Evaluating the impact of 'Numeracy Mats' designed to model self-questioning on GCSE pupils' metacognitive awareness and self-regulatory strategies.

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Background Literature

In 2012 30% of the 15-year-olds who participated in the Programme for International Student Assessments (PISA) failed to achieve Level 2 in Mathematics, sparking a national debate on the quality and future of the country's education (National Assembly for Wales, 2013). The OECD (2014) claim Level 2 is the "baseline of proficiency at which students begin to demonstrate competencies to actively participate in life" (p.3). This acted as the catalyst for fundamental reform across the curriculum, with the most radical changes in history made to GCSE Mathematics qualifications in Wales. The changes included a revised Mathematics GCSE and the introduction of a unique Numeracy GCSE with the intention for the latter to focus teaching and learning on the skills required in the PISA assessments.

In order to assess the types of mathematical skills that are necessary for cross-curricular study, work and everyday life, the Numeracy papers pose all questions in real-life context, an aspect believed to be lacking in the previous qualification. The ability to access and apply mathematics in real-world situations and therefore succeed in the Numeracy type questions relies on a student's level of mathematical literacy. Mathematical literacy skills are considered by the OECD to be on a "continuous, multidimensional spectrum ranging from aspects of basic functionality to high-level mastery" (de Lange, 2006, p.16). Pupils face difficulties solving intra- and extra-mathematical problems within a variety of domains as the ability to do so is a higher-order skill. In my experience, additional stress is caused by the cognitive overload perceived by pupils when answering these questions, leading to heightened anxiety, erratic 'all or nothing' approaches and an inability to recall key methods and/or formulae. This is particularly the case for a Year 11 Set 1 class who have recently sat their Numeracy and Mathematics GCSE examinations. If when solving a problem, the required method is not instantly identifiable or they are unable to make a link through visual representation immediately, they become frustrated. This frustration often turns into worry and panic and even when prompted in the direction of a method or formula, they have worked themselves up so much they quite often forget the methods or formulae. This prompted the design and development of a visual aid (Numeracy Mats, Figure 1.) that aims to model self-questioning as a metacognitive approach for problem solving whilst improving memory recall.

The format of the information on the mats is based on the theoretical perspective of metacognition and its influence on problem solving. Metacognition is active mental participation (Flavell, 1979) and has been defined as "actively attending to one's thinking" (Pate & Miller, 2011, p.73). Swanson (1990) suggested that when engaged in problem solving, pupils only have partial knowledge about a problem and its solution. This therefore creates a scenario where the student initiates a general search for information and possible solutions. It is this search that is guided by pupils' metacognition. Ozsoy and Ataman (2009) identified self-questioning as a strategy for developing metacognition within the framework of constructivist learning. Self-questioning can include teacher-generated questions or student-generated questions. The aesthetics of the Numeracy Mats (font and colour) were also carefully considered for the promotion of memory recall based on evidence but the impact of this will be investigated at a later date.

The Numeracy Mats, which are now stuck to every table in the classroom (six a3 pages) with self-adhesive clear plastic, provide explicit instruction and self-questioning prompts. The purpose of this is to support pupils in generating their own questions through systematic instruction and ultimately use the skill independently. To support this process, I initially modelled tackling Numeracy problems whilst using the Mats. Pupils have since used and referred to them during lessons when necessary.

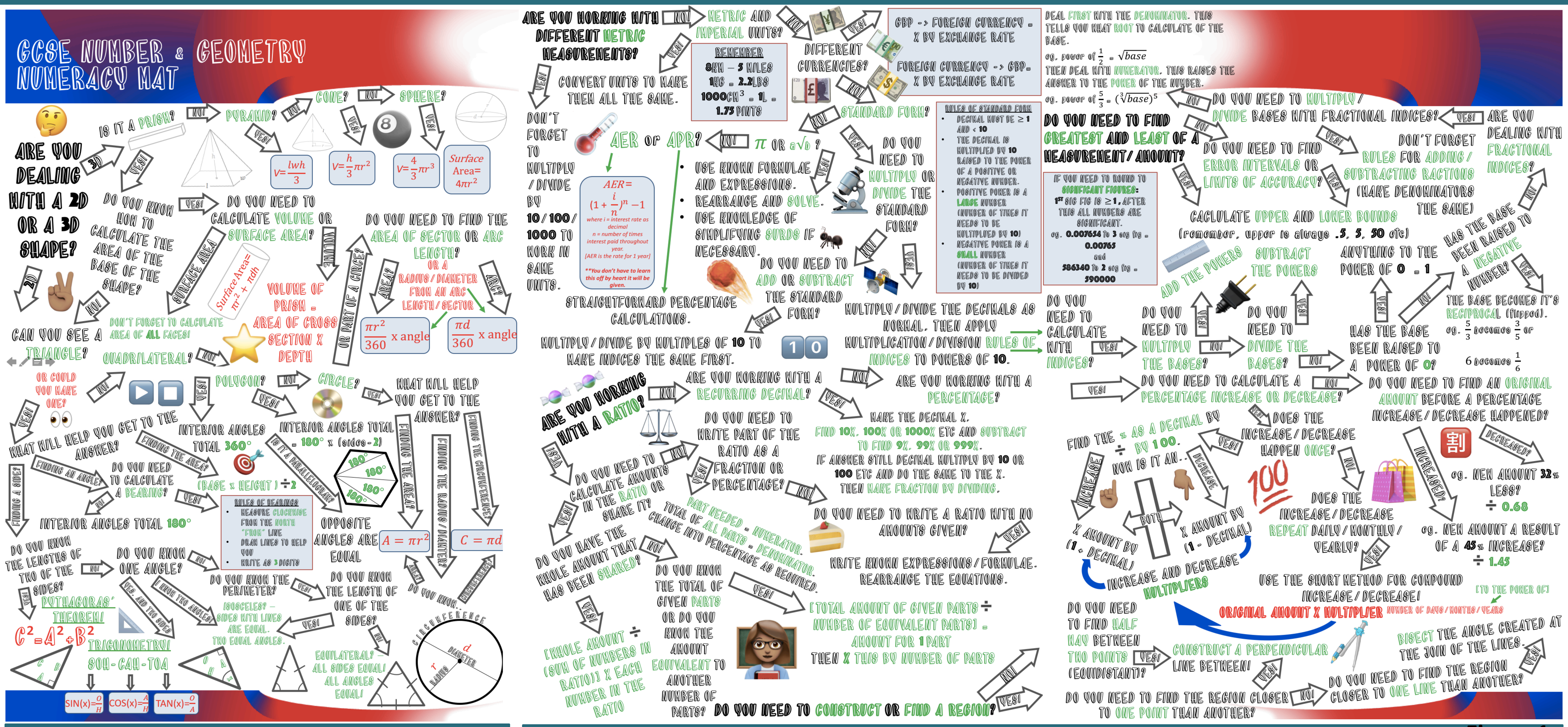

Figure 1.

Ethics

All pupils received a letter explaining the study and outlining their involvement. Ethical consent was gained for all those whose data has been included by a signature from parents or guardians. Pupils' right to withdraw their data at any stage was clearly communicated.

Methods

In order to examine the impact of the mats, I designed the Metacognitive Awareness in Maths Inventory (MAMI) that was implemented as a pre and post questionnaire. The MAMI derived from the Metacognitive Awareness Inventory (MAI) (Schraw & Dennison, 1994), the Metacognitive Awareness Inventory Junior Adaption (Version B) (MAI-Jr) (Sperling, Howard, Miller & Murphy, 2002) and the Questionnaire about Learning in Mathematics (QLM) (Peklaj & Vodopivec, 1998). It is a 31 item, likert-scale (ranging from 1 (never) to 5 (always)) questionnaire that was piloted with a group not part of the study and carried out a test of validity (Cronbach's alpha 0.82).

The results of the MAMI were analysed using a paired sample t-test to reveal if there were statistically significant differences between the data obtained before and after exposure to the numeracy mats. This was computed on SPSS 25.0 and the significance level was set to 0.05.

Results

78% of the items presented slightly higher scores following exposure to the Numeracy Mats. There was however significant differences between pre and post results for four items on the MAMI: 'When correcting a mistake I read the problem again to make sure I understand it', 'I consider several approaches to solving a problem before I answer', 'I ask myself questions about the information I'm given before trying to solve a problem' and 'When reading a problem, I slow down when I encounter important information.' (Table 1.)

Paired Samples Test

	Paired Differences				
	Mean	Std. Deviation	Std. Error Mean	t	Sig. (2-tailed)
Item15Pre – Item15Post	-.36364	.65795	.14028	-2.592	.017
Item17Pre – Item17Post	-.54545	1.18431	.25250	-2.160	.042
Item23Pre – Item23Post	-.59091	1.33306	.28421	-2.079	.050
Item24Pre – Item24Post	-.50000	1.01183	.21572	-2.318	.031

Table 1.

Discussion

The Numeracy Mats were designed for the purpose of developing metacognitive awareness and encouraging self-regulatory strategies when problem solving. It is disappointing that only four items showed a significant difference following exposure to the Mats every lesson for four months. However, these four months included the last two months of the academic year (June and July) when the focus was on completing the two year course in half the time for early entry. In this time the Mats were ignored to an extent whilst other topics were covered. The pupils were reminded of how they could use the Mats upon returning to school in September, but as not enough time had been spent building this into habit, the extent to which they did so was minimal. I believe with more time, improvements in metacognitive awareness would have been greater and the pupils would have been more likely to transfer these skills under exam conditions.

Conclusions

In conclusion, the Numeracy Mats had a small impact on metacognitive awareness, but with more opportunity to model and use them in less pressured circumstances (over the course of a year rather than immediately in the lead up to examinations) it is believed there is potential for impact to a greater extent.

The influence of the Numeracy Mats on memory recall was not investigated for this report, however, aesthetics for the promotion of this was considered in their design and therefore future research will consider this.

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