# From novel approach to mainstream policy? The impact of context-based approaches on chemistry teaching

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**ABSTRACT**
This paper reports part of a study of the ways in which students' everyday experiences are used in pre-university chemistry curricula in a centralised and a decentralised education system, in South Africa and England, respectively. The changing role of contextualisation over the last 15 years is explored, in the ideal, formal and perceived curriculum. Analysis of curriculum documents including examination papers and textbooks suggest that recent curricula make use of everyday contexts, as illustrations of chemical concepts, and less frequently as justifications for studying these concepts, or for application and synthesis of chemical knowledge. Discontinuities in the use of everyday experiences occur between ideal and formal curricula, or between the formal curriculum and textbooks in decentralised and centralised systems respectively. Meaningful contextualised assessment is problematic in a variety of curricula.

**KEY WORDS:** chemistry; curriculum; high school; everyday contexts; science-technology-society

## Introduction

The intense debate on the contribution of chemistry teaching to scientific literacy has put the use of students' everyday experiences in the spotlight. The fashion seems to prescribe the use of out-of-school situations in the chemistry curriculum, but to what extent is this only rhetoric, and to what extent is it new? This paper sets out to describe the changing profile of context-based approaches to chemistry teaching over the last 15 years. It focuses on ways in which the chemistry-society link is represented in curriculum documents. The findings can then inform the realistic use of everyday experiences in the implemented curriculum - the activities in chemistry classrooms.

## Approaches to curriculum development

Kelly (2004) identifies two different models of curriculum development. In a centralised education system, the centre-periphery model normally entrusts the development of the curriculum to a Curriculum Centre, sometimes part of a national Government Department or Ministry of Education, which generates curriculum documentation, and the supporting learning and teaching materials. In-service courses are provided in order to familiarise teachers with the new curriculum and its resources. More recently, even in centralised systems, teacher participation has increased through selective contributions to subject panels developing curriculum documentation, and through teacher participation in writing teams constructing classroom resources. In contrast, in a decentralised system the curriculum ownership has been shifted towards the teacher. The education administration outlines a brief curriculum framework, and teachers develop their own detailed learning outcomes, teaching programme and classroom resources adapted to their specific students.

Van den Akker (1998) differentiates between six, progressively more concrete, formats of the science curriculum as follows:

— the *ideal* curriculum describes the underlying socio-political vision of the curriculum including its general purpose;
— the *formal* curriculum provides science curriculum documentation translating the vision into learning objectives/outcomes and some recommended teaching strategies;
— the *perceived* curriculum describes the curriculum as seen by its users, especially textbook writers and teachers;
— the *operational* curriculum describes the instructional activities in the classroom;
— the *experienced* curriculum describes the ways the students experience classroom activities;
— the *attained* curriculum summarises the actual learning outcomes as attained by the students.

Frequently the first three curriculum formats are clustered together as the intended curriculum, and the last three formats as the implemented curriculum (Rogan and Grayson, 2003). Bulte et al. (2006) claim that the success of a curriculum innovation depends on the match between all six curriculum formats, i.e. a high fidelity (Hurd, 1987) between the attained and ideal curriculum.

## Using everyday contexts in science teaching

The justifications for including everyday experiences in science teaching may be grouped in three categories. Firstly, reasons for such contextualisation may relate to the perceived

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purpose of the curriculum, e.g. providing social or cultural relevance (Nganunu, 1988) including a recent emphasis on catering for Indigenous Knowledge Systems (IKS) (Snively & Corsiglia, 2000), or providing equitable access to science education for specific (disadvantaged) groups of learners such as rural learners (Peacock, 1995), cultural minorities (Campbell et al., 2000) or girls (Ramsden, 1992). Pre-vocational awareness may be considered a purpose of the science curriculum for which everyday contexts may contribute to responsible decisions on career choices. Educational contexts also feature prominently in resources aimed at developing scientific literacy (Millar, 2006).

Secondly contextualisation may be justified by perceptions of learning. For instance, explicit use of everyday situations from which relevant science concepts are identified (Campbell et al., 1994), provides the motivation for studying these new science concepts, increases students' ownership of their learning (Lubben et al., 1996), and facilitates crossing the borders between the everyday, school and science domains (Costa, 1995) encouraged by socio-constructivism.

The last category justifies the use of everyday contexts because of its effect on achievement. In a systematic review of the effect of context-based science courses, Bennett et al. (2006) conclude that, on balance, there is no difference in conceptual understanding between students taught through context-based teaching strategies and through traditional strategies. However, those following a context-based course have a more positive attitude to their science learning.

Kasanda et al. (2005) identify three ways in which everyday contexts may be integrated in science curricula:

— *context-infused curricula* - science courses that refer to issues in society, often presented as examples or applications of the science concepts;
— *context-focused curricula* – courses about science-based issues in society. Some scientific literacy courses fall within this category;
— *context-based curricula* – science courses taught through issues from society. The issues are presented at the beginning of a topic to identify the science concepts to be studied.

Duranti and Goodwin (1992) describe a context for learning as "a focal event in its cultural setting" (p. 960), and define four attributes. The setting provides a social, spatial and temporal definition for mental encounters with the focal event(s), i.e. the everyday situation. Each context requires a behavioural environment framing the instructional task for the engagement with the focal event, and the development of specific language associated with the focal event. Relevant background knowledge of science and of the event needs to be provided.

Gilbert (2006) uses these four attributes of a context for learning to describe four models of context-based chemistry courses as follows:

*Model 1: Context as the direct application of concepts*
This involves a one directional and rigid relationship concepts-then-application: "Applications are tagged on as an afterthought" (p. 971). In this model none of the four attributes are developed: usually no setting for the application and no behavioural environment (in terms of a contextual task) is provided.

*Model 2: Context as reciprocity between concepts and applications*. This involves a phased introduction of concepts on a need-to-know basis. Although the task (behavioural environment) may be relevant, and the required background knowledge adequately provided through reading or video materials, the context setting may not be appropriate as students may not see the need to develop chemistry knowledge for the given everyday situation.

*Model 3: Context provided by personal mental activity*
This strategy is often used (but not only) in informal chemical education, such as in fieldwork or extended individual projects. Almost all attributes are well developed. Setting and behavioural environment are well defined, before the development of chemical language, and drawing on background knowledge. Learners may not automatically engage with the setting if this is prescribed by the teacher.

*Model 4: Context as social circumstances*
Based on a genuine, sustained enquiry into a topic important in the lives of the community. The context provides a clear setting for community of practice behaviour, and learning comes from action, with the context shaping the meaning of the content, and vice versa.

In this paper we are interested in the changes in the use of context-based approaches over time. We intend to identify how these approaches are reflected in three curriculum manifestations: the ideal, the formal and the perceived curriculum. Thus, the study is led by the following research questions:

1. To what extent and in what ways does the context-based approach get incorporated in the ideal, the formal and the perceived curriculum for pre-university chemistry teaching?
2. How does the role of the context-based teaching approach change over the last 15 years?
3. How does this role differ for in a centralised and a decentralised education system?

## Methods

The data for this study derive from key documents defining the pre-university chemistry curriculum in South Africa and England over the period 1993 to 2008. The South African documents include general curriculum statements, chemistry curriculum specifications, exemplar examination papers and relevant textbooks for the subject Physical Sciences in the FET phase, i.e. Grades 10-12. Equivalent documents for the English chemistry curriculum define two pre-university GCE Chemistry courses offered by the Edexcel examination board (the 'traditional' Edexcel course and the Nuffield course) and two courses by the OCR examination board (a traditional OCR course and the Salters Advanced Chemistry course).

The Nuffield and the Salters courses are both named after their sponsors, The Nuffield Foundation and the Salters Institute of Industrial Chemistry. The Nuffield course has evolved over a period of some forty years, initially being characterised by a particularly strong emphasis on discovery learning. Salters Advanced Chemistry was developed in the early 1990s. Since its inception, it has been characterised by its wholly context-based approach to the teaching of chemistry, developing understanding of chemical ideas and concepts from a number of storylines, such as Elements of Life, Aspects of Agriculture, and Medicines by Design. The development of the course, its aims and its underpinning philosophy are described in more detail in Campbell et al. (1994) and, more recently, in Bennett et al. (2005).

The document analysis used grounded theory methods (Strauss & Corbin, 1998) in search for instances of linking everyday experiences with the school chemistry and the nature of these links, in particular the extent to which the documents promote context-based teaching strategies. Common themes and tensions (Gall et al., 2007) were identified within and between documents describing different formats of the same curriculum, and changes over time between sets of documents describing subsequent curricula. The nature of context-based teaching approaches reflected in the documents (if at all) were mapped on to Gilbert's (2006) four models of contextualised chemistry courses.

## Findings: Context-based teaching in England

### The curriculum environment

The school curriculum in England had, for many years, mainly decentralised characteristics. There was some move away from this when a National Curriculum was introduced in the late 1980s, setting out a coherent curriculum framework for the compulsory schooling of children from ages 5-16. Core content was also specified for the two-year pre-university (Advanced) level courses leading to the General Certificate in Education (GCE). A number of modifications have been made in the intervening years. Currently, two-year pre-university courses (which form the focus of this paper) have a self-standing Advanced Subsidiary (AS) GCE outline, and a second year leading to Advanced GCE certification. Schools in England select their curriculum from several subject specifications offered by three commercially competing examination boards, i.e. AQA, Edexcel and OCR. These Boards develop and manage the curriculum assessment for each of their courses.

Though successive moves over the last twenty years can, in some ways, be seen as a move towards more centralised control, there still remains a considerable degree of freedom in curriculum design. Core content has to be covered, and a Government body, the Qualifications and Curriculum Authority (QCA), has to approve all courses. However, there can be differences between courses in some of the content and in the teaching approaches. Two major curriculum changes in the last 15 years, Curriculum 2000 (C2000) and Curriculum 2008 (C2008), have seen an increased emphasis on a more modular approach to teaching, and particular curriculum content now being specified in each year of teaching.

At pre-university level, six chemistry courses exist. For this paper we focus on chemistry teaching at pre-university level, in particular on the curricula offered by Edexcel (a traditional version and the Nuffield curriculum), and by OCR (a traditional version and Salters Advanced Chemistry).

### The curriculum 2000 (until 2008)

#### *The ideal curriculum 2000*

One out of six aims of the ideal curriculum (QCA, 2005a) deals with the chemistry-society link where it encourages students 'to appreciate the contribution of chemistry to society and the responsible use of scientific knowledge and evidence' (p. 3). This aim appears again in two of the four assessment objectives, where students need to apply chemical principles and concepts to unfamiliar situations, including those related to responsible use of chemistry in society' (p.4). Thus, the ideal curriculum potentially supports Model 1 contextualised chemistry courses.

#### *The formal curriculum 2000*

The specifications for both chemistry courses offered by the Edexcel Board, the traditional (Edexcel, 2002a) and the Nuffield course (Edexcel, 2002b), include one aim fostering the 'social, economic, environmental and technical applications of chemistry, and the recognition of the value of chemistry for society and how it may be used responsibly'(Edexcel 2002a, p. 3).

For both courses, everyday contexts may particularly be included under five issues in two broad assessment objectives
— Spiritual, moral and cultural aspects
— environmental and health education (Edexcel, 2002a, p. 15).

For the traditional Edexcel course, examples of everyday contexts in assessment objectives are sporadic, and focus on 'knowing that', e.g. "recall that transition elements and their compounds are important catalysts in industrial processes" (Edexcel, 2002a, p. 36). Such minimal use of contexts as illustrations of chemical concepts shows that the traditional course reflects a weak version of a Model 1 contextualised chemistry course.

Instead, The Nuffield Edexcel course incorporates Special Studies (SS) Unit where students relate 'the chemistry they are studying to the real world' (Edexcel, 2002b, p. 3). Merit is given for 'studying the technological aspects of the area, including social and economic issues' (Edexcel, 2002b, p. 42). In addition, an extended investigation may require students 'to identify their own problem for study or be provided with a suitable problem brief' (Edexcel, 2002b, p. 57). In conclusion, the specifications for the Nuffield course exhibit frequent characteristics of a Model 1 course, with some aspects of a Model 2 and Model 3 contextualised chemistry course. However, overall the specification focuses on the teaching

OF applications, not teaching THROUGH applications.

The specifications for both chemistry courses offered by the OCR examination board, a traditional chemistry course (OCR, 2004) and the Salters Advanced Chemistry course (OCR, 2000a), link specific assessed content to the five curriculum issues mentioned above. Many provide opportunities to include everyday experiences. For instance, it states 'cultural issues, driven by society, are often perceived as 'chemical', for example drug dependency or pollution' (OCR, 2004, p. 13).

In the traditional OCR chemistry course, the objectives for each topic are described as a list of chemical concepts culminating in a societal application. For instance, after listing the required understandings on hydrogen carbon fuels (OCR, 2004, p. 46), students have to 'outline the value to society of fossil fuels in relation to the needs for energy and raw materials, and the need to develop renewable fuels, for example biofuels'. Overall, the traditional course resembles a Model 1 contextualised course, since everyday contexts are used as illustrations of the relevant chemical concepts.

In contrast, in the Salters course (OCR, 2000a) 'chemical principles are developed in the context of applications of chemistry' (p. iv). For instance, a detailed consideration of the industrial extraction of two elements (bromine and copper) forms the introduction to major classes of chemical reactions: acid-base, redox and precipitation. The Salters assessment format includes an individual extended investigation for which the topic may be determined by the student's own interests, and an open-book assessment requiring them 'to research given articles on as topic of current chemical interest' (p. 16). Overall, the specifications for the Salters chemistry course reflect a consistent Model 2 and Model 3 contextualised course.

### *The perceived curriculum 2000*

The Specimen papers for the traditional Edexcel course (Edexcel, 2000a) contain an occasional reference to everyday experiences, whereas this occurs often in the papers for the Nuffield course (Edexel, 2000b). The role of the contexts in the assessment also differs. In the traditional course a context is a mere description without any implications for answering the subsequent questions, whereas in the Nuffield papers responses require the interpretation of the context in chemical terms. Table 1 compares two contextualised items from specimen examination papers.

Whereas the assessment of the traditional course does not reflect any model of a contextualised course, the Nuffield course assessment exhibits several aspects of a Model 1 and Model 2 course, and potentially of a Model 3 course, i.e. depending on the extended investigation topic.

The Specimen Paper for the traditional OCR chemistry course (OCR, 2000b) shows several contextualised items in each of the six modular tests, with the Unifying Concepts in Chemistry and the optional Environmental Chemistry almost entirely contextualised. Although several context descriptions are not used in answering the questions, a few contexts are meaningful. Overall, the assessment for the traditional OCR chemistry specification suggests a weak Model 1 contextualised course.

In contrast, all questions in the Salters Chemistry papers (e.g. OCR, 2003) are contextualised, and the responses depend on the chemical interpretation of the information in the contextualised stems. Students are asked to compare insecticides Malathion and Parathion on the basis of ester hydrolysation, and comment on testing methods for their effectiveness and safety for mammals. Together with the open-book assessment, and the individual extended investigation, the assessment of the Salters course reflects a consistent Model 2 contextualised course, with opportunities for Model 3 approaches.

The approved textbook (Facer, 2005) for the Edexcel traditional chemistry course contains exceptionally few references to everyday experiences. For each of the 15 chapters the book includes a one-page spread with products from one element each, but these have no relationship to the chemistry dealt with in the respective chapters. In summary, the resource seems to support a non-contextualised course, or a Model 0 course in terms of Gilbert's (2006) scheme. In con-

**Table 1. Comparable contextualised items from two Edexcel specimen papers**

| **From traditional chemistry course:** | **From Nuffield chemistry course:** |
|---|---|
| When chlorine gas is used as a disinfectant in swimming pools it is possible to add too much. One technique to remove the excess chlorine is to add an aqueous solution of sodium thiosulphate, which reacts with the chlorine to produce sulphate ions, chlorine ions, and hydrogen ions. [chemical formulae provided].<br>(i) Give the change in oxidation number of sulphur and chlorine in this reaction.<br>(ii) Hence write a balanced ionic equation for the reaction between chlorine and sodium thiosulphate. | Water companies use chlorine to purify water for domestic use. Concentrations of chlorine are carefully monitored by testing water samples. Excess potassium iodide was added to a 1000 $cm^3$ sample of water. The iodine formed reacted with 14.0 $cm^3$ of 0.00100 M sodium thiosulphate solution.<br>(i) Calculate the number of moles of sodium thiosulphate used in the reaction [formulae given]<br>(ii) The ionic equation for the reaction between iodine and sodium thiosulphate is { } Calculate the number of iodine molecules, $I_2$, used in the reaction.<br>(iii) The maximum accepted concentration of chlorine in drinking water is 0.5 parts per million by mass. Show by calculation of the amount of chlorine in 1 000 000 g of water that the sample of water tested above is acceptable.<br>(iv) Suggest TWO reasons why the concentration of chlorine in water must not exceed 0.5 ppm. |

trast, the student book for the Edexcel Nuffield specification (Nuffield, 2000) provides frequent brief illustrative practical applications of chemical principles and some application signposts at the beginning of each topic. For instance, the chapter on *Hydrocarbons* starts with a picture of a drill platform with the caption 'Crude oil is the source of most of our organic compounds, especially plastics and synthetic fibres' (p. 176). In addition, each chapter is rounded off with a synoptic 'background reading' set in a social context, and with application questions requiring the use of previously learnt concepts. Thus this resource supports a Model 1 contextualised course, with some traces of a Model 2 course in the synoptic readings.

Ratcliff *et al.* (2000) supports the traditional OCR Chemistry specifications. The book does not contain an everyday context at the beginning of chapters, nor synoptic revision tasks at the end. However, a large number of photographs are included of products made from the compounds presented, for instance of PVC window frames, and anti-freeze products when alkenes are discussed (p. 107). Therefore, the book is an example of a resource for a Model 1 contextualised chemistry course. The student resource for the OCR Salters chemistry course consists of three books. The applications of chemistry in the *Chemical Storylines* (Burton et al., 2000) drive each unit, taking 'excursions' to *Chemical Ideas* (which consolidate the chemical concepts) and to *Activities* (which provide experimental activities or other tasks). These resources together reflect a consistent Model 2 contextualised chemistry course.

## The curriculum 2008

### *The ideal curriculum 2008*

As in C2000, the ideal curriculum for C2008 provides little explicit reference to everyday experiences (QCA, 2004), but the issues below (ten instead of five) provide an opportunity for contextualisation:

a) spiritual, moral, ethical, social, legislative, economic and cultural issues;
b) sustainable development, health and safety considerations (p. 51).

One of the aims in the chemistry subject criteria (QCA, 2006) highlights scientific literacy. The document introduces the notion of 'How science works' (p. 4) which mostly relates to the nature of science but includes amongst its 12 aspects also the contextual requirements below:

— consider applications and implications of science and appreciate their associated benefits and risks
— consider ethical issues in the treatment of humans, other organisms and the environment
— appreciate the ways in which society uses science to inform decision making.

The number of assessment objectives has been reduced from four to three, and the science-society link has been phrased in terms of science applications in AO2: *application of knowledge and understanding of science and of How science works*, amplifying that students need to 'apply scientific knowledge and processes to unfamiliar situations including those related to ethical, social, economic, environmental, cultural, political and technological issues' (p. 6). The spirit of the ideal curriculum has not substantially changed from C2000 and seems to consolidate the provisions for a Model 1 contextualised chemistry course.

### *The formal curriculum 2008*

Starting from 2008, the traditional and Nuffield Edexcel chemistry courses have merged (Edexcel, 2007), 'enabling motivating contemporary chemistry contexts to be included in the teaching and learning programme. Students will study aspects that are often in the media and affect their lives. These are *Climate change*; *Green chemistry*; *pharmaceuticals*; and *Chemistry Research*.' (p. 1). The description of each unit under three fixed headings *Chemical ideas, How chemists work and Chemistry in action* underlines the prominence of contexts mostly presented as applications after the exposition of the related chemical concepts. Consistently, the written papers for units 2 and 5 each contain a section with 'questions on contemporary contexts. This may contain stimulus materials on a scenario that students must read in order to answer the questions, which will focus on the underlying chemistry, and not be comprehension questions' (p. 11). Where as the previous aspects of the specification suggest a Model 1 contextualised course, the latter aspect opens opportunities for a Model 2 chemistry course. In this respect, the consolidated course has adopted the former Nuffield rather than the traditional approach.

The specifications for the traditional OCR chemistry course (OCR, 2008a) are 'divided into chemical topics, each containing different key concepts in chemistry. Once the key features of a chemical topic have been developed, applications are considered' (p. 4). Indeed, at the end of a section on Group 2 compounds, the assessment objectives require students to explain the use of calcium hydroxide in agriculture to neutralise acid soils; and the use of magnesium hydroxide in some indigestion tablets as an antacid' (p. 18). Thus, these specifications support a Model 1 contextualised chemistry course. In contrast, the Salters specification (OCR, 2008b) has changed little in terms of the use of everyday context. Inescapably, some of the contextual story lines have been updated (especially on alternative fuels), and thus contemporary content has been included. The specification continues to reflect a consistent Model 2 contextualised chemistry course, with the individual investigation providing opportunities for Model 3 aspects.

### *The perceived curriculum 2008*

The specimen paper for the new combined Edexcel chemistry specifications is unavailable during the time of writing this piece.

Very few references to everyday contexts are made within the specimen paper for the OCR traditional chemistry specifications (e.g. OCR, 2008c), and those contexts that do appear function as a descriptor of the use of the chemical under discussion but are not required for answering the question. This type of assessment suggests a weak Model 1 contextualised chemistry course. In contrast, the assessment for the OCR Salters specification is very similar to the format used previously, so continues to represent a consistent Model 2 contextualised chemistry course, with possibilities for Model 3 aspects.

The newly developed student book (Edexcel, 2008) to support the Edexcel chemistry course is content laden, with contexts often in the form of photographs as illustrations of the chemistry content presented, for instance a picture of spectacular fireworks as an application of the light emission occurring when magnesium reacts with oxygen. The resource seems to support a weak Model 1 contextualised chemistry course.

Acaster and Ryan (2008) support the traditional OCR Chemistry specifications. After the first five foundation chapters, the book contains frequent everyday contexts as illustrations of chemical concepts discussed. The books ends with a chapter on *Chemistry of the air & Green chemistry*. Therefore, the book is an example of a resource for a Model 1 contextualised chemistry course. For the Salters course, the Chemical Story Lines have been updated, but the teaching approach remains the same: based on the *Chemical Story Lines*. The Salters resources continue to reflect a consistent Model 2 chemistry course.

## Findings: Context-based teaching in South Africa

### The curriculum environment

The management of the South African education system is considerably centralised, but the nature of the centralisation has changed over the last 15 years (Sayed & Jansen, 2001). As an example, the national Department of Education sets curriculum policy, assessment criteria and resource allocation. Until 1995, curriculum implementation was directed by racially based education departments. The most notorious was the Department for Bantu Education for the majority African population. Currently, the system has adopted federal characteristics (Kahn, 1999) with the emerging influence of the provincial education departments on curriculum specifications, examinations, textbook approval and classroom implementation.

The role of chemistry in the South African school system has remained constant. During the first 10 years of schooling, i.e. the General Education and Training (GET) phase from Reception to Grade 9, science is taken by all students as *Natural Sciences*. During the subsequent three years, i.e. the Further Education and Training (FET) phase from Grades 10-12, science is optional as two separate subjects, *Life Sciences and/or Physical Sciences*. The latter includes chemistry and physics. The FET phase is completed with a National Senior Certificate Examination (usually called Matric). It is worth noting that there is no direct correspondence between grade level and pupils' age, which may vary by five years or more in a class of matriculants. This case study focuses on the pre-university chemistry curriculum, i.e. in the FET phase.

Three different curricula were used for Physical Sciences in the FET phase. Until 1995, the apartheid curriculum was in force, during the period 1995-2006 the Interim Curriculum (IC) directed teaching, and since 2006 the National Curriculum Statement (NCS) for Grades 10-12 is used, with the first cohort matriculating at the end of 2008.

### The apartheid curriculum (until 1995)

#### *The ideal apartheid curriculum*

The official apartheid curriculum policy did not recognise students' everyday experiences as it intended to enshrine the philosophy of Christian National Education (DNE, 1992). The school system was seen as a way of inducting young people in a race-based view of the world, confirming the hegemony of whites (i.e. people from European extraction). In the early 1990s conservative free market doctrine (Soudien, 2007) promoted the use of education for labour force production. Although such a labour market orientation could provide the school curriculum with an applied (contextualised) focus, the concern for labour force development expressed itself only through attempts to increase the number of school completers, not to change the package of knowledge, skills and values to be achieved (DNE, 1992).

Several opposition groups experimented with alternative curricula. In South African townships the democratic movement promoted *People's Education*, "an education which liberates and puts people in command of their lives as opposed to one that was designed to control and produce docile, subservient people' (Chrisholm & Fuller, 1996, p. 701). It was rooted in mass participatory democracy at school level, with involvement of parents, teachers and students taking control of schooling, including the curriculum. Since *People's Education* valued students' life experiences, it provides ample opportunities for context-based teaching.

#### *The formal apartheid curriculum*

The formal science curriculum did not differ very much between the various racial education departments – all were "academic, outmoded and overloaded" (ANC Education Department, 1994, p. 87). Naidoo and Lewin (1998) summarised the experiences of the majority black students as "a curriculum which many perceived as largely irrelevant to their needs, difficult to the point of impossible given the learning context" (p. 730). In these circumstances, the use of contexts familiar to the vast majority of students seemed actively being discouraged in the formal curriculum.

#### *The perceived apartheid curriculum*

Examination papers do not draw on everyday applications, but only assess the understanding of the body of chemical knowledge. Similarly, the standard chemistry textbooks of the time (e.g. Brink & Jones, 1984) focus entirely on the content topics listed in the Physical Sciences syllabus. Hardly any everyday contexts are used, and if at all, these contexts are included as an illustration of the chemical process. None of Gilbert's (2006) Models for contextualised chemistry courses could be recognised in the textbooks or the examination papers.

In contrast, materials serving *People's Education* (Dilley and Rollnick, 1991) contain practical tasks explicitly based on "things you have at home, a few you may need to buy from the super market or chemist" (p. 7), thus providing equity to students without access to formal laboratories. Also in other ways the student's experience is drawn on with comic strips featuring black youngsters, and a picture of Desmond Tutu visiting a Hiroshima victim to illustrate the effect of the atomic bomb after an exposition on nuclear fission. Thus, everyday experiences are used to generate interest in the learning of chemistry. Since these contexts mainly serve as interesting illustrations of chemical concepts but are unrelated to tasks, the resource is best classified as representing a consistent Model 1 contextualised chemistry course.

## The Interim Curriculum (1995-2006)

### *The ideal Interim Curriculum*

In the first half of the 1990s very intensive debate took place to inform the negotiations for the Government of National Unity, and to shape education policy after the democratic election in 1994. The National Education Policy Investigation (NEPI) resulted in a set of agreed core values for future education policy, i.e. democracy, equity, non-sexism and non-racism, within a unitary education system (NEPI, 1992). On insistence of the labour movement (a crucial partner in the liberation struggle) the National Qualifications Framework (NQF) was adopted, a unified qualifications system for school education and vocational training. The integration of vocational skills drove the debate towards an adaptation of the Australian experience of outcomes-based education (OBE) (Malcolm, 2001). OBE emphasises what learners are able to do after a course, rather than what teachers need to provide for the course. Support for socio-constructivist theories of learning, i.e. that learners make meaning on the basis of their existing knowledge and experiences, thus foregrounded everyday life as a learning resource. Learner-centred education (LCE) became the rallying cry.

### *The formal Interim Curriculum*

Very little of the ideal curriculum debate precipitated in changes at the pre-university FET level, apart from the principles of one unitary education system and non-discrimination, described as "the 'cleansing' of the curriculum of its racist and sexist elements in the immediate aftermath of the election [in 1994]" (Chisholm, 2005, p. 80). Also, the voice of the scientific literacy movement (Laugksch, 2000) was included in the new preamble stating that "it promotes scientific literacy and enables students to pursue science and technology-related careers" (Naidoo & Lewin, 1998, p. 736).

The emphases on workforce development and scientific literacy open up opportunities for the use of everyday contexts. However, little of either emphasis is reflected in the content specification for knowledge, skills or values to be developed (e.g. KwaZulu-Natal DoE, 1995). The focus is entirely on the academic understanding of the subjects of chemistry. Thus, none of the Models of contextualised courses apply.

### *The perceived Interim Curriculum*

Since the IC curriculum is not essentially different from the pre-1995 curriculum, examination papers (e.g. DoE, 2006a) do not draw on everyday applications. Also, many schools continue to use updated versions of textbooks of the pre-1995 period (including Brink & Jones, 1984). Even more recent texts focus entirely on the chemistry content listed in the Physical Sciences syllabus, although the depicted scientists and young people are now more often black and/or female. For the Interim Curriculum, none of the textbooks or examination papers reflects any of Gilbert's (2006) models for contextualised chemistry courses.

## The NCS Curriculum Physical Sciences (2006 onwards)

### *The ideal NCS Curriculum*

The National Curriculum Statement (NCS) lists nine underpinning 'Principles' three of which are directly relevant to the use of everyday contexts. The principle of *social transformation* intends to ensure "the development of scientifically literate citizens who are responsible and can critically debate scientific issues" (DoE, 2008a, p. 8). The principle of *valuing indigenous knowledge systems* connects directly with the experiences of the majority of learners as it refers to "the body of knowledge embedded in African philosophical thought and social practices" (DoE, 2008a, p. 9). In turn, these principles are incorporated in the educational principle of *outcomes-based education* "which encourages a learner-centred and activity based approach to education" (DoE, 2003, p. 2).

For the overall curriculum seven Critical Outcomes and five Developmental Outcomes are defined, four of these linking science and society. Learners should be able to *use science critically showing responsibility towards the environment and the health of others; recognise that problem solving contexts do not exist in isolation; participate as responsible citizens in the life of local, national and global communities; and be culturally sensitive, across a range of social contexts.*

These curriculum principles and intended outcomes provide considerable potential for the use of everyday contexts. Since they are phrased mainly as applications, this ideal curriculum seems to support a Model 1 contextualised chemistry course.

### *The formal NCS curriculum*

The subject specification for Physical Sciences (DoE, 2008a) states that "all scientific knowledge, including Indigenous

Knowledge Systems (IKS), is used to address challenges facing society." (p. 2) However, it is evident that "the nature of science forms the basis from which learning outcomes have been developed" (DoE, 2003, p.12).

The Physical Sciences curriculum focuses on three central Learning Outcomes (LOs). Firstly, *LO1: scientific enquiry and problem solving skills* deals with practical and critical thinking skills. *LO2: Constructing and applying scientific knowledge* provides the foundational conceptual understanding. Lastly, *LO3: The nature of science and its relationships to technology, society and the environment* incorporates values and attitude development. The latter embodies the four Critical and Developmental Outcomes in the ideal curriculum that allow most obviously for the use of everyday experiences. Attainment for LO3 mostly concerns society related applications of chemistry. Examples of such assessments include evidence that learners can summarise (using scientific principles) the dangers of ultra-violet radiation and the role of sunscreens, or can present arguments on the economic, social and environmental impact of various energy sources. (DoE, 2003, p. 30).

The documents prescribe work schedules (DoE, 2008a, p. 23) including a specific column for contexts mostly as illustrations of chemical concepts. This is indicative of Model 1 contextualised chemistry courses. However, the introduction of the NCS Physical Sciences content specification (DoE, 2006) for the Knowledge Area (KA) Chemical Systems clarifies that that is not the only way of using contexts.

> *Chemical Systems* provides for rich exemplification and application, either before or after theoretical ideas have been introduced. Some educators have been conditioned to believe that first you do the theory and then the applications. That sequence is however negotiable in the way this KA is constructed (p. 32).

This statement opens the possibility of using content-based teaching approaches, especially for the consolidation of chemistry content in *Chemical Systems*. Thus the formal NCS curriculum provides for Model 2 contextualised chemistry courses.

### *The perceived NCS Curriculum*

Almost all of the ten short answer items in the exemplar examination paper for chemistry (DoE, 2008b) are contextualised. Most items ask candidates to engage with the concepts fist and finish with an application sub-question, an indication of a Model 1 contextualised course. However, in two items the candidates themselves have to identify the relevant chemistry concepts from the context provided. For instance, a stem states that: "the chloralkali industry is one of the largest electrochemical technologies in the world. Chorine is produced using three types of electrolytic cells. The simplified diagram below shows a membrane cell". The industrial - thus socio-economic - context is needed for answering the first sub-question: "Give TWO reasons for why the membrane cell is the preferred cell for the preparation of chlorine." This example suggests a Model 2 contextualised chemistry course.

The NCS chemistry textbooks (e.g. Dilley *et al.*, 2005) contain several references to everyday and industrial contexts. Two aspects are notable. Firstly, texts lack any inclusion of indigenous knowledge. Secondly, most of the contexts are provided as illustrations of chemical concepts discussed earlier. For instance the task 'discuss how human intervention in the water cycle could affect life in South Africa over the next hundred years', follows an extensive description of the phenomenon of global warming. Thus, the books support only Model 1 contextualised chemistry courses.

However, some supplementary materials (Creative Commons, 2008) for *Chemical Systems* provide for 3-week structured group tasks to synthesise the environmental and socio-economic need for, impact of, and future of selected chemical industries. These projects result in a scientific report, a poster and a group presentation for the whole class. Such contextualised projects fit within a Model 3 contextualised chemistry course.

## Discussion

### The incorporation of contextualisation in chemistry curricula

The Models of contextualisation for the different pre-university chemistry curriculum in South Africa and England, based on the Gilbert categorisation, are summarised in table 2.

Table 2 indicates that chemistry curricula in these countries rarely adopt Model 3, and only sporadically adopt Model 2. The popularity of a Model 1 contextualised chemistry course may be explained by the fact that this Model allows for the continued hegemony of the structure of chemical knowledge (Van Berkel *et al.*, 2000) which also provides the format for a non-contextualised curriculum. A traditional curriculum specification in the form of a collection of topics conflicts with a context-based teaching approach. The latter requires clusters of across-topic concepts including concepts traditionally not considered belonging to the core content (George & Lubben, 2002).

Table 2 also suggests that the models of contextualisation are reasonably consistent across the different dimensions of the curriculum. This continuity suggests success in the contextualised aspect of the respective curriculum innovations (Bulte *et al.*, 2006), that is, for the intended curriculum. If discontinuity occurs it is between the ideal curriculum and the formal curriculum. This discontinuity may be explained by a methodological problem: descriptions of ideal curricula are, by definition, specific on ideas but unspecific on actions. Gilbert's (2006) four Models of contextualisation may therefore be less appropriate for classifying ideal curricula than perceived, operational or experienced curricula. Alternatively, the discontinuity between ideal and formal curricula may be due to the fact that the ideal curriculum naturally functions as a 'common denominator', a framework within which variation will be expressed in formal and perceived curricula.

**Table 2.** Models of contextualisation in pre-university chemistry curricula in **England** and **South Africa.**

| Time period | Curriculum description | Curriculum dimension | | | |
|---|---|---|---|---|---|
| | | Ideal curriculum | Formal curriculum | Perceived curriculum | |
| | | | | assessment | textbooks |
| | | England | | | |
| 2000-2008 | C2000 Edexcel traditional | 1 | weak 1 | 0 | 0 |
| | C2000 Edexcel Nuffield | - as above - | strong 1 +some 2 + 3 | 1+2 | strong 1, some 2 |
| | C2000 OCR traditional | - as above - | 1 | weak 1 | 1 |
| | C2000 OCR Salters | - as above - | strong 2 with 3 | strong 2 with 3 | strong 2 with 3 |
| 2008 onwards | C2008 Edexcel combined | 1 | strong 1 + some 2 | unavailable | weak 1 |
| | C2008 OCR traditional | - as above - | strong 1 | weak 1 | 1 |
| | C2008 OCR Salters | - as above - | strong 2 with 3 | strong 2 with 3 | strong 2 with 3 |
| | | South Africa | | | |
| Until 1995 | Apartheid curriculum (People's education) | 0 (strong 1) | 0 — | 0 — | 0 (strong 1) |
| 1995- 2006 | Interim curriculum (IC) | 0 | 0 | 0 | mainly 0, some weak 1 |
| 2006 onwards | National Curriculum Statement (NCS) | 1 | 1 +hint 2 | 1 + 2 | strong 1 supplement 3 |

### *The changing role of contextualisation over time*

Looking at changes over time, table 2 suggests for both case studies that non-contextualised chemistry curricula have disappeared recently. This demise appears in tandem with the increased prominence of scientific literacy, sustainable development and understanding of economic, cultural and ethical implications of science (in addition to understanding of the well-established social and environmental implications) as purposes of chemistry teaching.

The findings also suggests that with the disappearance of the Nuffield course in England, the share held by specifically context-based teaching approaches (essentially Model 2 courses) has decreased, particularly in the perceived curriculum dimension. In South Africa, curriculum contextualisation was part of the anti-apartheid ideal and perceived curriculum of *People's Education* in the early 1990s but, at pre-university level, this contextualisation was lost in the post-apartheid interim curriculum.

### *The role of contextualisation in different education systems*

In a centralised education system, curriculum variation, including different models of contextualisation, will only emerge within the perceived curriculum, particularly in textbooks. In contrast, in decentralised systems, curriculum variation will already occur at the level of the formal curriculum, for instance, compare the traditional and the Salters courses. In both cases such variation is controlled by commercial agendas, of publishers in centralised, and of examination boards in decentralised systems. Also, professional control is exercised by different quangos: the curriculum quality assurance organisation (the QCA in England) in decentralised systems, and the textbook approval committee in centralised systems. In a study on the process of textbook development in South Africa, Stoffels (2007) concludes that the textbook on the shelf "certainly is not the intellectual representation of the content and pedagogical content knowledge of the authors whose names adorn the covers of these books" (p. 11). Instead, the defining factor is the textbook evaluation process by the provincial Textbook Committees: "It's writing for the List" (p. 12).

In decentralised systems a similar converging movement occurs when professional control gets more intense. Reporting on standards of chemistry curricula in C2000, the QCA (2005b) itself notes a reduction in variety and opportunities for contextualisation. They conclude that "the adherence to national criteria and the further detailing of the syllabi reduced the flexibility of teachers to develop innovative approaches or engage students in those aspects of chemistry that may from time to time occur in topical news items" (p. 13).

In line with the current findings, Green and Naidoo (2006) found that the curriculum discourses in the NCS Physical Sciences curriculum represent a wide range of ideologies, for instance aiming for increasing knowledge versus changing behaviour, or seeing knowledge as academic versus utilitarian. They concluded that the NCS is open and multi-interpretable. However, their suggestion that the curriculum implementation will depend on what teachers chose to emphasise is only applicable in decentralised systems. In the centralised South African system, teachers' choices are mediated by textbooks, which have only very slight differences between them.

Part of the explanation of the discrepancy between the use of everyday contexts in the formal and the perceived NCS curriculum in South Africa lies in the ambiguous, sometimes contradictory, representations of Indigenous Knowledge Systems in the formal curriculum (Gundry & Cameron, 2008), with a subsequent absence in the exam papers and textbooks. Specific curriculum development is required, drawing on the work by Ogunniyi (2004), culminating in tested classroom materials involving everyday situations and conveying a practical and consistent interpretation of IKS in chemistry.

The frequent discontinuity in Models of contextualisation between the formal and the perceived curriculum, especially the examination papers, suggests that training is required of teachers, teacher advisors and examiners on how to construct meaningful contextual assessment items, where the candidate needs to identify underlying chemistry principles and concepts and engage with the implications of these within the given context.

The findings of this study documenting the Models of contextualisation in the intended curricula in South Africa and England will be used as base line data for a study of the ways these curricula are implemented in the classroom. Relevantly, Rogan and Grayson (2003) identify four levels for the *Science in Society* dimension of curriculum implementation, roughly parallel to Gilbert's (2006) Models of contextualised chemistry courses. However, one should be cautious about expecting achievement at the higher levels in the implementation, if the intended curriculum mainly supports the first two levels of contextualisation within Rogan and Grayson's (2003) classification.

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