Metacognition and Self Regulated learning

Exploring the impact of metacognitive strategies when problem solving, to foster greater independence in Mathematics

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Background Literature

Metacognition, first coined by **Flavell** (1979), describes the processes of learning how to learn. **Schunk & Zimmerman**, (1994) show that pupils who are able to self-regulate their learning achieve better outcomes than those who do not. **Dunlosky & Metcalfe**, (2008) further define metacognition as a process which requires both knowledge about how to learn and the ability to self-regulate learning. Since the launch of the **EEF** Teaching and Learning Toolkit in 2011, the strand on metacognition and self-regulation has consistently ranked as one of the most popular and been accessed over 120,000 times. It is becoming increasingly well-known in schools and teachers are interested it it. **Sir Kevan Collins**, Chief Executive from the Sutton Trust charity, the EEF states that "a large body of evidence tells us that when properly embedded, metacognitive approaches are powerful levers for boosting learning.

Being successful in mathematics is so important in the 21st Century; as **Schoenfeld** (2002) wrote, "to fail children in mathematics, or to let mathematics fail them, is to close off an important means of access to society's resources". Focusing on strategies of how to approach mathematics problems, using various techniques can be widely applied (**Kilpatrick**, 1985). This strategy follows the belief that pupils learn by doing and by thinking about what they do and follows **Polya's** (1957) four phases of problem solving: understanding the problem, devising a plan, and looking back. A recent response by the **National Network for Excellence in Mathematics** (NNEM) to the Welsh Government on improving mathematics education in Wales in view of PISA findings (2017), discusses the overview of PISA informed reports into mathematics learning and teaching. Three reports that have contributed to the literature on effective pedagogy in mathematics include: PISA in Practice: Cognitive activation in Mathematics' (Burge et al, 2015), 'Ten Questions for Mathematics Teachers (OECD, 2016b) and 'Equations and Inequalities: Making Mathematics Accessible to All' (OECD, 2016a). A key point for Wales, in particular is the need to support learners in applying their mathematical understanding and reasoning, and in formulating mathematical situations. Research into how problem solving can be taught shows that the classroom climate, communication and dialogue, the practical approach, heuristics and thinking skills have to be considered (**Flavell**, 1976, **McGuinness**, 1999, **Tanner and Jones**, 2002, **Taylor and McDonald**, 2007, **Graves** et al, 2009, **Jacobbe and Millman,** 2009).

With this evidence in mind, the iCalculate intervention attempts to explore the impact of metacognitive strategies when problem solving, to foster greater independence in Maths.

ETHICS

Ethical approval was granted by the **Research and Ethics Committee of the School of Education, University of Wales Trinity Saint David's** in May 2018. Following the principles of active informed consent, written consent was obtained at the school level from headteachers and teachers. Written information and opt-out consent forms were sent home to parents/carers of all pupils involved in the intervention lessons. Parents/carers were also given the opportunity to contact the research team for further information. Pupils involved in the semi-structured interviews completed an opt-in consent form prior to the interview. Pupils could not opt out of the series of the teaching and learning that was occurring as this was normal practice for pupils, but, all pupils were provided with ongoing and meaningful opportunities to opt out of any data collection throughout the intervention. Pupils were informed in advance of any data collection and were introduced to the research team members carrying out the data collection.

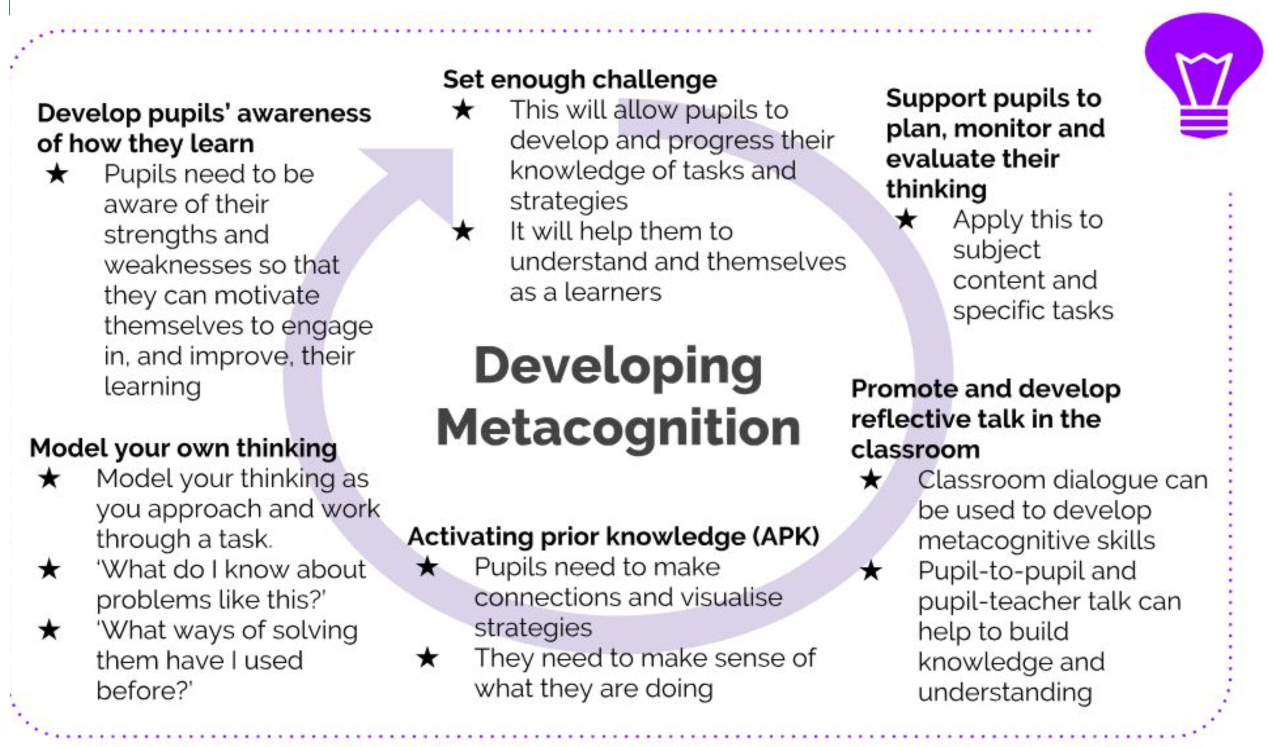


Figure 1. Developing Metacognition Mat

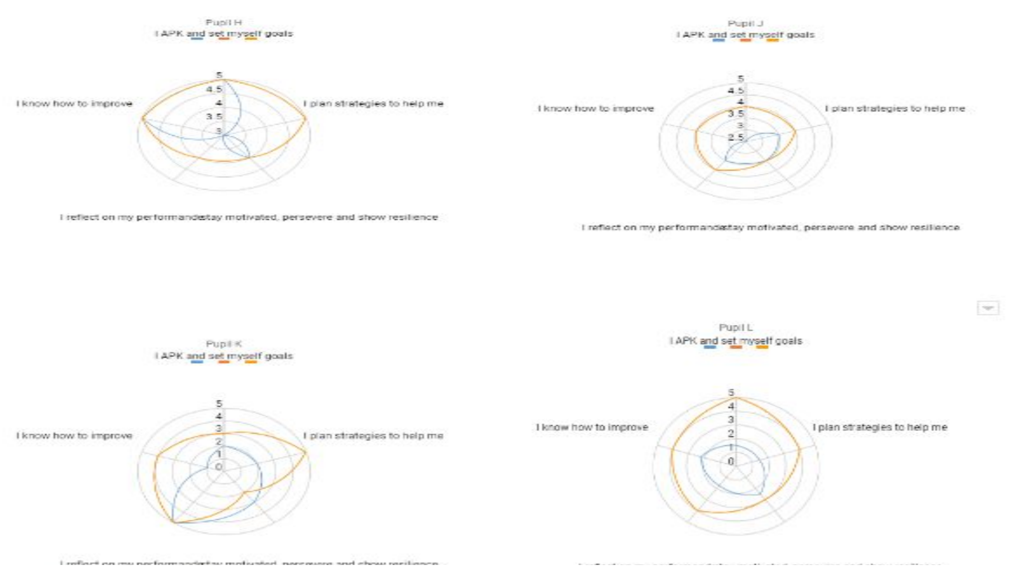
Methods

The approach adopted within this action research project, has been dependent on teacher time available to undertake school-based research. Therefore teacher researchers, two classroom teachers and 53 iCalculate pupils have been involved in a small-scale, short term, classroom based project. The action research approach has been considered to be the most appropriate method. The study took a pre-experimental design, with a pre and post-intervention. Teacher researchers introduced pupils to the project and explained the purpose of the lessons. Within each iCalculate class, six pupil participants were selected by their teacher, (two higher, middle and lower attaining pupils). Pupil participants were coded and identified with a letter from A-L. Both classes were observed during the baseline and during five intervention lessons, which were spread over a six week period. Data was collected from pupil participants prior to the intervention, during and after the intervention.

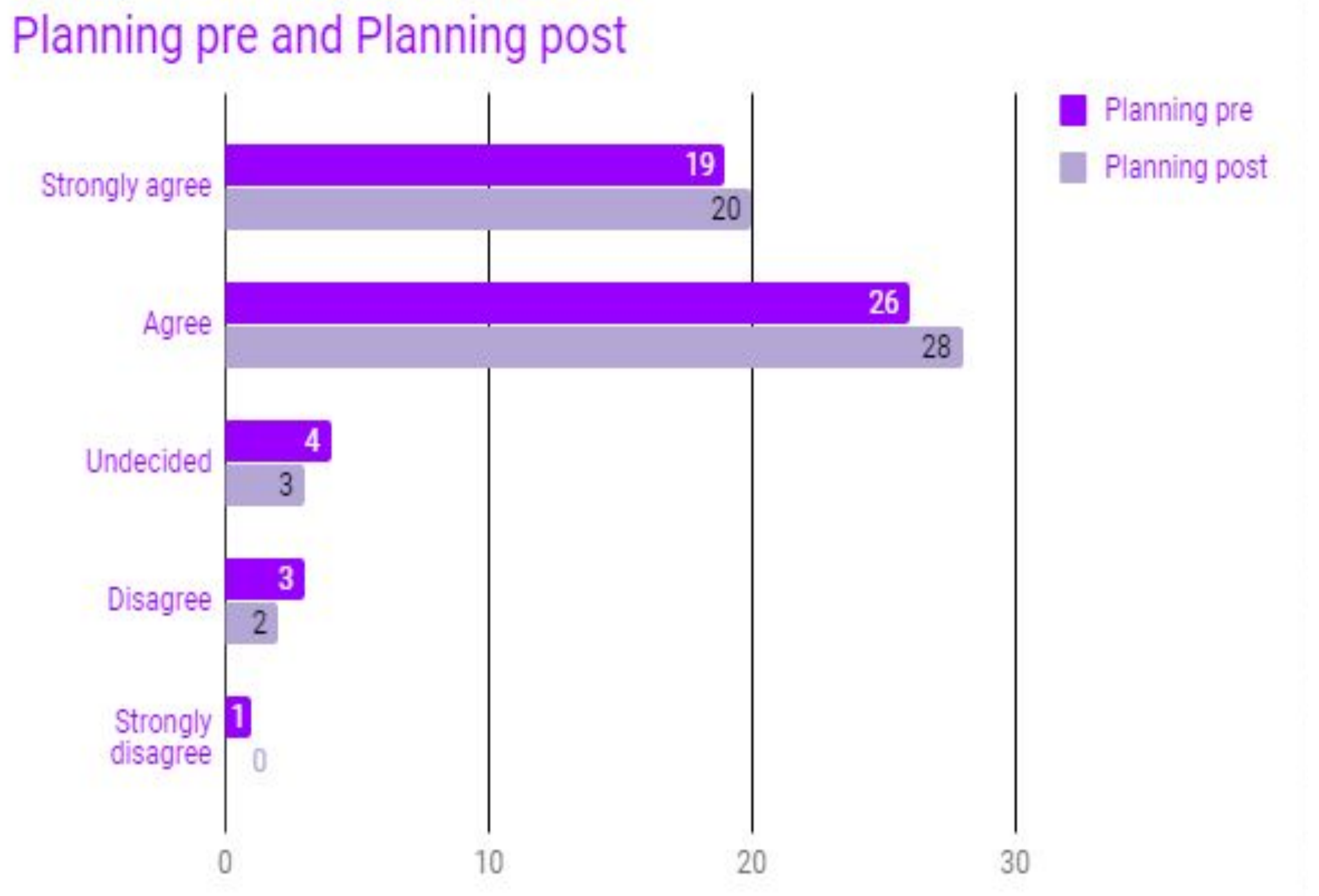
Results

From pupil pre and post questionnaires, responses suggest that pupils engage with a problem and follow instructions from their teacher. Pupils recognise that reading instructions forms an important starting point. However, this does not display pupil understanding of a given task. It is possible that learners are less familiar with the word 'goal' in mathematics and with writing down personal objectives. Whilst not surprising, we see this an opportunity to encourage pupils to set goals. Post-intervention, pupils had a better understanding of goal setting and were able to identify an objective as, for example, looking back in a book to find a similar procedure, when trying to solve a new problem. Post-intervention, 100% of pupil participants say they ask themselves if they are making progress towards their goals. Post-intervention, pupils were either neutral or agreed that they would reflect on how well they had achieved their goals once a task was complete. This could suggest that the intervention made a difference to pupils being motivated to self monitor.

Table 2. Radar diagrams completed by pupil participants pre and post intervention



In radar diagrams, pupil participants say they are aware of more strategies post intervention and when interviewed they say they are using them.



Discussion

After completing Maths problem 1, interview responses suggest that some pupils are able to articulate their thinking with clarity and confidence; their actions correlate with questionnaire responses. Other pupils are less at ease in a group interview and their thoughts are sometimes more confused. In some of the interviews, pupils are able to identify what might help them in the future. The comments and experiences of pupils are valuable to the team in understanding how the participants worked through the tasks. We can see that metacognition is taking place and that pupils can demonstrate the strategies they need as well as the problems they experience. We can also see where targets are set for future problem solving tasks. The most detailed and useful comments are recorded for activating prior knowledge, planning, evaluating and for metacognitive talk. Pupil self monitoring responses have so far been the least useful, this does not mean that pupils failed to self monitor, rather that they did not record much information on the resources provided.

Conclusions

We have successfully explored the impact of metacognitive strategies when problem solving. We have made a start at trying to foster greater independence in Mathematics, this we recognise will take time and will rely on teachers securing and spreading change. It will be important, we think, to embed the most successful strategies, so that they become a regular feature of iCalculate lessons. These need to evolve and become part of a routine, where pupils eventually can refine their own repertoire of problem solving strategies. This has already been discussed during post intervention teacher interviews. If learners are exposed to regular problem solving tasks and the resources are used alongside these tasks in the first instance, we believe that confidence and resilience will develop and grow. Teacher interviews and pupil feedback suggest that the planning and goal setting resources are the most beneficial here. Regular teacher modelling and scaffolded tasks which increase metacognitive dialogue in the classroom, will we believe narrow the gap between our most and lower attaining learners in Year 7 iCalculate lessons. This has been a positive starting point, and we acknowledge that we cannot comment on other classes or year groups. We recognise that iCalculate teachers will have their own strategies that are successful with their learners and we know that metacognition is already taking place in iCalculate classrooms. We believe that this is about empowering teachers and, with even greater focus, making strategies more explicit in our teaching and learning so that we can better tackle problem solving. Our findings will hopefully be an aid to reflection, offering some different perspectives to both teachers and pupils.

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