How can we address mathematics anxiety more effectively as a community?

Conference or Workshop Item

How can we address mathematics anxiety more effectively as a community?

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Abstract

Mathematics anxiety has been discussed for over 60 years. The majority of those suffering, unnecessarily, belong to an identifiable subgroup; often identified as 'female', learners with a 'feeling' rather than a 'thinking' preference or empathisers. These learners prefer to understand the value, meaning, purpose and narrative of the mathematical tools they are required to learn. Ten years ago, we planted a seed for change in thinking from practices that engender anxiety to those that build a positive stance. This seed has grown into a group of teacher and research practitioners working to overcome mathematics anxiety and build mathematical resilience. The paper discusses what is known, by these researchers and teachers, and how to develop innovative communication in order to work internationally toward elimination of the acquired, disabling condition of mathematical anxiety.

Introduction

Although mathematics anxiety has been discussed for over 60 years (Dowker et al., 2016) there is still little mention of it specifically, or the affective domain more generally, in Initial Teacher Training requirements in UK, nor in significant documents such as the Cockcroft Report (1982) and the Smith Report (2017) which reviewed post-16 mathematics. In contrast, students' views were summarised as 'I would rather die' than study more maths (Brown et al., 2008).

A recent survey conducted by the Open University (OU, 2017), sampled UK parents with children aged 6-16. The results could be thought of as shocking; for example, 20% completely avoid mathematics homework through fear; 29% struggle to help with mathematics homework for children aged six to nine. These parents are representatives of the population of potentially competent learners of mathematics. However, they have to learn "to control negative emotional responses to math stimuli" (Lyons and Beilock, 2012) if they are to avoid passing on their mathematics anxiety to future generations (Maloney et al., 2015).

The majority of those suffering mathematics anxiety, unnecessarily, belong to an identifiable subgroup most often described in gender terms; alternatively, learners with a 'feeling' rather than a 'thinking' preference (Hadfield and McNeil, 1994) or empathisers (Escovar et al., 2016), such learners prefer to understand the value, meaning, purpose and narrative of mathematical tools. Options to learn maths in an ALIVE pedagogy (Accessible, Linked, Inclusive, Valuable, Engaging; Johnston-Wilder et al., 2015), inclusive of such learners, are still limited with a focus on covering the syllabus.

In addressing this matter, we stand on the shoulders of Freire (2017), Tobias (1991), and Dweck (2000), amongst others. Freire proposed a pedagogy with a new relationship between teacher, student, and society, for those who had experienced oppression (Freire 2017). According to Freire, some learners respond better when treated as co-creators of knowledge. Freire proposed using education as a means to consciously shape people and society by developing critical consciousness (Freire, 2017). Similarly, Benard (1995) noted critical consciousness as key to developing resilience in young people. Freire (2017) proposed dialogic pedagogy to free learners from oppression, including shared experiences, cooperation and cultural synthesis; dialogue is “an indispensable component of the process of both learning and knowing” (p. 17). Similarly, Mortimer and Scott (2003) proposed dialogic teaching as part of a framework of varied pedagogies that enhance learning in STEM subjects.

Tobias (1991) introduced the term ‘mathematics mental health’. Hembree (1990) found treatment can restore the performance of formerly high-anxious students to the level associated with low mathematics anxiety. Nevertheless, work to enhance students' competence without addressing mathematics anxiety failed to reduce their anxiety levels (Hembree 1990). 30% of UK population do not have level 1 skills in maths (OECD, 2017) reducing their capability to take a productive role in society. We argue that only when their anxiety has been addressed would this sector of society be positioned to study more mathematics. Ten years ago, we planted the idea of promoting mathematical resilience as a seed for change in thinking (Johnston-Wilder and Lee, 2008). This seed has grown into a group of teachers and research practitioners working to overcome mathematics anxiety and to build mathematical resilience (Lee, 2016; Johnston-Wilder et al., 2017; Johnston-Wilder and Moreton, 2018).

Problem as experienced

Many teachers involved in our research observed learners, particularly in lower sets, remedial groups and re-sit classes, exhibit passive non-engagement, avoidance, anger, frustration and helplessness. Students reported experiencing mathematics anxiety as a result of difficulty of the material, competing with peers, hostility towards students, gender bias and insensitivity from teachers, and lack of remediation (e.g. Cousins et al., in press). Teachers of re-sit classes report feeling under pressure to re-cover the syllabus without addressing underlying affective barriers, missing an opportunity to give these young people a second chance. This does not work (Hembree, 1990), rather it causes more anxiety. Knowing the harm it causes, allowing and even encouraging young people to fail GCSE maths up to 8 times by age 16 (Johnston-Wilder, et al., 2015) without affective intervention could be termed mathematical abuse.

The teachers experience the impact of mathematics anxiety being currently under-estimated in all sectors. For example, common practice is to set a mathematics test at the beginning of secondary, FE and HE courses, to ascertain what learners know and can do. This approach fails to take account of both mathematics and test anxiety and under-estimates prior attainment. A learner with a D grade should gain a C grade the following year, but only if unhampered by mathematics anxiety. Such anxiety results in learners not progress or even regressing (Johnston-Wilder et al., 2015). Indeed, the UK pass rate for mandated re-sits is as low as 20%. Machin et al. (2018) demonstrated that “young people are not getting the support they need if they fail to make the grade” the first time. We find it helpful to use the analogy that mathematical anxiety is an emotional ‘handbrake’ holding up mathematics progress.

Mathematical resilience

We have defined mathematical resilience as *“maintaining self-efficacy in the face of personal or social threat to mathematical well-being”* (Johnston-Wilder & Lee, 2010). Mathematical resilience necessarily includes self-safeguarding from the often encountered features of mathematics education that result in mathematics anxiety. Our work developing mathematical resilience has involved many teachers carrying out action research projects designed to reduce anxiety and build resilience. One approach that has consistently been shown to have efficacy is the growth zone model (GZM; Johnston-Wilder et al., 2015, particularly when combined with the Hand Model of the Brain (HMB; Siegel, 2010) and the relaxation response (RR; Benson, 2000).

Figure 1. The growth zone model (GZM).

The GZM combines work of researchers such as Dweck (2000), Boaler (2015) and Bandura (1977) into a tool that teachers find accessible and effective. The growth zone represents the feelings of learners when they experience a task as challenge and are building self-efficacy; the anxiety zone represents experiences of threat due to internalised prior experience (perezhivanie; Vygotsky, 1994). In the growth zone, learners: feel safely challenged; make mistakes and learn from them; persist and persevere; seek support from others when needed; experience worked-for success. When learners are in the growth zone, teachers build learners’ self-efficacy using positive language about effort, allowing learners to struggle, listening to learners, expressing interest in mistakes and what can be learned from them, expressing belief in learners and highlighting when learners succeed (Bandura, 1977).

The hand model of the brain (HMB) is found to be a simple, effective device that helps learners recognise why they feel stupid when they are in fact feeling threatened and in their anxiety zone. When the student acknowledges they are in their anxiety zone the teacher must stop trying to teach mathematics and give the learner opportunity to recover. Learners come to know how to get out of this zone, “the perceived cliff edge becomes a sloping beach” (Baker, PhD student, personal communication). When the GZM, HMB and RR are introduced, learner behaviour often improves, learners often become prepared to undertake challenges, teachers become less protective and more able to challenge their learners (Lee, 2016; Johnston-Wilder and Moreton, 2018).

Discussion

Galtung (1968) provided a framework of *structural violence*, which enables the addressing of issues of systematic oppression, present when "somatic and mental realizations are below their potential realizations" (p. 168). According to this framework, violence is structural when its origins do not have a subject but rather a structural (economic or political) cause. Galtung's framework provides an excellent tool for thinking about the imposition on learners today of the requirement to 'succeed' in mathematical qualifications, and the accompanying classroom practices that are used by teachers to enforce these requirements which result in mathematics anxiety. School mathematics educational practices allow the mathematised people in power to strongly influence the values, norms, ideas, expectations, worldview, and behaviour of those who are currently excluded.

In sustaining unequal power relations between identifiable groups of people, governments, schools and other communities in respect of mathematics, structural violence is entrenched, leaving sub-groups open to exploitation, marginalization, under-employment; they become structurally oppressed. Greer and Mukhopadhyay (2012) use the term "hegemony" "with specific reference to how mathematics and mathematics education are implicated in various forms of interpersonal dominance and in ideological struggles, in particular cases of dominance and suppression of some cultural groups by others, and the attempts by dominated groups to find voice and agency." (p.229).

Mathematical resilience as consciousness raising

Everyone is born with an innate capacity for resilience, by which we are able to develop social competence, problem-solving skills, a critical consciousness, autonomy, and a sense of purpose (Benard, 1995). Similarly, everyone is born with an innate capacity for mathematical resilience that can be applied to learning mathematics. But many people grow up in a culture with a prevalent fixed mindset (Dweck, 2000) in which underachievement is regarded as inevitable, rather than arising out of 'a failure of nerve'(Tobias, 1991).

Theory of change

According to the 'Theory of Change' (Clark and Taplin, 2012), a rigorous, participatory planning process is needed to promote social change; articulation of long-term goals is needed and then to "identify the conditions [we] believe have to unfold for those goals to be met." There is a parallel here with the journey of the intervention known as mindfulness to reduce general anxiety in young people; from Benson's work which started in 1975 to a large scale DfE-funded research project (Anna Freud Centre, 2017) which took over 40 years. Planning social change to address mathematics anxiety needs a long-term strategy.

USA Initial Teacher Standards (AMTE, 2017) raise the possibility of mathematical harm, raising an awareness of concerns of the affective domain. These Standards require recruitment of teachers with both systemising and empathising skills, or developing such skills in the training program, both of which are feasible in theory; the document is not specific as to how. We argue that adoption of the Growth Zone Model will contribute to that strategy, giving learners language to articulate when they are feeling challenged or threatened by a mathematical task, enabling them to self-safeguard, and teachers to respond accordingly. Social justice requires an absence of oppression (Freire 2017) and structural violence (Galtung, 1968). First, we need to develop awareness of that oppression and structural violence in the mathematics education context, and awareness to how to progress towards addressing it.

References

Association of Mathematics Teacher Educators (AMTE) (2017). Standards for Preparing Teachers of Mathematics. Available online at amte.net/standards.

Bandura, A. (1977) ‘Self-efficacy: Toward a unifying theory of behavioral change.’ Psychological Review, 84, 191-215.

Benard, B. (1995). *Fostering resilience in children*. Urbana, IL: ERIC Clearinghouse on Elementary and Early Childhood Education. [ED386327]

Benson, H. (2000). The Relaxation Response New York, NY: HarperCollins Publishers

Boaler, J. (2015) Mathematical Mindsets, London: Jossey-Bass

Brown, M., Brown, P. & Bibby, T. (2008) “I would rather die”: reasons given by 16-year-olds for not continuing their study of mathematics, *Research in Mathematics Education,* 10:1, 3-18.

Cockcroft, W. H. (1982). Mathematics Counts. London: HMSO

Clark, H. and Taplin, D. (2012). *Theory of Change Basics: A Primer on Theory of Change* (PDF). New York: Actknowledge.

Cousins, S., Brindley, J., Baker, J., Johnston-Wilder S. (in press). Stories of mathematical resilience: how some adult learners overcame affective barriers. *Widening Participation and Lifelong Learning.*

Anna Freud Centre (2018) Department for Education award three major school programmes. https://www.annafreud.org/insights/news/2017/11/department-for-education-award-three-major-school-programmes/

Dowker, A., Sarkar, A., & Looi, C. Y. (2016). Mathematics Anxiety: What Have We Learned in 60 Years? *Frontiers in Psychology, 7*: 508.

Dweck, C. (2000) Self theories: Their role in motivation, personality and development. Lillington: Psychology Press, Taylor & Francis.

Escovar, E., Rosenberg-Lee, M., Uddin. L. Q., & Menon, V. (2016). The Empathizing-Systemizing Theory, Social Abilities, and Mathematical Achievement in Children. *Scientific Reports, 6,* 23011.

Freire, P. (2017) Pedagogy of the Oppressed, London: Penguin Classics

Galtung, J. (1968). Violence, Peace and Peace Research, *Journal of Peace Research, 23* (9), 167-191.

Greer B. & Mukhopadhyay S. (2012) The Hegemony of Mathematics. In: Skovsmose O. and Greer B. (eds) *Opening the Cage. New Directions in Mathematics and Science Education,* vol 23. Rotterdam: Sense.

Hadfield, O., & McNeil, K., (1994). The Relationship between Myers-Briggs Personality Type and Mathematics Anxiety among Preservice Elementary Teachers. *Journal of Instructional Psychology, 21(4),* 375-384.
Hembree, R. (1990) The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21(1),* 33-46.
Johnston-Wilder, S., & Lee, C. (2008). Does Articulation Matter when Learning Mathematics? *Proceedings of the British Society for Research into Learning Mathematics, 28(3),* 54-59.
Johnston-Wilder, S., & Lee, C. (2010). Developing Mathematical Resilience. BERA Annual Conference, University of Warwick, 1-4 September.
Johnston-Wilder, S., Lee, C., Brindley, J. and Garton, E. (2015). Developing mathematical resilience in school-students who have experienced repeated failure. ICERI2015, Seville, Spain, 16-18 Nov.
Johnston-Wilder, S., Pardoe, S., Almehrz, H., Evans, B., Marsh, J. and Richards, S., (2017). ICERI2017 November
Johnston-Wilder, S. & Moreton, J. (2018). Developing mathematical-resilience-promoting practices in teachers. ICERI2018, Seville, Spain, 12-14 Nov.
Lee, C. (2016). *Developing Mathematical Resilience: Teachers' reflections on working to develop mathematical resilience in learners.* Milton Keynes: Enigma MathsHub.
Available from: https://www.enigmamathshub.co.uk/copy-of-enigma-teaching-for-mastery
Lyons, I. M., Beilock S. L. (2012). Mathematics anxiety: separating the math from the anxiety. *Cerebral Cortex*, 22(9), 2102-2110.
Machin, S. McNally S. & Ruiz-Valenzuel, J. (2018). *Entry Through the Narrow Door: The Costs of Just Failing High Stakes Exams*. London: Centre for Vocational Educational Research.
Maloney, E. A., Ramirez, G., Gunderson, E. A., Levine S. C., and S. L. Beilock. (2015). "Intergenerational Effects of Parents' Math Anxiety on Children's Math Achievement and Anxiety." *Psychological Science.*
Mortimer, E. F. and Scott, P. H. (2003). *Meaning making in secondary science classrooms*. Maidenhead: Open University Press.
OECD (2017). *Getting Skills Right: Future-Ready Adult Learning Systems,* Getting Skills Right OECD Publishing Paris.
OU (2017). One in five parents suffer from arithmophobia http://business-school.open.ac.uk/news/one-five-parents-suffer-arithmophobia
Siegel, D. (2010). Mindsight: Transform Your Brain with the New Science of Kindness, London: Oneworld Publications.
Smith, A. (2017). Report of Professor Sir Adrian Smith's review of post-16 mathematics. London: DfE.
Tobias, S. (1991). Math Mental Health, *College Teaching*, 39:3, 91-93.
Vygotsky, L. S. (1994). The problem of the environment. In R. van der Veer & J. Valsiner (Eds.), *The Vygotsky Reader* (pp. 338-354). Cambridge, MA: Black.