) mathematics for the Leaving Certificate (end of second level state examination). The author decided to focus on ordinary level students as it was hypothesized that students in this cohort would provide a wider range of images. In addition, a majority of students (72.14% at the time of the study) took the ordinary level mathematics examination for the Leaving Certificate.

Findings

In this section, findings are presented in relation to parents' occupation and the relationship with students' images of mathematics. The quantitative data were analyzed using Statistical Package for the Social Sciences (SPSS) (version 19). In acknowledgement of the debate among researchers as to whether parametric or non-parametric methods of analysis should be applied to Likert scales (Jamieson, 2004), both methods were employed with similar findings (see Lane et al., 2014). The internal reliability of the eight scales was examined using Cronbach's alpha, with six scales found to have values above 0.8. The Value scale scored above 0.7, still a good internal consistency but the Beliefs scale was found to have a very low Cronbach's alpha of 0.21, possibly due to the short length of the scale – six items. The 84 items in total – referred to here as the combined image of mathematics scale – had a very high internal consistency of 0.94. Correlation was carried out on the scales, with each scale correlated with all other scales and also with the combined scale. The relationships between the scales was also examined using partial correlation, controlling for the effect of each individual scale on the relationship between the other seven scales. A Principal Components Factor Analysis and Multiple Regression Analysis were also employed. The analyses indicated that the Attitude towards Success in Mathematics Scale and the Mathematics as a Male Domain Scale were not found to correlate highly with the other scales used in this study and so the author has decided to not address these scales here. The median scores on each of the remaining six scales are examined according to parents' occupation. A higher score on any of the scales indicates a more positive attitude, belief, emotion etc.

As parents' occupation was an optional item on the questionnaire, this item received the lowest response rate out of the entire questionnaire with just over half of students providing an answer (n=179). Reported parents' occupations were qualitatively reviewed and grouped into categories. Occupations were grouped similarly to Lim (1999) in her study on the public image of mathematics. Due to the fact that the author wished to acknowledge occupations involving a significant knowledge of mathematics, i.e., financial banking, accountancy, mathematics teacher etc. it was decided to include a sixth category relating to this. Initially, parents' occupation was explored with categories that differentiated between one or both parents' occupations being provided. However, as some of these categories contained very few students, groups were collapsed into the 6 categories of: Professional; Managerial and Technical; Skilled (both manual and non-manual); Unskilled and Partially skilled; Mathematics; and Others (unemployed, retired and unclassifiable occupations). Median scores for these categories are also compared with those for students who did not provide their parents' occupations (Not Given).

Enjoyment of mathematics

The re-grouped categories of the parent(s)' occupation variable were first examined with regards to students' enjoyment of mathematics. The highest possible score for this scale was 55. Students with the highest median score for enjoyment of mathematics (40.5) had parents whose occupation involved

mathematics. The lowest median for enjoyment of mathematics (27.0) was found to be students whose parents' occupations were categorized as 'other'. There was little difference between the medians for the other 5 categories.

Value of mathematics

Parents' occupation was examined in relation to students' value of mathematics (highest possible score being 50) but the range of medians for the Value of Mathematics Scale was quite small with the highest median (38.0) being for students with parents grouped as Managerial and Technical as well parents grouped as Mathematics, and the lowest median (33.0) being for students whose parents' occupations were classified as Other.

Motivation in mathematics

The highest median score for motivation in mathematics (39.5 out of a possible 60) was found for the Managerial and Technical category. This was closely followed by the Mathematics grouping with a median score of 39.0. The lowest median score on the Motivation scale (30.0) was recorded for students' whose parents' occupations fell within the Other classification.

Beliefs about mathematics

For the Beliefs scale, the range of median scores was small for the parents' occupation categories. The highest median score on the Beliefs about Mathematics Scale (20.0 out of a possible 30) was found for students whose parents' occupations were classified as either Managerial and Technical or Other. The lowest median score (18.0) was recorded for students' whose parents' occupations fell within the Skilled grouping.

Mathematical self-concept

It was found that the students with the highest median score for the Mathematical Self-concept scale (43.5 out of 60) were those with parents in the Mathematics category. The lowest median score for the Self-concept scale (33.0) was recorded for students whose parents were classified as Professional. This was the first instance of the Professional grouping scoring the lowest on a scale.

Anxiety about mathematics

Finally, the parents' occupation variable was examined with regards to the Anxiety about Mathematics Scale. Students with parents who work with mathematics had a much higher median score for the Anxiety scale (43.0) compared with all other groups (meaning these students reported the lowest anxiety levels). The lowest median score for the Anxiety about Mathematics Scale (34.0) was recorded for two groups of students, those with parents in the Skilled and Other classifications.

Discussion

The most significant finding with regards to the relationship between parents' occupation and students' image of mathematics may be with regards to students whose parents are involved in mathematics-related occupations. For most of the scales, and also for the combination of the scales, the Mathematics category of parents' occupation showed the highest median scores and, in some situations, was set apart considerably from the other categories. Students with parents in the Mathematics classification of occupations were found to report the highest enjoyment of mathematics, the highest value of mathematics, a high motivation regarding mathematics, the highest

mathematical self-concept and the lowest anxiety levels with regards to mathematics. Given the suggestion in the existing research that parents can influence students' mathematics-related affect and possibly, their achievement in mathematics (Frenzel et al., 2010; Lane, 2013; Lim, 1999), it is perhaps to be expected that parents employed in mathematics-related occupations will have children with a more positive image of mathematics. In particular, it is not surprising that students whose parents work with mathematics would report a positive value of mathematics, but it would not necessarily be anticipated that these students would report higher enjoyment, higher self-concept or lower anxiety. While the PISA findings (OECD, 2014) indicate a relationship between parents' occupation and achievement in mathematics, the occupation category linked with higher achievement in that study was not specific to mathematics, although it would include mathematics related work. Their findings relating to parents' occupation and achievement are likely due to the better educational opportunities afforded to students whose parents are classified as professionals (the resources aspect of parental influence seen in Bosco & Bianco, 2005), but for the students in this study, there was no significant difference between students' reported images with regards to the type of school attended (Lane et al., 2016). Therefore, it can be hypothesized that the differences come from the parents themselves, and not from the educational opportunities afforded by parents. This ties in with the socialization and modelling aspects of parental influence (Bosco & Bianco, 2005). The significance of this finding lies in the important role parents play in positively influencing their children's mathematics-related affect. Another possibility is that parents involved in mathematics-related careers are more able to provide help with mathematics homework. This extra home support may also positively influence these students in terms of their image of mathematics. Similar findings were observed in the ASPIRES study (2013) in relation to parental influence and engagement with science and science careers. Whatever the case, parents who work in mathematics related occupations would seem to have children with a more positive image of mathematics, and while the possibility of other factors should be acknowledged, the relationship between parental influence and student affect with regards to mathematics is clearly one that requires attention. That students whose parents were employed in mathematics based occupations reported the highest self-concept and lowest anxiety regarding mathematics is particularly of note, as Pantziara (2016) highlights the predictive role of students' self-efficacy in their current and future education and course selection. Thus, the potential benefits of positive parental influence in terms of mathematics-related affect are far reaching.

Conclusion

Findings from this study suggest a relationship between parents' occupation and students' self-reported images of mathematics exist. The positive image of mathematics found to exist among students whose parents are employed in mathematics-related careers, may offer an insight into the role of parents in the formation of a student's image of mathematics, particularly in terms of the socialization and modelling aspects of influence (Bosco & Bianco, 2005). Parents with positive attitudes, beliefs etc. about mathematics, may pass this positivity to their children, thus creating a cycle of positivity and engagement with mathematics. These parents are likely to be in a better position to provide additional support with mathematics work. Given the role played by parents in terms of their children's education and future occupations (ASPIRES, 2013; Lawson et al., 2015), the influence of parents in students' image of mathematics formation (Lim, 1999; Lane et al., 2014) and the link between affect and future course selection and achievement (OECD, 2016; Pantziara, 2016), it is essential to recognize the part that parents may play in influencing students' engagement with

mathematics education and mathematics related careers. Due to the small number of students in this study with parents involved in mathematics based careers, these findings cannot be taken as conclusive and indeed further research would be necessary to clarify the relationship between parents' occupation and students' images of mathematics, and also the role of parents in influencing students' mathematics-related affect and indeed their current and future engagement in mathematics.

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