Initiatives to Prepare New Science Teachers for Promoting Student Engagement

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Introduction

In England and in many other countries there is a continuous need to review science curricula, not only in response to current political ideology, but also to maintain an appropriate focus for students in a changing world. The concern for science education is to include valuable components of scientific knowledge and inquiry in the curriculum while responding to the call for change. We need to provide a curriculum that not only enables students to progress in their scientific understanding and demonstrate successful performance, but that also has the potential to stimulate students' curiosity and interest in science. To implement the curriculum to enhance students' affective response to science requires skilled teachers who have a repertoire of teaching approaches that can provide stimulating experiences and learning environments. In this chapter we explore contemporary thinking on student engagement in science and how this might be enhanced through the development of initiatives in the training of new science teachers.

Student engagement is conceptualised in different ways, but can be considered to involve a behavioural component when students do science, an emotional component as they become interested in science, and a cognitive component when they are motivated to want to continue with science in higher education or as adult citizens (Hampden-Thompson and Bennett 2013). We are concerned with all three components and how they are influenced by teachers and teaching in science classrooms. The day-to-day teaching of science primarily focuses on behavioural and emotional engagement, as teachers aim to prepare lessons where students can do science activities that they find interesting. A longer-term aim is to provide positive experiences in science classrooms that will motivate students to invest sustained effort in learning science. Thus not only is positive engagement seen as a

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means of enhancing science learning in school, but as fundamental to securing future career scientists, promoting scientific literacy, and preparing all students for engaging in scientific issues in adult life.

An assumption underlying interpretations of emotional and cognitive engagement is that attitudes towards science determine interest in and choice to study science beyond compulsory schooling. Hence there have been a substantial number of studies concerning students' attitudes to science (Barmby et al. 2008; Krapp and Prenzel 2011; Osborne et al. 2003; Simon and Osborne 2010) which have shown a range of influencing factors. The steady decline in students' attitudes towards science as they progress through school, particularly secondary school, has been well-established. We question whether this decline can be overcome, given that some studies show how school factors can contribute positively to sustained engagement (e.g., Vedder-Weiss and Fortus 2011). In this chapter we shall explore what we have learnt from such studies that can make a possible difference in schools, though it may be difficult to draw simple conclusions given the complexity of student attitudes (Barmby et al. 2008). In particular we will focus on findings relating to teachers that can inform an agenda for preparing new science teachers to address students' engagement in science.

Understanding students' cognitive engagement in science involves knowing what factors motivate students to want to learn or carry on working with science and how students perceive the relevance and value of learning the subject in relation to their own lives (Aikenhead 2006; Osborne and Collins 2001). Moreover, the ways in which students identify with the science culture embedded within the science teaching and learning they experience (Archer et al. 2010) can also contribute to engagement. The first part of this chapter will focus on the concept of engagement by reviewing recent understanding of attitudes towards science, and issues of relevance, motivation and identity with the subject.

Learning to teach science involves developing the knowledge of how to prepare lessons that enhance students' interest and motivation to want to learn more. Our experience shows that adult teacher learners do not always know what interests and motivates students in science. Supporting such understanding in student teachers (STs) is clearly an important feature of initial teacher education (ITE) programmes, but making this knowledge explicit and providing opportunities for the exploration of these ideas is not straightforward. The second part of this chapter will focus on how initiatives for teacher training with STs address components of student engagement. In particular we will look at how student/teacher relationships develop as STs provide out-of-classroom learning experiences, how STs can deploy digital technologies to provide interesting and relevant contexts for students, and how action research projects with STs can lead to the creation of innovative resources that promote all aspects of engagement. The examples we present here show how certain features of our Postgraduate Certificate in Education (PGCE) course are designed show STs what is possible in science education. The STs are introduced to theoretical perspectives that explain why certain pedagogical approaches might be useful, and given time and space to develop their skills in using a variety of approaches. These skills allow STs to design learning experiences that enable students to fully participate in science programmes and that encourage the building of positive relationships between teachers and students.

Attitudes Towards Science

Studies of attitudes towards science using a range of methodological approaches and theoretical positions have provided many indicators of the influences that can come to bear on students' engagement in the subject (Osborne et al. 2003; Simon and Osborne 2010). The meaning of what is meant by 'attitude' has been much studied (Barmby et al. 2008), but essentially has a component of behaviour, as captured in a definition adopted by Ramsden (1998):

> attitude is best viewed as a set of affective reactions towards the attitude object, derived from concepts of beliefs that the individual has concerning the object, and predisposing the individual to behave in a certain manner towards the object. (p. 13)

Behaviour has, therefore, become a central focus of many studies concerned with students' attitudes. However the picture is not straightforward, as positive attitudes may not necessarily lead to future engagement when other influencing factors are prominent. A student may be interested in science but not show positive engagement if motivated to behave in a certain way by the influence of peers who have a negative attitude. Many studies of attitude and behaviour are driven by the need to investigate reasons why students do or do not choose to study science beyond compulsory schooling, some drawing on theories of behaviour such as the theory of reasoned action (Ajzen and Fishbein 1980; Fishbein and Ajzen 2010). Here, behaviour is seen to be determined by intention—a product of attitude towards the behaviour and how others regard that behaviour (the subjective norm).

Studies of peer and others' influences are not, however, conclusive in linking attitude and behaviour. A study by Korpershoek et al. (2013), framed by the theory of reasoned action, investigated why some students do not continue in science-oriented studies in higher education though suitably qualified and interested in science-related subjects (Science, Technology, Engineering and Mathematics, or STEM). The authors looked into influences by significant others on students' choices and found that many students, though advised by others to choose STEM subjects, did not actually do so. The authors conclude that the influence of significant others on students' study choices is still unclear, but suggest teacher initiatives aimed to "develop new salient views" (p. 500) that strengthen intentions towards science. Sjaastad (2012) also studied the influences of others on students' STEM choices, and of the contribution of others to defining and modelling the self and STEM in ways that students come to see themselves as STEM-oriented. Essentially, those persons who have most influence have interpersonal relationships with students.

Research clearly points to the effects of influence by others on attitudes and behavior. How should we take this finding to inform our work with STs? As well as foregrounding the need to get to know their students and present science in a positive way, new teachers also need to learn how to make learning environments positively engaging for students, to convey in their interpersonal relationships with students an enthusiasm exemplified by an engaging agenda. Our initiatives—which place STs in teaching situations outside the classroom, or show the potential of digital technologies or innovative activities as part of action research, all of which involve reflective evaluation—are designed to help them to learn to address aspects of student engagement as they plan their science teaching.

In a study of students' voices, Logan and Skamp (2013) investigated the relationship between interest in science and pedagogy. Their findings show that students' perceptions of their learning environment, including practices and teacher attributes, determine interest. Specific practices identified by Logan and Skamp as stimulating interest include: experiments, particularly with the student as investigator; debates on socio-scientific issues; making science relevant to their lives; different uses of information and communication technologies (ICTs); clear explanations; and out-of-school excursions. These reiterate earlier findings from Barmby et al. (2008), that students stress the importance of practical science, teachers explaining things well, and science lessons being relevant, and by Raved and Assaraf (2011) whose students noted the importance of variety, including "peer teaching and discussions, contests and games, movies, presentations, models, field trips and experiments" (p. 1213). Thus from a host of studies on attitudes towards science and what influences student engagement, the quality of teaching is consistently identified as contributing to student engagement, in particular the appropriate choice of teaching and learning activities (Hampden-Thompson and Bennett 2013) and the development of interpersonal relationships. The findings from all these studies reinforce our understanding of ways in which STs can be encouraged to take into account student voice and perceptions.

Providing a meaningful learning process requires an awareness of what influences attitudes so that poor and irrelevant learning experiences are avoided (Raved and Assaraf 2011). It is, therefore, important to focus on the attributes that can be fostered in ITE that enable the ST to become a 'good teacher', as defined in what Raved and Assaraf identify as professional and emotional attributes—which include interpersonal relations between the teacher and students. The initiatives presented here aim to address these features as STs learn what to do to engage students.

Relevance, Identity and Motivation

Central to students' cognitive engagement is the need to make contexts more meaningful and contemporary, and this has been a feature of recent developments in science curricula. Holmegaard et al. (2014) suggest that students may see the potential of science without necessarily being able to understand every aspect themselves. They also maintain that students have different ways of interpreting what relevance to everyday life means: relevance may mean direct influence on their own lives or a broader view of what is important to society. Whatever their view of relevance is, how students see the purpose of STEM being taught is one of the decisive factors students consider in making subject choices (Holmegaard et al. 2014). Thus it is important for teachers, and STs, that they listen to students and do not make assumptions that their own ideas of what is relevant predominate, or that what counts as relevant is 'fixed'.

There has been much recent work on identity with science (e.g., Archer et al. 2010; Taconis and Kessels 2009), and we argue that better portrayal of the subject to students by focusing on its image and potential relevance/usefulness is important for individual students to feel that they can identify with science. The typical form and content of school science may be at odds with how students see themselves or how they want to be. For example, the idea of being "an autonomous self-managing individual" (Holmegaard et al. 2014, p. 209) may be in tension with traditional science teaching and learning that leaves little space for self-determination, which might 'drive' students to be motivated in their learning. Taconis and Kessels (2009) refer to identity as managing one's personal choices that relate to everyday matters, such as clothes, taste in music, sports, but is also related to school and classroom. Engaging in and choosing science is part of identity development and "school science is perceived as not allowing room for self-realisation or intellectual freedom" (p. 1117). Thus the culture of science teaching that is promoted in the classroom leads to self-selection by students who will fit well into that culture. For most students this cultural gap is large (Aikenhead 2001), and selecting a subject for future engagement is made on the basis of matching oneself with a specific subject culture (Taconis and Kessels 2009).

In addressing the issue of declining motivation to learn science, researchers have looked to psychological theories to define and explain motivation, for example, achievement goal theory (Ames 1992). The key construct in this theory is goal orientation, which in the context of school science is how and why students engage in learning the subject. Vedder-Weiss and Fortus (2011) use achievement goal theory to consider student engagement in science in terms of both classroom engagement, which includes behaviours such as effort, persistence, concentration, attention, asking questions and contributing to discussion, and also continuing motivation to be engaged in science beyond the classroom—which should be an important outcome of science teaching. These authors focus on school culture beyond the classroom and show that in certain school cultures (democratic schools), classroom engagement and continuing motivation are more stable through early adolescence. This is an important finding as it appears that the decline in motivation is not inevitable; school and classroom culture can make a difference. That new science teachers should embrace these ideas and contribute to positive school cultures is an important aim for the PGCE science programme.

Enhancing the prospect of cognitive engagement is therefore an aim embedded within our PGCE initiatives with STs. In a study of PGCE student teachers' views about what features make a creative science lesson, Manning et al. (2009) showed that at the start of an ITE course, their focus is on variety, relevance to the learner and the need to establish an appropriate classroom atmosphere. We surveyed one cohort of STs towards the end of their PGCE year and asked them to name something they learnt during the course that would help to engage their students' interest in science. For the 57 out of 72 STs who responded, we grouped the 'things' they mentioned thematically, some of which matched the findings of Manning et al. (2009). The range of ideas the STs reported is broad, with most important being those which provide motivation and interest. For example, the use of exciting visual representations of science, especially using technology challenge, and relevance to students' lives either through things they may have seen or experienced. This finding in many ways matches the study of students' voice by Barmby et al. (2008) and Logan and Skamp (2013). These data suggest that our PGCE course is helping to support the development of the next generation of teachers who, in turn, can change the "salient views" (Korpershoek et al. 2013, p. 500) of their students and encourage engagement in science at school and beyond. Through our initiatives with STs we aim to embed these fundamental ideas about the importance of and influences on school students' cognitive engagement in science. The following section provides details of how these initiatives are introduced in our PGCE programme.

Initial Teacher Education Initiatives

Designing learning experiences that are engaging for school students involves providing motivating experiences that support the development of a personal identity with science and that help them to recognise relevance in what they are learning. Much of our PGCE course is designed to do this through encouraging the STs to be both creative and reflective in their teaching. However, these skills are not necessarily easy to acquire and require careful support to ensure that their development becomes embedded in the STs' professional practice, and not simply an 'add-on'. In the discussion below we explore three training initiatives that we have developed as examples of the way that our ITE course is purposefully structured to provide opportunities for the STs to develop their own practice. These initiatives exemplify the way the relationship between some of the important research and expertise of the PGCE tutor team have become integrated in the course and how this is then translated into teacher preparation. The three initiatives we discuss are:

- Learning science outside the classroom
- Learning science with technology
- Supporting teacher creativity through action research

Learning Science Outside the Classroom

There is a long tradition in science education of learning outside the classroom, for example, in museum and field visit settings (e.g., Falk and Storksdieck 2010; Rickinson et al. 2004) with experiences of this type having been shown to provide unique opportunities for encouraging students' learning. Moreover, according to Falk and Dierking (2000), when the experiences are well organised they facilitate both intrinsic and extrinsic motivation. An essential element of non-formal learning is that teachers and students recognise the differences between the established norms and values of the everyday classroom setting and those of the non-formal learning environment. This is important because, while liberating to both teachers and students, this shift can be potentially problematic if the new norms and values are neither articulated clearly between teacher and student nor recognised by both parties as being important. That is to say, transferring teaching from the classroom to the 'outdoor classroom' does not mean bringing with it the structure of school and the expectations surrounding what typically takes place in school. Instead, learning experiences away from the classroom are experiential and liberating exactly because students are not expected to act as if inside the classroom (Braund and Reiss 2006) and go some way to support the closing of the 'culture gap' that Aikenhead (2001) identifies as being a major barrier to students' learning in science. Non-formal learning in science is also important because, as Hodson (1996) argues, it can provide students with 'real-world science' or 'authentic' learning experiences. Although debate exists about what is meant by authenticity in science (Braund and Reiss 2006), the central tenet is that it means providing experiences in ways that are similar to the activity of 'real' scientists. This feature has important implications as it echoes ideas of students identifying with science and seeing utility in their learning.

Use in Initial Teacher Education

Despite the importance of non-formal learning in science, its use in initial teacher education is in decline (Lock and Glackin 2009). Members of our tutor team have specific interests in this area of science education and we have developed an extensive teaching outside the classroom programme as part of our PGCE course. The programme involves the STs working at both the Royal Botanical Gardens, Kew (Kew Gardens) and the Science Museum, London, details of which are in Table 1.

A major emphasis of our training is that the STs should consider how the non-formal learning experience affords creative learning opportunities that engage students in their learning of science. Here, we draw on work undertaken by the tutors into the role of field visits (Amos and Reiss 2006, 2012), museums (Chapman and Herrington 2008) and the Queen Elizabeth Olympic Park (Amos and Robertson 2012) in learning science. This work has explored the importance that

Table 1 Details of the work that STs carry out at the Royal Botanical Gardens, Kew and the Science Museum

Stage	Details
Briefing	Students are given logistical information about the work they will carry out, as well as details about the theoretical assumptions associated with non-formal learning
Training day	Students receive a half-day training session at both Kew Gardens and the Science Museum. Tutors, and in the case of Kew, tutors and Kew staff, introduce them to a variety of activities suitable for school children aged 11–13 years
	Working in groups of 5–7, the STs then plan a range of activities. At Kew Gardens they are free to use the various glasshouses and outdoor areas, with a focus in on sustainability. At the Science Museum they are able to make use of three major galleries, as well as an interactive zone
	The plans are then discussed with ITE staff and the STs are encouraged to justify and reflect upon their design
Teaching day	Students from schools that work with us on the PGCE programme come to Kew Gardens and the Science Museum and the STs teach groups of about 18 children
	The days end with a reflective, summary session that draws out the major themes learnt by the STs through the experience

'place' plays in being both engaging and motivating students, for example, in providing access to what Braund and Reiss (2006) call 'rare materials' not normally available within a classroom setting and learning experiences that are both interesting and provide 'memorable moments' (Bebbington 2004). In addition, we draw on the theoretical perspectives of Holzman (2010) who emphasises the significance of creativity and play in learning. Holzman's work is mainly situated within 'Arts' subjects but has much to say about how student learning benefits from settings that allow them to explore their own understanding and develop their own meanings. In doing so, she reconceptualises Vygotsky's (1978) Zone of Proximal Development by arguing that "creative encounters" support accelerated learning; what Vygotsky calls "becoming a head taller" (Vygotsky 1978, p. 102). These ideas, where students have a degree of freedom and autonomy in their learning, have proved useful in explaining why working outside the classroom can be so powerful for student learning and engagement.

In preparation for the teaching days at Kew Gardens and the Science Museum, many of our STs are anxious about the logistics of 'controlling the students' and 'not knowing the students well enough', as well as worrying about their own expertise and ability to 'answer tricky questions about things I'm not sure about' (e.g., Chapman and Herrington 2008). Typically the STs are also concerned about how the students might behave away from the structures of schools. However, through these experiences, they reconceptualise the novel learning environments and recognise the special opportunities they offer, both in terms of learning and in the building of positive interpersonal relationships (Raved and Assaraf 2011). The training and planning stages (see Table 1) of the process give the STs confidence in their ability and change their perspective on what is important in terms of the learning experience, with a notable shift from the mechanistic organisational aspects to one very much focused on student learning and the special significance of the learning environment. Almost all of the activities that the STs design are creative in nature, for example, a 'time machine' which 'transports' the students to important periods of history in the "Making the Modern World" gallery in the Science Museum, as they examine how communication devices—technologies which are particularly significant to students—have changed since the invention of the telegraph. Activities of this type provide the learner with opportunities to relate the context to their own lives (Aikenhead 2006) and, in doing so, give students opportunities to see relevance in their learning in terms of its utility and relationship to their own lives. Helping students to identify with science in this way (Taconis and Kessels 2009) has powerful implications for learning, and observations of students working in these settings reveal a high level of engagement, with evidence of the development of links between what appear at first to be disparate pieces of information and ideas.

Using Technology in Learning Science

Supporting student engagement has also been enhanced through our PGCE course through encouraging STs in the use of emerging digital technologies. While the course provides experiences of using technology within the classroom, we also place emphasis on its effective use in out-of-classroom learning, where it has much to offer. Hammond (2014), for example, discusses the important role that digital technologies play in allowing students to learn in new ways and promote engagement in science (see also Cowie and Khoo, this volume). However, while the range of digital technologies available to both teachers and students in schools is great, much of it is often underused or used in limited ways (Cox and Webb 2004; see also Selwyn and Cooper, this volume). An important concern is that while digital technologies have an important role to play in providing novel opportunities for learning that are motivating and engaging, the integration of these tools and appropriate pedagogies is challenging and problematic because teachers are ill-prepared for their effective use (Mishra and Koehler 2006; Muijs and Lindsay 2008).

While many teachers are enthusiastic and motivated by the potential learning experiences offered by digital technologies, and are keen to integrate them into their practice (Russell et al. 2003), their use has still tended to be for fairly 'low-level tasks' such as word-processing or presentations, with teachers most commonly using them with students for internet-based research (Kreijns et al. 2013). Unsurprisingly, teacher confidence with using digital technology plays a key role in how technology is used by the teacher and students, and the frequency of use (Hennessy et al. 2005). There is still a lack of emphasis within teacher training programmes on using digital technology in the classroom and this is something that appears to be changing only slowly (Hammond et al. 2011).

Use in Initial Teacher Education

Our PGCE course aims to support STs in their use of technology, and by drawing on a range of expertise within science education and technology education we have developed a number of initiatives using digital technology. One example is a recent project, *GeoSciTeach*, which made use of mobile technology to promote spatial thinking skills in science. This project provided a good example of how STs becoming involved in a research project as participatory-designers immerse themselves in learning experiences and show features of developing sophisticated pedagogical approaches (Price et al. 2013).

The project involved 12 STs designing a smartphone application (app) called *GeoSciTeach* that was developed to support spatial thinking in science for use in the work that the STs carry out in Kew Gardens. Spatial thinking encompasses a suite of skills related to understanding the nature and representations of space (Downs 2006) and mobile devices can support spatial thinking through their easy to use Global Positioning Systems (GPS) technology. Basing the design on the concrete example of the Kew Gardens activity provided a scenario to ensure that the application 'worked', and enabled the STs to think about the technology—where and why it might be functionally useful—while also linking this with spatial concepts. The project involved a number of workshop sessions where the STs reflected on their use of technology, planned the development of, and tested prototypes of the app, and planned activities for using it at Kew Gardens. Data were collected from each stage of the project through mixed methods of observation, focus groups and interviews.

At the start of the project, most of the STs' experiences of using digital technology within school had been related to sensor and data logging equipment, a common use of technology in school science (Donnelly et al. 2011). Relating their use of technology to spatial thinking was always at a fairly superficial level, with tagging collected data to specific locations. As the project developed, and having trialed the prototype *GeoSciTeach*, the STs developed a greater understanding about how the app could support understanding science and spatially-related ideas (for a fuller discussion, see Price et al. 2013). Towards the end of the project, the project STs worked in mixed groups with non-project STs to design a learning activity using the app at Kew Gardens in teaching and learning episodes with students aged 11–12 years. The collaboration within the groups gave the project STs the chance to share their knowledge and, in doing so, reflect on how they had changed—something that was profound for a large number.

The learning activities the groups developed were engaging in a number of ways: they encouraged the school students to work collaboratively and develop understanding about various aspects of plant biology through problem-solving and they allowed the students to draw on additional information, for example from websites, to support and deepen their understanding. In doing so, using the 'tools' as well as the processes of science arguably transformed the students from learners of science into scientists, promoting their identity as people capable of 'doing' science. This project was focused on a specific area of research, but from the success of this work a number of initiatives have emerged that we have incorporated into the PGCE in terms of how STs can use technology to develop engaging learning experiences.

Teacher Creativity Supported Through Action Research

As highlighted in the introduction, understanding the nature of engaging activities is something that many of our teachers want to develop and that provides a focus for much of their thinking. Two important aspects for consideration are how motivation and relevance can be used to encourage engagement in the classroom and how teachers can be supported in their work in this area. Providing a challenging learning environment is an important feature of engagement (Schweinle et al. 2006; Turner and Meyer 2004) and something we see develop in our STs as they progress through the PGCE course.

Engaging students in learning science can be a challenge, and a key aspect of developing effective pedagogy is teacher reflection. As mentioned previously, development of the 'reflective-practitioner' model of teacher education is an important feature of our PGCE course, with many of our teaching sessions designed to support the advancement of this skill. In addition, we have developed a specific focus on reflection through the Masters-level assignments where the STs carry out a short action research project. In the spring and summer terms (semesters), the STs work on a 5000-word assignment that investigates the use of creative resources in assessment of student progress. Very much embedded in classroom practice, the assignment requires the STs to engage with the literature on learning theory, assessment and children's ideas in science and, using this literature and their evaluations of what makes effective practice, develop a novel resource which supports students' understanding of a specific scientific concept. The resource is then used in the classroom to assess student progress against nationally prescribed assessment criteria. The STs evaluate the use of the resource in terms of how it encouraged student engagement, how it supported student progress, and whether it proved effective in allowing both teacher and student insights into student progress. The assignment culminates in a section where the STs reflect on the process of producing their own resources and consider how their personal progress on the PGCE course has evolved and how they are positioned as they move from being a student teacher to an in-service teacher.

The range of resources the STs develop is impressive and includes games, practical activities, technology-based learning experiences, and role-plays. A good example was an activity entitled 'A theatre production of the placenta' that, as part of a teaching sequencing on human reproduction, involved 11–12-year-old students using the classroom space to enact the function of the placenta in providing the fetus with oxygen and food, and removing carbon dioxide and returning it to the mother. The ST, Steven, had experienced a very traditional education, having been schooled in a private boarding school for much of his childhood. At the start of the

PGCE course he adopted a transmissive, teacher-led approach in the classroom and found personal reflection a challenge and “something I have never been asked to do before”. Steven identified that students were often confused by the role of the placenta in fetal growth, thinking, for example, that blood from the mother flows directly into the fetus and having little awareness that materials the mother ingests and inhales may affect the developing fetus. Having reviewed the literature and considered his and other teachers’ practice, he decided that role-play would be an effective tool to support student learning because it has been shown to deepen understanding of scientific ideas (Abrahams and Braund 2012) and provide an opportunity for students to engage with all their senses. The activity involved the classroom tables being rearranged to have narrow spaces between them, forming a semi-permeable barrier between the ‘fetal’ side of the room and the ‘maternal’ side of the room, each of which was demarcated by its own ‘home-table’. The students represented the blood in either the fetal or maternal circulatory system and walked in single file in a loop, in the opposite direction for the fetus and mother, to represent a counter-current blood system. As they passed their ‘home-table’, the students collected and dropped off cards, which represented carbon dioxide, food, oxygen, etc. The cards were ‘exchanged’ at the placental interface to represent materials moving across the placenta. Assessment was carried in a number of ways: teacher observation of the activity, students’ oral explanations of their role in the activity and what they were doing at certain times, and a short written task.

In reflecting on the effectiveness of the lesson in supporting student understanding of the function of the placenta, Steven reported that the role-play had been very effective in engaging the students in understanding an abstract concept and had enhanced their ability to explain how blood materials are passed between mother and fetus. He reported that the students were excited by the prospect of the activity and talked about it in subsequent lessons, requesting that similar activities be used in the future. Following Di Bianca’s (2000) notions of criticality, Steven’s reflections were sophisticated as he considered the limitations of the approach, including organisational issues, the need to model the role of the umbilical cord in transporting materials to and from the placenta, and the benefits of asking the students to reflect on the effectiveness of the role-play as a model. Something that was important to him was that the students began to feel like ‘experts’ and grew in confidence in their use of scientific language and explanatory skill, a response that echoes work of Taconis and Kessels (2009) surrounding the development of identity. In this example we see the changes that are typical of STs throughout the PGCE course: starting with a teacher-centred pedagogic approach and struggling with the challenges of self-reflection and critical analysis before moving towards a more student-centred pedagogy with growing confidence and reflective abilities. Steven is not unique and demonstrates a typical model of how many of our STs develop throughout their training.

Conclusion

In this chapter we set out to review contemporary views on student engagement in science to show how our current initiatives in training new teachers aim to help them to address components of engagement in their practice. The literature shows that issues of motivation, relevance and identity are important factors in supporting sustained engagement and that students become engaged through establishing positive relationships with their teachers. Developing this understanding in STs is clearly an important feature of ITE programmes, but making it explicit and providing opportunities for the exploration of these ideas is not straightforward. The examples we have presented demonstrate how aspects of our PGCE course are designed to show STs what is possible in science education as well as provide time and space for them to develop their skills in using a variety of pedagogic approaches. These skills, both generic and specific (Harris 2010), enable STs to design learning experiences that allow students to fully participate and encourage the building of positive relationships between teachers and their students (Anderson et al. 2004).

Evidence from STs at the end of the one-year PGCE course suggests that they are aware of activities that engage students, but that there are a variety of possible approaches for fostering engagement, as experienced on teaching practice. STs need to develop the skills to enable them to provide the seeds of student engagement through becoming competent with a variety of teaching approaches. Yet the combination of curriculum requirements and the complexity of learning to teach science often means that the affective agenda for science education takes second place to the pressure for examination success in the school setting. It is hoped that immersing STs in initiatives like those presented here will enable them to build a repertoire of approaches that can be used to maintain student interest in their science learning while addressing curriculum and assessment requirements. At a time when, for example in the UK, routes into teaching are rapidly changing, and student and public engagement in science is worryingly low (Wellcome Trust 2011), it has never been more important that we understand good practice in preparing the next generation of science teachers. Further research on the effectiveness of our ITE approach would help to inform future teacher education programmes for both pre- and in-service teachers.

Many of our student teachers continue their professional development by undertaking further study for a Masters degree in Science Education. For their dissertation, we find that many science teachers want to undertake an enquiry to explore some aspect of student engagement. Teachers sense that engagement is essential to successful teaching, not only as they believe it optimises the prospect of good cognitive outcomes, but also because student engagement gives high job satisfaction. Such Masters' studies usually explore how initiatives and interventions are perceived, or how a learning environment impacts on engagement. Clearly student engagement is a central issue for teachers not only at the outset of their teaching, but as they continue to develop their practice. Although there is a wealth of accessible research about influences that relate to engagement, such as students' attitudes towards science, perceptions of relevance and identity with science, *our teachers continue to want to explore these issues for themselves in their own contexts*. We conclude that student engagement is complex and fluid—its multiple influences are ever-changing and are determined by an environment that is also constantly changing. Our concern as teacher educators is how we can prepare new teachers to value and understand student engagement as part of their ongoing professional learning so that they have the confidence to listen to students and be alert to exploring pedagogical practices that are relevant to them.

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