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Teachers' experiences of science curriculum reform

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Abstract (100 words)

We report on a three year study of teachers' experiences of a major reform of the national science curriculum for 14-16 year olds in England. Teachers' responses to this curriculum reform were guided by: *personal* aims and biography; *internal* features of their workplace such as departmental collegiality; and *external* features such as educational policies outside of science. We argue that reforms should provide teachers with sufficient flexibility to allow them to adapt reforms appropriately to local contexts. Policymakers should also consider how different educational reforms might interact over time. Professional development activities should not be seen as opportunities to promote particular curriculum reforms; rather they should support teachers in developing an informed and critically reflective perspective on curriculum policy directives.

Keywords: curriculum; reform; policy; scientific literacy.

Curriculum change and teachers' working contexts

It seems that everyone has a different view on the science that young people should learn within compulsory schooling (Fensham, 2009). Experienced science teachers often reflect back on a career of constant curriculum change. Furthermore, those involved in developing science curriculum reforms often report that teachers do not implement reforms as intended. One reason commonly given for this 'failure' is that teachers do not understand the reform and/or the motivations behind it, and therefore that teachers need to develop their knowledge and skills about the curriculum reform in order for its implementation to succeed as intended. However, we argue that such an interpretation reflects an inadequate understanding of the working contexts of teachers. Whilst teacher understanding of a reform is clearly important, there are many other issues that also impact on science teachers' responses to a curriculum reform. In this article we draw upon a study of teachers' experiences of a recent reform to the science curriculum in England, and consider the implications for those involved in science curriculum reform.

Examining teachers' responses: The EISER study

The Enactment and Impact of Science Education Reform (EISER) study included an analysis of teachers' experiences of a major reform of the science curriculum for 14-16 year olds in England implemented from 2006 (Banner, Donnelly, Homer, & Ryder, 2010; Ryder & Banner, 2012). This was a statutory reform of the national curriculum in England for the final two years of compulsory science schooling. The reform included an emphasis on the teaching of socio-scientific issues and the nature of science, within the curriculum theme 'How Science Works' (DfE, 2013; Orrow-Whiting, Edwards, & Slade, 2007). Greater flexibility was provided through provision of a range of science courses aimed at enabling teachers to better match the needs of their students. This included a science course focusing on the aims of 'scientific literacy' taken by the majority of students. Here 'scientific literacy' refers to the goal of enabling all students to:

> 'read simple newspaper articles about science, and to follow TV programmes on new advances in science with interest, [to] enable them to express an opinion on important social and ethical issues with which they will increasingly be confronted' (Millar & Osborne, 1998, p. 9).

This 'core' course was taken alongside optional courses, either with a more traditional academic focus, or addressing science within employment settings ('applied science' courses).

As part of the EISER study we have analysed the experiences of this science curriculum reform amongst a sample of 22 teachers from 19 schools in England. These teachers were

each interviewed in the third, fourth and fifth years of the reform. Interviews lasted 40-60 minutes. Areas of questioning included how the teacher and department had prepared for the introductions of the reforms, students' responses to the new science courses, opportunities and challenges arising from the reforms, and teachers' plans for working with these reforms in the future. Box 1 provides a summary of the issues raised by teachers, categorised in terms of personal, internal and external contexts of their work (Goodson, 2003). These are exemplified and discussed in the following sections.

PERSONAL PERSPECTIVES OF TEACHERS
Teaching aims (e.g. preparation for future science study, 'scientific literacy')
Perceived audiences – the people who teachers see as 'judging' their work
Teachers' subject knowledge and pedagogical skills
Professional biography

INTERNAL SCHOOL CONTEXTS
School priorities (e.g. preparation of students for university)
Student intake
Whole school reform agenda (e.g. personalisation of curriculum, assessment for learning)
Department leadership style
Staff working practices

EXTERNAL CONTEXTS
National science curriculum reform
Other national or regional school reforms (e.g. assessment practices)
Accountability measures (e.g. pressures on student attainment via school league tables)

BOX 1: Influences on teachers' responses to curriculum reform

A variety of teacher experiences

We were struck by the wide variety in teachers' responses to the curriculum reforms. Some teachers reflected back on a long personal work biography of curriculum change, leading to some disillusion with the latest such reform:

> I sense the education pendulum here, I do sense it, and I think we've moved away from [subject matter knowledge] but I just sense it will come back again.

Other teachers highlighted the positive impact this major curriculum change had had on their professional lives:

> I have to say, it was exciting, it was great, I wouldn't have missed it for the world.

For many teachers the need to respond to the curriculum reform made them rethink some cherished practices:

> I think it has caused me to re-think why you do practical work (…) rather than just do the things that traditionally you've always done.

For this teacher, external reform is experienced as a challenge to existing practice, and therefore a lever for change.

A common message was that responding to the curriculum reforms was a long term process:

> I don't feel like even now into the third year of it (…) I don't even feel that it's really settled down yet. We're slowly getting to grips with it.

The following sections explore some of the reasons behind this rich variety of teacher response.

Personal contexts of teachers' work: Aims and perceived audiences

The following teacher reflects on his experiences of teaching courses that, in his view, provide less emphasis on traditional science content:

> I tell you what else worries [me] as well. Imagine starting [post-compulsory science courses] and they don't know the formula for a nitrite. They know how to plot a graph, they know how to pull data off of it, they know how they can spot an anomalous results and all the other bits and pieces, great. But they don't know stuff like [the formula for a nitrite]. Those kids are going to go to university and there's going to be a lecturer pulling his hair out thinking 'what are they teaching them in schools?'

This teacher is focusing on his personal teaching goal of preparing students for post-compulsory science study. However, this aim is not solely a personal perspective of the teacher. It is also reflected in, and perhaps partly constituted by, the internal context of his school: a high performing 11-18 school with large post-16 science groups and a significant proportion of students going on to study science at university. The emphasis on teaching 'How Science Works' in the new curriculum is seen as moving the school subject away from the perceived needs of his students and those teaching post-compulsory science courses. In this case, the challenge for reformers is to convince such teachers that their students can indeed develop their understanding of 'the formula for a nitrite', and much other traditional science content, through an appropriate enactment of the available science courses within the reform.

By contrast, the following teacher identifies multiple groups of students with differing needs for science education:

> I think the idea of splitting it into three [courses][1] is because there is the science that everybody should do whether they're going to be a scientist or not, which is in the Science course. And then there is the science that you need if you're going to potentially be a professional scientist, which is in the Additional Science [course]. And then there's the science that, everyday use of science, which is the way I see the Applied [Science] course. So the reason for offering all three is because you've got three different sorts of people out there (…) There are some students for whom learning the nitty-gritty of Newton's laws of motion and the Bohr model of the atom are just not for them (…) So I'm sure that giving kids appropriate courses is a key to getting them to do well.

For this teacher, working in a school with overall student attainment just below the national average, the range of science courses available within the reformed science curriculum provided the flexibility to match the perceived differing needs of his students. Looking beyond these two examples, there was a strong tendency for many of the teachers in our study to respond to the curriculum reform with reference to the perceived needs of their students.

Internal school working practices

The style of staff leadership within a science department was referred to by several of the teachers. In some schools it was clear that the Head of Science was a charismatic leader

[1] Here the teacher refers to, in turn, the 'Core' science course with a focus on 'scientific literacy', the Additional Science course with a more traditional academic focus, and the Additional Applied Science course presenting science within employment settings. The majority of students will complete the Core science course and then either the Additional Science, or the Additional Applied Science course.

with a strong sense of a professional mission in education and a desire to persuade and motivate teachers towards achieving this goal. In addition to leadership style, how staff worked together within a department also featured in teachers' reflections. In particular, teachers spoke of the value of a collegial working atmosphere within a department.

> I think people did feel nervous, but the fact that we all talked to one another and people said, 'well (…) I found that geo-hazard worksheet worked better than that one.' People did start talking. I think the challenge was to get people to come to department meetings and say, 'you know what, I've tried that and it didn't work.' (…) I think people are comfortable to talk to one another here and admit when they get things a bit wrong or it doesn't work or what am I doing?

It is likely that departments with strong leadership, and a collegial working atmosphere, are in a stronger position to respond effectively to externally-driven curriculum reform. However, beyond those cases in which teachers raised this issue, our study did not explicitly explore the link between departmental leadership/collegiality and reform response.

Some teachers referred to an alignment of changes in the science curriculum with initiatives within the school beyond the science department:

> So the whole skills thing is really a big thing in [this] school, and [within Key Stage 3] we're just bringing in a Key Stage 4 passport[2] where they have to hit certain skills before they can move to Key Stage 4. So the whole discussion thing, and other things like that [within the science curriculum], is kind of what we're trying to push being taught more anyway.

Such 'internal policy alignments' helped many teachers to respond to changes to the science curriculum. By contrast, as shown earlier, for some teachers in our study this external curriculum reform was seen as conflicting (rather than aligning) with internal school policy emphases such as preparing highly attaining students for future science study.

External policy contexts

Many teachers referred to pressures from the external assessment of student attainment at age 16:

> At the end of the day we are now becoming more and more accountable for what we do with the kids and accountability relates to the exam results. If your

[2] Within secondary schooling in England Key Stage 3 refers to students aged 11-14 years; Key Stage 4 to students aged 14-16 years.

> exam results are successful and you're getting good results for the kids then why change?

This teacher is referring to the influence of an external context of 'high stakes testing' on his work as a science teacher. Such pressures are experienced by teachers *alongside* the requirement to respond to a science curriculum change. Indeed, in the broader school context 'high stakes testing' is the key (and in some cases arguably the sole) subject-related concern for senior management teams within schools.

Implications for future curriculum reform

Our study reveals the wide range of factors that impact on teachers' experiences of curriculum reform. The personal, internal and external contexts identified in Box 1 provide a 'checklist' of issues to consider in understanding teachers' responses to science curriculum reforms. In this section we consider the implications of this characterisation of teachers' working contexts for future science curriculum reforms.

Teacher professional development

A starting point for the design of teacher development activities associated with a specific science curriculum reform is to consider the reform as *necessarily* interacting with a range of aims for school science education. For example, professional development activities related to the teaching of socio-scientific issues and the nature of science should aim to show how such teaching impacts on a wide range of aims, e.g. achieving 'scientific literacy' for all, but also challenging high attaining students, preparing students for advanced study in science, and motivating students disaffected with school science.

Several teachers in our study provided a reasoned challenge to some cherished assumptions of science curriculum reformers, e.g. the need for more scientists, or that teaching about socio-scientific issues and the nature of science in school will necessarily support people in engaging with science-related issues in adult life. Thus, it may be that teachers do not enact curriculum reform as intended by designers because they don't think that it will help their students. Professional development activities should not be seen as opportunities to 'promote' a specific curriculum reform. Instead, activities need to recognise, indeed emphasise, a reflective analysis of new curriculum reforms, with this seen as a signature of professionalism within teaching.

Recognising the professional: Providing teachers with flexibility within curriculum reform

Box 1 demonstrates that teachers work in widely differing contexts. Providing flexibility, around a core reform, is one way of supporting teachers to address these differences. In the reform context examined here the curriculum element 'How Science Works' was a core innovation, with flexibility provided through provision of a range of qualification routes for 14-16 year olds, all of which included this innovative curriculum theme. This appears to have enabled many of the teachers in the EISER study to better meet the differing needs of their students. Our analysis supports a model of curriculum reform policy that incorporates a core innovation running through a flexible package. Such a model allows for external reform of the science curriculum; it does not simply accept that teachers should be left to their own devices. However, at the same time, it provides legitimate space in which teachers can exercise their professional judgement, enabling them to enact external reform policies in ways that reflect the needs of their students and the priorities of their schools.

Education policy: The need for reform coherence

Teachers in the EISER study referred to many other educational policies when talking about their experiences of the science curriculum reforms. Curriculum reformers need to recognise these interactions with other educational reforms. For instance, the 2006 curriculum reforms emphasised teaching and learning about socio-scientific issues and the nature of science ('How Science Works'). A key question to ask therefore is how such teaching might be integrated with, and perhaps supportive of, broader cross-subject reforms such as the 'personalisation' of curriculum to individual student needs. Consideration also needs to be given to how the teaching of socio-scientific issues and the nature of science supports or constrains schools in addressing the realities of school accountability through student attainment and associated school 'league tables'. A key practical outcome would be to ensure that learning about socio-scientific issues and the nature of science is assessed within external examinations of student learning. A further goal would be to ensure that 'How Science Works' appears as a curriculum element within post-compulsory science progression routes, providing curriculum continuity and a clear policy message that this curriculum innovation is highly relevant to high attaining students who plan to continue with their science studies.

Recognising timescales for educational reform

Many of the teachers in our study were still developing their classroom enactment of the new curriculum at least 4-5 years after the introduction of the reform. Our analysis suggests that this timescale is an inevitable consequence of change within the complex institution of school. Curriculum policy reformers need to recognise this timescale. Ideally, evaluation studies of pilot reforms need to be conducted over several years, in a broad range of school

contexts. Thereafter, curriculum reformers need to provide periods of curriculum and assessment policy stability (on the basis of our analysis at least three years) in order to enable and encourage teachers to invest time, material resources and personal energy into changing the nature of their practice and the places in which they work.

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