Context led Science courses: A review

Frances Wilson Research Division, **Steve Evans** OCR and **Sarah Old** OCR

Introduction

Internationally, there is growing concern about secondary Science education. In many developed countries[1], uptake of Science subjects has been falling (Bennett, Gräsel, Parchmann, & Waddington, 2005), leading to fears that there will be a shortage of people with the scientific skills and knowledge needed in the twenty-first century. The lack of uptake has been attributed to various causes. In particular, Science curricula are often considered to suffer from an overload of content, leading to the perception that Science subjects are among the most difficult. Furthermore, students have difficulties connecting the isolated facts which they are taught, and do not develop coherent mental schema. Content is often presented in an abstract manner that is remote from students' everyday experiences, so that many students do not understand why they should learn the materials which they are studying, and frequently fail to do so. As a result, students have difficulty applying scientific concepts in a context beyond the one in which they were taught that concept (Bennett et al., 2005; Fey, Gräsel, Puhl, & Parchmann, 2004; Gilbert, 2006; Nawrath, 2010; Pilot & Bulte, 2006). In this article we examine one approach to Science education: context led Science courses, which have been developed as a result of these concerns.

Context led Science

Traditional Science courses can be said to be "concept led", that is, they are structured from the perspective of a scientist, with scientific concepts organised in a way that makes sense to a scientist (Reiss, 2008). In contrast, a context led approach can be characterised by the "use of contexts and applications of Science as the starting point for developing scientific understanding." (Bennett et al., 2005, p.1523). A structure based in contexts may relate better to students' own knowledge about the world. For example, a concept led Biology course might structure the course into topics such as 'Biochemistry' or 'Cell Biology', whereas a context led course might use the context of crop production and global food security to introduce plant transport, reproduction and the biochemistry of photosynthesis. From this starting point, a context led course would then revisit other biochemical topics in other contexts at a later point in the course.

Context led Science courses aim to address the problems associated with traditional Science courses by breaking down boundaries between school Science and everyday contexts to increase the social and cultural relevance of Science for students, by making the relationship between social issues and scientific knowledge more prominent. It is hoped that this sort of approach will provide greater access to Science education for groups of learners who traditionally do not participate fully in post-compulsory Science education, such as certain cultural minorities, or girls. Furthermore, it has been argued that by relating school Science to authentic scientific contexts, students may develop a greater understanding of the range of scientific careers which are available, potentially increasing uptake of Science subjects (Lubben & Bennett, 2008).

What is a context?

Although the term "context led" is commonly used, "context" may have several meanings. For example, at its widest, it might refer to the social and cultural environment in which the student, teacher and institution are situated, or, more narrowly, refer to the application of a scientific theory (Bennett et al., 2005). Giamellaro (2014) proposes that the process of contextualising knowledge involves forming specific connections between the content knowledge which is taught, and an authentic environment in which the content can be relevantly applied or illustrated. Decontextualised knowledge, on the other hand is typically only used in scholastic environments, and is abstracted away from the content knowledge as it is typically used in practice (p.2849). For example, knowledge of intermolecular bonds, such as hydrogen bonds is decontextualised, but can be contextualised when linked to polymer properties. A context led course uses the authentic environment as a starting point for teaching and learning, whereas a traditional concept led course starts with decontextualised knowledge, which might (but not necessarily) then be applied to a context. Giamellaro further distinguishes between learning *with* context, using a second hand context, such as a case study, and learning *in* context, such as an internship. However, what is considered to be an authentic environment may vary. For example, it is not clear whether a hypothetical case study, such as a boy who has had a stroke, can be considered to be truly authentic, if the case study has been designed specifically for educational purposes.

Attributes of contexts

Gilbert (2006), following Duranti and Goodwin (1992), proposes that an educational context can have four attributes. For example, a context used to study the Chemistry of global warming (focal event) would have the features shown in Table 1.

The contexts used in Science courses may include social, economic, environmental, technological and industrial applications of Science. Some courses select contexts which are directly relevant to students' personal circumstances, while others may focus on societal/community issues, or contexts which are relevant from a vocational perspective. (Kazeni & Onwu, 2013). In general, for younger students, contexts which have direct applications to students' lives are typically used, whereas for older and more advanced students, contexts which explore 'what scientists do' may be more common. Pilot and Bulte (2006) and Gilbert (2006), in the

1. In England, there has been a recent increase in the percentage of A level entries for Science (http://sciencecampaign.org.uk/?p=12878), although since this follows a period of decline over several decades (Bennett, Lubben, & Hampden-Thompson, 2013), this growth needs to be sustained over several years to allow uptake to recover fully.

Table 1: Attributes of an educational context (adapted from Gilbert, 2006, p.961)

Attribute	*Example*
Setting: Where, when, how is the focal event situated?	The setting is the specific example of the focal event. The focal event is the general phenomenon of global warming, manifest throughout the world in different settings,
Behavioural Environment: What do people do in this situation; what actions do they take?	People take various measures to reduce the production of relevant gases, and remove those already in the atmosphere.
Language: What language do people use to speak about their actions?	The molecular structures of relevant gases are discussed, with a particular emphasis on the way that internal vibrations lead to the effects that are observed.
Background Knowledge: What is the background knowledge of those who act?	The need for a general education about molecular structure and energy conversion is required.

context of Chemistry education, outline four criteria needed for the successful use of context:

1. Students must value the setting, and recognise that it falls within the domain of Chemistry. It must arise from the everyday lives of the students, or social issues and industrial situations that are of contemporary importance to society.
2. The behavioural environment must include problems that are clear exemplifications of chemically important concepts, so that students engage in activities from the domain of Chemistry, such as experimental laboratory skills.
3. Learners should be enabled to develop a coherent use of specific chemical language which is brought into focus by the behavioural environment.
4. The behavioural environment and the language used to talk about it should relate to relevant extra-situational, background knowledge, building productively on that prior knowledge.

(Gilbert, 2006, p.961)

Additionally, across a course as a whole, curriculum developers must plan contexts which allow students to revisit scientific concepts, albeit from a different perspective, in a way which allows students to build up their understanding of scientific topics. These contexts should enable students to make analogies between contexts, so that it is clear that concepts can be transferred to these new contexts (Gilbert, 2006).

However, for curriculum developers, there may be significant challenges in meeting these criteria, particularly if a Science course is to be taught to students from diverse backgrounds. Not all contexts are suitable for use in every context. For example, Kazeni and Onwu (2013) give the following context which was used successfully in a context led course on genetics in South Africa:

> *Mr. and Mrs. Sizwe have been married for twelve years. They have four daughters, and no son. According to Mr. Sizwe's custom, not to have a son means that there would be no heir to succeed him. Mr. Sizwe decided to consult his elders about his situation. After consulting with them, he decided to take on a second wife who would bear him a son. To his dismay, the second wife gave birth to a girl.*
>
> *The question is: How can the situation about sex determination be resolved scientifically?*
>
> (Kazeni & Onwu, 2013, p.55)

Although students in South Africa may be able to relate to this context, it seems unlikely that it could be successfully used in secondary schools in England, where students may not be familiar with the cultural need for a son, nor the practice of taking a second wife. Furthermore, Taasoobshirazi and Carr (2008) note that if students become too emotionally engaged with the context, then this might distract them from learning the relevant scientific concepts. Similarly, contexts which are too complicated, or provide too much interesting, but not relevant, information might be confusing. However, if such contexts are not part of the everyday lives of students, or they are not engaged with particular social issues, then they may not be engaging enough.

Pedagogy in context led Science courses

Context led Science courses are strongly associated with particular pedagogical approaches to teaching Science. Bennett et al. (2005) note that context led courses typically use a "spiral" curriculum, in which students encounter the same concepts, albeit from a different perspective across multiple contexts at different stages of the course. This may help students to connect otherwise isolated facts, and develop coherent mental schema. Revisiting the same concept in different contexts allows students the opportunity to transfer their application of a concept to different contexts. For example, in the Salters A level Chemistry course, chemical equilibrium is introduced initially in the unit "The Atmosphere", in relation to reversible reactions to explain the role of carbon dioxide in the oceans. It is later developed further in "The Steel Story", by looking at redox reactions, and then revisited in "Aspects of Agriculture" to explain ion-exchange equilibria. Towards the end of the course, the concept is extended to more complex situations, such as pH and buffer solutions.

Context led Science courses are generally characterised by the adoption of a student-centred approach to teaching, which requires students to engage in meaningful activities, rather than rote learning (Overman, Vermunt, Meijer, Bulte, & Brekelmans, 2012). For example, King and Ritchie (2013) describe a project undertaken by 11th grade Chemistry students in Australia, in which students investigated the water quality in their local creek by carrying out tests on water from the creek taken from three locations. Students were required to conduct background research on each test (e.g., for Dissolved Oxygen, pH, turbidity, Biochemical Oxygen Demand, salinity, and faecal coliforms), and then report on the overall water quality based on their understanding of the various tests, and the chemical concepts underpinning these tests. The use of a local context helped to make the project meaningful to students, while their research into each water quality test helped them to develop the appropriate language to talk about the underlying chemical concepts.

Such student-centred approaches to the organisation of the curriculum have their roots in constructivist theories which emphasise the importance of learners actively constructing their knowledge. In particular, constructivist approaches are based on the principle that students must be actively involved if they are to achieve understanding, and that students and their ideas should be respected, so that teaching allows students to use what they already know, and can address difficulties that result from a naïve understanding of scientific ideas (Gilbert, 2006; Gilbert, Bulte, & Pilot, 2011). Educational constructivists would further argue that a traditional, transmission-based approach[2] to

2. Transmission-based approaches are centred around the transmission of information from teachers to students, in which the teacher structures and organises the information for the students. As such, it is a teacher-centred approach (Overman et al., 2014).

teaching is unlikely to lead to students developing a meaningful understanding of the content, and that this is only achieved by teaching methods which allow students to engage with the material (Overman et al., 2012). A successfully applied context allows students to use their own background knowledge and understanding of the context, helping them to make the scientific concepts associated with the context meaningful. However, one consequence of this link between pedagogy and context led teaching is that teachers who switch from a traditional concept led course may also need to learn new pedagogical approaches at the same time. As a result, this may make a shift towards context led courses particularly demanding for teachers. Furthermore, this type of pedagogical approach may be challenging when classes are large and diverse in terms of prior knowledge and experience, and future goals (Gilbert, 2006).

Despite the relationship between constructivist pedagogy and context led Science courses, Peşman and Özdemir (2012) note that it is possible to use student-centred learning approaches in a traditional concept led course, and transmission based teaching in a context led course. Indeed, in a short term (five weeks of teaching time) study, they found that a student-centred, active learning approach was more effective for a concept led course, compared to a context led course. Somewhat surprisingly, transmission methods of instruction seemed to be more effective with context led courses. It is possible that introducing only one innovation (a change in teaching method or a move to a context led course) was most effective over this time period, because students and teachers were able to adapt to one innovation but not both. Furthermore, even if teaching activities (such as inquiry based projects or student discussions) which are promoted by constructivist approaches are not used, the use of a context to introduce a topic may help students to engage with the topic, and understand why the scientific concept is relevant to their everyday lives. Similarly, a concept led course which is taught in a way that recognises students' prior knowledge and experiences may be more successful than one which uses a traditional transmission pedagogy.

Models of embedding context

Given the range of different understandings of the term 'context', combined with potentially different approaches to teaching context led courses, context led Science courses should not be considered a homogenous group. Gilbert (2006) and Gilbert et al. (2011) propose four models for context led courses. Each model represents a different way in which context is embedded in the course.

Model 1: Context as the direct application of concepts

This model represents what is typical of many concept led courses. Concepts are decontextualised, and typically presented as abstractions. Contexts are only subsequently introduced, typically allocated little time, and not used in assessment. Such courses are not generally considered to be context led, because contexts are introduced after concepts.

Model 2: Context as reciprocity between concepts and applications

Contexts are selected as a means through which concepts can be taught, and juxtaposed with the relevant concepts. This model may be considered to be more context led than Model 1, because it does provide a setting and behavioural environment which students may use as a framework, and may enable them to relate what is being learned to their prior knowledge. However, the lack of a clear rationale for the integration of contexts may mean that students do not relate strongly to the context. Furthermore under this model of contextualisation, the degree to which concepts are repeatedly recontextualised may vary.

Model 3: Context as provided by personal mental activity

This model focuses on learners who are working as individuals, typically from a book or online courses. It is characterised by the use of a narrative to frame historical events, which may allow students to empathise with the participants in the narrative. For example, students may study the events leading to an important scientific discovery. This model lacks a social dimension.

Model 4: Context as the social circumstances

In this model students and teachers work together on an enquiry into a topic which is considered of importance to the lives of their community. Learning takes place as students experience a setting, and by participating in interactions with members of their community.

Examples of context led courses

In this section we describe four different context led Science courses, which were developed with similar aims, but in different educational contexts.

Salters – England

The Salters project began in the early 1980s, when a group of teachers and Science educators met at the University of York to discuss how Chemistry education could be made more appealing to secondary school students. Since then, the Salters project has expanded to include Biology and Physics as well as Chemistry, leading to the development of Science courses for students aged 11–18 (Bennett & Lubben, 2006), and has been used as a model for context led courses internationally (Parchmann et al., 2006). All Salters courses are based on the same design criteria, namely that the contexts and concepts selected for study should enhance students' appreciation of how Science contributes to their lives, or the lives of others around the world, and to help them understand the natural environment better (Bennett & Lubben, 2006). The courses use a spiral curriculum, such that scientific concepts are re-visited in different contexts throughout the course.

Here we focus on the Salters A level courses, which were first developed for Chemistry in the late 1980s (Bennett & Lubben, 2006), for Physics (Salters-Horners) in the early 1990s (Institute of Physics, 2003), and in the early 2000s for Biology (Salters-Nuffield) (Reiss, 2005). The Biology course was introduced later than the Physics or Chemistry course because there are in general fewer concerns about the uptake of Biology, although Biology teaching has been criticised for using activities which require little student involvement, and do not include enough practical work (Reiss, 2005). All three A level courses have been developed as a partnership between the University of York and exam boards (Oxford, Cambridge and RSA (OCR) for Chemistry, Pearson-Edexcel for Biology and Physics). Pilot and Bulte (2006) argue that the integration of the Salters courses with national examinations facilitated uptake of the courses, and was critical to their success. The courses are distinct from traditional concept led A level courses due to the use of a spiral curriculum, based around different contexts, and the use of personal investigations conducted by students. At AS level, these include a report based on a literature review or a visit to a site (e.g., zoo, local chemical industry) (Astin, Fisher, & Taylor, 2002; Dunkerton, 2007) and at A2, an extended experimental investigation (Lewis & Scott, 2006).

Until 2008, separate specifications and assessments were developed for the Salters context led courses, and traditional concept led courses. However, when A level specifications were re-developed for first teaching from 2008, the Biology and Physics courses (both Pearson-Edexcel) were designed so that both the Salters and the traditional courses shared the same assessment, but teachers could choose whether to teach the content using a context or concept led approach[3]. It is not clear whether this approach to assessment is successful: sample assessment materials for these courses (Edexcel, 2014) seem to predominantly assess students using concept led questions, with the exception of the questions based on a scientific article. The use of concept led questions may not allow students who have followed a context led course to fully demonstrate the skills which they have acquired, and the content and form of the assessment is likely to influence teaching and learning (Pilot & Bulte, 2006). However, Braund, Bennett, Hampden-Thompson, and Main (2013) found no significant difference in the marks obtained by students following a concept led course compared to a context led course, suggesting that neither teaching approach disadvantages students. In this study, centres were classified according to a combination of self-report, access to context led teaching resources and historical teaching approach, so it is likely that there was some diversity of approach within both the concept and context led groups, which possibly reduced any difference in outcomes between the two groups.

Bennett et al. (2005) investigated A level Chemistry teachers' views on the OCR Salters A level Chemistry course and the traditional concept led Chemistry course. Overall, teachers of both courses thought that the course that they taught provided a sound knowledge base for progression to university study. However, teachers of the traditional course were concerned that students do not acquire sufficient chemical knowledge when following a context led course, because the context course does not cover conceptual knowledge sufficiently. This was linked to the use of a spiral curriculum. However, teachers who taught the Salters course thought that the spiral approach was beneficial, because it allowed students the opportunity to revisit and revise topics, leading to greater understanding. Teachers using the concept led course thought that their chosen course could be taught in a logical sequence, but they did have concerns about continuity.

The Salters courses are designed to use more student-centred activities than traditional concept courses. Both groups of teachers thought that the Salters Chemistry courses were more student-centred, and used a wider range of teaching methods. Perhaps as a result, both groups of teachers thought that the Salters Chemistry course was interesting and motivating for students. Teachers who taught the Salters Chemistry course felt that it promoted good study skills and developed independent study in their students. In contrast, teachers who taught the traditional course were concerned that their students were too reliant on the textbook. The Salters course was considered to be more demanding to teach. This was largely due to the nature of the coursework at A2: an individual experimental investigation. Teachers found it challenging to manage large groups of students who were working on individual projects, both in terms of laboratory organisation and providing sufficient academic support to each student. However, the coursework was considered to be a useful learning activity for students. Teachers who taught traditional courses also thought that the Salters' coursework would be time-consuming. In an evaluation of the Salters Biology A level course, Lewis and Scott (2006) also found that teachers sometimes struggled to adjust to the more active learning approach used in the course at first, although this improved as they gained more experience. Furthermore, in an investigation of a Biology course with a shared assessment for concept and context led approaches, Braund et al. (2013) found that some teachers preferred to teach some topics using a context led approach, and other topics using a concept led approach.

The Salters A level Chemistry course was evaluated by Lubben and Bennett (2008) with respect to the Gilbert (2006) models. They concluded that the course was predominantly Model 2, with some elements of Model 3, because all examination questions were contextualised, and the supporting materials were organised by different contexts ("storylines"), which provided some opportunities for Model 3.

Chemie, Physik, Biologie im Kontext – Germany

The *Im Kontext* projects began in the late 1990s, and were initially based on the ideas and experiences resulting from the Salters project in England (Parchmann et al., 2006). The projects started as a result of national discussions in Germany about Germany's surprisingly weak performance in the TIMMS and PISA international comparison studies, leading to a general recognition that reform was needed at a national level (Parchmann et al., 2006). However, in Germany, each Bundesland (federal state) has a different school system, with a variety of different structures for Science education, leading to a wide range of different curricula. For example, in some Bundesländer, Science is taught as an integrated subject during early secondary education, while in others it is taught as three separate Sciences. This variety leads to significant challenges for the implementation of educational reform at the national level. The *Im Kontext* projects addressed this issue by using a symbiotic implementation strategy, in which teachers and researchers worked together in learning communities, to develop teaching units which were suitable for their own teaching situation. These units were then trialled by teachers in schools, and shared with other learning communities (Fey et al., 2004; Parchmann et al., 2006). While this approach has led to a feeling of ownership of the process by teachers, facilitating their own professional development, the lack of an overarching plan for the whole curriculum led to difficulties in providing systematically planned opportunities for students to transfer knowledge to other contexts. Furthermore, although students reported increased motivation, they felt that they sometimes got "lost in the context" (Pilot & Bulte, 2006). Additionally, teachers reported that they found it difficult to integrate a context led approach into existing curricula, and felt that they needed to place more emphasis on developing understanding of scientific concepts. However, this might have been the case because teachers spent time developing appropriate contexts, reducing their focus on concepts (Fey et al., 2004).

The *Im Kontext* projects value socially embedded group learning, which is promoted for both students following the courses, and those involved in the development process. As a result, Pilot and Bulte (2006) argue that the *Im Kontext* projects could be described as Model 4 under Gilbert's (2006) framework. However, given the autonomy with which the different learning communities operate, it is difficult to evaluate whether all curriculum units can be said to fall under the same model.

National Curriculum Statement – South Africa

Until 1995, the official South African curriculum (apartheid curriculum) was a very traditional, concept led curriculum, with little opportunity for

3. Salters Chemistry A level, offered by OCR, retained a separate assessment.

contextualisation. However, there were alternative curricula. In South African townships, the democratic movement promoted "People's Education", which valued students' life experiences, and provided opportunities for context based learning. Despite this, even within this movement, most contexts were provided as an addition to the scientific concepts. Between 1995 and 2006 an Interim Curriculum was introduced. Although curriculum documents mentioned the need for students to develop scientific literacy and prepare for the workplace, contexts were not used in the content specification, such that the Interim Curriculum could also be described as a concept led curriculum (Lubben & Bennett, 2008). Since 2006 the National Curriculum Statement has been used, which recognises the need to "value indigenous knowledge systems" (p.258), and to be able to use Science critically in various contexts. Textbooks developed to support this curriculum use context to exemplify concepts previously taught. However, some supplementary teaching activities do allow a greater interaction between context and concepts, as do some parts of the assessment, leading Lubben and Bennett (2008) to conclude that while the majority of the course could be described as Model 1, there are some elements of Models 2 and 3.

Chemistry in Context – USA

In the USA, university students study a broad curriculum, so that many Science departments teach students who are not planning to continue their study of Science, and who may or may not have studied particular areas in high school. As a result, some universities offer courses targeted at these students, recognising that they have different needs and interests from those who are planning to continue to study Science. *Chemistry in Context* is a university textbook aimed at students who are not planning to specialise in Chemistry at university (Schwartz, 2006). In this respect it differs from other context led Science courses discussed in this article, which aim to provide a foundation for further study as well as meeting the needs of students who will not continue to study Science. The textbook was developed by university teachers, on the basis of their own teaching experience, rather than educational research, and aims to motivate students to learn Chemistry, and understand its societal significance, while developing an understanding of the fundamental concepts of Chemistry. The concepts and contexts which are taught are organised on the principle of a spider's web, showing links between different concepts and contexts. The contexts which have been chosen are typically real-world societal problems; these contexts were chosen in preference to topics relating to students' self-interests, due to their maturity levels. However, the inclusion of such topics may be challenging to teach, because instructors are likely to be Chemistry specialists foremost, and may not have specialist knowledge of the societal issues included in the course. Only topics which had a significant chemical content were chosen, to allow students to develop their knowledge of Chemistry concepts. However, typically more information about the underlying Chemistry is provided than is needed to understand the context. Despite this, the selection of conceptual content was largely driven by the choice of contexts, because there was no need to cover particular content as a preparation for further study. This may help to prevent the curriculum becoming overloaded (Pilot & Bulte, 2006). Similar to the *Im Kontext* projects in Germany, the textbook has been used in different institutions working in different learning environments, so it is difficult to evaluate the impact of the course. However, Schwartz (2006) reports that students following courses using the textbook showed more positive attitudes towards the study of Chemistry. Pilot and Bulte (2006) estimate that the *Chemistry in Context* course supports a Model 3 or 4 approach, due to the importance of the context and the emphasis on active learning.

Discussion and implications for A level reform

Context led Science courses share the aim of making Science education more relevant to students' lives, increasing their interest in, and motivation to study Science. They are now used in many different educational contexts, and have been shown to be effective in increasing student motivation (Bennett et al., 2005; Braund et al., 2013; King, 2012; Parchmann et al., 2006; Schwartz, 2006). However, context led courses can also be characterised by their diversity. There are many different types of contexts which can be used as a framework to explain different scientific concepts, from issues which may directly impact on students' lives, to global issues which may have a less direct impact on their everyday lives. Alternatively, a context can serve to make students aware of ways in which Science is used in industry, which may increase their awareness of possible careers in Science. For a context to be used successfully, students must be able to engage with it, either at a personal level, or through an appreciation of the importance of an issue, and be able, with support, to make the link to the appropriate scientific concepts. The choice of context used in a Science course should therefore depend on the aims of the specific course, and the situation in which it is taught. However, there is a danger that students will spend too much time learning about the context, rather than the concept (Fey et al., 2004; Parchmann et al., 2006). Furthermore, if the structure of the curriculum does not allow students to revisit concepts in different contexts in a structured way, then they may not be able to transfer their understanding of a concept to a new context, nor develop a full understanding of that concept (King, 2012). For example, Barker and Millar (2000) found that students' experiences studying basic thermodynamics in the context of a fuel-oxygen system meant that they formed a strong association between covalent bond formation and energy release, which they found hard to extend to ionic bonding. However, as King (2012) notes, this is also true of traditional concept led courses.

Context led Science courses are typically associated with constructivist ideas surrounding teaching and learning, specifically, the need to draw on students' prior knowledge and understanding to allow them to engage actively in constructing meaning, so that learning can take place. The use of everyday contexts may help students to relate what they are learning to their everyday experiences. However, not all students are likely to be equally familiar with all contexts, and in the case of industrial contexts, very few students may have any direct experience of the contexts used. Furthermore, as noted by Peşman and Özdemir (2012), it is possible to use traditional transmission based pedagogies in a context led course, and student-centred pedagogies in a concept led course. However, since the supporting materials for many context led courses use a student-centred, active learning pedagogy, teachers who choose to use a context led course may need to learn new pedagogical skills, as well as developing their knowledge of the contexts to be taught in the course. This may make the introduction of context led courses particularly demanding for teachers (Lewis & Scott, 2006). As a result, the successful implementation of context led Science courses is dependent on the attitudes of the teachers and the support which they are given. Enabling teachers to contribute to the development of materials may help to develop their sense of ownership of the projects, and contribute to the success of the context led approaches (Fey et al., 2004).

The perceived overloading of Science curricula was one motivation for the introduction of context led courses. However, it could be argued that adding context exacerbates this problem, by adding additional material to be taught, potentially at the expense of conceptual understanding. Gilbert (2006) proposes that the conceptual content should be reduced to make space for contexts. However, this is not always possible, particularly when the conceptual content to be taught is regulated. Bennett et al. (2005) found that teachers who taught concept led courses had concerns about conceptual development in context led courses. In general, little research suggests that students who follow a context led course are disadvantaged in terms of conceptual knowledge development (Braund et al., 2013; King, 2012). However, there are considerable challenges in comparing concept and context led courses. Firstly, it is not clear how concept knowledge should be assessed in a way that allows a direct comparison, because students from each group are used to answering questions framed in a different way: a context led student would presumably find it easier to answer a question framed in a context than a concept led student, and vice versa.

Implications for A level reform

Pilot and Bulte (2006) argue that the integration of the Salters courses with national, large scale assessments (e.g., A levels) was critical to its success. However, this creates a tension in those contexts where national assessments are heavily regulated, because it is necessary to design assessments which conform to regulatory requirements, while recognising that concept and context led courses need different assessment approaches. In England and Wales, reformed Science A levels will be first taught from 2015. Currently two exam boards offer context led Science A levels: OCR offers Salters Chemistry, and Advancing Physics (Ogborn, 2003), while Pearson-Edexcel offers Salters-Nuffield Biology and Salters-Horners Physics. Advancing Physics was originally developed with the Institute of Physics, although their financial interest in the course has now ended. Currently OCR offers different assessments for traditional A level courses and context led courses, whereas Pearson-Edexcel does not. When the reformed A levels are introduced, OCR will offer a full suite of context led A levels (Advancing Biology, Advancing Physics and Salters Chemistry), while Pearson-Edexcel will continue to offer context led A levels in Biology and Physics. Of these A levels, only the reformed Pearson-Edexcel Salters-Horners Physics course will use an assessment shared with a traditional concept led course.

An important feature of the Salters context led A levels is the individual experimental investigation. Teachers report that they consider the investigation to be educationally beneficial, though very difficult to manage, in terms of workload for themselves and their students (Bennett et al., 2005). The reformed A levels will share a framework for practical assessment: throughout their course, students will be required to conduct practical activities from twelve different areas. Although the framework is shared, within this model there is considerable scope for teachers to choose practical activities which match the type of course which they are teaching. For example, the context led OCR specification for Advancing Biology allows teachers to choose practical activities for each of the 12 areas (OCR, 2014). The inclusion of research skills as one of the 12 areas enables students to research appropriate contexts, and link these to the laboratory work which they undertake, allowing students to develop independent study skills throughout the course. This may reduce concerns which teachers have expressed about workload when teaching context led specifications, because high-stakes practical work will no longer be concentrated in one part of the course, potentially increasing uptake of the context led courses. However, this aspect of the reform will also reduce the distinctive nature of the context led A level courses, and reduce the scope for future innovation.

The choice of contexts used in a context led Science course is crucial to its success. It can be challenging to introduce contexts when the conceptual content is highly specified, as is the case for the reformed A levels, because there is a risk that the curriculum can become overloaded. However, the reform process provides an opportunity to reflect on the contexts used in a course, to ensure that the most appropriate contexts are used. For example, the new context led OCR A level in Biology (Advancing Biology) uses contexts which were selected using a variety of methods. Firstly, contexts which had been used in earlier context led courses were re-evaluated and updated, based on the experiences of teachers and developers. This is similar to the process used in the *Im Kontext* courses in Germany, where teachers were involved in the development and evaluation of context led materials. Secondly, as discussed above, there is a strong link between certain pedagogical approaches and context led teaching, and so course developers were also involved in the development of support materials for teachers. Both of these approaches help to ensure that the contexts which are chosen clearly highlight important biological concepts in a way which is clear to students and teachers. Additionally, the need to conform to content standards specified by the Department for Education led to particular emphasis being given to certain contexts and topics (e.g., natural selection), to ensure that the required conceptual content would be studied in sufficient depth. Finally, for those areas of the course which were new (e.g., Plant Biology), additional consideration was given to ensuring that contexts (such as food security) which are of particular contemporary importance were included, to help students to link their developing biological knowledge with issues which they may have encountered in the media. The assessment was developed to reflect these aims. For example, as part of the assessment, students will read a scientific article exploring a particular context, which will then be used as the basis for examination questions. When the course has been taught for the first time, further evaluation of the contexts chosen will be undertaken, based on the experiences of teachers.

Conclusions

The context led courses described in this article were developed either as a result of a top-down drive for reform (South Africa, Germany), or evolved in educational situations which allowed for diversity in the approach taken to Science teaching and learning (USA, England). Indeed, the German *Im Kontext* projects could be considered to be both, in that they were instigated at the national level, but developed to allow for diversity in different educational situations within different Bundesländer. When the Salters project began in England in the early 1980s, the regulatory frameworks in place allowed substantial diversity in assessment, so it was possible to develop Science courses which combined innovative approaches to teaching and assessment. Since then, however, increased regulation has led to much greater uniformity across qualifications. For the reformed Science A levels, the assessment requirements have been highly constrained, with common weightings for the Mathematics (with variation across Science subjects), and a shared approach to practical assessment across awarding bodies. While this increased uniformity may lead to increased comparability across qualifications, it reduces the potential for important innovations such as the Salters project in the future.

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