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It Takes a Village: Including Diversity of Pupils' Needs in Science Classes

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Abstract: Science teaching for promoting inclusion (Step-IN) project is Teacher Development Agency (TDA) funded collaboration between a secondary school and a higher education institute. This project was based on a collaborative research philosophy to promote inclusive science teaching using evidence-based teaching strategies. The purpose of this continued professional development (CPD) project was to create the space for science teachers to identify potential inclusion issues in their classes and to develop strategies to tackle such issues. The CPD model included peer-collaboration and evidence-based reasoning about inclusive science teaching. This CPD experience was perceived to be an unequivocally positive one for the teachers. Inclusion of teacher's voices, developing their own CPD agenda, was found to be one of the major findings of the project.

Keywords: Continued professional development, science teaching, inclusion.

Bütünleştirici Eğitim Takım İşidir: Farklı İhtiyaçları Olan Öğrencilerin Fen Derslerinde Desteklenmesi

Öz: Bütünleştirici eğitimi destekler Fen Bilimleri öğretimi (Step-IN), İngiliz Öğretmen Gelişim Ajansı (TDA) tarafından desteklenmiş bir lise ve bir yüksek öğretim kurumu işbirliği projesidir. Kanıta dayalı öğretim stratejileri kullanılarak bütünleştirici fen bilimleri eğitimini destekleyen proje işbirlikçi araştırma felsefesi üzerine kurgulanmıştır. Bu mesleki gelişim projesinin amacı (CPD) Fen Bilimleri öğretmenlerine zaman yaratarak sınıflarında bütünleştirici eğitimi hayata geçime sürecindeki engelleri tespit etmek ve buna yönelik çözüm üretmelerini sağlamaktır. Projede adapte edilen mesleki gelişim modeli bütünleştirici Fen Bilimleri eğitimi hakkında meslektaş işbirliği ve kanıta dayalı akıl yürütmeyi içermektedir. Bu model araştırmaya katılan tüm öğretmenler için pozitif bir deneyim olmuştur. Çalışmanın ana bulguları içinde öğretmenlerin seslerini duyurabilmesi ve kendi mesleki gelişim ajandalarını oluşturabilmeleri en önemli bulgular arasında sıralanabilir.

Anahtar Sözcükler: Sürekli mesleki gelişim, fen bilimleri eğitimi, bütünleştirici eğitim.

An increasing number of pupils with diverse needs is being educated in mainstream schools as a result of a broad inclusion agenda supported and legislated in England and around the globe in the last few decades. Teachers, as the frontrunners of the inclusion

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agenda, however are not always equipped with the necessary skills to reach out to the diversity of pupils' needs, in particular regarding those with special educational needs (SEN) (Abel, 2014; Moon *et al*., 2012; Villanueva, *et al*., 2012; Cawley *et al*., 2002). One of the recent surveys by the Training and Development Agency (TDA, 2011) indicated that Newly Qualified Teachers (NQT) were feeling better prepared than previously to teach learners with SEN and learners of range of abilities. Despite this positive trend, it is increasingly recognised that many providers do not have a comprehensive approach to inclusion in teachers' professional development. Schools are expected to find innovative and effective schemes to develop within-school support to meet the diversity of pupils' needs and to implement the Special Educational Needs and Disability (SEND) Code of Practice (DfE, 2015).

The purpose of this continued professional development (CPD) project was to create the space for science teachers to identify potential inclusion issues in their classes and to develop strategies to tackle such issues. The main proposition of this project was that teacher collaboration and support in a challenging school environment as well as considering the diversity of their pupils' needs can create a positive and relaxing environment leading to confidence in teaching all pupils and as a result better student outcomes. Central to the project was enabling teachers' ownership of a CPD process that focused on promoting science teaching for inclusion

Model of Continuing Professional Development

There is substantial body of literature on teachers' professional development. Within proposed and implemented CPD models, it is widely accepted that these models are based on a belief that learning to teach is a linear process and that educational change is a "natural consequence of receiving well-written and comprehensive instructional materials" (Hoban, 2002, p. 13). However for CPD to be effective, a more complex view of professional development is required (Hattie, 2012). From the onset of this project, it was evident that educational change is complex and it takes time (Fullan, 2001), and it was never anticipated that fundamental and substantial changes could be achieved within a short period of time such as the timeframe of this project. Furthermore, within the UK context of accountability and high stakes assessment, the aim of the project was to initiate change that could inform professional development programmes that could be implemented within systems that experience curricular constraints.

To achieve the objectives of the project, we incorporated many of the elements that Supovitz and Turner (2000, p. 964) identify as critical to high-quality professional development. Such development, for example, must immerse participants in inquiry and experimentation; be intensive and sustained; engage teachers in concrete teaching tasks and be based on teachers' experiences with students; focus on subject-matter knowledge and deepen teachers' content skills; and, be connected to other aspects of school change.

Within relatively short time-scale of the project (i.e. five months) it was not feasible to address the elements of sustainability or connectedness to other aspects of school change at a broader level. Rather, the objective of the project was to identify some concrete strategies and examine changes in the classroom practice of teachers who were willing to initiate change. The focus was therefore on ways in which teachers supported processes stemming from their classroom cultures, including the facilitation of student discussions, practical work and participation. A significant aspect of the project was to construct a forum for deliberation about practice that contrasted with the norm of privacy which dominates most schools (Spillane, 1999). To this end, the university researchers encouraged collaborative teaching, peer mentoring and coaching and sharing of lesson resources. Although this forum facilitated the important process of reflection on previous experience (reflection-on-action), it was difficult to anticipate the extent to which the project would initiate the process of reflection-in-action, or reframing (Schön, 1987), that would result in constructing new pedagogical understanding of inclusion in science.

The understanding of CPD underpinning the project was strongly influenced by research evidence on teachers' learning. For instance, our framing of teachers' knowledge was strongly influenced by Shulman and his colleagues' conceptualization of teachers' subject-matter knowledge in terms of *content knowledge*, *pedagogical content knowledge* (PCK), and *curricular knowledge*. According to Shulman (1986), content knowledge refers to "the amount and organization of knowledge *per se* in the mind of the teacher", including knowledge of the *substantive structure* and *syntactic structure* of the academic discipline. Also named *subject-matter knowledge for teaching*, content knowledge was subsequently elaborated upon by Grossman *et al.* (1989) as consisting of the following four components: Content knowledge—the "stuff" of a discipline; Substantive knowledge—knowledge of the explanatory framework or paradigms of a discipline; Syntactic knowledge—knowledge of the ways in which new knowledge is generated in a discipline; and, beliefs about the subject matter—feelings and orientations toward the subject matter.

In the project, science was the content knowledge of teaching. Some of the strategies that the teachers used (e.g. group discussions, practical work) formed the basis for their pedagogical content knowledge. Beyond teachers' subject-matter knowledge, the project also posited teachers as researchers investigating their classrooms in order to promote inclusive practices.

Project Philosophy

This project was based on a collaborative research philosophy driven by teacher team partnership to promote inclusive science teaching using evidence-based teaching strategies. This was a steep learning curve for both partners that embedded tensions and uncertainties especially at the outset of the project.

Project Participants

As part of teachers' CPD, the project aimed to support teachers including *all* children in their science classes. However, both the identification of the issues and the way forward came from the teachers as the key players in their classrooms. With the exception of the first workshop when the teachers were introduced to the goals of the project, there was no direct input by the university researchers into the CPD process. Instead, the researchers' role was defined as that of "critical friends" and "facilitators", supporting the teachers in the conduct of the CPD.

The school team comprised of five members of staff, including a science technician and four teachers at different career stages: a newly qualified teacher (NQT), a mid-career teacher (MT), an experienced teacher (ET) and a learning support teacher (LST). The science technician was instrumental in coordinating the practical work in the lessons. The university team consisted of specialists in science education and inclusive education.

Project Organization & Process

The project lasted for five months. During this period, the teachers met regularly on the school premises, had four workshops at the university. A project team meeting was also held at the school. The first workshop introduced the aims and objectives of the project, and had the greatest input from the researchers. Following the introduction of the key objectives and strategies of the project, a group discussion on inclusion was facilitated by the university researchers, and documentation on inclusion was provided to the school team. The agenda for subsequent workshops were identified by the teachers and primarily focused on selecting evidence from their teaching to reflect on their professional development and on promoting inclusion in science teaching. Thus the second workshop consisted in a day during which the teachers collaboratively considered the specific inclusion issues in each of the three targeted classes and planned for incorporating inclusion strategies in their teaching.

The teachers had been asked from the beginning to be involved in the production of a DVD as part of the project. Hence they had a particular product in mind from the beginning. Towards this end, they were asked to engage with evidence from their classrooms. To facilitate this process, some writing frames had been provided by the researchers at the onset of the project to support the collection of teaching evidence. The third and fourth workshops immersed the teachers in the selection and interpretation of the evidence supported with more writing frames. Two whole-day workshops were dedicated to the selection of evidence from classroom practice that demonstrated the implementation of inclusive strategies. The teachers viewed the video tapes and selected clips based on some rationale, for instance the illustration of a particular inclusion issue such as gender. The viewing and editing of the video-clips immersed the teachers as a group in the selection and justification of teaching and learning actions. Individual, pair/group teacher interviews following some lessons took place during the course of the project concluding with individual interviews at the final workshop.

Teacher Ownership of the Project

The CPD model for the project rested on empowering the school team and allowing the team to control the choice of inclusion issues and strategies to implement in their teaching. At the first workshop, this seemed to create some apprehension and confusion among the teachers, indicating that this CPD model did not echo their "usual" experience since most of their prior experiences of CPD could be summed up as placing them in the role of "passive participants". Ongoing feedback throughout the course of the project suggested that the teachers appreciated and enjoyed developing their own agenda of CPD where they had freedom to choose what to focus on and develop strategies collaboratively.

The university researchers were available for support throughout the project to help formulate the issues, discuss the teaching strategies the school team had developed and to facilitate the videotaping of lessons. What had not been anticipated was that the teachers would so enthusiastically embrace the data-collection phase of the project. Indeed, they decided to be heavily involved in the data collection and videotaped some lessons themselves. This was seen as part of the peer observation aspect of the project, and served as a basis for peer or group discussions following lessons and as a powerful tool for self-reflection.

Setting up the Inclusion Agenda

Inclusion was the focus for the first teacher workshop, and took on the form of a group discussion facilitated by the university researchers. In this activity, teachers were asked to identify and discuss a set of inclusion-related concepts that they considered highly relevant, somewhat relevant or irrelevant to their school context. The university researchers facilitated this discussion by introducing a set of key concepts (eg. values, attitudes, teaching assistants, diversity, culture, respect, ethnicity, and removing barriers).

The teachers also generated other concepts that were relevant from their point of view. They identified the following concepts, in order of importance, as very relevant and somewhat relevant to their school context respectively: *Communication*; *Resources*; *Multi-agency collaboration*; *Attitudes; Culture; Diversity; Respect; Stereotypes; High expectations; Staff development; Collaboration; Removing barriers; Ethnicity; Race;* and, *parents.*

At the outset of the project the teachers agreed that their school had achieved a notion of equal opportunities, and they felt fairly confident regarding issues around disability. Their initial reaction to the discussion on inclusion exposed perceptions of inclusion that tended to reflect a limited definition of inclusion in terms of SEN and disability. It became evident that the teachers' notion of inclusion had changed by the end of the project:

> The word [inclusion] has been used over the years to deal with specific problems that some children have. I've sort of seen it too narrowly. (ET)

> I don't think I was 100% sure… or at least my definition of inclusion was perhaps a little naïve to begin with. And since we went through inclusion in the blue

> handbook [i.e. Index for Inclusion] and were looking at a few of the questions and realising that inclusion is on a much bigger scale than just in the classroom, it involves a school as a whole…. (NQT)

A significant issue that this project exposed was the gap between policy, theory and practice. Indeed such gap exists in many regions across the globe including developed countries (e.g., Opretti and Belalcazar, 2008; Polat, 2011). One of the first indications of this was teachers' lack of awareness of existing guidelines published by the Qualifications and Curriculum Authority (QCA) (2001) on teaching science to students with learning difficulties. They were similarly unaware of further materials developed by a range of professionals to support schools in developing more inclusive cultures such as the *Index for Inclusion* (Booth & Ainscow, 2000). The *Index for Inclusion* is a set of materials developed to help schools reduce barriers to learning and participation as well as valuing *all* pupils equally.

Identifying the Students

Teachers identified 3 classes from different year groups (Years 7, 8 & 10) characterised by different pupil needs ranging from gifted & talented to behavioural difficulties. Once the groups were identified, in addition to teachers' within-school think-tank sessions, there were research away-days at the University in order to identify barriers to inclusion in each year group, and design and develop collaborative strategies to remove these barriers in order to maximise pupil participation and inclusion. The characteristics of each group and inclusive strategies designed to increase participation in each group are summarised in Appendix I.

Principles of CPD

A set of principles guided the CPD. The principles were partly based on research literature and partly generated through collaborative engagements between the teachers and the researchers. Overall, the teachers were keen on having input from researchers in an effort to extend their teaching repertoire based on research evidence:

> There is so much research, research into teaching styles, research into the kids, teachers and how they've worked and how they think and how to break down the barriers. I think people have preconceived ideas and some people can have quite a negative attitude, so it's quite nice to break down those bridges and make them view a project in a positive light. And research into inclusion as well. (MT)

The project capitalised on the following principles:

Distributed expertise and peer-mentoring provide the structure and support for teachers to learn with and from each other – this led to the project including a team of teachers from different stages in their careers;

Teachers as researchers situate teachers at the centre of their own learning, investigating problems and devising solutions to their teaching and learning needs – teachers in the project identified their own issues and the means to address them;

Reflective enquiries into teaching promote learning based on concrete examples of teaching and meta-cognitive awareness of own pedagogical content knowledge – the project was based on teacher reflectivity enhanced by the use of video and peer feedback;

Collaborative planning, teaching and reflection facilitates teachers' learning through communication and sharing of the knowledge and skills required of teaching – a team of teachers was set up and given time resources to share knowledge and work collaboratively;

Evidence-based teaching engages teachers in the modes of thinking and acting that promote understanding of syntactic knowledge of science, and provide rationale for decisions about teaching and learning – the university-school partnership provided instruments for gathering evidence and a forum for developing such evidence-based thinking.

Science Teaching and Learning

Curriculum Context. The project agenda was consistent with the recent curricular reform efforts in England and Wales. For example, the increasing emphasis on "How Science Works" component in the National Science Curriculum was explicitly addressed in the project. The contemporary curricular scene stems from a history of concern over the effectiveness of the science curriculum in facilitating pupils' understanding of science and scientific literacy.

Apart from a substantial body of research evidence on the ineffectiveness of traditional methods of science teaching and learning, popular press reports highlight the outdated nature of much school science, and the decline in pupils' enthusiasm for science:

> GCSE Science is based on rote learning of facts of little use, and has made practical work a 'tedious and dull activity', the House of Commons Select Committee (on Science and Technology) were told (BBC, 2002).

The social and ethical issues rose by science, appearing almost daily in the news, were ignored by earlier curricula and therefore not discussed in science lessons. The GCSE (14–16) examination specifications – published in 2005 and taught from September 2006 – represent a new model in curriculum development reform in England and Wales (Baggot-Lavelle & Erduran, 2007). The underlying philosophy of the 2006 National Curriculum, particularly the sizeable section entitled *How science works* (DfES/QCA, 2004) is different from its predecessors (i.e. DES/WO, 1988; DFE, 1995; DfEE/QCA, 1999).

Two main changes have occurred in the science curriculum in recent years: (a) less emphasis on knowing and understanding a body of scientific facts – substantive content; and (b) a greater emphasis on knowledge, skills and understanding of how science works both in society and in the laboratory – procedural (syntactic) content. In this context, a particular challenge for the teachers in the project was the adaptation of the new curricular policy goals to the practical realities of the classroom. The series of lessons planned, implemented and evaluated by the teachers reflect their striving to attain new curricular goals for science teaching. The teaching and learning strategies adapted in the project are consistent with new visions for how to support the learning of science through 'How Science Works'. For instance, for the Year 10 lesson on space exploration, the Experienced Teacher designed and taught a lesson based on the pupils generating arguments for and against space exploration. To this end, the pupils were engaged in group discussions, evaluation of evidence on space exploration and finally group presentations to the whole class.

The descriptors in the new science curriculum imply a range of aspects of scientific enquiry skills for learners, such as the ability to use evidence to reach justified conclusions. The requirement is that "*teachers should ensure that the knowledge, skills and understanding of how science works are integrated into the teaching of the Breadth of Study*", which is listed as (a) Organisms and health, (b) Chemical and material behaviour, (c) Energy, electricity and radiations, and (d) Environment, Earth and universe (DfES/QCA, 2004). The topics selected by teachers in the project, namely magnetism, acids and alkalis and space exploration, coupled with the "How Science Works" framework in the space exploration activity are consistent with the new science curriculum.

Teaching Strategies

The teachers used a range of strategies to teach a variety of topics in Year 7, 8 and 10 classes. Coupled with the inclusion agenda of the project, these strategies represent a willingness to engage all learners in science and promote participation in classroom activities (Mitchell, 2014):

Practical science enquiries immerse pupils in investigations where pupils collect, interpret and present data to generate scientific explanations, models and arguments;

Group discussions and presentations engage learners in the social and cultural practices of science through communication, dialogue and public display of ideas based on evidence;

Role play enables pupils to evaluate different points of view including a range of explanations for a particular phenomenon; it engages learners in the generation and application of criteria for discriminating scientific ideas from other ways of knowing;

Differentiation provides the opportunity to tailor the science content to the needs and abilities of individual pupils;

Peer assessment promotes pupil voice in the classroom and creates a context for learning among pupils.

Overall, the strategies represent a sample of teaching approaches that promote active learning and engagement with science. Furthermore the strategies model ways of acting, thinking and communicating that form the fabric of the culture of science as a discipline. For example, scientists themselves argue about different hypotheses, theories and models (role play); science cultures tend to have a range of expertise where problems to be investigated are differentiated according to background and interests (differentiation); professional peer review systems validate and justify the dissemination of scientific knowledge (peer assessment and presentation).

Impact on Teachers and Pupils

Collaborative Consultation and Teaching

Collaborative educational approaches supporting children with SEN are 'becoming increasingly embedded in educational systems around the world' (Mitchell, 2014: p.75). Teaching can be defined as a process that enables a group of educational professionals with a range of expertise to combine their resources to generate solutions to problems over a period of time (Idol *et al.*, 1994). Views expressed showed that teachers hardly had any time during a school day to discuss their experience and exchange, let alone having time to initiate collaborative work to learn from each other's strengths and weaknesses tackling challenges they face in their classrooms:

> I think teaching's very often seen as something that you do on your own in a room with students and… although there are elements of team teaching at times… there isn't the value put on what you gain from discussing things with your colleagues. This has sort of made us value it more and feel that it's got a positive role to play in improving an individual's teaching. (ET)

The school teachers appreciated the value of team consultation and team teaching immensely and the experienced teacher highlighted that team teaching should not be limited to subject specific areas, such as science, and should be more encouraged as part of their CPD:

> I can think of occasions when I have been part of group meetings to discuss children with special issues where teachers who teach the same child get together to discuss them. And that's often been very valuable. Because it's seen as something as an add-on, and therefore something that you know you have to give up other time to do. Whereas I think if it got included in CPD in some form it might get to be valued for itself, rather than something that you just have to find time to squeeze in elsewhere. (ET)

Schools, if willing, can make the most of the experience, skills and knowledge of their teachers to meet the diverse needs of their students encouraging and creating opportunities for communication and collaboration between teachers (Creese, *et al.*, 1997; Reynolds, 2001). Moreover, such collaboration can extend beyond within-school exchanges to communication between neighbouring schools to create support schemes between schools.

Collaboration and Inclusion. Teacher training programmes do not necessarily equip teachers with the essential skills to meet the diverse needs of today's school population (e.g. Villanueva *et al.*, 2012; Fetters *et al*., 2003). This limitation is being recognised by the TDA and as a result there is expected to be more emphasis on meeting diverse needs of *all* pupils including those with SEN during initial teacher training as well as through CPD for qualified teachers. The school research team's collaborative consultation and teaching during the course of this project resulted in significant steps towards more inclusive education in target year groups. Not only were the teachers able to recognise and identify issues for each class taking into account each other's perspectives and experiences but they also produced alternative strategies towards tackling such issues and enabling full participation and inclusion of *all* pupils. One of the strengths of the school research team was that all the team members were at different career stages and held responsibilities with the school science team.

> We get so little time to work together, all teachers. It is very much a 'I have my work to do I'm going to get on with it. But this was brilliant being able to, especially for an NQT, pick other people's brains and giving you new ideas a fresh outlook on things that I'd never had before. (NQT)

This project fulfilled the early professional development aims for CPD by supporting the individual needs of the NQT with reflective activities designed and applied by the school teachers. It cannot be overemphasized that all members of the school team contributed to collaborative consultation and teaching, as noted by the NQT:

> Because I'm fresh out of the PGCE system I'm totally up-to-date with all the new initiatives, and all the new teaching ideas. So I think I was able to input 'Oh I learnt this while I was on my PGCE', whereas like [more experienced members], 'Oh we'd forgotten about that'. … but obviously experience in teaching's invaluable, being able to draw on those experiences and 'Oh we've done that before but that didn't work', I think was really really useful. (NQT)

Although teachers are the key players within their own classrooms, the process of inclusion cannot be achieved through the sole effort and input of teachers. Inclusion is about culture, policy and practices within an institution. Therefore, communication, collaboration, valuing all members of the community's experiences and views, including parents, pupils and school staff is of utmost importance. The school researchers' mutual communication and collaboration during the course of this project signifies an appreciation of complexity of inclusion and highlights how CPD can play a role towards this goal:

> The whole school needs to get together, the whole school needs it... I mean for a school our size, 150 teachers that would be impossible, but why not get three key people from each department to work together as a department to have their CPD. Why not? It'd be absolutely brilliant. Because I don't think they're aware of all the issues that go on. Within our school it's so big, you're quite isolated, so you feel like your issues are just your faculty's issues or your classroom's issues. (NQT)

Inclusion and Science

Teachers' views were sought regarding whether or not there were particular barriers to inclusion in science classes. The data revealed mixed views among teachers. According to some scientific terminology created extra barriers towards inclusion in science classes while others believed that inclusion is not a subject specific matter. Moreover, behavioural issues were considered to be one of the main barriers in science classes:

> If a kid doesn't behave in a lesson you can't have him doing a practical lesson because it's unsafe, so they can't be part of that lesson, and they miss out on that learning. It's difficult to get round that kids get annoyed If you have to stop a practical because of one child they all get narked off, and to be honest they all .. get punished for that one child. And that happens a lot with science. So I think science is particularly difficult. (MT)

> I'm not sure that it's [inclusion] specific to science. Science emphasises some aspects of it things like the practical nature, the safety, the behaviour of children affecting their ability to be included. Perhaps focuses on certain aspects that would exclude them more than other subjects. But I don't know … things like [terminology] might make it more difficult for some children to access it. So that it sort of draws elements from a lot of other subjects I suspect. Rather than having one set of particular issues of its own. (ET)

The complexity of science texts has been highlighted by a range of researchers (e.g. Wilson & Rupley, 1997; Maccini *et al.*, 2002). Moreover, there is international acknowledgement of the difficulties that mainstream teachers are likely to face in providing meaningful accommodation for the diverse needs of *all* learners in science lessons (e.g. Villanueva *et al.*, 2012; Mastropieri *et al.*, 2003; Palincsar *et al.*, 2001). The data further revealed that teaching science in "a fun way" in order to engage learners can be a way forward to include all pupils. Indeed, teachers sensed high expectations regarding science teaching on the part of pupils transferring from primary school, which often led new secondary pupils to feeling "a bit of a let-down":

> I think a lot of them get turned off very early on when they realise that science isn't all whizzes and bangs. And to do something which is a bit more fun way of doing their lessons and to work out something which every child can then use in a classroom to make sure that they are having a fun and interactive lesson has got to be helpful somewhere along the line. Even if helps with the subject of Science or any other subject in the school and I think the subject of Science is one of the only ones that is a bit of a letdown when they get there, everything else seems quite exciting. (LST)

The literature evidence suggests the effectiveness of activity-based approaches in science learning for pupils with diverse needs (e.g. Zembylas *et al.*, 2002). Teachers can be supported via in-service training and CPD to develop their repertoire of creative hands-on activities provided that the National Curriculum is flexible enough to foster and encourage such creativity to meet pupils' diverse needs.

Overall Impact on Teachers

The outcomes of the project, in terms of impact on teachers, were very positive. According to the teachers this project was "an eye-opening experience" at many levels. One of the teachers, the NQT, noted that the research project, as part of her CPD, "touched four of five core standards" which she is expected to meet. She specified the standards as "collaboration", "appreciation of inclusion", "deepening her knowledge of inclusion" and "appreciation of meeting the needs of [*all*] pupils in her classroom". Overall the teachers considered that the main impact on them had been related to collaborative consultation and teaching, reflective teaching, and understanding the concept of inclusion:

> I thought inclusion originally meant getting everybody to complete what I thought they should have done by the end of the lesson. And I realised actually it's a little bit further-reaching than that. … I was quite sort of naïve about what it would mean for a lot of kids. So taking on board much more of how each individual child works as opposed to getting the more academic achievements or the targets. (NQT)

The above quote, in a sense, points to a hotly debated "controversy" putting standards versus inclusion (e.g. Farrell *et al.*, 2007). On the one hand schools aim to be at the top of the league tables yet on the other hand they are expected to be as inclusive as possible with limited resources.

Senior teachers observed notable progress in more junior teachers. This aspect of the project, brought out by collaborative team work, touches on the TDA's revised arrangements for performance management where teachers are expected to be empowered and confident to engage fully with performance management to develop their skills and careers. And beyond institutionalised forms of peer mentoring the project revealed wider self-reflection practices in which teachers regarded their own teaching as well colleagues' teaching practices:

> I think [NQT] hugely benefited because she was NQT and quite short on ideas, just through lack of experience, as to how you can manage a class. So to sit with us and go through not just issues she's got with her class and the fact that she could actually say that she's got issues, and feel relieved that we say 'God, we know exactly what it's like to go through that'. The fact that we've then gone through it with her and she can see our thought processes and see how we worked with the problem has greatly helped her. It's opened her eyes to how she can do things and where she can go to for help. Because I think a lot of NQTs worry that they can't, that the training has stopped, that they can't go to anyone for help anymore. But the fact is if you're doing team work, I think actively encouraging them to go and continue asking for help. (MT)

The project outcomes were disseminated at Faculty and school level and school researchers seem to enthusiastically promote inclusion at school level. One of the teachers reflected on her experience of the monthly faculty meeting. She had reported back on the project, sharing the team's perception of inclusion, emphasising the need to consider the issue at school level, and pointing out the amount of time and hard work it requires:

> Before I started this [project]… I thought inclusion was SEN in the classroom trying to integrate people with disabilities into the classroom. But after doing this I see what inclusion is - every child in some way needs inclusion in the classroom, whether it's because they're gifted and talented, whether it's because their writing isn't as neat as others. Now when I go into the classroom I can think 'Right I need to plan for this person in my lessons more..'. At the beginning of the year I thought they're all [Y8 group] in the bottom group, differentiation for them will not be so much of an issue. And what I've actually found is they are so diverse in their needs that differentiation is the issue. And it's in terms of how can you make that lesson individualised for each of these people who have diverse needs that **a one size fits all approach is out of the window**, it just doesn't work. (NQT)

Although some of the teachers were initially hesitant to be involved in the project, the results demonstrated that their views changed significantly and they enjoyed the process and outcome of the project:

> And I think the spin-offs for [one of the teachers] have been brilliant. I think her positivity towards the project has improved,… she's been ace, because she's thought about why we're doing it. And it's forced her to think from the kids' point of view. I think before she saw them as a mass of girls that she needs to teach, but now she perceives as a group of individuals who have their own needs. So it's a whole positive leap, the more you give to them the more they give back… which is wonderful. (MT)

Findings suggest that teachers are ready and willing to improve their teaching practice provided that there are ongoing training opportunities to scaffold such professional development. The teachers grasped every opportunity to learn from the *Index* which seemed to widen their understanding of educational inclusion. They were provided with equipment (video) and created their own tools to reflect on their teaching, which they found very valuable both in terms of how they run their classes as well as increasing pupil participation (Roth. *et al.,* 2011). The process of the project seemed to support personal professional development of each and every team member. Last but not least, they valued collective reflection on their individual and team teaching which seemed to add value to their teaching repertoire since as a team they were able to better plan their lessons focusing on how to include *all* pupils in their classes, an area where all felt somehow weak and less confident. The collaborative teamwork also fostered greater transparency since the teachers had

collaborative ownership of the design and process for each class and collaborative constructive evaluation of what had really worked and why.

Impact on Pupils

Overall, the project seemed to have a positive impact on students' behaviour, their self-perception and perception of their teachers, as well as their motivation to actively engage in learning processes. Regarding the all-girls' group, teachers had identified a number of girls suffering from low self-esteem, and the teachers' enthusiasm and concern for them seemed make a very positive impact on the girls' perceptions of their teachers, their self-perception as well as peer interaction. The strategy applied by the teachers to maximise the girls' active participation in the learning process somehow indicated that they were important to their teachers and the teachers cared about them. Caring is an important component of education and can work wonders when mutually communicated between NQTs and pupils (e.g. Noddings, 1992). It is equally important to develop positive self-beliefs in one's students, gain and maintain their attention and actively involve them in the learning process. The following quote illustrates the impact of a caring and enthusiastic teacher on pupils:

> The girls' group are very emotionally aware. They hid away and it was okay to hide away - no one noticed them. [Teacher] said that they worked it out the fact that they knew we knew, made a difference. And I think some of them were quite chuffed that we had spent time and effort thinking about them as individuals. I think the fact they actually felt they'd been noticed even though they were trying to hide, the fact that they'd been noticed paid dividends... The relationship between the girls and [the teacher] I think has greatly improved. Because they've seen her as a person who cares about what each of them is up to and how each of them is. They're much more willing, they're much more at ease with her, and they're much more at ease with each other. (MT)

Introduction of new strategies (e.g., the use of green cards, positives book & hands-on-activities) seemed to have a positive impact on Year 7 pupils' behaviour and participation. The strategies introduced were chosen as a result of collaborative consultation between the teachers and were deemed effective. Moreover, the teachers had varying degrees of interaction with the pupils that equipped them with considerable observational and experiential knowledge which helped them in their selection of strategies.

> So although we hadn't really considered in detail the overall impact on the whole class, I think it's done great things for them. They're actually thinking about their behaviour, how they are going to do well, how they are going to get the green card. And they're enjoying Science because they know every Friday they're going to get a practical. (MT)
>
> Much more positive. When you walk in a classroom now you can feel a much more positive atmosphere. I'm no longer screaming at them. (NQT)

Effective teaching in an inclusive classroom requires resourcing. In this case, teachers' experiences led to identification of new strategies. Given the time and financial constraints of the project such strategies were limited but effective according to the participants. In addition to teacher observations and video recording of classroom interaction of pupils, the teachers also administered a questionnaire to the all-girls group in order to find out what they thought of their group and individual presentations. Almost two-thirds of the girls (n=15) were classified as "loud" or somewhat loud by their teachers and the remaining third (n=8) were classified as "quiet". There were a total of 11 questions exploring aspects of their presentation ranging from "how well the group expressed their arguments" to "if they felt that this exercise had enabled them to feel more confident in expressing their opinion". Series of independent t-tests were carried out to compare the two groups of girls (i.e. loud vs. quiet). The results revealed a significant difference between the two groups for only one out of 11 questions. This can be interpreted as the teaching strategy being somehow effective in creating more positive self-perception among the 'quiet' girls group. The 'quiet' girls group felt that the presentation of their argument was average (M= 3.25, SD=.46291) while the 'loud' girls group felt that theirs was above average (M=4.1, SD=.79881) (p=.01).

Overall, as anticipated, 'louder' girls seemed to feel more confident putting their arguments forward both within the small group and to the whole class. However, the results also suggested the exercise raised awareness among the 'quieter' girls that their teachers were observant of their self-perception and were prepared and willing to challenge these self-beliefs when they were perceived as detrimental to the girls' personal development and academic attainment. Although it is not possible to claim that the observed changes in pupils' behaviour, participation and motivation will be long-lasting, we expect that such changes can be sustainable provided that the teachers carry on their enthusiastic collaborative, informed and caring teaching strategies.

Conclusions

This CPD experience was perceived to be an unequivocally positive one for the teachers. One of the main factors for its effectiveness was inclusion of teachers' voice. The teachers, to a great extent, determined the CPD agenda since it was about their context, themselves and their pupils. Secondly, providing an opportunity for the teachers to reflect on their own practice by means of recording their own teaching sessions as well as collaborative reflection from the team proved to be very effective. An important component of effective teaching and learning, as noted by Hattie (2012), is teacher's perception of their role. Teachers' should be in a position to evaluate their impact on pupils. Teachers should be enabled to systematically implement range of strategies and approaches aiming to actualise positive impact on pupils' academic achievement and psycho-social well-being. Thirdly, the teachers were appreciative of the model of professional development underpinning this project. In particular, having goals and a structure for CPD through collaborative work was rated as being very encouraging. Another aspect that was considered important by the teachers was the link to the wider school workforce and how the project provided a context for extending

the teachers' work to the rest of the school. Teachers were also affirmative about how the CPD affected them as teachers. Whilst certain aspects of their attitudes towards inclusion may not have changed, other aspects such as understanding of inclusion in a wider sense had changed in their thinking.

In terms of school and university collaboration there were obvious institutional and cultural differences between the university and school teams. Some of these differences can be extensive considering the range of expectations within the school and university teams, leading to the question of "whose expectations matter the most" or "whether we had common expectations". It has to be noted that right at the outset of this project, the university researchers' understanding and expectations were about facilitating school teachers' professional development via resources for promoting evidence-based teaching. Overall, this expectation appears to have been well communicated by the university researchers and the school teachers welcomed the shared ownership of this CPD process. The university researchers' role in this project can be seen as setting the scene, acknowledging that the process has just started and will be ongoing as inclusion is not a *state* but a *process* that evolves according to the changing and diverse needs of student cohorts. As noted previously, there are many other aspects of the inclusion agenda, for instance, that were not taken into account such as school-as-a-community.

In summary, the project demonstrated importance of including teachers' voice regarding their professional development with a specific emphasis on inclusive science teaching. It is important for CPD providers to assess areas of professional developments by involving one of the primary beneficiaries of CPD in determining such agendas.

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References

Abels, S. (2014). Inquiry-based science education and special needs – teachers' reflections on an inclusive setting. *Journal of Education, 2(2)*, 124-154.

Baggot-Lavelle, L., & Erduran, S. (2007). Argument and developments in the science curriculum. *School Science Review, 88(324)*, 31-39.

BBC (2002) News website. 11 July 2002. Retrieved on 8.03.2016 from http://news.bbc.co.uk/2/hi/uk_news/education/2120424.stm

Booth, T., & Ainscow, M. (2000). *Index of Inclusion*. Bristol: Centre for Studies on Inclusive Education.

Cawley, J., Hayden, S., Cade, E. & Baker-Kroczynski, S. (2002). Including students with disabilities into the general education science teaching classroom. *Exceptional Children, 68(4)*, 423-435.

Creese, A., Daniels, H., & Norwich, B. (1997). *Teacher Support Teams in Primary and Secondary Schools*. London: David Fulton.

DES/WO (1988). *Science for ages 5 to 16.* London: HMSO.

DFE (1995). *Science in the national curriculum*. London: HMSO.

DfE (2015). *Special Educational Needs and Disability Code of Practice*: *0 to 25 years.* London: HMSO.

DfEE/QCA (1999). *Science: the National Curriculum for England*. London: HMSO.

DfES/QCA (2004). *Science: The National Curriculum for England*. HMSO.

Dyson, A., Farrell, P., Polat, F., Hutcheson, G., & Gallanaugh, F. (2004). *Inclusion and Pupil Achievement*. London: D*f*ES Publications.

Erduran, S., Polat, F., Raveaud, N. (2008). *Science teaching for promotion Inclusion (Step-In): professional development through evidence-based peer collaboration*. Bristol: University of Bristol.

Farrell, P., Dyson, A., Polat, F., Hutcheson, G., & Gallanaugh, F. (2007). Inclusion and achievement in mainstream schools. *European Journal of Special Needs Education, 22 (2)*, 131-145**.**

Fetters, M., Pickard, D., & Pyle, E. (2003). Making science accessible: Strategies for modifying science activities to meet the needs of a diverse population. *Science Scope, 26(5)*, 26-29.

Fullan, M. (2001). *The new meaning of educational change* (3rd ed.). London: Routledge-Falmer.

Grossman, P. L., Wilson, S. M. and Shulman, L. S. (1989) Teachers of substance: subject matter knowledge for teaching. In M. C. Reynolds (ed.), *Knowledge Base for the Beginning Teacher (pp.* 23–36). New York: Pergamon.

Hattie, John (2012). *Visible learning for teachers: Maximizing impact on learning*. London: Routledge.

Hoban, G. F. (2002). *Teacher learning for educational change*. Buckingham, UK: Open University Press.

Idol, L., Nevin, A., & Paolucci-Whitcomb, P. (1994). The collaborative consultation model. *Collaborative consultation* (2nd Ed.), (pp. 1-15). Austin, TX:Pro-ed.

Maccini, P., Gagnon, J. C., & Hughes, C. A. (2002). Technology based practices for secondary

students with learning disabilities. *Learning Disability Quarterly*, *25*, 247-261.

Mastropieri, M. A., & Scruggs, T. E. (1994). Text based vs. activities-oriented science curricula for students with disabilities. *Remedial and Special Education*, *15*, 34-43.

Mastropieri, M. A., Scruggs, T. E., & Graetz, J. E. (2003). Reading comprehension instruction for secondary students: Challenges for struggling students and teachers. *Learning Disability Quarterly*, *26*, 103-116.

Mitchell, D. (2014). *What really works in special and inclusive education: Using evidence-based teaching strategies*. London: Routledge.

Moon, N.W., Todd, R.L., Morton, D.L., & Ivey, E. (2012). *Accommodating students with disabilities in Science, Technology, Engineering, and Mathematics (STEM)*. Atlanta, Georgia: SciTrain.

National Curriculum Council (1991) *Science in the National Curriculum: A report to the Secretary of State for Education and Science on the statutory consultation for attainment targets and programmes of study in science*. London: NCC.

Noddings, N. (1992). *The challenge to care in schools*. NY: Teachers College Press.

Opretti, R., Belalcazar, C., 2008. Trends in inclusive education at regional and interregional levels: issues and challenges. *Prospects*, *38*, 113–135.

Palincsar, A. S., Magnusson, S. J., Collins, K. M., & Cutter, J. (2001). Making science accessible to all: Results of a design experiment in inclusive classrooms. *Learning Disability Quarterly*, *24*, 15-32.

Polat, F. (2011). Inclusion in Education: A Step Towards Social Justice. *International Journal of Educational Development*, *31*(*1*), 50-58.

QCA (2001). *Planning, Teaching and Assessing for Pupils with Learning Difficulties: Science*. London: QCA.

Reynolds, M. (2001). Education for inclusion, teacher education and the Teacher Training Agency standards. *Journal of In-service Education*, *27(3)*, 465-476.

Robinson, S. (2002). Teaching High School Students with Learning and Emotional Disabilities in Inclusion Science Classrooms: A Case Study of Four Teachers' Beliefs and Practices. *Journal of Science Teacher Education, 13(1)*, 13-26.

Roth, K.J., . Garnier, H.E, Chen, C., Lemmens, M., Schwille, K., . Wickler, N.I.Z (2011). Videobased Lesson Analysis: Effective Science PD for Teacher and Student Learning. *Journal of Research in Science Teaching*, *48(2)*, 117–148.

Schön, D. (1987). *Educating the reflective practitioner: Toward a new design for teaching and learning in the professions*. San Francisco: Jossey-Bass.

Schwab, J. J. (1964) The structure of the disciplines: meaning and significance. In G. W. Ford and L. Pugno (Eds.), *The Structure of Knowledge and the Curriculum (pp.* 6–30) (Chicago: Rand McNally).

Shulman, L. S. (1986) Those who understand: knowledge growth in teaching. *Educational Researcher, 15(2)*, 4–14.

Spillane, J. S. (1999). External reform initiatives and teachers' efforts to reconstruct their practice: The mediating role of teachers' zones of enactment. *Journal of Curriculum Studies, 31(2),* 143-175.

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching, 37(9),* 963-980.

TDA (2007). *Results of the newly qualified teachers' survey*. Retrieved on 01.03.2016 from http://dera.ioe.ac.uk/7117/1/nqt_report_%202007.pdf

TDA (2011). *Results of the newly qualified teachers' survey*. Retrieved on 01.03.2016 from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/182543/nqt_survey_results_2011.pdf -

Training and Development Agency for Schools (TDA) (2007). *Professional Standards for Teachers: Why sit still in your career*? London: Training and Development Agency for Schools. Retrieved on 10.03.2016 fromhttps://www.rgs.org/NR/rdonlyres/13C47A9B-633C-436F-8617668966AEAEB7/0/CGT_Online_TDA_standards2007.pdf

Villanueva , M.C., Taylor , J., Therrien, V. & Hand, B. (2012). Science education for students with special needs, *Studies in Science Education*, *48(2)*, 187-215,

Wilson, V. L., & Rupley, W. H. (1997). A structural equation model for reading comprehension based on background, phonemic, and strategy knowledge. *Scientific Studies of Reading*, *1*, 45-63.

Zembylas, M., & Isenbarger, L. (2002). Teaching science to students with learning disabilities: subverting the myths of labelling theory through teachers' caring and enthusiasm. *Research in Science Education*, *32*, 55-79.

APPENDIX I: The description of pupils' year groups and characteristics

The Year 7 group had ***behaviourally challenging*** pupils. All pupils were considered able to access learning but some chose not to do. Half of the pupils were dedicated and hard-working while the remainder were not so engaged and would not join in. The teachers identified three key students who displayed challenging behaviour (e.g. difficulty in obeying authority and attention-seeking behaviour). Key strategies, designed to increase the participation of all pupils, developed by teachers were:

- Keeping records of good behaviour by distributing green cards to pupils during the lessons;
- Positives book – signed by head of year once a week;
- Contract signed by each pupil that stays in the positive book;
- Motivational factor– a "fun" lesson with no writing once a week for all pupils having received green cards in the previous lessons;
- Letter home to parents for well-behaved pupils.

The Year 8 group was a small ***special educational needs group*** in which two students in particular were considered to be in need of extra attention. The teachers provided descriptions of the two pupils' behaviour and motivation [I do not understand this given that what follows reads as labelling]. One of the students was described as "lazy, zoning out for the lesson, lacking motivation, actively not working, doing no homework and not responding to positive praise". Although the second target pupil was described as highly motivated he lacked skills in "time management, handwriting, working on his own, and was excluded from other student groups". The activity described below was chosen to encourage group involvement in that it was based on the following factors: "no opting out; response to praise from peers rather than adults; strict time limits; group cohesion and membership; use of ICT to support writing difficulties; achievable targets set for each individual pupil":

- Student production of a poster for their individual contribution to the group;
- Specific differentiated task designed by the teacher for each pupil;
- Prize to motivate completion of the task by all (i.e. poster display, a video of their work in class and of the final result).

The Year 10 all-girls group, formed of the ***highest science achievers*** in their year, was identified as having a group of girls with ***low self-esteem***. In order to challenge low participation of the somehow "quieter" girls the following activity was organised:

- The class was divided into groups of four and each group was composed of girls with a similar within class participatory profile (i.e. quieter girls were group together and "loud"/ outspoken girls were grouped together;
- Each group was assigned to a project and within groups each member was allocated to a unique role;
- Each group was to make a decision based on provided evidence as to whether to fund further exploration of outer-space;

Each group presented their group's decision to the whole class.