Mathematics self-efficacy and its association with parental support and teaching practices in UK secondary school mathematics

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In this report, we draw on data from a study of UK secondary school students with a focus on mathematics self-efficacy (MSE) and its relation with other variables. We are particularly interested in parental support and perceptions of teaching practice, and to further explore if these relationships are affected when considering student characteristics, such as gender and year group. Our methodological approach includes a validation stage with the use of the Rasch model and a modelling stage with linear regression. Some indicative results with the sample of 13643 students are discussed in relation to their implications for practice and also in the context of an upcoming (comparative) study in Macau.

Introduction

Our research focus in the present study is on the mathematics self-efficacy (MSE) of the UK secondary students. The reason that we focus on MSE is because of its critical importance for students' mathematics achievement, academic and career choices as shown in various research studies (e.g. Hackett, 1985; Pajares & Miller 1997; Williams & Williams, 2010). For example, PISA (OECD, 2013) showed that one unit of MSE index is associated with an average difference of 49 points in maths performance across countries, which is the equivalent of an additional year of school.

Previous studies had identified many socio-cultural factors to be related with students' dispositions and decision-making in education, especially in the STEM subjects: gender, class, ethnicity, parents and peers, amongst others. Moreover, in our recent studies, transmissionist teaching practice was found to be negatively associated with UK secondary students' mathematics disposition (e.g. Pampaka et al., 2012; Pampaka & Williams, 2016). However, there is less research on the possible influences of the combination of parental, teaching as well as students' individual characteristics on this mathematics affective disposition - namely MSE – which is what we aim to address in this paper.

Overview of literature

Bandura (1997) had initially contextualised the self-efficacy construct into two dimensions: personal self-efficacy and outcome expectancy. Thus, the theoretical perspective of this study as well as the construction of the instrument for measuring MSE, are mainly based on this perspective. Bandura (e.g. 1986) defined self-efficacy as an individual's self-confidence of his/her capability to organise and have control over his/her own actions, "*in order to produce given attainments*" (1997 p. 3), while perceived self-efficacy "*is a judgement of one's ability to organise and execute given types of performance…*" (Bandura 1997, p.3). Following this perspective, a robust self-efficacy measurement should be contextualised and specific to a discipline (e.g. Pajares & Miller, 1995). These measurement implications are also shown in the methodology of this study. Bandura (1997) also postulated the four determinants of

self-efficacy, including mastery experiences, vicarious learning, verbal persuasion, physiological and emotional state. However, the academic socialisation model (Taylor, Clayton & Rowley, 2004) suggested that parents' academic beliefs and behaviours can be socialised to their children through daily practices. This conceptual model reflects both the principle of the ecological theory of development (Bronfenbrenner, 1986) and the contextual system model (Pianta & Walsh, 1996), in order to link intergenerational influences with children's academic outcomes. Thus, in this study, we aim to address how parents' academic supporting behaviours (e.g. checking and helping homework and giving home-learning resources) can affect UK secondary students' MSE. Finally, we are informed by the general argument for the importance of the quality of mathematics teaching on students' learning, and the call for more dialogical and connectionist pedagogies for conceptual, metacognitive, and affective outcomes (e.g. Black & Wiliam, 1998; Wilkins & Ma, 2003). This was also shown in our previous work in post compulsory education (Pampaka et al., 2012; Pampaka & Williams, 2016).

Thus, in this study, we aim to unveil the relationship between students' perceived parental academic support, perception of the teaching practices they experience (transmissionist teaching) and their MSE, by considering their individual characteristics simultaneously.

Methods and data

Project design and sampling

The results presented here are part of a larger ESRC (Economic Social Research Council) funded project of teaching and learning secondary mathematics in the UK (www.teleprism.com). The project was largely based on longitudinal surveys of students and their teachers in all 5 year groups of compulsory secondary education (Year 7 to 11, i.e. students aged 11 to 16) and took place from October 2011 to December 2012. The study employed a varied sampling frame to ensure maximum coverage of the schools of England, establishing collaboration and responses from 40 of them (for more details on sampling see Pampaka & Wo, 2014; Pampaka & Williams, 2016). For this analysis we draw on data from the first data point which includes responses from 13643 students who were in year 7 (N=3926), year 8 (N=3039), year 9 (N=2716), year 10 (N=2127) and year 11 (N=1835).

Instrumentation

Data collection took place from October to December 2011 involving a questionnaire covering students' attitudes towards mathematics, confidence on various mathematical topics (MSE), future aspirations, and their perceptions of the teaching they encounter. For the measurement of MSE we followed the same approach as described in previous work (Pampaka, Kleanthous, Hutcheson & Wake, 2011; Pampaka & Williams, 2010) with items appropriate for the involved year groups. Students were asked to report their confidence, using a 4–point scale (Not confident at all (1), Not very confident (2), Fairly Confident (3), and Very confident (4)) on solving each of the given mathematical tasks (but emphasising that they should not solve the problems).

Analytical Approach

The first analytical step involves a measure validation stage which is performed within the Rasch measurement framework, seeking validity evidence through various statistical indices (e.g. item fit and category statistics, Differential Item Functioning, person-item maps). The method has been extensively used within our current and previous work (e.g. Pampaka et al., 2012; Pampaka & Williams, 2016), which allows for the construction of continuous measures based on the responses to various ordinal items, and for checking if the data fit the model and fulfil its assumptions. Once the measures' validity is established, we use these new measures in further statistical modelling with linear regression (Hutcheson & Sofroniou, 1999) to investigate and model students' MSE and its associations with students' characteristics, parental support and their perception of transmissionist teaching.

Results

Overview of Validation with Rasch Measurement

Rasch model results show good psychometric properties for the MSE construct. With regards to the construct validity, both item fit and category statistics are within acceptable ranges (i.e. between 0.75 and 1.3 infit and outfit meansquare). Insignificant differential item functioning (DIF) also confirms measurement invariance across groups of interest (e.g. gender). The person-item map (histogram, Figure 1) also shows good distribution of students and items on this common measurement scale (i.e. ranging from -8 to +7 logits. The same approach (which is only overviewed here due to space limitation) have also been used for the validation of the other measures used in this study: perceived transmissionist teaching (i.e. the higher the score the more 'traditional' or teacher-centred the practices as reported by students), and perceived parental support (i.e. higher scores indicating more perceived parental support).

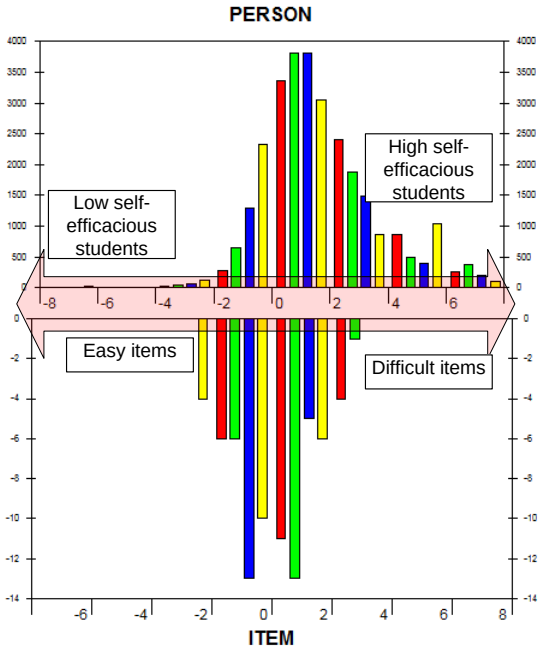

Figure 1: Person-item map (histogram) for MSE scale

Regression Models of MSE

The resulting measures (i.e. person scores from Rasch model) were subsequently analysed with regression models (General Linear Modelling with R). We adopted a stepwise procedure to input explanatory variables into models following theoretical assumptions (MSE as the outcome variable in all models):

- Step 1: Gender and year group of students (Model 1);
- Step 2: Parental academic support (Model 2)
- Step 3: Whether parents have participated in higher education (Model 3)
- Step 4: Students' perception of transmissionist teaching (Model 4)

The results of this process with model fit statistics and the coefficients of each model are summarised in Table 1. Further explorations informed the need to include the interacting variables as with Model 1 (where we found a significant interaction between gender and year group on MSE) for the subsequent modelling steps. This interaction can be best illustrated with Figure 2. As shown in the figure, male students show significantly higher MSE than female students across year groups. In particular, male students' MSE increases consistently across year groups while female students report an obvious drop in MSE from year 8 to year 9. Model 2 shows that parental academic support is significantly and positively associated with MSE, when accounting for the effects of gender and year group. Similarly, Model 3 shows that both parental academic support and whether parents have participated in HE are significantly associated with MSE; but with a slight decrease in the effect of parental academic support (the coefficient). This suggests that part of the effect of parental academic support on MSE may be mediated by whether parents have participated in HE. This possibility is further supported when looking at the association between the two variables as shown with a model of parental support as the outcome and parental participation in HE as the explanatory variable: students perceived their parents who have participated in HE as showing significantly higher academic support than parents who have not participated in HE (0.27 logit higher, SE=0.02, p<.001) and those who do not know if their parents have participated in HE (0.15 logit higher, SE=0.02, p<.001).

Lastly, Model 4 of MSE shows that students' perception of transmissionist teaching is significantly and negatively associated with their MSE, when controlling for other explanatory variables in the model. Similar to previous models, both parental academic support and whether parents have participated in HE are still significant positive correlates of students' MSE in this model.

Exploratory variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Constant	1.37 (0.05)	1.38 (0.05)	1.80 (0.05)	1.83 (0.05)
Gender (Ref: Male)	-0.33 (0.06) ***	-0.35 (0.06) ***	-0.32 (0.06) ***	-0.31 (0.06) ***
Year Group (Ref: year 7)				
Year 8	0.12 (0.07)	0.13 (0.07) *	0.16 (0.07) *	0.17 (0.07) *
Year 9	0.41 (0.07) ***	0.43 (0.07) ***	0.47 (0.07) ***	0.48 (0.07) ***
Year 10	0.58 (0.07) ***	0.61 (0.07) ***	0.62 (0.08) ***	0.64 (0.08) ***
Year 11	0.84 (0.08) ***	0.89 (008) ***	0.95 (0.08) ***	0.98 (0.08) ***
Gender (Ref: Male):Year group (Ref: year 7)				
Year 8	0.13 (0.09)	0.15 (0.09)	0.05 (0.09)	0.04 (0.09)
Year 9	-0.37 (0.09) ***	-0.35 (0.09) ***	-0.40 (0.10) ***	-0.39 (0.10) ***
Year 10	-0.40 (0.10) ***	-0.38 (0.10) ***	-0.38 (0.10) ***	-0.37 (0.10) ***
Year 11	-0.30 (0.11) **	-0.29 (0.11) **	-0.33 (0.11) **	-0.33 (0.11) **
Parental academic support		0.09 (0.02) ***	0.06 (0.02) ***	0.04 (0.09) **
Parent have been to HE (Ref: Been to HE)				
Not been to HE			-0.59 (0.04) ***	-0.59 (0.04) ***
Don't know			-0.84 (0.04) ***	-0.84 (0.04) ***
Perceived Transmissionist teaching				-0.14 (0.04) ***
Model Fit Statistic	**Model 1**	**Model 2**	**Model 3**	**Model 4**
F (degree of freedom)	50.16 (9,12721)	48.44 (10, 12702)	82.2 (12,11593)	77.13 (13, 11586)
R^2	0.03427	0.03674	0.07842	0.07965
Adjusted R^2	0.03359	0.03598	0.07746	0.07862
p-value	<.001***	<.001***	<.001***	<.001***

Note. Model parameters on the top part of the table are presented as: coefficients (Standard error) & significance (p<.001***; p<.01**; p<.05*). Gender : Year group is the interaction analysis.

Table 1: Regression models for MSE (as the outcome variable).

When comparing the interaction pattern between gender and year group on MSE across models, it can be seen they are similar (as shown in Figure 2), even when accounting for parental and teachers' influence.

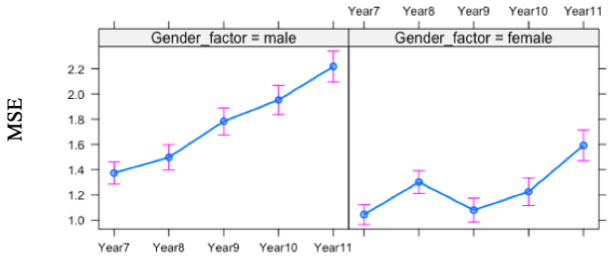

Figure 2: Effects plot for MSE (Model 1) showing the interaction between gender and year group.

Conclusion and Discussion

In this study, we have focused on using data collected from our previously constructed measures of MSE, parental academic support and perceived transmissionist teaching in regression models for MSE (as the outcome). After overviewing the measures' validation approach and results, modelling results have shown that social contextual factors at home (i.e. parental academic support and whether parents have a HE background) and students' perception of transmissionist teaching are significantly associated with their MSE, when accounting for the effects of students' personal characteristics (i.e. gender and grade year). Similarly, when accounting for the effects of the above factors, students' personal characteristics are also significant correlates of MSE. Such findings can help teachers and parents adopt approaches with students for better maths learning experiences.

Our findings suggest that parents who have participated in HE would show higher academic support to their child, such as helping with homework, finding a tutor to help with homework and giving appropriate encouragement, which in turn help improve their child's MSE. This is consistent with a previous study suggesting the positive effect of home resources on students' MSE (Kung & Lee, 2016). Moreover, our findings also suggest that more transmissionist teaching practices are related to decline in secondary students' MSE. This is also consistent with our previous findings that more traditional transmissionist teaching would increase the decline in students' learning disposition towards mathematics (Pampaka & Williams, 2016). Our results also confirm previous findings about the importance of students' gender on MSE. Across our modelling analyses, there is a consistent and significant interaction between gender and year group on MSE, when we account for both the impact of parents and perceived teaching practice. UK female students show a significant decline in MSE from year 8 to year 9, which is not observed from male students. Thus, there is a need to further explore this gender differences.

Our findings also provide directions for future cultural comparison study of MSE: Social and contextual factors such as parental influences, social comparison and school teaching may help investigate the universal utility of MSE across cultures, especially in the Chinese Confucian culture that highly values family, groups and teachers. This research direction will be emphasised in an upcoming comparative study of MSE in Macau context.

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