Research into teaching problem solving to primary teacher trainees using Schoenfeld's (1985) timeline

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Problem solving is at the forefront of Mathematics Education. PISA results show that pupils in Wales have poor problem solving skills. Problem solving skills need to be taught in schools. Teachers and teacher trainees need to be able to solve problems themselves in order to teach problem solving. This small case study focussed on how problem solving can be taught to undergraduate teacher trainees and what impact it had on their own problem solving. A problem solving course was designed and evaluated. Problem solving skills were analysed, by pre and post investigations, using Schoenfeld's (1985) timeline. Problem solving can be taught subject to certain factors e.g. knowledge of heuristics, subject knowledge The teacher trainees' problem solving skills changed from a novice like approach to an expert like approach with respect to Schoenfeld's (1985) timelines. This was useful in small group situations depending on whether the students worked co-operatively or collaboratively.

Keywords: problem solving; teacher trainees; Schoenfeld

Introduction and background

To explore what is meant by mathematical problem solving it is important to define 'problem'. Krulik and Rudnick (1987) explain a problem as "a situation, quantitative or otherwise, that confronts an individual or group of individuals, that requires resolution, and for which the individual sees no apparent or obvious means or path to obtaining a solution" (Carson, 2007, 3). This implies that what constitutes a problem to some individuals may not be to others. A problem is only a problem to the individual if the solution is not immediately obvious to them. Schoenfeld (1985) concurs with this saying a problem is always relative to the individual. So what is meant by problem solving? Problem solving can be defined simply as the pursuit of a goal when the path to that goal is uncertain (Martinez, 2006). As early as the 1920s, Polya had an interest in problem solving and goes on to describe it as the process used to solve a problem that does not have an obvious solution (Polya, 1945). When discussing solving problems Polya(1945) explains that there are four phases:- understanding the problem, making a plan, carrying out the plan and looking back. Dewey (1933, cited in Mosely et al, 2005), Krulik and Rudnik (1980) and Schoenfeld (1985) all included or adapted these when discussing how to solve problems. These steps can also be called heuristics (Polya, 1945).

Research into how problem solving can be taught shows that the classroom climate, communication and dialogue, the practical approach, heuristics and thinking skills need to be considered when teaching problem solving skills (Flavell, 1976, McGuinness, 1999, Tanner & Jones 2002, Taylor & McDonald, 2007, Graves et al, 2009, Jacobbe & Millman, 2009).

Schoenfeld (1985) in his research on approaches to problem solving observed the behaviour of and strategies used by students to solve problems before entering a problem – solving course and at the end of the course. To carry out his research he needed to label the different strategies used by the students which he termed 'episodes.'

> "An episode is a period of time during which an individual or a problem- solving group is engaged in one large task" (Schoenfeld, 1985 p. 292).

Although, as acknowledged by Schoenfeld, this labelling was subjective, it was also essential to produce a timeline. His episodes were reading, planning, analysing, exploring, implementing, verifying. He then produced typical timelines based on these episodes for the 'novice' problem solver and the 'expert' problem solver.

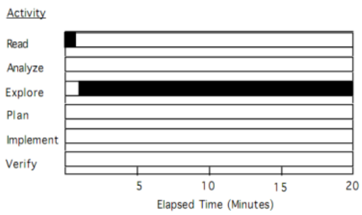


Figure 1. Timeline of a 'novice' (Schoenfeld, 1985)

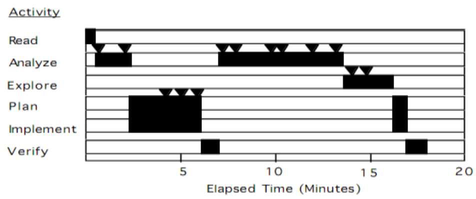


Figure 2. Timeline of an 'expert' (Schoenfeld, 1985)

Methodology

The main theme of this paper is using Schoenfeld's (1985) timeline to analyse problem solving skills of trainee teachers before and after a carefully designed problem solving course,

I undertook a case study (Bell, 1999, Cohen et al, 2007) with eight undergraduate teacher trainees. I gave a pre-test, in the form of an investigation, to the teacher trainees at the start of the course before any teaching had occurred. I designed a problem solving course based on literature and research which I undertook for the eleven week term with the trainee teachers. After the course the teacher trainees were then given a post-test, in the form of a close transfer investigation, in order to explore the impact of my course. I analysed the teacher trainees' problem solving strategies using Schoenfeld's (1985) timeline episodes. I undertook a pilot study with Secondary Mathematics PGCE students.

'Problem solving course' design.

The factors which were considered when planning to teach problem solving skills were the classroom climate (Graves et al, 2009), communication / dialogue (Trickey & Topping, 2004), the practical approach (Pinter, 2011), heuristic strategies (Jacobbe & Millman, 2009) and thinking skills/ metacognition (Tanner & Jones, 2002).

Use of Schoenfeld's (1985) timeline.

A pilot study was undertaken with my Secondary Mathematics teacher trainees. As all the teacher trainees had consented to take part in the pilot study I videoed them trying to solve 'Terminator' (Tanner & Jones, 1995). From the observation of the videos I found that I was able to analyse individual performances using Schoenfeld's (1985) timeline even though the teacher trainees were working in groups. This might have been due to the nature of the task as the teacher trainees worked co-operatively rather than collaboratively in that they naturally split into different roles, working together to the same end (OECD, 2010). Therefore an individual's behaviour and problem solving strategies did not depend on the others in the group. However, analysing the group as a whole proved to be more difficult as the individuals didn't work together collaboratively for the main part of the problem. Nevertheless, as this could have been dictated by the nature of the task, I concluded from my pilot study that the use of Schoenfeld's timeline in order to analyse problem solving strategies used in groups merited further research.

Main Study

A baseline assessment investigation was given to the teacher trainees at the start of the course to assess their prior knowledge and ability to solve problems. The teacher trainees were split into two friendship groups of three. The two groups were given the same pre investigation with little explanation as I was interested in their problem solving strategies without my influence. This investigation was called the 'Painted cube' (Shell Centre for Mathematical Education, 1984) and was chosen because it had a 'real life' element with which the teacher trainees could identify and secondly because a general formula could be found, making it a mathematics problem. I videoed the teacher trainees working in their groups on the Painted cube problem as a 'non- participant observer' (Cohen et al, 2007, p.259). I set out to analyse both individual and group performance using Schoenfeld's timeline which involves plotting phases of problem solving against time (Schoenfeld, 1985) based on 'reading', 'analysing', 'exploration', 'planning- implementation', 'verification' and 'teacher intervention' which I added as a result of the pilot study This was repeated for the post investigation 'The Mayan Pyramid' (Shell Centre for Mathematical Education, 1984)

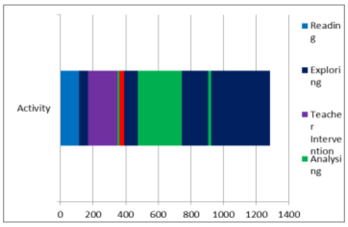
The data collected included the videos of the pre and post investigations, the transcribed observations of the videos, the teacher trainees' informal notes on what they observed in the videos and my informal observation during the period.

The Ethical Guidelines for Educational Research published by the British Educational Research Association (BERA) and the Economic and Social Research Council (ESRC) (Silverman, 2010, 155) were followed throughout my pilot study and main research.

Results and conclusion

The problem solving course

Analysing and comparing the teacher trainees' approaches from the pre investigation to the post investigation provided explicit evidence that the teacher trainees had become more expert in their problem solving approaches which could have been attributed to the problem solving course. My observations of the sessions, the trainee teachers' notes and their evaluations also provided evidence that problem solving can, in this situation, be taught. All sessions contributed to the teaching of problem solving but I think that allowing the trainee teachers to solve problems themselves was perhaps the most important as it allowed them to develop their problem solving skills in several areas, e.g. thinking, planning, monitoring.



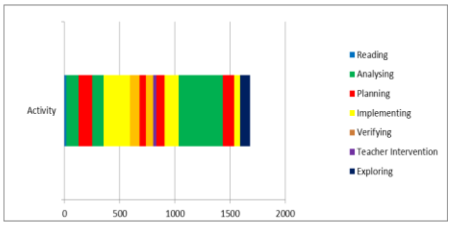


Figure 3
Pre- investigation task
timeline of one group.

Figure 4
Post- investigation task
timeline of same group

It can be seen from the timelines above that the problem solving strategies used for the pre investigation to the post investigation became more like Schoenfeld's 'expert' timelines. This could have been due to the problem solving course.

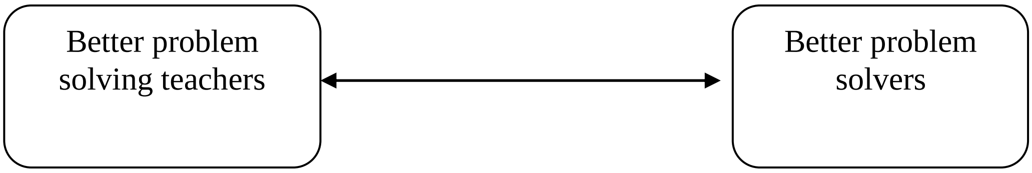
The analysis using Schoenfeld's (1985) timeline

As part of my research I was interested in whether Schoenfeld's timeline could be used in small group situations. In order to research this I first undertook a pilot study (Cohen et al, 2007) with my Secondary Mathematics PGCE teacher trainees. The results of this, discussed in the methodology section, were that it was easier to use the timeline for individuals than for groups. Interestingly the opposite was found in the main research. I found that I could analyse each group's performance quite successfully using Schoenfeld's (1985) timeline. The fact that this could be done in the Painted Cube (Shell Centre for Mathematical Education, 1984) and the Mayan Pyramid (Shell Centre for Mathematical Education, 1984) could be down to the teacher trainees working collaboratively together, all working on the same task to solve the problems. Due to the same reasons, and opposed to the pilot study, I was not able to analyse individuals' performances as well in these tasks. It was difficult to concentrate on one individual as what was said needed the context of the other responses in the group. These individual ideas might have 'bounced off' or been prompted or scaffolded (Wood, D., Bruner, J. S., & Ross, G.,1976) by other teacher trainees in the group. Although it was possible to use Schoenfeld's timeline on these individuals very subjectively, based on my thoughts, these results cannot be relied upon to produce consistent, dependable evidence and therefore, as a research tool, reliability (Cohen et al, 2007) is questioned and I didn't pursue this.

In summary I found that I could use Schoenfeld's (1985) timeline to analyse the problem solving approaches used by small groups. However I found that it depended on the nature of the task on whether the approaches of either the individual or the group could be analysed. If the group worked collaboratively on a task (e.g. Painted Cube) it was easier to analyse the whole group approach whereas if they worked co-operatively (e.g. Terminator) it was easier to analyse individual approaches.

Overall the results of my case study show that problem solving can be taught, subject to a number of conditions and factors. The teacher trainees' problem solving skills did develop in most cases. Schoenfeld's timeline can be used in group situations depending on the nature of the task and the way in which the group worked together.

As the role of problem solving becomes more and more important in Mathematics education, it is useful to note that in this specific study, problem solving can be taught and in most cases quite successfully. There is evidence to show that teacher trainees can become better problem solvers as a result and hopefully, this will lead to better teachers of problem solving in the future.



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