Trial and error skills in mathematics problem solving: How can we improve this aspect of teaching and learning?

Southwold Primary School Lower Phase

Abstract

The purpose of this study was to investigate the current skills and confidence levels in teaching problem solving skills in maths in years 1-3. Over the course of 3 months teachers explicitly taught trial and improvement lessons in maths and reflected on their successes and struggles in phase meetings, developing for the next lesson. The results showed that by explicitly teaching skills in trial and improvement, teachers became more confident in teaching and supporting children. Furthermore the teacher's perceptions of pupils' skills in trial and error investigations improved dramatically.

Introduction

Southwold School is a larger than average school in the borough of Hackney, London. The percentage of children eligible for pupil premium is significantly higher than the national average. Many children starting the school in EYFS are significantly behind age-related expectations for children their age. The school is culturally and religiously diverse and the number of children who speak English as an additional language is significantly higher than the national average. The school performs well above the national average in terms of pupil progress.

The specific area of study for this research was mathematical problem-solving skills. One of the three core aims of the 2014 National Curriculum for Mathematics is that pupils 'can solve problems by applying their mathematics to a variety or routine and non-routine problems with increasing sophistication, including breaking down problems into a series of simpler steps and persevering in seeking solutions,' Department for Education (2014). Research and government guidance are widely in

agreement that problem solving should be a core focus on mathematical teaching. For example, OFSTED (2011) found that in schools which were successful at teaching maths *'pupils' confidence, fluency and versatility are nurtured through a strong emphasis on problem solving as an integral part of learning within each topic.'* Furthermore, the wider benefits of teaching children problem solving in maths can be

seen when considering how problem solving skills in maths are actually thinking skills that can be widely applied to other areas of learning, working and living. Derek Haylock (2010) explained that *'not only does mathematics develop logical, deductive reasoning but- somewhat surprisingly – engagement with this subject can also foster creativity. So mathematics is an important context for developing problem-solving strategies that potentially have significance in all areas of human activity.'*

There is much guidance and research to suggest the importance of providing children with a wide range of tasks in order to develop different problem solving skills. The Primary National Strategy (2004) suggested 5 different types of problem in maths and noted the importance of providing learning opportunities for all types. Liz Woodham (2014) highlighted the range of skills that children need to practise repeatedly and explicitly in order to become excellent problem solvers. She noted the following skills as important in the primary classroom:

- Trial and improvement
- Working systematically
- Pattern spotting
- Working backwards
- Reasoning logically
- Visualising
- Conjecturing

She also explained how *'having a skills-based focus to a lesson or series of lesson can work well'* with children aware of the skill that they are practising. For the purpose of this paper, so as not to be too broad in my enquiry, I decided to focus on

one of the skills noted by Woodham – trial and improvement. This was chosen as I was unable to identify many trial and error style investigations in the maths books of teacher in lower phase. To be more specific, it was decided that we would look at helping children to keep trying at a problem without giving up, think about how they could adapt their approach as they try again and to enjoy this type of mathematical enquiry.

Whilst children at the school make good progress in maths from the end of EYFS to kS1 and from KS1 to KS2, evidence in books and planning suggested a narrow range of problem solving opportunities were being delivered to the children, with a focus on open-ending finding all the possibilities style lessons. In order to address this, it was decided that the project would start by trying to ascertain possible reasons behind the trend towards one particular problem-solving skill, then plan training during phase meetings to support teachers to develop their skills and in turn improve pupils' outcomes in trial and improvement lessons. Each teacher was asked to identify one child from each ability group in the class (5 children) and track their problem solving skills before and after the project, which ran from January to March. It was expected that the project would result in teachers planning and teaching for a wider range of problem solving skills and the pupils would develop a greater resilience in maths lessons.

Research Process

The project was coordinated by the phase leader and supported by 5 classroom teachers. A total of 25 children were identified to provide sample representative of the whole class. 5 children of varying abilities were chosen in each class. Qualitative data was collected in the form of informal phase meeting discussions where questions were posed in order to ascertain the current training needs of the teachers and their perceptions of mathematical abilities in the class, (see appendix 1). It was decided to carry out data gathering in this manner in order to get the most honest and reliable information from teachers. Phase meetings normally being a regular forum for honest discussions in judgment free setting. Teachers were also asked to answer a questionnaire about the 5 children were responses were levelled from 1-5,

(appendix 2). This provided a quantitative method of analyzing the children's progress in skills. Finally maths, books and planning were analysed for the number of problem solving opportunities that allowed children to develop skills in trial and error.

After the initial meeting where current teacher knowledge and confidence in teaching problem solving in mathematics were ascertained, activities were planning for subsequent phase meetings. In a particular two main aims were established:

1. To provide the teachers with examples of activities that would facilitate the learning of trial and error skills.
2. To give teachers ideas for how to lead input and support children effectively in a problem solving lessons which had a trial and error focus.

In order to address the first aim, teachers were asked to read 'Using NRICH Tasks to Develop Key Problem-solving skills' (Woodman, 2014). This provided an overview of different problem solving skills and their value and place in the primary classroom. We discussed which teachers felt more and less confident in teaching and what their current knowledge level about different mathematical skills was. Most of the teachers had never received any training on the different problem solving skills nor had they considered these when planning. Teachers' hesitations and concerns about teaching trial and improvement skill focused lessons were then ascertained in order to plan the subsequent phase meeting focusses. Finally the teams were provided with a range of activities appropriate to their year group which would provide an opportunity to practice trial and improvement skills. Each task was discussed in terms of how we could help children to be resilient in the lessons and how we could introduce tasks to help children find a starting point for their own work.

Teachers then had 3 months to try out the activities with regular discussions at phase meetings to ask questions and discuss progress and concerns. After 3 months teachers were questioned once again to ascertain their perceptions about teaching mathematical problem solving and note any changes in confidence, attitude and knowledge or skill base (appendix 3). Some of the questions remained the same

as the initial questionnaire in order to provide data for comparison. Teachers were also asked to assess the 5 children from their classes which were assessed to establish a baseline at the start. This would provide quantitative data on progress in trial and improvement skills as perceived by the teachers, when compared with the data from the start of the research.

Findings

Generally the project was well received by the team and all teachers expressed how they had developed skills and knowledge as a result of taking part. Many teachers felt that they enjoyed the time spent picking apart important pedagogy and were keen to learn more about mathematical problem solving. The various data sets also back this up.

At the start of the project, the teacher interview supported the initially view from book looking and planning scrutiny that teachers had quite a narrow repertoire of teaching skills and experiences in terms of the different problem solving skills. The interview led to the general impression that teachers did not feel like they had received much in-depth training of mathematical problems solving nor did they feel confident in teaching a wide range of skills. For example, when asked about what skills children develop in their problem solving lessons the focus seemed to be on word problems rather that investigative maths: one teacher said ‘ability to do word problems’ as the only skill that they develop. When the same question was asked at the end of the project, the results were much more varied with teachers suggesting multiples skills and resilience in learning was a common theme from all teachers involved. There was a significant rise in the number of teachers who now feel confident in teaching and planning trial and improvement lessons in maths.

Furthermore, at the start of the project teachers’ perceptions of pupil skills relating to trial and error investigations showed a picture of low skill level across all ability groups (see appendix 4). In particular the children were deemed to be weakest at using different approaches when previous approaches didn’t work. When comparing the average score across the 3 statements, children in all groups and classes progressed in terms on trial and improvement skills relating to mathematics

investigations. When sharing this with the teachers and asking why they thought this to be the case, the consensus was that they has made the skill focus of the lesson explicitly about trial and improvement skills rather than the calculation skill that the task might involve.

Impact and Conclusion

The impact of this study has been very positive and teachers all felt that they had deepened their own understanding about problem solving in maths as a result of taking part. One teacher said that she thought many more teachers in the school and federation could benefit from having similar guidance and that she was keen to look into how to develop her own teaching of other problem solving skills as identified in the Nrich article that I shared with them at the start

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In order to improve the study it would support future studies to include some interviews or questionnaires with pupils to ascertain if their attitudes towards problem solving and getting the right answer in maths had changed during the course of the project. Pupils' opinions would have added a third dimension to the data collection that would make the conclusions more robust. The research opened up a few questions in terms of planning for learning problem solving skills. Perhaps it is more beneficial to plan an investigation lesson starting with the skill focus rather than the calculation skills that might be needed. Furthermore it posed the question of whether soft skills such as 'being brave when the answer is wrong' should be included on success criteria in many maths lessons to embed the teaching of resilience in learning further into the mathematics curriculum.

References

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Appendix 1: Teacher questionnaire from the start of the project.
Teacher responses in red

What different skills do children develop in your mathematical problem solving lessons?
"ability to do word problems"
"keeping going to keep finding answers"
"using their calculation skills in a real life context"
"they can add and subtract in money and measures lessons too"

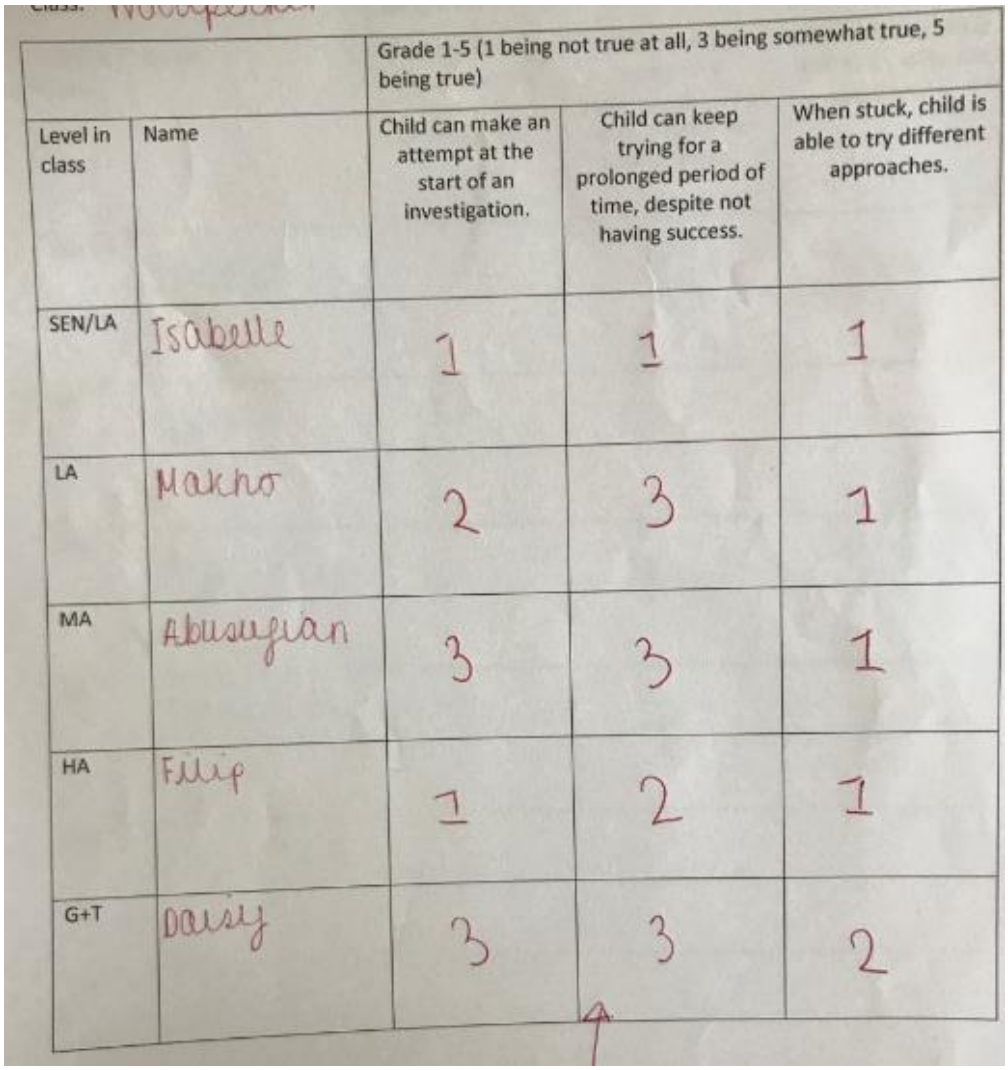
What training have you received in the past regarding mathematical problem-solving?
"none we are just told to do them and we have been given examples of deepening understanding tasks but these aren't really supporting investigation lessons"
"none"
"none, I have never really thought about it"

How confident do you feel in planning and teaching problem solving lessons and investigations?
"I find it hard to come up with investigations that are appropriate"
"It's hard when they are stuck to help without helping too much"
"sometimes it don't know where to find an investigation to do"
"I enjoy planning the lessons but I don't always teaching them in the whole class setting. I really like giving them to my high ability children"
"I do them on Wednesdays or Fridays because they don't really need marking"

To what extent to you feel confident it planning an investigation lesson where there is only one correct solution?
***"**On reflection I barely do them"*
"Even my bright children find those lessons hard and they are hard to differentiate"

Why do you think they find them hard?
"because they get frustrated when they don't get it right and they lose interest and then this causes behaviour problems" (nodding and agreement around the table at this point)

Appendix 2:



		Grade 1-5 (1 being not true at all, 3 being somewhat true, 5 being true)		
Level in class	Name	Child can make an attempt at the start of an investigation.	Child can keep trying for a prolonged period of time, despite not having success.	When stuck, child is able to try different approaches.
SEN/LA	Isabelle	1	1	1
LA	Makno	2	3	1
MA	Abusujian	3	3	1
HA	Filip	1	2	1
G+T	Daisy	3	3	2

Appendix 3: Teacher questionnaire from the end of the project
(Teacher responses in red)

What different skills do children develop in your mathematical problem solving lessons?

"being brave in lessons" "they can change what they are doing as they are going along"
"they develop resilience and can keep trying"
"applying their calculation skills"
"talking about their ideas and explaining their approach to a problem"
"resilience" "practice addition etc"

How confident do you feel in planning and teaching problem solving lessons and investigations?

"I find them easier to plan now, but I sometimes don't like the part of the lesson when some have solved the problem and some are still working on it. I feel like I have to spread my weight between all the children"
"I plan how to support them a bit more carefully which helps the lessons run more smoothly. I use the nrich guidance which helps me teach the lesson without giving them too much help"
"I enjoying planning and teaching them but I am sometimes unsure if I am pitching it completely correctly for the whole class."

To what extend to you feel confident it planning an investigation lesson where there is only one correct solution – a trial and error investigation?

"I feel happy to teach these lessons especially when being resilient is in the success criteria for the lesson. The children have got used to use talking about not giving up"
"pretty confident. I think some of gifted children who used to find maths easy and then be really thrown when I gave them problems like this, now they enjoy these lessons much more"
I feel confident in choosing the tasks but would like more help planning the input phase of "the lesson"
"Yeh I think I am happy to do them. Finding all the possibilities would always be an easier lesson to plan and teach though"

Appendix 4: Teacher perceptions of pupil skill at the start of the project (average from all classes)

	Grade 1-5 (1 being not true at all, 3 being somewhat true, 5 being true)		
	Child can make an attempt at the start of the investigation	Child can keep trying for a prolonged period of time, despite not having success	When stuck, child is able to try different approaches.
SEN	1.2	1	1
LA	1.2	1	1
MA	2	2	2
HA	3.5	2.8	2
Gifted and talented	3.5	2.8	2

Appendix 5: Teacher perceptions of pupil skill at the start of the project (average from all classes)

	Grade 1-5 (1 being not true at all, 3 being somewhat true, 5 being true)		
	Child can make an attempt at the start of the investigation	Child can keep trying for a prolonged period of time, despite not having success	When stuck, child is able to try different approaches.
SEN	3	2	1
LA	3	2.2	1
MA	4	3	4
HA	4	2.8	5
Gifted and talented	5	2.8	5