Reducing mathematics anxiety in primary school teachers through collaborative reflection using the knowledge quartet

Fay Cosgrove

St Joseph's Cathedral Primary School

The current research concerns a possible professional development intervention to reduce anxiety felt by teachers when teaching mathematics, in turn aiming to reduce the anxiety passed on by teachers to their pupils. The design of the professional development intervention was based on the theoretical ideas of The Knowledge Quartet which focuses teachers on subject-specific skills for teaching mathematics. The research took place over three months in the academic year 2017-18 and involved four teachers in primary schools in Swansea. Teachers videoed their own lessons and in pairs discussed critical incidents captured, linking to the 20 codes of the Knowledge Quartet. Findings suggest that mathematics anxiety may be reduced and teacher learning promoted. Implications for future research are discussed.

Key Words: Mathematics Anxiety, Reflection, Collaboration, Knowledge Quartet

Mathematics Anxiety

Anxiety caused by doing mathematics or considering doing mathematics has long been known as Mathematics Anxiety (MA). First reported by Tobias in 1978, MA has since been the topic of many dozens of publications (e.g. Beilock, Gunderson, Ramirez & Levine, 2010; Punaro & Reeve, 2012; Hill et al., 2016). Highly mathematics-anxious people are prevented from demonstrating their maths abilities by the fear they feel (Beilock, 2008, National Mathematics Advisory Panel, 2008). Gresham (2009) suggests that teacher efficacy is negatively correlated with MA. Ramirez, Hooper, Kersting, Ferguson, and Yeager (2016) and Beilock et al. (2010) show a negative correlation between teacher MA and pupil attainment.

Professional Development Intervention – a focus on reflection

Hendel and Davis (1978) and Tooke and Lindstrom (1998) suggest that interventions with mathematics anxious teachers can be effective in reducing MA. What these studies have in common is an element of reflection: counselling in the case of the former and discussions about pedagogy in the case of the later. However, as McIntosh (2010) suggests, modern education systems often require teachers to reflect but rarely do they prepare practitioners to understand reflection or train them to do it effectively. In his opinion, reflection by those ill-equipped to reflect is superficial and fails in its purpose.

One possible method to assist teachers in meaningful reflection is for them to video themselves teaching and use the recording as a stimulus while reflecting. Coffey (2014) states that video is a more permanent record of teaching on which to

base reflection. Likewise, Hollingsworth and Clarke (2017) recommend the use of video to aid analysis of practice, commenting that it both supports and provokes teacher learning. Baecher, McCormack and Kung (2014) see video as a tool to allow teachers to examine their own teaching and focus on behaviours that might otherwise go unnoticed. Kourieos (2016) reports that video stimulated reflection was beneficial in helping form links between theory and practice and that the greatest potential was when guided reflection and peer dialogue were informed by the use of video.

There is also evidence from pre-service teachers that the involvement of a mentor is beneficial when reflecting. For example, Prouty (2009) suggests that mentoring increases preparedness for teaching and enhanced content knowledge. Turner (2012) reports that teachers benefit from the involvement of a 'more knowledgeable other' while reflecting, particularly when reflecting on specialised content knowledge.

Methodology

Context & Purpose

The current research took place in an inner city Catholic primary school with 518 pupils on roll. As is common in primary schools in Wales, teachers are generalists and teach the full breadth of the curriculum. Mathematics is taught for an hour every day. The school is led by a Head Teacher who promotes and encourages teacher involvement with initiatives such as classroom research. The current wider political climate in Wales supports teacher enquiry. Education policy is moving towards classroom practitioners determining effective practice (Welsh Government, 2016).

The purpose of the current research is to explore a) whether reflection on the teaching of mathematics could change teacher attitudes to mathematics and b) the design of an in-school professional development initiative to promote effective reflection.

In a previous, unpublished study, I trialled a questionnaire for primary school teachers to identify individuals who were more worried about teaching mathematics than literacy. This identified two teachers who agreed to participate in the current study. An open invitation produced two further participants giving a total of four, two of whom were likely to have high MA and two of whom were less likely to feel substantial MA. This formed a small, convenience sample of volunteers. According to Etikan, Musa and Alkassim a convenience sample has the advantage of requiring only "limited resources, time and workforce" (2016, p. 1) however they point out that such samples have drawbacks not least of which is a decreased usefulness for generalisation. Since the current research does not claim to be generalisable, the advantages of this type of sample outweigh the disadvantages.

Each participant completed online questionnaires to measure baseline MA and teaching efficacy beliefs (both general and mathematics specific). The MA tool was based heavily on Suinn & Winston's (2003) 30 item Mathematics Anxiety Rating Scale (MARS). It included nine Likert scale items and a tenth open ended item asking respondents to describe their experiences, feelings or memories from studying mathematics before they became a teacher. An online questionnaire of general teaching efficacy beliefs and of teaching efficacy for mathematics was also used. These measures were repeated after the intervention was complete to allow within participant analysis.

A priori, it was not known what differences, if any, would be captured by the quantitative measures. In order to triangulate any changes or in the case of no changes to provide an opportunity to observe fine-grained changes not measureable by questionnaire, qualitative measures were also employed. Participants completed an open ended task in which they were asked to draw themselves doing mathematics. It was hoped that this would allow participants to reveal their feelings in a less threatening way. Occasional unstructured questions were asked to elicit explanations and probe thoughts and feelings. This activity was video recorded.

This task was also repeated at the end of the intervention when the exit interview was conducted.

Intervention

In order to focus participants on mathematics-specific elements of teaching rather than general skills for teaching, a reflection framework was selected. I chose a framework developed by Rowland (2009) called the Knowledge Quartet (KQ) mainly because it resonates with my own ideas about teaching mathematics. I have found it effective in helping me to reflect on my own teaching. It consists of four dimensions; Foundation, Transformation, Connection and Contingency. The KQ was written with non-specialist teachers and observers in mind making it appropriate for use in primary schools where almost all teachers are generalists. It provides,

> a process of structured reflection whereby teachers – at any stage of their career – can take control of the development of their expertise in teaching mathematics. (Rowland et al., 2009, p. xv)

Participants voluntarily attended a half day seminar with Tim Rowland, co-author of the KQ, aiming to introduce participants to the core concepts associated with the framework and with its origins. At the end of the seminar, instructions were given for participants to video record themselves teaching using a camera on a tripod to remove the influence of introducing an extra adult into the classroom. They were asked to use the KQ to reflect on their teaching individually and select critical incidents exemplifying strengths or opportunities for improvement matched to KQ codes. Identified incidents were discussed during joint reflections and written comments amended or augmented. This cycle of record, reflect, and discuss was repeated four times over three months.

Bassot (2016) points out that teaching is often an activity undertaken without other adults and that reflecting jointly can be both refreshing and illuminating. Thus the four participants were to form two partnerships (participants 1 & 3 and participants 2 & 4). However participant 4 withdrew from the study leaving participant 2 without a partner. By mutual consent, I became participant 2's reflective partner. The first pair could be considered a 'peer' partnership while the pair I joined was considered a mentor partnership. This difference was perhaps important because it had an impact on the reflective discussions (see later).

Data Analysis

Quantitative measures were scored and comparisons were made between the pre- and post- intervention total for each scale. These data were triangulated using qualitative data from interviews, lessons, joint reflections and drawing task recordings. Through critical incident analysis (Bassot, 2016), I sought evidence for or against a number of themes; attitudinal changes to mathematics or to the teaching of mathematics;

attitudes to reflection and to the use of the KQ framework; attitudes to video recording and evidence of teacher learning. I wrote memos as I reviewed various forms of data, recording preliminary interpretations and conceptualisations of the data.

Data

Participant	Maths Anxiety	General Teaching Efficacy	Maths Teaching Efficacy
1 (Lowest MA at start)	Increased by 13% (15 to 17)	Increased by 2% (negligible)	Increased by 7%
2	Decreased by 38% (16 to 10)	Increased by 21%	Increased by 28%
3 (Highest MA at start)	Decreased by 18% (17 to 14)	Increased by 2% (negligible)	Increased by 6%

All participants showed changes in MA. This could be due to genuine changes in the participant's thinking attributable to the intervention or to unknown factors occurring at the same time as the intervention. However, it must be acknowledged that some of the differences in scores could be due to problems with the questionnaires. Well-known, publicly available scales have associated test-rest reliability data that would indicate whether the current changes are genuine changes in thinking or within the normal range of variance (for example, Hopko, Mahadevan, Bare, & Hunt, 2003). Given that the current research used adapted versions of well-known scales, we cannot rely on the associated reliability data of the original versions. No such reliability data exists for the adapted versions of the scales. Instead, reference to the qualitative data gathered allows triangulation and interpretation.

In the case of P1, whose MA score increased a little, the qualitative data implies that the change in MA score is due to test-retest variance rather than a real increase in MA. There is nothing in her interview comments or elsewhere to suggest that she actually worries more since the intervention.

P3's MA score decreased a little. Qualitative data suggest that it may be a real reduction in anxiety: there are marked differences between pre and post intervention data. Before the intervention, she stated that having another teacher to work alongside while teaching mathematics would reduce the anxiety she felt so it might be expected that her anxiety would be reduced by reflecting collaboratively. Contrary to my conclusion about P1's change in MA, I believe that P3's difference in score is due to a real, if small, reduction in anxiety.

P2's reported MA changed the most, decreasing from 16 to 10 (a change almost twice the magnitude of any other) and her self-efficacy scores increased considerably more than those of the other participants. The size of the changes and her qualitative indicators imply that this is a real change in MA. Comments before the intervention include dreading and being frightened of mathematics and of mental shutters going down when under pressure whilst after the intervention she stated she felt relieved and had enjoyed the experience.

Discussion

One possible explanation for the greater changes reported by P2 could come from the use of time within joint reflections. P2 & I reviewed the video recordings and identified critical incidents before we met. P1 and P3 did not prepare in this way. As a

consequence, they spent three and a half times as long as we did simply watching recordings. It follows that our discussions were in greater depth and offered more value to P2.

It could also be argued that the apparent benefits of the intervention came from recording and reviewing teaching as much as from collaborative reflection. Indeed, participants claimed to have benefitted from watching their own teaching. Like Kourieos (2016) and Hollingsworth and Clarke (2017), I would argue that reviewing video footage for reflection is most valuable in combination with dialogue focused by the use of a framework. The results of the current research suggest that there is some value in watching recordings but that this value is increased when observations are focused and shared.

There is also a risk that P2's responses were biased in favour of the intervention as a result of possible increased loyalty to me. I spent more time with P2 than with the other participants potentially fostering a closeness which might have influenced her responses to the post-intervention measures.

Recommendations

It would appear that the intervention made a difference to at least one teacher's feelings about mathematics and about teaching mathematics. An intervention of this type may help reduce teachers' feelings of MA though it is impossible to generalise from such a sample.

It would appear that the intervention was effective in promoting teacher learning. In my opinion, it may be that teachers are more used to being scrutinised than supported and that any collaboration is seen as a refreshing change and therefore is received positively. If this is true, then it may follow that almost any intervention could stake a claim to making a difference to teacher learning. A larger study with an indication of effect size would facilitate a more critical evaluation of the current intervention and give guidance on the generalisation of the current findings.

This research was funded by the National Network for Excellence in Mathematics (in Wales).

References

Baecher, L., McCormack, B., & Kung, S.-C. (2014). Supervisor use of video as a tool in teacher reflection, *Tesl-Ej, 18*(3), 1-16

Bassot, B. (2016). *The reflective journal* (2nd Ed.), London: Palgrave

Beilock, S., Gunderson, E., Ramirez, G., & Levine, S. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences of The United States of America, 107*(5), 1860-1863

Beilock, S. (2008). Math performance in stressful situations. *Current Directions in Psychological Science, 17*(5), 339-343

Coffey, A.M. (2014). Using video to develop skills in reflection in teacher education students. *Australian Journal of Teacher Education, 39*(9), 86-97

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics, 5*(1), 1-4

Gresham, G. (2009). An examination of mathematics teacher efficacy and mathematics anxiety in elementary pre-service teachers. *The Journal of Classroom Interaction, 44*(2), 22-38

Hendel, D.D., & Davis, S.O. (1978). Effectiveness of an intervention strategy for reducing mathematics anxiety. *Journal of Counseling Psychology*, *25*(5), 429-434

Hill, F., Mammarella, I.C., Devine, A., Caviola, S., Passolunghi, M.C., & Szűcs, D. (2016). Maths anxiety in primary and secondary school students: Gender differences, developmental changes and anxiety specificity. *Learning and Individual Differences*, *48*, 45-53

Hollingsworth, H., & Clarke, D. (2017). Video as a tool for focusing teacher self-reflection: Supporting and provoking teacher learning. *Journal of Mathematics Teacher Education*, *20*(5), 457-475

Hopko, D. R., Mahadevan, R., Bare, R. L., & Hunt, M. K. (2003). The abbreviated math anxiety scale (AMAS) construction, validity, and reliability. *Assessment*, *10*(2), 178-182.

Kourieos, S. (2016). Video-mediated microteaching – a stimulus for reflection and teacher growth. *Australian Journal of Teacher Education*, *41*(1), 65-80

McIntosh, P. (2010). *Action research and reflective practice: Creative and visual methods to facilitate reflection and learning*. London: Routledge

National Mathematics Advisory Panel. (2008). *The final report of the National Mathematics Advisory Panel, U.S. Department of Education*. Retrieved from https://www2.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf

Prouty, D. (2009). Developing math and science teacher pedagogical skills through electronic mentorship. *Distance Learning*, *6*(4), 36-42

Punaro, L., & Reeve, R. (2012). Relationships between 9-year-olds' math and literacy worries and academic abilities. *Child Development Research*, *2012*, 1-11

Ramirez, G., Hooper, S.Y., Kersting, N.B., Ferguson, R., & Yeager, D. (2018). Teacher math anxiety relates to adolescent students' math achievement. *AERA Open*, *4*(1), 1-13

Rowland, T. (2009). *Developing primary mathematics teaching: Reflecting on practice with the knowledge quartet* (Vol. 1). Thousand Oaks: Sage

Suinn, R., & Winston, E. (2003). The mathematics anxiety rating scale, a brief version: Psychometric data. *Psychological Reports*, *92*(1), 167-173

Tobias, S. (1978). *Overcoming math anxiety*. New York: WW Norton & Company

Tooke, D.J., & Lindstrom, L.C. (1998). Effectiveness of a mathematics methods course in reducing math anxiety of preservice elementary teachers. *School Science and Mathematics*, *98*(3),136-139

Turner, F. (2012). Using the Knowledge Quartet to develop mathematics content knowledge: The role of reflection on professional development. *Research in Mathematics Education*, *14*(3), 253-271

Welsh Government. (2016). *Masters in educational practice: Professional learning – teachers as researchers*. Retrieved from http://learning.gov.wales/resources/learningpacks/mep/professional-learning/teachers-as-researchers/action-enquiry/?lang=en