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Working to meet the needs of school pupils who are gifted in science through school-university initial teacher education partnerships

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Abstract:

This chapter considers the potential role of initial teacher education (ITE) in bringing about change in educational practices, drawing upon the example of preparing new teachers to meet the challenge of providing educative science learning activities for the most able and advanced learners they will meet in their classes. It considers in particular the former route, which has potential to influence teachers' practices throughout their careers, and operates before teachers have become fixed in comfortable classroom habits or have assimilated the culture of custom and practice within specific schools. In school science the nature of the curriculum, and its associated assessment apparatus, has constrained effective teacher practice in working with gifted learners. Two of the major potential routes for research findings to influence teaching practice, without being overtly channelled by political ideology, are through initial preparation and continuing professional development for teachers. Time in schools includes seminars and observations, but is based around a phased induction into professional practice.

Setting the context

This chapter considers the potential role of initial teacher education (ITE) in bringing about change in educational practices, drawing upon the example of preparing new teachers to meet the challenge of providing educative science learning activities for the most able and advanced learners they will meet in their classes. The chapter is written from the context of initial science teacher education in England, and offers background on that context to support readers in considering the extent to which the situation discussed here can inform other educational contexts.

ITE here refers to courses of preparation undertaken by teachers before they are assigned to take full responsibility for classes in schools. The term gifted is used here in a contextual sense (Taber, 2016a) that is, that learners should not be considered gifted (or not) per se, but rather evaluations must relate to particular subjects, learning activities, and phases of a learner's learning progression. The key idea of educative provision is a match between learner capability and assigned tasks, such that learning tasks should be challenging but achievable - neither trivial, nor unrealistically difficult - given the support provided (Taber, 2015).

As has been discussed elsewhere (see '*Teaching science to the gifted in English state schools*', this volume), there has been ongoing concern with the level of provision of science education (indeed, education more generally) for the most able learners in English state schools. Due to the ideological influences prevalent in the system for some time, meeting the needs of the most able learners has not been a strength in most English state schools. In school science the nature of the curriculum, and its associated assessment apparatus, has constrained effective teacher practice with gifted learners.

The impact of research on educational practice

An issue of long-standing concern in education is the impact of educational research - that is, how research can have influence on educational practice, given that academics (in view of how they are primarily judged for appointment, promotion and the like) have to write for academic audiences in scholarly journals. Teachers are usually too busy to read primary academic literature, do not have access to much of it, and may not readily engage with the writing style and technical language expected in journal articles.

The issue of access may be shifting, as increasingly publicly funded research is being published in open-access sources, or with archiving into some kind of open-access repository. However, it is likely that much relevant research will continue to only be generally accessible through expensive subscriptions for the foreseeable future, and regardless of accessibility school teachers rarely have much time for accessing primary educational literature. Governments may well consider it is part of their role to highlight key research findings and bring these to the teaching profession, but particular governments tend (given the nature of politics) to view research from particular ideological positions, and may be suspected within the profession of 'cherry picking' results and implications that fit their own policy preferences (i.e. selection bias). Moreover, in the English context discussed here at least, government-led initiatives to offer research informed pedagogic advice may oversimplify and decontextualise issues to such an extent that it can undermine the potential value in real classroom contexts - such is the advice given on responding to students' alternative conceptions (Taber, 2010).

The role of initial science teacher education

Two of the major potential routes for research findings to influence teaching practice, without being overtly channelled by political ideology, are through initial preparation and continuing professional development for teachers. This chapter considers in particular the former route which has potential to influence teachers' practices throughout their careers, and operates before teachers have becomes fixed in comfortable classroom habits or have assimilated the culture of custom and practice within specific schools.

Initial teacher preparation can take place in specialised colleges or departments of education or similar institutions, or can take place in schools themselves. It is argued here that ideally preparation for the teaching profession has some elements of both. Learning to be a teacher within authentic institutional contexts can be a very powerful and effective part of initial teacher preparation. Working alongside experienced practitioners who have developed custom and practice, within the culture and norms of a real school, provides the context for making sense of theoretical ideas about curriculum, pedagogy, learning, and so on.

Components of initial preparation based outside the school context offer time and space for reflection, and allow the considered exploration of diverse perspectives that is important for ensuring new teachers enter the profession with a broad base of alternative ideas about what is potentially desirable, and what is possible. Whilst school-based elements of practice are probably the most effective way of learning about the norms and practices of teaching (at least in the specific placement context which, may not be typical of other schools), they offer limited scope for considering alternatives options (including potentially innovative alternatives) deriving from diverse standpoints, that are not reflected in the norms and discourse practices in the specific placement context.

Research-based approaches and government-sponsored initiatives may well be represented in practice in a particular school, but such representation is often (inevitably) somewhat distorted when compared with the original scholarly research or official policy intention (Terhart, 2013). (That is certainly the case with the 'Gifted & Talented policy in English state schools - as discussed in the chapter '*Teaching science to the gifted in English state schools*', this volume). That is only likely to become apparent to a new teacher when they are able to stand outside the specific school placement context - both in terms of space and time, and in terms of institutional affiliation. The student teacher may be considered part of the teaching department when in school, and may indeed 'go native' (behaving in accord with the norms and practices in that department - for example in terms of the extent to which provision for the most gifted learners is, or is not, taken into account in lesson planning and teaching), but retains another identify as part of a group of learners when back with the student teacher cohort in the faculty environment.

That is, ITE should offer both opportunities for immersion within specific cultures of practice as this best supports the enculturation of existing cultural norms and practices, and opportunities to engage with, and consider, diverse theoretical, research-informed, perspectives, outside of the high pressure environment of the school, as this best supports the development of broad evaluative frameworks for reflecting on teaching. Preparing school teachers to reproduce existing culture (i.e. teaching culture) is best undertaken in schools, and preparing teachers to consider and adopt new approaches is best undertaken elsewhere (such as in the universities). A balance of both is desirable. When considering an area of practice considered to need improvement, such as working with gifted learners in science classes in English state schools (Ofsted, 2013), the contribution of the university-based component may be especially significant.

The context of the work discussed in this chapter

In the English education system there is what is called 'qualified teacher status' which has acted as a kind of license to teach in state schools (although in recent years schools have been increasingly allowed to employ unqualified teachers). The registration is undertaken by an agency of the national government department, despite the supposed status of teaching as a profession (that is, self-regulating). In 2000 the government established a professional body for teachers (the General Teaching Council for England) which was supposedly to become responsible for maintaining professional standards among teachers, but this was never widely considered independent of government control - something confirmed when the government decided to simply abolish the Council in 2012.

The common pattern for teacher qualification in England has for some decades been via a course administrated at a university or similar provider. These courses are ideally based on partnerships between a university and a group of schools who offer placements to the 'trainees' (in England ITE is officially considered initial teacher *training*). This model (see figure 1) has become the norm over several decades (McIntyre & Hagger, 1992), having been an innovation on previous practice which had largely seen the role of schools as simply providing placements for student teachers 'from' the university to practise teaching skills.

Most secondary teachers, that is teachers who teach a subject specialism such as a science, first graduate in an academic subject, then take a post-graduate course in education that includes qualified teacher status. Teachers preparing for secondary science teaching could have degrees (and often also higher degrees) from a wide range of scientific disciplines: electrical engineering, astrophysics, geochemistry, marine science, zoology, industrial chemistry, materials science, etc. They are usually expected to teach across the science curriculum at least at lower secondary level (for 11-14 year olds). The usual pattern is a course of 36 weeks over one academic year, with one third of the time based in the university and two thirds on placements in schools. The curriculum is taught by both university and school teaching staff, and is split between subject specific and cross-curricular groupings and topics. The subject based course elements are divided between subject specialist (biology, chemistry, physics) and more generic science teaching components.

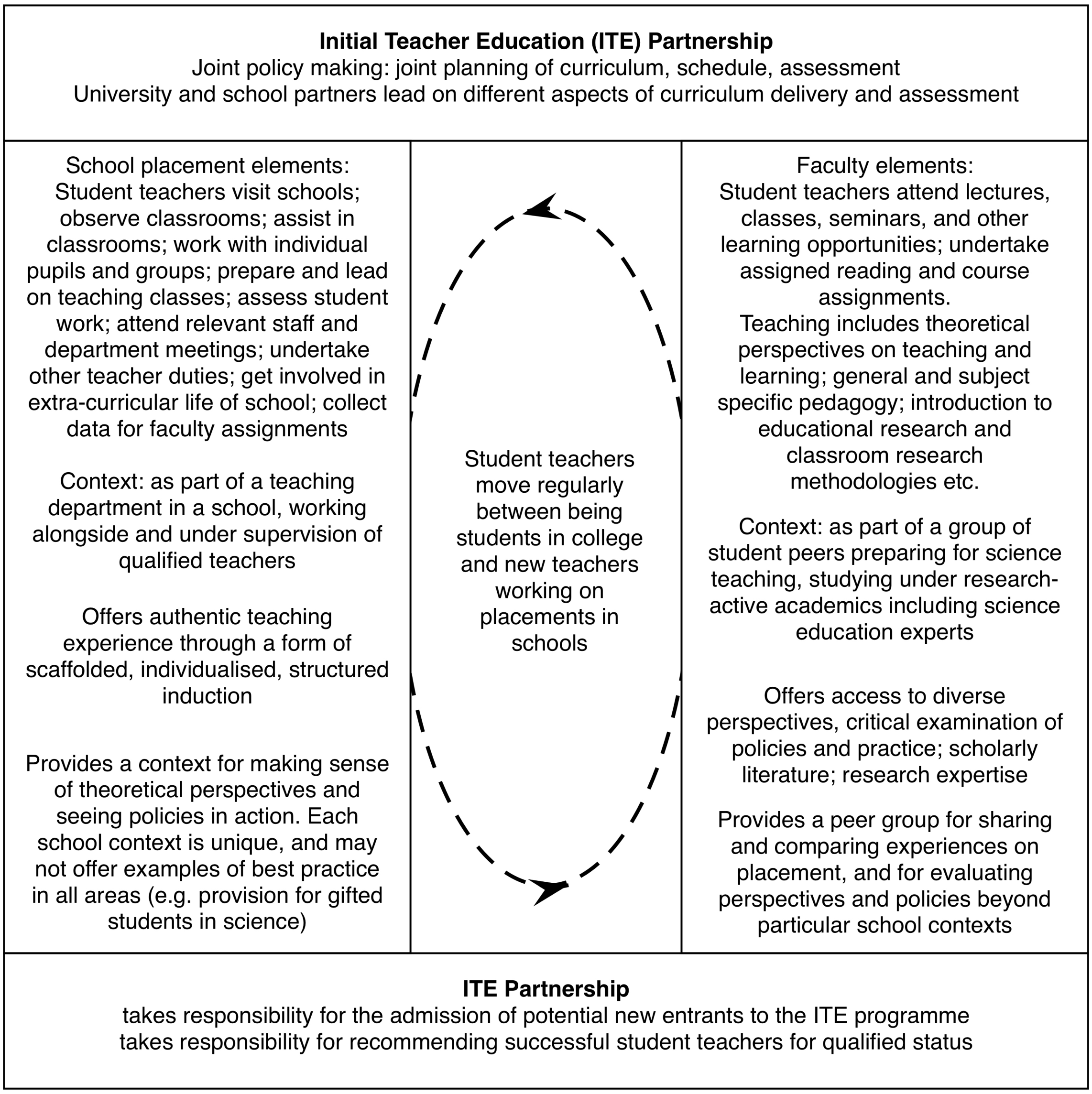

Figure 1: The university-school partnership context of initial teacher education common in England

Time in schools includes seminars and observations, but is based around a phased induction into professional practice. A new science teacher will be working with a subject mentor in the school, and will slowly progress from helping out in classes (usually with several different teachers), to leading components of a class within a team teaching context, to planning and teaching whole lessons, to eventually taking responsibility for extended sequences of lessons for a range of classes. This is a kind of apprenticeship model with student teachers moving from peripheral to central participation in the work of teaching (Lave & Wenger, 1991). Qualified teachers remain responsible for classes, but increasingly withdraw from being visible in lessons as the student teacher develops skills and confidence. The timetabling of such courses is designed to shift the balance of time more towards school based work over the year, but with opportunities to move between the two types of context (see figure 1) to best facilitate synergy between faculty-based learning (as part of a cohort of students) and school-based learning as - increasingly - a near autonomous classroom practitioner.

Preparing the fully professional teacher - engaging with research

The type of one year post-graduate course of teacher preparation discussed here is commonly credited at master's level (often potentially counting towards an MEd or MA degree), and is therefore expected to engage student teachers with research. This is usually interpreted not simply in terms of reading and critiquing research, but also developing research skills that can be applied in the professional context. Being considered a fully professional teacher means both being able to critically evaluate research findings of potential relevance to classroom work, and also having the skills and know-how to investigate issues empirically and test out innovations that have consequences for the teacher's own practice (Taber, 2013).

Student teachers commonly complete classroom research-based assignments as part of the assessment of the university qualification, and some of these may be quite sophisticated - especially given the limited familiarity of most science graduates with the types of methodologies suitable in the social sciences. It is not unusual for such work to be considered suitable for reporting beyond the context of the placement school or cohort of student teachers (for example, the University of Cambridge publishes an on-line *Journal of Trainee Teacher Educational Research* so that teachers in partner schools, amongst others, have access to the research carried out by student teachers on placements).

Involving the new teacher in opportunities to learn about gifted learners in science

The work reported in this chapter derives from a series of small projects undertaken in the Faculty of Education at the University of Cambridge that involved student teachers ('trainees') who were undertaking one of the one-year post-graduate courses of secondary teacher preparation discussed above. The student teachers were involved in different modes of contribution to these projects, which can be considered to offer examples of possible approaches that can be drawn upon in other programmes of teacher preparation. The first two examples both concerned engagement that might be considered extra-curricular and involved opportunities beyond the core teacher preparation programme. The final example was integrated into the normal programme.

Project 1: Teaching about ideas and evidence in science - preparing student teachers to undertake their own classroom research

The first project was part of a wider government initiative related to teaching about (scientific) ideas and evidence in lower secondary science. This was in response to a recognition that the aspect of the national curriculum in England concerned with teaching about the 'nature of science' (NOS) was a weak area of practice, with teachers often feeling ill-equipped and under-resourced to teach about this theme. The context was within what became known as the 'National Strategies', a set of initiatives to improve classroom teaching, and which had particular strands related to the core school subjects (i.e. in the English context considered to be mathematics, English, science). Much of the wider initiative was designed to be implemented through continuing professional development (i.e. in-service education for teachers) but there was also a strand related to ITE. It was decided the sub-strand concerned with science teachers in preparation would be delivered through projects on the theme of teaching about ideas and evidence in science to lower secondary age (11-14 year olds in this context) pupils (Braund, Erduran, Simon, Taber, & Tweats, 2004).

Providers of ITE were invited to bid for involvement in this project. Some modest funding was provided by the government, which was later supplemented by matched funding from an educational charity (Gatsby SEP). The Cambridge bid proposed linking the theme to teaching gifted learners in particular, given how NOS themes offer potential for stretching the highest achieving learners (Taber, 2007a, 2016b). This focus was selected to fit with an existing initiative, a seminar series on the theme of meeting the needs of the most able in science that was ongoing in the Faculty (Taber, 2007b). The project had two phases, the first being a collective small-scale research project, the second being based on individual enquiry undertaken during the student teachers' particular school placements.

A research team was made up of student teachers who volunteered to be involved: five secondary biology specialists, six secondary physics specialists, and three graduates preparing to teach 'middle school' grades. (Secondary here means teaching students aged 11-18, and middle school refers to 7-14 year olds. The overlap represents different patterns in school organisation in different local areas.) A meeting of the team explored ideas of how lower secondary school age pupils (e.g. 11-14 year olds) should understand the key terms 'theory', 'explanation', 'law', 'hypothesis', 'experiment' and 'models'.

In the first phase, following a basic research training session, the student teachers undertook research visits to two contrasting local schools and carried out a small-scale survey to explore pupil understanding of these basic terms related to the NOS (Taber, 2006). This was intended to both provide some initial research experience and to provide some background knowledge about the typical state of pupil understanding of the NOS at this age. The pupil groups surveyed were from a selective school and a top science set in a comprehensive (non-selective) school.

The student teachers were then tasked to carry out a small scale project about teaching some aspect of the NOS in the context of the class teaching they were due to undertake as part of their teaching placement in a partner school. Student teachers reported on their involvement in the project in a public seminar, in materials that were included on a government website, and in some cases through publication in journal articles (Taber, Cooke, et al., 2006; Taber, de Trafford, & Quail, 2006).

This second phase was integrated into the student teachers' normal workload. However involvement in the project was purely voluntary, with training sessions, the research visits, and involvement in the seminars all being outside core requirements of the ITE programme.

Project 2: 'ASCEND' - involving student teachers in a funded development project with local schools

The second project was funded by the educational charity, Gatsby SEP, and was based on co-operation between the Faculty of Education and a small group of local comprehensive schools (Taber, 2007a). The project (ASCEND - Able Scientists Collectively Experiencing New Demands) was intended to establish a suitable programme of science enrichment for gifted science learners from the City of Cambridge schools. The programme (mostly organised around NOS themes) was offered to 14-15 year old pupils that were considered by their schools as gifted in science and likely to benefit from a challenging extra-curriculum experience. The programme was organised as an after-school activity at the University faculty site and was staffed by volunteer graduate students. The team comprised four higher degree students researching areas of science education and nine graduate student teachers preparing to teach sciences in secondary or middle schools.

The graduate students were not involved in developing the programme, but took on roles that were in effect hybrids of teaching assistants and research assistants. In particular they were asked to make observations of how the delegates (the school pupils) responded to the tasks they were set. Some limited training was given, but perhaps more significant was the documentation for each session, where the rationale for the week's activities was explained in relation to the expected characteristics of gifted learners, and particular foci were suggested for the session observations.

The student teachers were working on the project in parallel with working on teaching placement in partner schools. The project offered a contrasting context in terms of the voluntary attendance of pupils, the concentration ('critical mass') of more able learners, and the roles they were asked to take (being less directive than when working in the classroom on their placements). As well as offering observations on each session, the student teachers were invited to respond to some questions based on their reflections of involvement in the project (see Box 1). Comments offered including observing that despite being both nominated for the programme and coming voluntarily, a few of these 'gifted' learners seemed less engaged and spent much time off task (a useful reminder that one should not make blanket judgements of pupils under a label such as gifted),

> "Some of the students were arrogant and cocky, which is to be expected. Some were surprisingly disinterested in the whole thing, which perhaps implies school or parental pressure. Some were able to carry on an informed and interesting discussion, and to demonstrate curiosity and the ability to investigate answers to satisfy that curiosity."

It was also noted that despite being nominated as gifted, pupils tended to struggle with some of the challenges: in particular dealing with information overload in one activity where timely completion required skimming, selecting, and sharing out the reading among the group, and on a task where groups of pupils needed to integrate information from across the science disciplines,

> "I was surprised at how difficult they found it to assimilate ideas from different sources and present them in a way other than just copying them. For example the plant nutrition exercise. I was also surprised how difficult some groups found it to organise themselves when instructions were left purposefully open for them to follow. Perhaps this is because they are often spoon-fed in school but many of the students obviously like to know exactly what they have to do and find it difficult when that structure is not there."

One of the student teachers noted that some of these pupils considered gifted by their schools "have a lot of the same confidence issues that a lower ability student might. They feel they need to justify their 'label' as a G&T [gifted & talented] student". Some of the graduate student reflections are included in text box 1.

[Working on the project] has certainly raised my awareness in terms of extending the more able - the need to do it to keep their interest and therefore motivation
[From the project I have learnt] how to approach extending the more able students in terms of their way of thinking rather than making the work harder
I was impressed by general levels of knowledge,especially about topics not directly on the syllabus. Also impressed by their ability to remain focused.
You should never underestimate the ability of your students. I think many students lack challenge and could achieve a lot more but they are not pushed or encouraged to think. Normal school science can be very programmed and require little actual engagement of brains. It would be nice to encourage more thinking not just learning. They need to be challenged more and can grasp some very difficult concepts.
I think I have realised that the students getting the right answer is not always the most important thing and that if you want to really stretch them it becomes even less important. It is allowing them the time to explore difficult ideas and develop their scientific thinking without worrying about them coming up with the right conclusion.
[After working on this project] I have the confidence to allow possible G&T [gifted and talented] children to work more independently.
[From the project I have learnt] that given a starting point, discussion and research into the areas that interest them can be extremely beneficial - if prompted to remain thinking about science! And that they can feed off each other really well, but they need to remember their fallibility and check things when they are not sure.
It's been great to be able to focus on such a specific issue, and to have input from other teachers and researchers. I fully intend to implement some of the techniques that I observed.
[I was surprised that the students could cope with] some surprisingly complex knowledge.
Interest and curiosity were expressed, as well as asking questions, some which were quite deep. Some pupils clearly had excellent subject knowledge, and in addition extra curricular information
[From the project I have learnt] the need to develop specific strategies for them, and differentiated learning objectives (but I already knew this, I suppose it has been emphasised).

Box 1: Graduate student reflections from working on a science enrichment programme for gifted 14-15 year old pupils

Comments such as those in Box 1 demonstrated that working on the project enabled student teachers to focus on the nature of gifted pupils, and the kinds of tasks needed to genuinely challenge them, reinforcing their prior learning ("I already knew this, I suppose it has been emphasised"), and offering a context where innovation beyond normal school practice (which could allegedly "require little actual engagement of brains") was possible.

Project 3: The Challenging Science Day - student teachers organising an event for pupils from local schools

The final project discussed here was different in that it was organised as a core part of the student teachers' workload. The sequencing of the student teacher's programme included a substantial period on school placement towards the end of the year, followed by a final fortnight which was largely faculty-based and which acted as a kind of capstone period for the ITE programme, allowing groups of trainees to reflect together on the year, and engage in activities which drew upon their professional learning throughout the course. It was expected that some of the time during this fortnight would involve working with school children, although the format for this was left open for the teaching staff responsible for different subject groups to decide. The physics specialist group were tasked with leading on organising a 'Challenging Science conference' when pupils from local schools would be invited into faculty for a day working under the supervision of the student (but very nearly now qualified) teachers.

Activities developed as part of ASCEND (project 2, above) were made available for use during the day, and a number were selected as the basis for a rotation of group based activities, where 'classes' (which were engineered so that pupils from the different schools were mixed together) would be taught by small teams of student science teachers. These teaching teams had to prepare in advance by familiarising themselves with the rationale for the activity they would lead on, as well as the teaching materials, and consider how to organise their classroom.

The group of student teachers also planned and presented a number of mini-lectures on themes they thought could engage and challenge the pupil delegates. These were entitled 'cool science', 'event horizon' and 'the science of superheroes'. The group of student teachers also took responsibility for producing a record of the day as a website.

The Challenging Science day provided a synoptic activity for the student teachers, requiring them to apply much of their learning about teaching, organisation, classroom behaviour management and so on in the context of learners that were largely unknown to them. More specifically, the effective organisation and execution of the event depending upon the student teachers appreciating the aim of the day and being aware of the needs of those pupils requiring greater challenge in their school science.

Discussion - in praise of ITE partnerships

It was suggested earlier that ITE has particular potential to facilitate changes in teacher practices by influencing new teachers before they become set in their ways of thinking and acting. The three projects briefly outlined above illustrate some examples of potential approaches that can be incorporated within ITE programmes to introduce student teachers to the issue of providing the most able learners in science classes with sufficiently challenging work.

The important feature these projects had in common was that they involved the student teachers in actively working with potentially gifted science learners in a context that was carefully supported and scaffolded. In the first project the students were primed for their individual classroom projects by attending an open seminar series and participating in a survey exploring high achieving pupils' understanding of key NOS terms and ideas. The 'meeting the needs of the most able in science' seminar series attracted academics, students, and local teachers to its meetings (Taber, 2007b).

The students undertook research as a team of interviewers working with a structured interview schedule. That is, they engaged in research but with basic training and on an activity that required limited research skills (e.g. compared to undertaking more open-ended interviewing). As well as comparing notes on their experiences, the students were involved in reporting the work at one of the open seminars.

In the second project, the student teachers were asked to supervise and observe groups of gifted learners working together, and primed to look at particular features of the interaction - again a form of research engagement that did not require extensive research experience or specialised training. The student teachers were given a rationale for the activities they were asked to observe, and expected to consider critically how well the educational objectives were being met - in particular in relation to the reported characteristics of gifted learners.

The third project also involved teaching groups of gifted learners using existing resources targeted for this group, as well as taking responsibility for leading on aspects of the organisational planning and developing engaging short demonstration lectures. This was a faculty-based activity, but teaching pupils from, and organised in co-operation with, local partner schools - who sent staff to accompany the children, and observe the day. This acted as a synoptic exercise for student teachers who during their programme had regularly moved back and forth moved between the critical and open academic environment of the university, and the specific reality of actual practice as a member of school science teaching department. These student teachers had regular opportunities to take ideas offered in the academic setting for scrutiny in realistic classroom contexts, and to report and reflect upon their classroom experiences in the 'safe' environment of a peer group of student science teachers working across a range of schools.

The students on this ITE programme were taught something about the nature of gifted learners in science, and approaches to responding to their educational needs, but not simply in a discrete teaching session (offered as part of the formal programme of classes) but also through a context where there was a need to apply the ideas in an authentic (research/teaching) engagement with groups of gifted learners.

It has long been recognised that ITE that has largely distinct and discrete college-based courses with school-based blocks to practise teaching is not always effective in helping teachers conceptualise the 'theory' in ways that allow them to fully draw upon this learning in reflective practice once they have classes to teach. Partnership approaches to ITE where a university and schools work together to devise a programme of integrated induction into the professional and scholarly work of teaching have much greater potential. Although university-based and school-based staff may take the lead on different aspects of the programme (reflecting their specialist strengths), it can none-the-less be a coherent and well integrated learning programme, with the different staff aware of the work of others, and with scheduling to allow effective movement back and forth between the different learning contexts. The projects described above were possible because of this type of integrated programme context which facilitates both the adoption of theory-into-practice and the development of research-based approaches to responding to perceived challenges to effective classroom teaching and learning.

Whilst school-based preparation is an essential component of preparing for teaching, it largely works to reproduce the existing culture - the existing norms, expectations, practices. Of course there are mechanisms for bringing about changes in school practices, but learning to be a teacher solely from within a school tends to mean learning to be a teacher like those already in the school, and adopting the existing customs and practices.

That is far from ideal when it is recognised that current practices need to be changed. One recognised weakness in the English state school context that provides the background to this chapter has been the provision for those pupils considered gifted, and this has been a particular problem in school science (see the chapter *Teaching science to the gifted in English state schools*, this volume). ITE is a major conduit for refreshing teaching through introducing new teachers to research and policy before their thinking becomes impermeable and their practice less open to being informed by alternative perspectives. Schools that work in the kind of ITE partnership discussed here often acknowledge how both involvement in working with faculty on partnership planning, and (especially) the influx of new thinking and open-mindedness that comes with hosting a student teacher for some months, acts as a major catalyst and supporter of school refreshment and development (McIntyre & Hagger, 1992). The projects reported here had potential to influence practice in the partner schools as well as in the schools where the student teachers would go on to teach after completion of their preparation.

Arguably the development of partnership models of ITE has been one of the successes of the English school system, and one of the innovations that can act as a positive model for many other countries. Ironically, at the present time, this very model is under threat from government policies that increasingly see teaching as a craft best learnt 'on the job' (Gove, 2014). The long-standing partnership models of ITE offer genuine opportunities to influence and change custom and practice. Where existing custom and practice often falls short of what would be desired (such as meeting the needs of the most able in science classes), many schools are ill equipped to train up new teachers in best practice. This is certainly one area where input during ITE can help teachers and schools shift suboptimal practices. Whatever the future trajectory of ITE in England, the examples reported here illustrate the value of organising ITE in a context where the Academy shares a leading role *alongside* partner schools, and can initiate small-scale initiatives that intimately involve trainee teachers as scholars, researchers, curriculum developers and educators. Such initiatives as those reported here only reach modest numbers of pupils directly - but they support teacher development and so may act as catalysts for improving practice by ensuring new teachers can engage with innovative and research-based ideas through authentic practice, whilst within the 'safe' (supported) context of a teacher education course.

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