Developing a 'dynamic' and collaborative pedagogy for postgraduate certificate (PGCE) secondary mathematics students

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Abstract
In this paper we explore the development of 'dynamic', collaborative and 'real time' pedagogy for teacher education. This pedagogy has emerged organically as secondary mathematics student teachers work collaboratively in teams of three or four alongside school mentors, pupils and university tutors. The pedagogy of teacher education reported here is underpinned by the innovative, and possibly counter intuitive, notion of 'dynamic mentoring', where reflexivity and meta-cognition take place openly and in real time during the teaching and learning of pupils in the classroom. We examine the evidence that the developing pedagogy has improved pupil attainment and also student teacher retention and attainment.

Keywords
Teacher education; pedagogy; collaborative; dynamic; mentoring; mathematics.

Background to research

In England and Wales, teacher education programmes are subject to government requirements that specify the length of time that student teachers should spend in school during the programme. The year-long postgraduate training is intensive and student teachers need to be proficient enough to meet the Teachers' Standards (DfE, 2012a) by the end of the course. The most common secondary training route (at the time of writing) is through a partnership between a university and a secondary school. The university is often the lead partner: it is required to find a school placement for the student teacher within partnership schools.

This project arose out of the need to find good quality school placements for our mathematics (hereafter 'maths') post-graduate certificate in education (PGCE) student teachers. This was at a time when there was an increased number of maths (and science) training places funded by the (then) Training and Development Agency (TDA) to meet the shortage in teacher supply (Wilson & Bolster, 2011). An increase in student teachers led to a shortage of even adequate placements in schools. One strategy, supported by the TDA, was to place students in paired/ multiple placements (TDA, 2008). The benefits of paired placements for student teachers can include psychological and emotional support (Sorenson, 2004), gaining a better understanding of how pupils learn and an increased confidence to take risks (Wilson & Bolster, 2011). The willingness of a school to engage fully with teacher education and multiple placements in particular was, at that time (2009), unusual. It is the authors' experience that schools can be very reluctant to accept large cohorts of student teachers. This can be due to concerns about the impact of student teachers on the attainment of pupils, particularly for examination classes (Hurd, 2008).

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As the difficulty in finding maths placements was especially acute, the authors of this paper - the university tutors and school mentors from a large partnership school - agreed to explore the pedagogical development of groups of student teachers during their placements within the maths department. Initially working in pairs, the model developed so that students planned and taught in groups of three or four as well.

In order to support student teachers, collaborative teaching was modelled at the university and reinforced by mentors in school at the same time, thus encouraging the student teachers to explore different models of collaborative teaching in their teaching practice. The school mentors demonstrated openness to exploring possibilities, through experimenting with models of collaborative teaching and mentoring with the university tutors in this way. One of the early unexpected outcomes from the multi-placement model was an improvement in student teacher retention from 65% (2007/8) to 96% (2010/11). At the same time the school observed an improvement in pupil outcomes in the GCSE A* - C grades in maths (see Table 1.).

Table . 1 Pupils' GCSE mathematics results, 2008-2012.

Year	**% A*-C GCSE**
2008/09	45(52)
2009/10	54(48)
2010/11	59(52)
2011/12	65(52)

Note: the numbers in brackets indicate the expected results in Maths based on Fischer Family Trust (FFT) data.

With seemingly symbiotic benefits of improved student teacher retention and pupil performance, it was decided to investigate possible reasons for the success of the multi-placement model in this school. From observations in the classroom and discussions with student teachers, we found that models of pedagogy were emerging. Student teachers were using a model we have termed '*dynamic collaboration'* and a mentoring style had developed to a model we have termed '*dynamic mentoring'*. Before describing the methodology and findings in more detail, we turn first to the literature on paired placements and collaborative teaching.

Literature

Previous studies of students in multiple placements have focused primarily on paired placements (e.g. McKeon, 2006; Menendez & Oulton, 2007; Sorenson, 2004). These papers report on the benefits to the student teachers, as well as the difficulties of these placements both for student teachers and for mentors. There is some consideration of how mentors work with the student teachers, but the majority of this work focuses on the development of capacity of the student teacher and mentor experience (McKeon 2006; Sorenson, 2004; TDA, 2008).

Although there are various models of collaborative or co-teaching (Murawski, 2012; Strogilos & Tragoulia, 2013) student teachers in paired placements seem to use mainly the one teach/one support model or the driver/navigator model (Wilson & Edwards, 2009). In this model, one trainee leads the class, while the other acts as a teaching assistant (Wilson & Bolster, 2011: 17). However, this can lead to one trainee taking the lead more often than the other. On the positive side, Wilson & Bolster (2011) describe how student teachers in a paired placement can develop an empathy that gives them the confidence to interrupt each other during the lesson and steer it in a new direction. This has been termed 'dynamic deep questioning'. The university tutor described it as "like watching

England's midfield when they are working at their best!" (Wilson and Bolster, 2011: 47) This process seems to have arisen organically and the interruptions do not seem to be planned.

There are also various reports of how mentors work with students on paired teaching placements (e.g. Bullough et al., 2003; McKeon, 2006; Wilson & Bolster, 2011), including discussion of the types of mentoring that are undertaken and the different roles that are adopted by mentors in helping students through different phases of the PGCE course. Within the classroom, the role of the mentor seems to be quite similar whether it is a pair or a single student teacher: the mentor generally observes how the lesson progresses and provides feedback after the lesson. In these studies, there are some examples provided of mentors interjecting briefly or of others taking over the lesson completely due to inadequate explanations on the part of the student teachers or due to the lack of control of pupil behaviour (as in Wang, 2010). In these cases the teachers were reacting to critical incidents of practice and there did not seem to be an on-going dialogue within the classroom.

Methodology

The main aim of our research is to explore why the multiplacement model is successful for student teachers. Although we are aware that pupils' attainment has also improved this is not the focus of research in this paper.

In this study, we have looked at how student teachers working in pairs and groups of three and four collaborate in the classroom. We have used existing models of collaboration as points of reference and identified how 'dynamic collaboration' is different. We have also explored how mentors work with groups of student teachers and the opportunity this presents to develop mentoring practices. The area of 'dynamic' mentoring and 'dynamic' collaboration as defined by us does not seem to have been practised or researched in any detail within the UK context and the impact of this approach on student teachers has not been explored.

In order to explore the complex sets of interactions involved in student teachers working together in the classroom, the approach taken was exploratory and interpretive - we felt that this approach would allow us to understand the students' interpretation of collaborative teaching (Cohen, Manion, Morrison, 2013). A positivist approach was deemed inappropriate as the sample size was small. It was also felt that it would be difficult to explore any changes in student teacher perceptions of this approach over time through questionnaires, as these are not sensitive enough to capture fluctuations and nuanced outcomes in perception

As co-observers (university tutors and school mentors) of the student teachers' collaborative practices as they developed, it was felt that there were some benefits that we would not necessarily be aware of, if observations were used as the sole method of inquiry. We had built up a variety of anecdotal experiences and observations over time that needed to be addressed and considered that semi-structured interviews would allow the freedom to ask questions and follow up issues with other questions as necessary (Robson, 2011). Furthermore, collecting data using the interview method was appropriate to this work as it was a 'small-scale research project where you … are wanting to carry out a study … in which you are already an actor' (Robson, 2011: 279).

It was anticipated that the collaboration would result in complex sets of outcomes where the impact could only be fully identified by exploring what the student teachers perceived the outcomes to be. To capture the different possible strands that might exist, a focus group approach was also used. This allowed the participants to voice their perspectives (Morgan, 2013). Two separate focus groups were convened, the first focus group comprised 5 participants and a second group comprised 3 participants. In order to capture as broad a range of views as possible, the first focus group was drawn from students who had not taught together collaboratively and different cohorts were

represented. The second focus group was smaller and was comprised of students from the same cohort who had taught together. While we had a small group of participants for the focus groups, it was necessary to make sure that the problems associated with this scenario were overcome or at least minimised. Denzin and Lincoln (2005) highlight the potential in focus groups for the domination of the group by an individual. In order to overcome the possibility of the lack of participation by some interviewees, we felt that we would overcome this by two of the authors being present at both groups to manage and moderate the interview process.

The combination of the focus group with semi-structured interviews allowed themes to emerge which could be further interrogated with more detailed interviews of individuals. While it was still important to use the interviews to elicit views from individual student teachers, after initial analysis it was also deemed necessary to use a more 'directive interviewing style' (Morgan, 2013: 109) to focus the interviewee on the areas that we wished to pursue further. Five students were interviewed individually, these represented student teachers of cohorts from 2009 – 2013.

A schedule of questions was carefully planned for the different focus group interviews. Open ended questions allowed us to record students' perceptions of their experience of teaching collaboratively so that we could explore the reasons why it was successful, what successful collaborative teaching looked like and the role of the mentor.

The interviews were recorded and transcribed. The analysis was interpretive and we identified the aspects of the collaborative practice that the students were highlighting. We used that information to determine the themes that we would take up in the individual interviews.

Findings

The student teachers questioned worked collaboratively in pairs or groups of three or four, with most student teachers working in several groups of different sizes. For example, student D worked in a pair, in a team of three and a team of four; student C worked in a pair and in a group of four; while student A worked only in a pair. Overall student teachers were positive about learning to teach by working collaboratively in the classroom and enjoyed the collaborative teaching. Previous studies have identified that student teachers enjoy the mutual support (Wilson & Bolster, 2011), the meeting of basic needs (Sorenson, 2004) and having the opportunity to share expertise (Wilson & Bolster, 2011). For example:

> 'It is useful to learn off other people and it's useful to plan with other people, learn from people's strengths'
>
> (student teacher B.).

Planning collaboratively is effective as it can help students develop a recognition of the different ways of understanding maths.

> 'people's maths knowledge will be different or they will see something different and them seeing different things means that you get exposed to all the misconceptions … straight away'
>
> (student C.).

Other students agreed with this and commented that it happened in the classroom as well as in the planning stage. In the classroom students perceptions were that collaborative teaching had an effect on their pupils:

> 'because they (pupils) see us more as a team . . . you've got a bit more authority or respect'

(student teacher E.).

The effectiveness of collaborative teaching was also felt after the lessons. The students recognised that self-evaluation is interpretive and that their evaluations of the lesson were informed by the vantage point they occupied (location in the classroom, interactions with pupils and pedagogical interpretations). The advantage of collaborative teaching is that it provides the opportunity for a comparison of evaluations and the students identified this as one of the reasons why they felt collaborative teaching helped them develop their own practice.

We explored the models of collaboration that students used. Our findings point to paired teaching limiting the nature and extent of collaboration for students. We found that the co-teaching approach of one teach/one support (Murawski, 2012; Strogilos & Tragoulia, 2013) or driver-navigator model (Wilson & Bolster, 2011) was the predominant collaborative teaching model that paired student teachers employed. Within this model, there is the opportunity for students to plan together and for each to have the opportunity to lead the lesson; but, despite the flexibility of the teachers being together in the lesson, there was some evidence that they were not truly collaborating, as in the following example:

> 'I don't think we got the point of the collaborative thing. . . we just sort of split up and planned our own lessons'
>
> (student teacher A.).

Dynamic collaboration

However, when groups of three or four student teachers taught in collaborative groups, a greater range of approaches was observed: for instance, team teaching, parallel teaching, station teaching (where teachers facilitate individual work stations and groups of pupils rotate through multiple work stations see Murawski, 2012) and alternative or complementary teaching. These are models that have been previously reported on (e.g. Murawski, 2012; Strogilos & Tragoulia, 2013). Dynamic deep questioning as observed in Wilson and Bolster (2011) was also observed. However, we also found what we consider a development of this model which we have termed '*dynamic collaboration*'.

As identified through observation and further exploration in the interviews and focus groups, dynamic collaboration begins at the planning stage. Student teachers identified the main objectives of the lesson and the essential mathematical concepts that they understood to underlie the objectives. The key mathematical alternative conceptions pupils might have about the mathematical topic need to be understood by all the student teachers involved in a lesson in order for the teachers to provoke cognitive conflict amongst pupils and thereby encourage a refinement of their understanding (Swan, 2006). The student teachers planned so that they taught incorrect answers, partially correct answers alongside correct answers, in order to move pupils away from the idea that maths is simply about getting the right answer. The primary focus was on the discussion of the logic of the work being put forward and refining the elegance of a solution to a maths problem. The options given by experts (the student teachers) created a dynamic in the classroom where the quest became interesting for the pupils, and there was no fear associated with being wrong, because the experts were not fully correct themselves. The student teachers often added to the drama by accepting the wrong arguments and if the pupils saw that there was a problem with the argument then they challenged the other student teacher without worrying about being wrong. The potential for how student teachers can use this interaction amongst themselves as well as with the pupils is enormous. This was initially modelled at University by the university tutors in lectures and workshop sessions.

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An illustration of some of this approach was observed in a lesson where the pupils were asked by one of the student teachers to factorise $12x + 24$. The four student teachers each worked with groups within the class and then gave an answer, as shown in this extract from the observer's notes at the time:

Student teacher 1: 'The answer is $12(x+24)$.' She writes this on the board.
Student teacher 2: 'I (we?) have got $2(6x+12)$.' Again, writes this on the board.
Student teacher 3: 'I have $6(2x+4)$.' This answer is written on the board.
Student teacher 4: 'And I have $12(x+2)$.' Answer again written on the board.

The pupils were thus presented with four possible answers, each given by experts and encouraged to discuss the merits of each of the answers. Each teacher then provided the reasoning for their answers. While these explanations were given, the other student teachers were able to interject and critique each other. This created an atmosphere in which pupils were comfortable to join in and discuss the relative merits of each answer. In the example given, pupils were provided with the opportunity to discuss factorisation and partial factorisation and the merits of full factorisation.

Dynamic mentoring

The discursive and lively classroom we have described also evolved from a different style of mentoring. With a large number of student teachers overall, most of the maths teachers in the partner school were also mentors. The models of mentoring the teachers adopted varied. We noticed a particular pedagogy that could be employed effectively by mentors who had a team of student teachers in the classroom.

While most teachers adopted the traditional style of observation and feedback at the end of the lesson, two teachers adopted a model we have termed 'dynamic mentoring'. In this approach, the mentor was prepared to direct the student teacher to change how they were teaching the pupils while the lesson was being taught, if the mentor felt that it would impact positively on the pedagogical development of the student-teacher. In the traditional mentoring model this action could be seen as disastrous in undermining the confidence of the pupils in the student teacher. We would suggest that the dynamic collaboration we observed may have evolved as such conversations about pedagogy and content occurred between mentors and student teachers as the lessons progressed. A culture seemed to be created in the classroom where interventions of this type were not seen as detrimental to the student teacher. The mentor interventions were similar to the challenges to the student teachers' 'incorrect' answers during dynamic collaboration. These roles of 'right' and 'wrong' could be reversed during planning so that a culture was created where the pupils became equally accepting of the mathematical and pedagogical points that both the mentor and the student teachers were making, thus leading to the development of a learning community. As one student teacher commented about this approach:

> 'It's fantastic for engagement, the kids loved it'
>
> (student teacher B.).

In this approach, the influence of the power relationship between the mentor and the student teacher was reduced in terms of teaching and learning. The planned interventions could then give way to situations where the student teacher was actually teaching the class and the mentor wished to change how the lesson was being taught. When this was done within a positive learning climate, the pupils did not consider it unusual, as they were used to that kind of interplay between the student teacher and the mentor.

It was also possible for this culture to develop as we observed in some cases where the pupils, student teacher, mentor and the university tutor were all involved in learning and this process of learning was being recognised by all the participants. This could reach the point where the pupils were able to comment on what they found useful in the interventions and the actions of the adults and the environment seemed to be a learning one for all to analyse each other's development. While the purpose of dynamic mentoring started off with a limited remit, of giving feedback to the student teacher during the lesson and thereby altering the direction of the lesson immediately, rather than waiting until the next lesson to see the development of the student teacher, the culture that was created seemed to suggest some corresponding benefits and we discuss these further in the next section.

Benefits

We would argue that by giving feedback during the lesson, the student teacher's progress is accelerated, thus avoiding periods of time when pupils are not learning and when the student teacher's practice is not developing. This ensures that the pace of the lesson does not drop. Not all the student teachers interviewed had experienced dynamic mentoring; however, they were mostly of the opinion that it was a beneficial experience, but daunting at the same time, as the following views indicate:

> 'Instead of being dropped in the deep end it felt like I was being dropped in the middle of the ocean'
>
> (student teacher C.).

> 'I think it has probably made me a better teacher but it was just a scary ride'
>
> (student teacher A.).

For dynamic mentoring to be effective, we would suggest that the student teachers need to work in supportive collaborative teams so that they can provide emotional and psychological support to each other, as one interview example demonstrated:

> 'If you are in the same lesson and it goes wrong for all of you, you can all try to dissect it and try to figure out routes together, whereas if you are on your own you've only got your own feedback and someone else's and you might not agree with their opinions'
>
> (student teacher C.).

The student teachers recognised the importance of the relationships within the group. For example, student teacher B worked in several groups and noted that lessons ran more smoothly when the relationships in the group were good.

When this approach to teacher education was explored further in the interviews, the student teachers identified key factors in successful dynamic collaboration, such as: time to plan effectively, the quality of relationships between the student teachers and matching student teachers of similar ability in groups. These findings are in agreement with previous reports of paired placements and co-teaching (Murawski, 2012; Strogilos & Tragoulia, 2013; Wilson & Bolster, 2011). Working in different groups did impinge upon the time students had to plan collaboratively and we would suggest it is probably only possible for student teachers to work effectively in a maximum of two different teams.

Limitations

Some difficulties encountered by multi-placements were evident, as observed previously (Sorenson, 2004; Wilson & Bolster, 2011); therefore, it is important to configure and match student teachers

and mentors carefully. Several of the student teachers described how 'unequal pairing' (weak subject knowledge or computer skills) could detrimentally affect the dynamic of the group. However, with large numbers of student teachers in the department, it is possible to reconfigure groups if pairings are unequal or relationships break down.

Student teachers within groups teaching collaboratively, and engaged in discussions about pedagogy within the classroom, can find this a very intense experience and the intensity does need to be recognised when preparing teaching timetables. As one student teacher put it:

> 'You feel like you've run a mini marathon or something after the lesson' (student teacher C.).

Implications of this model

We report these findings at a time of considerable change in teacher education. There is currently an expectation of schools taking on a larger role through the School Direct programme (DfE, 2011). At the same time it has been recognised that as early as 2016 there will be an increased demand for secondary school places due to a sharp increase in population in England (DfE, 2012b). This model may point to ways of developing capacity for teacher education in secondary schools.

Our findings are tentative, but we would suggest that the multi-placement model, combined with dynamic collaboration and/or dynamic mentoring, offers potential benefits to the student teachers, the pupils and teachers in school.

For dynamic collaboration to be truly effective student teachers need to understand the rationale for this approach to teacher training. They need to be aware of the different models of teacher collaboration in the classroom and particularly how they can exploit multiple approaches to mathematical problems to engage pupils. With a number of student teachers in the room it gives a range of what student F referred to as 'observational stances' – different views both physically and pedagogically of the maths classroom. Most of the student teachers interviewed commented on the benefits of discussing the lesson afterwards with the group in order to help them evaluate their teaching.

One aspect all the student teachers interviewed recognised was the importance of having adequate time to plan and reflect. One cohort had worked in different groups and finding time to meet with the different groups was very difficult. We would suggest that students work in no more than two groups teaching collaboratively.

Larger groups of student teachers do give the opportunity for a change in mentoring practices – dynamic mentoring – which can lead to all participants in the classroom developing a deeper understanding of the effectiveness of different pedagogies. The mentors need to inculcate the recognition of the community of learners. There are various ways this could be developed, but preparing mentors for a change in practice is essential. At a local level some student teachers in their second or third year of teaching have gone on to dynamically mentor trainees but the condition of success is that the concept of the community of learners is established.

The changes to mathematics teacher education pedagogy have evolved over a period time. It is not a 'quick fix' solution, but one that requires commitment from the participants, the mathematics department and from the senior leaders in school. We would suggest that once established in the mathematics department it is a transferable model which could be adopted and adapted by other subject departments.

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