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Preface

PATT is the acronym that has now been used for over 30 years to indicate a series of conferences and sessions at ITEEA Annual Conferences in which researchers in technology education from different countries present and discuss research studies in their field. At the 75th Annual ITEEA Conference, held in Columbus, OH, March 7-9, 2013, PATT sessions were held and in these Proceedings the written papers have been collected and edited. Those who were there will remember the stimulating experience we had when listening to each other’s presentations and having excellent discussions. For those who were not there, these Proceedings offer the opportunity to get to know the interesting work that was presented and discussed.

I want to thank all presenters/authors for their cooperation. Also I want to thank ITEEA’s executive Director (at the time), Dr. Kendall Starkweather, who initiated the concept of PATT sessions at ITEEA Annual Conferences and has been a warm supporter for those ever since. He has been extremely valuable for the connection between ITEEA and PATT and for that he is to be acknowledged by all who gained from this fruitful cooperation. This was the last time that he was ITEEA’s executive director. During the 2013 Annual Conference, Steve Barbato, his successor, expressed an interest in continuing the cooperation. I look forward to working with him from now on. Also I want to thank Susan Perry, who has always taken such well care of the organizational aspect of the PATT sessions. Without people like these, the PATT sessions would not have been possible.

I look forward to continuing the series in Orlando, FL, March 27-29, 2014.

Delft, August 2013

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Student Teachers’ perceptions of ‘enduring ideas’ in design & technology

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Abstract
This paper considers the so called ‘weak epistemological roots’ of the school subject design & technology by a) engaging student teachers with identifying enduring ideas that might underpin the nature of the subject in schools, b) comparing these ideas with those produced by an expert group and c) suggesting ways in which those responsible for initial teacher education might approach the task of developing an orthodoxy with regard to the epistemology of the school subject design & technology.

Introduction
This paper builds on a previous PATT conference paper by P John Williams and John Lockley (2012) in which the authors explored the views of early career science and technology teachers as to what might be considered ‘enduring ideas’ within the subjects they taught. Interestingly this research revealed that whilst the science teachers had little difficulty in identifying such ideas this was not the case for the technology teachers. The authors noted that this may be in part due to the extensive place of procedural knowledge in technology but also that technology has no commonly agreed upon epistemology. Recently in England an Expert Panel commissioned by the government to make recommendations with regard to a revised National Curriculum commented on the ‘weak epistemological roots’ of the school subject design & technology. Against this background the authors decided to engage some student design & technology teachers with identifying enduring ideas in the subject they would be teaching. Firstly the student teachers were given a brief introduction to the work of Williams and Lockley and the views of the expert panel. Second the student teachers were shown an enduring ideas map for school chemistry as an example of the sort of map that can be developed. Thirdly the student teachers were given a starter map for design & technology which contained the following five elements: materials, manufacturing processes, designing, making things work and critiquing. The student teachers were allowed to discuss these starting points in groups and then in pairs they produced a map of enduring ideas related to each of these starting points. The content of these maps will be analysed in terms of: a) the nature of the ideas that they considered enduring b) consistency/variation across student teachers’ perceptions, and c) comparison with a map produced by a group of school design & technology experts. This analysis will be used to suggest ways in which student design & technology teachers’ knowledge and understanding of the epistemology of design & technology can be enhanced.
Engaging trainee teachers with the task

A group of 32 student teachers at the beginning of a one year post graduate teacher training course in design & technology were introduced to the problem facing their subject as identified by an Expert Panel set up the minister of education Michael Gove to redefine the National Curriculum in England (DfE 2011). The Expert Panel recommended that design & technology should be reclassified as part of the Basic Curriculum on the grounds that, although important in balanced educational provision it did not have sufficient disciplinary coherence to be stated as a discrete and separate National Curriculum subject arguing that design & technology had weaker epistemological roots than those categorised as core or foundation subjects.

To indicate that some subjects had little difficulty in developing a map of enduring ideas the authors presented a map of school chemistry. The presentation began with four key features and then proceeded to add various details until the completed map was developed as shown in Figure 1.

Figure 1 A map of the enduring ideas in the school subject chemistry

One of the authors is an experienced chemistry teacher and he was able to guide the trainees through the map and help them relate it to their own experiences of being taught chemistry. Then the trainees were set the challenge of developing a similar map for the school subject design & technology. The starting point for their map is shown in Figure 2.
The students were able to discuss the task in small groups and then to work in pairs to develop their map of the school subject. The students responded to the task enthusiastically but indicated that they found it difficult. Several groups found themselves discussing why the subject was important as opposed to what the subject taught.

Preliminary analysis of trainee responses

Each map was inspected for key ideas associated with each of the five starting points for the map: materials, manufacturing processes, designing, making things work, and critiquing.

Concerning materials
Of the 16 responses eight mentioned environmental and sustainability considerations. Only six mentioned properties and only half of these mentioned the relationship between property and use. Only one mentioned finite resource depletion.

Concerning manufacturing processes
There was wide variation in response here including general skill acquisition under tool use, understanding industrial process and appreciating environmental impact of manufacturing. Several mentioned CADCAM and one trainee mentioned the relationship between tool choice and material to be worked.

Concerning designing
Responses here varied from a listing of specific design strategies, more general approaches e.g. developing ideas, the requirement to be realistic, meeting user needs and considering consumers.
Concerning making things work
The majority of students interpreted this as applying to an overall designing and making process i.e. how to be effective in solving emergent problems as opposed to defining enduring or significant ideas concerned with providing functionality into artefacts and systems.

Concerning critiquing
Half the students saw this as dealing with pupils reflecting on their own performance in the subject. The other half saw this as dealing with environmental issues.

One other comment
Interestingly several students added to their maps the phrase “You make what you learn”. A brief discussion with the group indicated that most of them had some sympathy with this rather enigmatic statement and that they saw the product of pupils’ designing and making embodying their learning although they did not have a shared view as to what that learning might be.

Overall we can see that across the students there is little uniformity concerning enduring ideas and that there is considerable difference between their individual perceptions of the nature of the subject which does add weight to the Expert Panel’s view concerning design & technology’s lack of disciplinary coherence.

The map developed by an expert group
The E4E (Engineering for Education) group within the Royal Academy of Engineering has spent some considerable effort in developing a re-conceptualisation of the school subject design & technology. The key proposals are to be launched on 7 March 2013 and the accompanying documentation will be available online soon after. The proposals take the position that design & technology has its own fundamental body of knowledge, principles and concepts which are not provided elsewhere in the curriculum.

The E4E model sets out an overarching set of concepts and principles that can be applied to any aspect of design & technology regardless of the medium in which the pupils are working. Using key concepts and principles, the approach has been devised to create a shift in emphasis from teaching separate sub-disciplines to a more coherent curriculum for design & technology. In keeping with the practical nature of D&T, E4E have called this approach the Design & Technology Tool Box, shown in Figure 3. This Toolbox is split into four groups: Design, Technology, Critique and Data. The E4E Design & Technology Tool Box is not that different from the mapping starting point given to the students. The major difference is the omission of data from the mapping starting point.
A more detailed view of the toolbox is presented in Figure 4. Here we can see a range of categories for each of the four starting points which point to considerable substance in terms of the knowledge base that underpins design & technology. In the E4E proposals this substance is further clarified.

Hence in the section concerned with identifying needs and wants pupils will be expected to be know about and able to:

- Use tools for collecting data about users e.g. observing, recording, questioning, interviewing.
- Use tools for analysing and interpreting the data to identify needs, wants and opportunities.
- Use tools for developing briefs and specifications such that these incorporate different design requirements e.g. for ease of maintenance, disassembly, rapid manufacture, recovery within a circular economy.

In the section concerned with understanding materials and their properties pupils will be expected to know about and be able to:

- Identify and work with different materials. Materials which they might work with during their work include: paper and card, fabrics, metals and alloys, timbers and timber products, polymers, ceramics, composites, modern and smart materials, organic materials, food stuffs. Pupils should be able to understand that different materials have different properties and these properties affect the characteristics of the materials.
- Understand a range of material properties e.g. mechanical, thermal, electrical,
magnetic, optical, chemical, nutritional and sensory. Pupils should be able to use information about the properties of materials to decide on which materials to use for particular applications.

![Design & Technology Toolbox](image)

**Figure 4** The E4E Design & Technology Tool Box (more detailed view)

Through this epistemological clarification it becomes clear that there is a considerable and robust body of knowledge underpinning the school subject design & technology and that embedded within this body of knowledge are indeed enduring ideas. The response of the students in trying to draw a map of such idea indicates that they have inklings of these ideas but that they are not developed nor organized into a coherent assemblage. Similarly the extent to which such ideas are known and seen as important by those currently teaching the subject is questionable. These issues will be addressed in the following discussion.

**Discussion**

We begin this discussion by recalling a conversation one of the authors had with Dr. Rosa Bruno-Jofré, then Dean at the Faculty of Education, Queen’s University, Kingston, Ontario. The Dean had for the first time taken a class of technology education student teachers for a course on the history of education. She commented, “The problem is that they cannot deal with anything unless it is concrete, ideas as such are a mystery to them!” This led her to be very supportive of the Young Foresight initiative in which pupils aged 14 years are required to design but not make products and services that use new and emerging technologies as
their starting point. Rosa reasoned that having to deal with design ideas that were not to be made would be an important starting point for educating the trainees in both the importance and nature of ideas. This lack of appreciation of ideas as opposed to artefacts has some resonance with the trainees’ view that “You make what you learn”. However this apparent disregard of ideas within the school subject does it a disservice. It makes it difficult to be clear about the intellectual aspects of pupil learning and this makes progression in such learning difficult to define. Also it can reduce the subject to simply acquiring psychomotor skills with the result that it is seen as particularly suitable for those who are less academically able.

In discussing the place of knowledge in technology Marc de Vries (2007) indicates that normativity is important. Normativity refers to the worth of the knowledge that technologists use. They make judgments as to its worth with regard to particular applications. A material that is strong and stiff may be a ‘good’ material for some applications but a ‘bad’ material for other applications. The properties of the material do not change in the move from one situation to another but the fitness for purpose of the material does. This has implications for the school technology curriculum. It will be insufficient for pupils to possess scientific knowledge about in this instance the properties of materials. They will need to learn how to make decisions in the application of such knowledge. It is noteworthy that the E4E knowledge statement about materials includes the sentence “Pupils should be able to use information about the properties of materials to decide on which materials to use for particular applications”.

It appears that we have a situation in which those entering the profession of design & technology teaching do not have a robust view of the knowledge that underpins their subject. This is perhaps not surprising as this area of the curriculum is relatively new, existing as such in England only since 1990 and those who teach the subject come from a wide range of backgrounds. This situation is compounded by teachers in school having little time to reflect on the nature of the subject they are teaching having to concentrate on the day to day business of teaching their pupils such that they are successful in those forms of assessment that are used as measures to make judgements about school performance. Such assessments do not contain much in the way of assessing the understanding of ideas concentrating almost exclusively on procedural competence. The relationship between procedural competence and the understanding of ideas that can be seen as intellectually significant in the subject goes largely unexplored. Where does that leave us in the quest to help trainee design & technology teachers develop a more powerful epistemological view of their subject?

**Suggestions for initial teacher education**

One of the authors began their own initial teacher training by responding to a request to produce a map of key ideas in chemistry. Interestingly there was considerable unanimity in the maps produced across the group of chemistry graduates starting their teacher training. This does not seem to be the case for those starting to train as design & technology teachers. So a first step might well be to introduce trainees to the E4E Tool Box approach to defining the subject. This alone we suggest would not be sufficient. It will be important that the students visit this approach at regular intervals throughout their initial training to explore the way it relates to and informs the activities that pupils undertake in design & technology lessons. If the activities concentrate exclusively on developing making skills then the curriculum experience can be seen to be inadequate. Similarly if pupils are denied the
opportunity to make knowledge dependent design decisions then again the curriculum experience can be seen to be inadequate. If significant parts of the Tool Box are not engaged with then again the curriculum experience can be seen to be inadequate. We hope that using the Tool Box approach to audit the quality of pupils experience through a focus on the significance of underpinning knowledge will lead student teachers and their mentors in schools to question the nature of their curriculum offering and develop design & technology curricula that cannot be accused of lacking disciplinary coherence.

References


A bumpy ride – Curriculum change and its impact on Technology Education in South Africa: Voices from the academy

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Abstract

Curriculum review gets varying responses from stakeholders in education. The South African national curriculum (Curriculum 2005) was reviewed in 2000. The review which resulted in Curriculum 2005 being renamed the National Curriculum Statement (NCS). The NCS was also reviewed in 2009 and it is now called the Curriculum and Assessment Policy Statement (CAPS). No research has yet been conducted on how these reviews might impact the delivery of the technology education. Thus, this paper reports the possible impact of the national curriculum review on the delivery/implementation of technology education. While curriculum review is ideal for new educational developments, for a relatively new subject like technology education, it breeds mixed feelings that may negatively affect the growing of the subject. In fact, the findings from interviews with technology lecturers indicate the implied impact of the review in terms of the Intermediate-Senior Phase transition of learners, technology teacher training, universities’ role as teacher training providers, physical resource provisioning and the science-technology tug of war. The results of the study should assist with understanding the impact of the review technology education. Stakeholders should be aware of the merits and demerits of the curriculum review and strategise on how they may fill the gap that the review might create, while strengthening the positive side of the review.

Introduction

The main reason technology education was introduced in the South African national curriculum and other countries in the world was the recognition of the need to produce engineers, technicians and artisans needed in the modern society as well as the need to develop a technologically literate society for the modern world (Lewis, 2005). But the realization of the goals implied in this reason might be thwarted by the reviews of the curriculum which may disfavour technology education. Hacker (1999) views this state of affairs in the light of impediments that thwart efforts to institutionalise technology education in the nation’s schools. These impediments mitigate against the establishment of technology as a core discipline (Hacker, 1999). This paper thus reports the findings of the study which was conducted to tease out the impact that the curriculum review might have on technology education. How technology education might be affected by the review is important to understand given the fact that technology education is still regarded as the new arrival in the curriculum, thus it is a ‘fragile baby’ that needs to be handled carefully. Reviews that do not make attempts to motivate the thriving of the subject may kill its existence, putting a stoppage to producing engineers, technicians and artisans.
The implementation and curriculum review were accompanied by a host of studies many of which were on C2005. With regard to technology education per se, many studies were carried out particularly in the area of pupils’ attitude towards technology (PATT) (Ankiewicz et al., 2001; Burns, 1992; Rennie & Tregust, 1989; Van Rensburg & Ankiewicz, 1999; Volk, 1999). But little research has been conducted about technology education curriculum review. The few studies conducted that are closer to the problem that was investigated in this study include those of Stevens (2005) and Kahn et al (2003). They relate to the constraints faced by technology education from the time of the first curriculum review in terms of teacher training and the political drive behind the introduction of technology education.

Another important point for noting is that there were no teachers qualified to teach technology at the time of its rolling out in 1998. Teachers qualified in other subjects were asked to volunteer to teach technology. Unfavourable developments about technology education may dampen the spirits of these teachers and in turn those of learners who are trying to gain experience and learn technology. Furthermore, curriculum reviews that disfavour technology education may compromise efforts to resource schools for the subject. Discourses about this issue is deemed crucial because they have a potential to advise a way forward that will promote technology education rather than discontinue it. Thus, voices of sampled academics were deemed important to highlight some of the constraints that curriculum reviews might pose on technology education. The presentation for this paper goes: an overview of technology education curriculum reviews with their motivation on a global perspective; available approaches as options that technology education curriculum reviews might take and their implications on South Africa’s choice; reflections; research design that was followed in gathering the views of academics on these reviews; then presenting the findings from these gathered views.

**Technology education curriculum reviews – a global perspective**
Changes that affect the implementation of technology education can be better understood from the global trends about this phenomenon. These trends inform curriculum reviews of and curriculum approaches to technology education (de Vries, 1992; Eggleston, 1993; Brown, 2008; Wilson & Harris, 2004).

The tradition of technology education can only be discerned in historical vocational programmes in the traditional craft subjects (Glover, 1996; Kimbell, 1997; Page, 1996; Sherwood, 1996; Raizen et al., 1995; Siraj-Blatchford, 1996; Williams, 1996). Change in industrial training placed a high premium on factors like creativity, initiative, entrepreneurship, critical thinking and self-governed work teams (Williams, 1996). What followed was a need to introduce technology education in a school curriculum. This review of industrial change resulted in workplaces characterised by participatory management styles, shared goals, multi-skilled workers and flat management structures. This was to enable those being managed a space to showcase their potential. These requirements necessitated a school curriculum that focused on a need for workers’ competencies (Williams, 1996). The relevance of educational programmes was thus brought into question, which meant that action had to be taken.

In the United States, the Department of Labour’s Commission on Achieving Necessary Skills (SCANS) developed ‘workplace know-how’ based on workplace competencies and foundation
skills (Williams, 1996; Zuga, 1997) to create a balance between theory and practice. The implementation goals include the following (Rasinen, 2003:40):

- Technology should be integrated as one of the core subjects from kindergarten to junior and senior high schools, and even beyond;
- Technology Education can be integrated with other school subjects, especially with science and mathematics;
- Technology should be compulsory at every study level, for girls as well as boys;
- local conditions, aspirations of individuals, career goals, and abilities should influence the development of the curriculum for technological literacy; and
- the ultimate goal is to realize technological literacy for all.

In 1989, the United Kingdom's Secretary of State for Education incorporated six core skills in the programmes of all 16-19 year-olds via its National Curriculum Council. These skills were communication, problem-solving, personal skills, numeracy, information technology, and modern language competence. In England in particular, the national curriculum was revised in 2000 (Rasinen, 2003:34). Member countries of UPDATE (Understanding and Providing a Developmental Approach to Technology Education) introduced technology education integrated with other subjects (Rasinen, 2011). In New Zealand, competencies (essential skills) were developed as part of the national curriculum. These were communication, numeracy, information, problem-solving, self-management and competitive, social and cooperative, physical, and work and study skills. In Australia, the Mayer Committee determined key competencies for young people for effective participation in the emerging patterns of work and work organisation – communicating ideas and information, planning and organising activities, working with others in teams, using mathematical ideas and techniques, solving problems, and using technology. The Minister of Education in Australia declared:

_The main sources of productivity growth are technological change, increases in capital intensity, improvements in labour efficiency and economies of scale. Education and training will play a vital role in productivity performance, directly conditioning the quality, depth and flexibility of our labour force skills_ (Treagust & Mather, 1990: 51).

According to Rasinen (2003:34), in Australia Technology programmes can be structured and delivered either as discrete programmes or combined with other areas of learning. Technology programmes in primary schools give students a broad foundation for further learning. They are taught by classroom teachers, sometimes in association with specialists or resource people, with varying allocations of time to allow different activities. In the secondary school, Technology Education includes a number of different areas of study.

In France, technology studies must continue from primary school to secondary school without any gaps in the coverage of topics (Rasinen, 2003:36). In Netherlands, at the primary level technology education is not offered as a separate subject area but is integrated with crafts, arts, and natural sciences (Rasinen, 2003:37). At the secondary level it is a subject area of its own, but it is also integrated with mathematics, science, and social studies (Raisen, 2003:37). In the first and second years of secondary technology, it is studied for two teaching hours per week, whereas at the secondary level, 180 teaching hours are allocated to technology education (Rasinen, 2003:37). Finland curriculum is revised every 10 years (Rasinen, 2011).
The focus in this article now turns to the Australian competency skills as it seems that they resonate with the South African critical outcomes (see Table 1 in this regard). Demands for curriculum change brought a shift in the teaching enterprise from the traditional teacher dominance to a teacher-learner partnership. The latter featured in C2005/RNCS/NCS/CAPS to differentiate between the old and new teaching approaches. It encapsulated the principles of facilitation of learning and learner-centred teaching, amongst others.

Table 1: Similarities between Australian key competency skills and South African critical outcomes

<table>
<thead>
<tr>
<th>Key competency skills for effective participation in emerging patterns of work in Australia</th>
<th>Critical outcomes for envisaged learners in relation to emerging patterns of work in South Africa</th>
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<tbody>
<tr>
<td>Collect, analyse and organise information.</td>
<td>Collect, analyse, organise and critically evaluate information.</td>
</tr>
<tr>
<td>Communicate ideas and information.</td>
<td>Communicate effectively using visual, symbolic and/or language skills in various modes.</td>
</tr>
<tr>
<td>Plan and organise activities.</td>
<td>Organise and manage oneself and one’s activities responsibly and effectively.</td>
</tr>
<tr>
<td>Work with others and in teams.</td>
<td>Work effectively with others as members of a team, group, organisation and community.</td>
</tr>
<tr>
<td>Use mathematical ideas and techniques (needed to be able to manipulate the relatedness of systems through problem-solving).</td>
<td>Demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation.</td>
</tr>
<tr>
<td>Solve problems.</td>
<td>Identify and solve problems and make decisions using critical and creative thinking.</td>
</tr>
<tr>
<td>Use technology.</td>
<td>Use science and technology effectively and critically showing responsibility towards the environment and the health of others.</td>
</tr>
</tbody>
</table>

As indicated above, the curriculum trends triggered a need to introduce technology education as a school subject to prepare learners for the new industrial demands. Certain curriculum approaches for technology education had to be decided upon. Indeed, it was possible to arrive at a number of approaches which could be considered during the curriculum review and development. For example, offering technology as an integrated subject with natural science was among the existing approaches, which shaped the technology education curriculum review in South Africa.

**Approaches informing technology education curriculum reviews**

The following approaches are discussed (Black, 1996; Raizen et al., 1995):

**Craft approach:** The emphasis is on knowledge about the materials and skills required to transform them into fabricated objects. The cultural and personal value of the combination of manual skill, aesthetic sensibility and traditional design is preserved. Learning activities involve making things based on prescribed designs in classrooms equipped with machines and tools from woodworking, metal working, electrical, catering and textile trades. The emphasis is more
on psychomotor skills rather than on design. Training in this approach has traditionally provided the skills foundation for learners moving into a vocational craft or trade. It balances a practical component with a purely academic school curriculum.

**Occupational/vocational approach:** The emphasis is on the hands-on transformation of materials into products. The focus is on current industrial practice rather than traditional craft skills. It is an industrial production-oriented approach. The nature of classrooms is similar to in the craft approach, but they typically include machinery from industry, either models retired from the factory floor or scaled down, or purposely built classroom versions. Teachers have usually been trained in industry. In certain cases, learners are expected to spend time in a workplace setting undertaking a work-experience or internship programme. They are equipped to enter current technical or practical vocations on leaving school.

**High-tech approach:** This approach is visible in schools in which a substantial amount of new technology has been introduced through fundraising efforts in conjunction with industry partners. The reasons for introducing this approach vary and include a desire by industry to shape the skill base of the future workforce and a desire on the part of schools to appear progressive in an environment of technological change. It also embraces a “modern technology” approach, which looks to the nature of work in the next century and focuses strongly on information technology. Teachers in this case are from a traditional technology education background and have undergone retraining.

**Applied science approach:** Science teachers have developed this approach. Rather than teaching scientific ideas as abstractions, familiar products and processes are used as both the dissection table and the test bed for scientific ideas and theories. It places more emphasis on cognitive elements than practical work, though there is clearly potential for using this model to explore new applications of technology. This approach assumes science and technology ought to be studied in close association with each other.

**Technology concepts approach:** In this case the emphasis is on learning about the processes that enable technological developments to take place. Thus, this approach emphasises theoretical understanding rather than practical action. In addition, it emphasises the systems concept, i.e. the flow of matter energy and information rather than an understanding of how to make or repair any of the components of a system.

**Design approach:** This approach can be seen as a “practical capability” approach that emphasises personal and active involvement of learners in tackling realistic problems. In addition to this, the design approach is seen by some as a central concept in the study and practice of technology. Its emphasis is on learners’ own decisions about what kind of product is needed and what the product will look like, how it will work and how it should be made. Learners are first asked to produce a design brief describing a need or a problem to be solved using specified resources, then progress through stages of concept development, construction of prototypes, and testing, and then redesign and perhaps manufacture. Classrooms are often equipped and arranged similarly to those used for craft-based teaching, with teachers at secondary level having a craft or industrial background.

**Science-technology-society (STS) approach:** This approach is based on the assumption that curricula are organised around societal issues. Teachers should establish connections between
their classrooms and the outside world by explicitly focusing on local issues relevant to learners, discussing the knowledge and skills needed to address these issues, and bringing in outside speakers or taking learners on field trips to places in the community where science and technology are practised. Being the STS movement, this approach calls for the study of technological innovation as a driving force for social change and of its interaction with other forces that also drive change. This approach also draws on a problem-solving emphasis, focusing on an understanding of the nature of social needs in the definition of problems and on the need for a cross-disciplinary approach to tackling issues.

**Integrated subject approach:** This approach is based on the integration of several subjects or areas of study into a framework that aims to provide both an understanding of technology and its interrelatedness with other disciplines and with life outside school. The Scottish and US examples embrace technology, science, social studies, health education, and information technology under the umbrella of environmental studies, and science, mathematics and technology (SMT) as integrated disciplines. Technology in this context includes the role of computers and other new media and technologies as tools for learning and programme delivery but is not limited to using computers in the classroom. Within the SMT approach, technology ought to be considered as a subject area with its own content, goals and contributions. This approach to curriculum is seen as a learner-empowerment approach to come up with new solutions to problems not yet uncovered.

**Technology education curriculum review – a South African situation**

The last three approaches above seem to have been adopted in the technology education curriculum (Technology Grades R – 9 and CAPS). Design approach is explicitly expressed in the first learning outcome (NCS) or aim (CAPS) – *The learner will be able to use the technological processes and skills ethically and responsibly using appropriate information and communication technologies*. The science-technology-society approach is embedded in the third learning outcome (NCS) or aim (CAPS) – *The learner will be able to demonstrate an understanding of the interrelationship between science, technology, society and the environment*. The integrated approach was followed when technology education was merged with natural science on the roll out of C2005 in 1998, and now in CAPS.

The changes that ushered in the democratic South Africa led to the introduction of the new Curriculum 2005 (C2005) post 1994 democratic elections. C2005, implemented in 1998, replaced the old apartheid curriculum. However, C2005 has since undergone a few reviews, the first in 2000 (Chisholm, 2003; Jansen, 1999). It also underwent a name change and became the NCS (Department of Education [DoE], 2002). This curriculum review attracted some research (African National Congress, 1994a; 1994b; DoE, 1995, 1996; 1997; Chisholm, 2003) to assess its viability. The second curriculum review took place recently in 2009, resulting in the current CAPS (Department of Basic Education [DBE], 2010). Even though the focus of this paper is not on the differences between C2005, the NCS and CAPS, it should be noted that CAPS bears many features of the NCS which in turn bears the features of C2005. For example, it still encapsulates the curriculum principles and learning outcomes in the form of specific aims. In fact, CAPS is basically about the revised strategy to implement NCS.

Technology education was introduced with C2005 for the first time in 1998 (Stevens, 2005). It was integrated with natural science at intermediate phase (Grades 4-6). It was anticipated that it would thrive as part of the national strategy to skill and impart technological knowledge to the
country’s learners. However, the review of Curriculum 2005 created ambivalence among educational stakeholders, mainly the teachers. Ambivalence means the coexistence of opposing feelings in one person’s mind (Allen, 1990). It was felt that C2005 was flooded with difficult terminology (e.g. range statements, phase organisers, assessment criteria).

The curriculum review in 2000 recommended the scrapping of the Technology Learning Area (TLA) with a reason to lessen the curriculum overload (DoE, 2000). Teachers still complained about the difficulty related to the implementation of the curriculum emanating from the challenging terminology again and complex approaches. They also complained about the big jump for learners with 3 learning areas at Foundation Phase to 8 learning areas at Intermediate Phase. The resultant was the decline by government, of the recommendation to scrap TLA from the curriculum. Instead, TLA was separated from natural science in the Intermediate Phase.

The second curriculum review in 2009, which produced CAPS, made the TLA the casualty of curriculum overload once more. It was once more recommended that TLA be re-merged with natural science in the Intermediate Phase. The main reason was again to lessen the curriculum overload in this phase. Thus, the Review Committee recommended the reduction of 8 learning areas to 6 subjects. This created a problem with regard to the time allocated for the teaching of technology (De Jager, 2011): the former 3 hours per week allocated for natural science and 2 hours per week for TLA were now reduced to 3 hours per week combined in the merged subject – natural science and technology. The TLA content was compromised even though the design process would be emphasised. Some of the basic principles of technology education were as a result exported to Senior Phase (Grades 7-9) even though only 2 hours is allocated to the TLA at this level. It would seem that curriculum integration has not gone down well with attempts elsewhere. For instance, Loepp (in Erekson and Shumway, 2006) has noticed barriers to curriculum integration, which include turfism, discipline envy, inadequacy, time constraints, lack of integrated curriculum materials, school structure, and college admission requirements. Loepp (in Erekson and Shumway, 2006:30) states in this regard:

*The barriers to curriculum integration are readily apparent. Turfism runs rampant throughout the educational enterprise. Teachers trained to teach a discipline become threatened when others impinge on their subject area. They also tend to feel inadequate when asked to stray from their traditional subjects. Also, teachers in elementary and secondary schools are loaded with day-to-day responsibilities and have little time to reflect on curriculum – let alone integration. Further, most readily available curriculum materials are discipline-specific and only casually refer to content from other disciplines. For many years, schools have been organized around various disciplines. Additionally, high school graduation requirements and entrance requirements to higher education institutions are discipline-specific.*

**Reflections**

The consulted literature presented this far casts light on the motive behind the Technology Education curriculum review and its context-specific reasons like addressing issues of curriculum overload in the case of South Africa. Indeed, the decision about curriculum overload in the Intermediate Phase was to alleviate too much pressure on learners (DoE, 2010). There could however be a gap between the Intermediate Phase and Senior Phase in terms of the depth of
the knowledge that must be covered. Besides, even though the integrationist approach suggests the merging of technology education with other subjects, it leaves one wondering about what motivated the recommendation to want to sacrifice it.

Regarding teacher training, only few technology teachers have received formal training this far. For example, according to Potgieter (2004), some 137 teachers participated in workshops, and some 950 teachers earned an Advanced Certificate in Education at Unisa. The author also co-facilitated the training of more than 300 senior phase teachers in Gauteng and Mpumalanga in 2008 and 2009. This being the case, it should equally be noted, that technology teacher training has not been easy or clear (DoE, 2009). Teachers were asked to volunteer to teach technology for the first time. Sithole (2009) relates teachers’ lack of ease with the training (also see Carl, 2005; Laukgsch et al., 2007). According to Reitsma and Mentz (2009), short workshops by the DoE do not offer teachers the opportunity to study and reflect on the new information. The difficult situation seems compounded by the under-qualified and inexperienced educational officials who also give the training as Reitsma and Mentz (2009:20) found out: “Only few of the subject advisors themselves, who acted as trainers, had training in technology education”. However, it is not even clear from the Curriculum Review Report (DoE, 2009) as to who will now be expected to teach Technology – will it be Science teachers, Technology teachers, or a team of Science and Technology teachers? Challenges like those experienced by the United Kingdom (Stables, 1997) seem to be experienced in South Africa, too.

In a recently completed doctoral study, Mapotse (2012) conducted an action research with 18 technology teachers from selected secondary schools in Limpopo Province. Through observations and fact-finding he discovered that some teachers in whose schools his student teachers were placed for practice teaching could not teach technology to a point that student teachers changed roles with them, i.e. student teachers ended up mentoring their mentor/senior teachers. In the sampled schools Mapotse found out that 11 teachers had less than 6 years experience teaching technology, 11 teacher had no qualification in technology education, 8 teachers could not plan a technology lesson at all. So, the aim of the study was to empower these teachers. Gumbo and Williams (2012) conducted a case study with four lower secondary school technology teachers. The aim was to study these teachers’ pedagogical content knowledge. Three teachers had only four years technology teaching experience, one had seven years.

Higher education institutions (HEI’s) are earmarked to help train both pre- and in-service teachers. Due to the shortness of the training sessions, the quality of the training might be compromised to some extent. The DoE seems restricted to a large extent by labour laws which preclude the in-service training of teachers during their holidays or weekends. Technology education presents an opportunity to a thinking teacher to augment his/her teaching by harnessing the available resources in the immediate environment. On the other hand, the new integrated subject may help heighten the need for resource provisioning. Sithole’s (2009) findings include, amongst others, a lack of teaching resources and improper training. This has also been identified as a constraint elsewhere (Olaniyan & Ojo, 2008). To integrate certain aspects of technology education into natural science is not an unthinkable possibility in line with the subject integration approach above, particularly when one considers the interface that exists between maths, science and technology (Sanders, 1999; Kahn et al., 2003; Berlin & White, 2011). However, this does not suggest a simplistic approach whereby science and technology are lumped together (Millar & Osborne, 2000) as though the two were one and the same thing.
The new name, *Natural Science and Technology* may downplay technology education since emphasis on science may heightened more than technology. Existing differences between the two should provide space for their individual status. Thus, Sanders (1999:36) cautions: “Because of these fundamental differences, the study of technology must be much more than simply another unit of study added to the science curriculum. To be meaningful and effective, the study of the technological world requires an activity-based curriculum that includes the design, development, and evaluation of solutions to technological problems”. This claim is motivated by the fact that in CAPS, little about technology has been accommodated only in terms of aspects of technology (DBE, 2010). Existing differences between the two should provide space for their individual status. Each subject should be accorded the right to an independent existence, particularly technology education since it is a relative newcomer in the curriculum.

**Research methods**

The research problem being addressed is: How might the curriculum review impact the implementation of technology?

This study followed a qualitative approach so that the views of 9 technology lecturers could be gathered. At the time of investigation these lecturers were based in the institutions of higher learning in the Gauteng Province. Probability sampling technique was used to select these lecturers due to its convenience, using e-mail address system (Schonlau et al., 2001). The lecturers were asked if they were available to participate in the study. The researcher introduced himself to them via e-mail, stating the purpose of the study, ensuring them of anonymity and confidentiality during the use of the data gathered from them. The e-mail about this request was not sent as a bulk e-mail, but individually to prevent any possibility of the lecturers from consulting each other in the process of responding to the interview questions. As a way to practically manage the turn-around of feedback expected from them, a date in 2011 on which the interview questionnaire was to be e-mailed was indicated as well as the latest date on which feedback was expected from them. The researcher made the lecturers aware of their freedom to withdraw in the process of data gathering if they so wished. Their e-mail responses to this request would be filed to signify their granting of their consent to participate in the study. All 9 lecturers who were asked to participate responded positively to the researcher’s request, indicating their willingness to participate.

An open-ended questionnaire was e-mailed to the participants to gather their views about the impact of curriculum review on the implementation of technology education. The questionnaire aimed at gathering the views of the lectures on the impact of the curriculum review on the Intermediate-Senior Phase transition of learners, technology teacher training, universities’ role as teacher training providers, physical resource provisioning and the science-technology tug of war. The choice of an e-mail interview was considered for its practical value and convenience of World Wide Web as a tool for this study (Schonlau et al, 2001). Advantages of e-mail interview for purposes of this study included asynchronous communication, downloadability of the interviews from the computer, a saving in transcription time, the saving of resources as there was no need to travel, etc (Bampton & Cowton, 2002; Opdenakker, 2006). The lecturers were asked to acknowledge receipt of the questionnaire. They were given three weeks to fill in and return the questionnaire. Three of them acknowledged receipt after a week, indicating that they
were not available at the time the questionnaire was sent to them. They thus asked for an extension of returning the questionnaire a week after the stated date. The researcher agreed to the request. All the 9 lecturers returned the filled questionnaire, even though two of them e-mailed to indicate that they were facing a very busy schedule at work and promised to return the questionnaire two weeks after the due date. These were not those who asked for extension. They indeed returned the questionnaire during the second week on their extension.

There was no need to transcribe the data and do member checking since the responses were types and clear, and sent as attachments to the lecturers’ e-mails. The analysis of the data followed a thematic approach according to the items in the questionnaire – Intermediate-Senior Phase transition of learners, technology teacher training, universities’ role as teacher training providers, physical resource provisioning and the science-technology tug of war.

The findings are presented subsequently.

**Findings**

**Intermediate-Senior Phase transition**

The lecturers’ views acknowledged the review’s efforts to reduce the curriculum overload for teachers and learners. The responses showed that if teachers are equipped in both learning areas (natural science and technology education), they can develop a project that covers both the subject in accordance with the design process, as well as put an emphasis on the relationship between these two subject. In that sense the learners will be helped to understand these subjects better. One lecturer gave an example of a project that can produce a cardboard truck artifact with electric circuits for lights. Another lecturer said that the specific requirements in the present CAPS would lay the foundation in Intermediate Phase, which includes certain aspects of technology education and its links to natural science. It was not really clear what this lecturer meant exactly with specific requirements. Apparently he referred to the fact that in CAPS the approach (aims, themes and methods) have been specified to a larger extent for the teachers. According to him the emphasis on the design process should have a positive effect on the learners transiting to Senior Phase.

The third lecturer said that some teachers are familiar with the old topic-based curriculum, i.e. the curriculum prior to the introduction of C2005. He however stated that learners will be deprived of acquiring skills and knowledge in technology education at an early stage due to the scanty coverage of the technology education themes at this stage. The other two lecturers expressed a concern at the lack of synergy between the Intermediate Phase and Senior Phase. One of these two lecturers stated in particular that the CAPS draft document did not include the design process for Intermediate Phase, providing no foundation for the same process in Senior Phase. Apparently this lecturer was not well informed about the CAPS because it does include the design process. Since the CAPS document had just been released at the time of the investigation, the lecturer’s apparent ignorance about this can be seen in that light.

Another lecturer shared his views: “technology might be underplayed and not be offered the time and tuition it deserves; this might compromise its themes per se”. According to him, it would appear that the initiative to address technological skills shortage and invest in the future of South African citizens is being compromised. The lecturers cautioned that the little time
accorded to the integrated subject, i.e. Natural Science and Technology may compromise the emphasis on the challenging technological themes of structures, systems and control in the Intermediate Phase, which will create a tendency not to teach them thoroughly, which will then impact negatively on the transition to Senior Phase. Again, these lecturers were not as yet aware of the fact that structures and systems as themes were integrated in the new subject. Perhaps what should have been a concern is the depth to which these themes would be treated given the little time allocation to the new subject, that is 3.5 hours per week.

**Technology teacher training**

The findings revealed that the envisaged retraining of teachers will help the natural science teachers consolidate their understanding of science with that of technology. According to one lecturer, this will not mean any great changes since content knowledge still takes the form of topics in CAPS. Pedagogically, teachers know the logistics of lesson planning from their former training, particularly as the new approach in CAPS reverts back to the old curriculum. Indeed, many teachers still clung to the old traditional approach to teaching instead of the outcomes-based teaching that was expected in Curriculum 2005 through the NCS. Now that the CAPS has reverted back to this old approach to some degree, it would indeed set teachers at ease. However, the creativity and critical thinking that technology education promotes might be profusely compromised by this traditional approach.

Due to this reverting back to the traditional approach, the lecturers felt that minimal time was required to develop teachers on the themes prescribed in the syllabus. However, one lecturer expressed his dismay about what he referred to as the “chameleon-speed” of teacher training and consequently teachers’ shallow technological knowledge. He also stated that some teachers might be made redundant or redeployed as a result of this change. Another lecturer felt that teachers who had begun to understand the OBE approach would now have to change to the old approach again.

For the third lecturer, technology teacher training could become very diluted and one-sided because teacher training institutions will most probably concentrate on the basic themes specified in the CAPS documents. Another lecturer commented on the fate of the technology teachers already trained in teaching technology alone, not as integrated with natural science: “Former technology-only teachers will now need training on former natural science-only topics and teachers’ morale will be dented by the ever-changing curriculum and new teacher training”. To this lecturer it was not clear yet what form of teacher training might result from the review. This question was raised by the researcher to the education official who was invited as a keynote speaker during the Teacher Education Conference hosted by Unisa’s School of Education in 2011. This official spoke on the review and CAPS. He did not have the answer to the question.

**Universities as teacher training providers**

The findings revealed the opportunities for the higher education institutions (HEIs) resulting from the review:

- Development of new materials for CAPS in general, and Natural Science and Technology as the new subject in particular;
- Programme development for CAPS and Natural Science and Technology in particular; and
Teacher training in CAPS and in particular in Natural Science and Technology.

Lecturers expressed their concern about the burden of programme review which may be thrown away by another possible curriculum review. For them it would appear that the taking over by a new minister of education comes with a possibility to change or review the curriculum. The lecturers will have to redesign their course based on the NCS to one based on CAPS and develop the INSET programmes to train teachers. All their module content will have to be revisited and adjusted according to CAPS, and be aligned and modified to meet the demands of the transition. A new specialized training, especially for the Natural Science and Technology teachers, will have to be considered, placing additional pressure on the facilities and capabilities of HEIs. In the words of one lecturer, “universities will have to seriously consider a training model that caters for an ongoing on-site support for teachers that they trained”.

Physical resource provisioning

One lecturer stated that the demand for new resource provisioning might grow, much to resource service providers’ advantage. He further stated that the new kits for the Natural Science and Technology subject will need to be produced. For the other lecturer, the resource service providers and education consultants may be helpful in providing resources for teaching and learning. Yet another lecturer stated that the curriculum review presented an opportunity for Department of Education to provide resources that will ensure that technology education receives the attention that it deserves within CAPS. However, two lecturers indicated that resource provisioning may be minimized in the Intermediate Phase owing to the limited content to be covered. One lecturer stated further: “The Education Ministry should be prepared to spend and support schools with equipment needed.” All the lecturers unreservedly expressed a concern about the under-resourced schools. According to them technology education is a theory-practice based subject and as such teaching it without the necessary resources limits the understanding of learners hugely. They argued that as much as teachers are required to be creative and amass resources available around the school’s locality, Department of Education should not shy away from its responsibility to resource schools.

The science-technology (sci-tech) tug of war

It was found that CAPS presents an opportunity to end the sci-tech tug of war through the integration of science and technology education. The lecturers seemed to be aware of the debates between the science and technology education practitioners both on scholarship and practice levels. On practice level in particular the integrated subject might encourage teamwork between the science teachers and technology teachers, even though it was not yet clear as to whether it would be the science-only teachers or technology-only teachers that would be trained to teach the integrated subject. Another expressed view was that not only teachers but learners will learn to appreciate the relationship between science and technology. Yet another finding was that technology teachers should be appointed as heads of department to neutralize the dominance of science teachers being the ones appointed as senior teachers. The lecturers’ worry was that this dominance comes with a tendency to promote science more than technology education. One lecturer suspected that teachers will now teach more science than technology, thus compromising the status of technology education. According to him technology education is different from science education.

Conclusion
The study being reported in this paper investigated the impact of the review of curriculum on the implementation of technology education. The review has been received with mixed feelings as it is evident from the findings of this study, causing some degree of ambivalence in the lecturers that were interviewed.

The findings suggest an evaluation of CAPS (Natural Science and Technology) in line with the expressed views so that corrections can be made where possible. The evaluation should come in the form of monitoring the impact of the review on the Intermediate-Senior Phase learner transition, teacher training, the role of HEIs on the implementation of CAPS (Natural Science and Technology), resource provisioning, and the science-technology synergy.

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Electronic tools that support inquiry learning

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Abstract
Teaching can be challenging, particularly if it involves teachers developing student centred inquiry approaches. Collaboration, sharing ideas and co-construction of ideas and understandings requires changing teaching and learning practices that allow students to learn how to collaborate to solve problems in areas of their interest.

This presentation is concerned with how electronic networking tools such as the Internet or mobile technology can support authentic inquiry in classrooms. An example from a Teaching and Learning Initiative funded project will be presented that involves science teachers from high schools in New Zealand. Class activities include using moodle to explore and share ideas, developing videos to answer questions from a local pre school, using mobile phones to record classroom activities, and using wallwisher to communicate with science students in Denmark.

The early findings suggest that use of the e-tools supported students growing ideas and understandings. Specifically, the tools afforded opportunities for collaborating, sharing ideas and co-constructing ideas as part of the science inquiry learning process, which has implications for teaching technology. As a result, students began to undertake more responsibility for their learning to think, talk and share ideas critically in the classroom.

Introduction
This research project aimed to explore and theorise how inquiry teaching and learning in science can be supported through e-networked environments and how online resources accessed through the Internet can afford individual and group exploration of content, skills and resources. The focus was on using this approach to address how education can be made more relevant and responsive to the needs and interests of students from diverse backgrounds. This was achieved by building on existing research, particularly that from New Zealand. Overall, the project goals were to:

- understand what networked inquiry looks like in secondary science classrooms
- understand the relationship between teachers/students, the goals of the science inquiry and how networked tools mediate in this process.
While this research project focussed on science teachers and students, there are many parallels with technology such as the focus on student activity, dealing with authentic issues and problems which are relevant to students, and using electronic networks to facilitate and record student communication and outcomes. The rationale and related terminology for such a focus is of course different. Science is identifying this student centred approach, in which students decide on an issue to explore, as inquiry learning, with the rationale being both engagement and understanding the nature of real science. The more longstanding focus in technology has been the identification by students of problems or needs and the design and manufacture of a solution, with the rationale also being engagement, and the concurrent development of important cognitive skills.

School science and technology has been criticised for lacking authenticity and has been described as having little to do with important public issues and problems (Roth, Eijck, Reis, & Hsu, 2008). This lack of relevance has been associated with students’ lack of interest and motivation to continue with science and technology beyond the compulsory years at school (Bolstad & Hipkins, 2008). Fensham (2006) argues that education ought to provide opportunities for students to connect with real-world science and technology issues that they will be interested in and find personally engaging if the problem of declining student interest in science and technology is to be addressed.

In New Zealand, and internationally, claims are being made about the potential of inquiry based learning to address the challenges of relevance for school science (Aikenhead, 2005; Bolstad & Hipkins, 2008). Inquiry learning means that students investigate their own questions to relevant scientific problems, gather and make sense of data and information, construct explanations, and convey their conclusions (Duschl, Schweingruber, & Shouse, 2007; Lee, Linn, Varma, & Liu, 2010). It would seem inevitable that learning experiences which relate to students’ real life situations will have an important role in raising motivation and interest in science in and beyond school.

This study investigates whether inquiry learning in science that is supported through networked online environments is able to realise a vision for school science that includes ‘the potential for self-realisation, creativity and innovation, working with people and helping others’ (Bolstad & Hipkins, 2008, p. 15). The project examines the roles and possibilities ICTs may play in four schools to support students’ transitions and meaning making. It aims to do so by building on the ways students use ICTs to network in their out-of-school life and in this process will help them develop, share and act on science knowledge.

The discussion of networks in classrooms in this research project means the use of web-based communication tools to share information (Feldman et al., 2000). Such web-based technologies may be used to gather, share or disseminate information, locally or remotely and may include websites, e-mail, as well as audio and video applications (Khoo, 2010).
Research outside of science and technology education has illustrated that the use of ICTs can lead to a significant cultural shift in teaching practice through the way it changes the flow of information and challenges the power of the teacher as the person with the most knowledge and ultimate control over what counts (McCrory Wallace, Kupperman, Krajcik, & Soloway, 2000). ICTs such as the Internet allow students to exercise more agency in accessing and selecting information (Erstad, 2005). At the same time this raises the need for students to exercise discernment over which sources of information might be legitimate and reliable, something that is an important skill as part of the process of reaching consensus about what constitutes valid and useful knowledge. It is also an important skill if students are to become active, critical and informed participants in our society where science and technology play such important roles (Ministry of Education, 2007). The use of Internet based information with inquiry learning in science, and design activity in technology, provides an authentic context for the development of this skill of discernment (Williams, 2009).

This research project aimed to understand what networked inquiry learning looks like in junior secondary science classrooms. Being primarily interested in understanding and transforming practice in a social world (Roth, Lee & Hsu, 2009), cultural–historical activity theory was employed to design and theorise classroom inquiries. Evidence to understand the relationship between actors (students and teachers) and the goals and outcomes (broadly defined) of their inquiries, the communities they belong to and access, and the tools that help them (or not) to achieve these goals were investigated. The nature of the inquiries is shaped by the affordances of the tools used and accessed and by the rules that exist between community members. The project focussed on student learning outcomes to trace how individuals and groups of students and their teachers re-shape patterns of social interaction towards those more conducive to an inquiry processes with and through the use of networked online resources and support.

**Research questions**

The research questions listed below were identified through an analysis of the literature. As the project progressed, new related questions were generated by the research team to reflect what had been learned and any issues that emerged. The guiding questions were:

1. What are the existing ideas, experiences and visions that the six secondary science teachers have about teaching through inquiry learning?
2. What particular research skills do the students in this study require and acquire when they are involved in inquiry learning?
3. How do individual understandings change as the students in this study collaboratively engage in inquiry learning projects?
4. How do networked environment in this project impact on collaborative inquiries where students and teachers communicate through the web in addition to the face-to-face
Research design and data collection methods

School science curricula now recognise that in addition to understanding the conceptual structures and cognitive processes used when reasoning scientifically students need to develop an understanding of the epistemic frameworks used to develop and evaluate scientific knowledge, and the social processes and contexts that shape how knowledge is communicated, represented, argued, and debated (Duschl, 2008; Ford & Forman, 2006). School technology curricula now recognize that while developing procedural skills and knowledge when realizing design ideas, students also develop a range of cognitive skills and conceptual structures as the foundation for their technological literacy, which is essentially contextualized within a social and cultural frame (ACARA, 2013).

In the classroom, this means that students need opportunities to be involved in decision-making about the focus of their learning, the appropriateness of solution methods, and the legitimacy of solutions, at the same time they need to learn about the nature of science or technology. Tracing and collecting evidence of such experiences means that a range of data sources is needed. Consequently, for this project, data was collected:

- before classroom observations (lesson plans, pre-assessment of student knowledge, beliefs and values, transcripts of team discussions).
- during classroom observations through videos of individuals and videos of the whole class, observational notes, photos of teacher/student interactions, informal interviews with teachers/students, to provide evidence of learning and teaching in the classrooms.
- from student work (hard copy books, electronically prepared work including blogs, digital storybooks, e-mails, work that students have highlighted being particularly significant to their learning, reflections and selections of instances that are of relevance to students), to collect evidence of students’ learning journeys.
- after the teaching of a unit (collaborative evaluations of teaching plans, collaborative analysis of videos, post assessment of student knowledge, beliefs and values), to hone in as a team on telling examples for further exploration and to share insights from researchers and teachers.

Data analysis

This outcomes were developed in six case studies, one from each teacher and their class in each year, with nested cases of interest from a small number of individual students and or groups when they were engaged in networked inquiry in science classrooms. These provided rich detailed descriptions of how the process of networked inquiry in science evolves and can be
stimulated. These cases were subject to cross case analysis to search for themes. The goal of the analysis of the cases was to understand innovative pedagogical practices using network technology in science classrooms, how these innovations change, what it is that teachers and students do in science classrooms, the roles ICT plays in supporting them, associated with various outcomes and contextual conditions.

The study built on earlier work (Cowie, Otrel-Cass, & Moreland, 2007) and used activity theory as a lens to design and make sense of how students learn science through inquiry approaches supported with and through online networks (Engeström, 1987). Activity theory provided a perspective on action as mediated and cognition as distributed where the minimal meaningful context for understanding human actions is taken to be the activity system. The activity as a system includes a subject (an actor or actors) whose agency is chosen as the point of view in any analysis and an object that is the goal the subject is seeking to achieve (Engeström, 1987). Achievement is considered to be mediated by the tools the subject uses, which can be signs, symbols, artefacts and or persons. Individuals are acknowledged as being constituted in communities with their actions or interactions mediated by the rules (the norms and sanctions that specify and regulate the expected correct procedures and acceptable interactions) of this community. This approach illuminated the broader consequences of teachers’ perspectives on the mediation of student knowledge construction through and with the help of technology.

**Analysis process**

To gain a deeper understanding of what was observed in the classrooms the data analysis included initial reflections by and with teachers, students and researchers after each classroom observation. These reflective conversations generally began with an assertion, followed with telling examples from observations or interview/discussion excerpts. This first level analysis was shared by researchers in the online environment of Goggle Docs to provide a trail of records which helped to maintain the credibility of the project (Guba & Lincoln, 1989). The first level assertions and the field note content then informed the next step of the analysis process, the focus of intensive, off-site face-to-face or online discussions soon after the events occur.

Such examinations informed the selection of sequences of video from the classroom observations. Teachers also selected video sequences of interest to view, share insights and provide feedback on these that were then be shared with the group, to more deeply understand classroom events. These processes constituted the second level of analysis. The teacher video selections were the focus of further scrutiny by the researchers using the analytical software programme Nvivo in a third step of the analysis process. Combined, these video analyses became a central information source in the meaning-making process at a micro-level (Erickson, 2007). Through this process of data collection and collaborative analysis, the social construction of knowledge when students are involved in collaborative face-to-face and networked online science inquiries and further put forward a framework for understanding networked science inquiry learning was described.
Findings

1. **E-networked tools supported students’ inquiry skills by providing multimodal opportunities for them to access, collaborate, discuss, co-construct and communicate their developing science ideas.**

Examples of e-networked tools that provided opportunities for students to access, collaborate, share, co-construct and communicate ideas included on-line information searches using search engines, mobile devices and web quests for production of knowledge, and skype and email to access to work with scientists and to ask questions and discuss their developing ideas with them.

Not only did these tools support their understanding but also promoted realistic perceptions of scientists and the work that they do. The students were working with scientists and each other to undertake authentic scientific inquiry. As some students reported:

   *We learnt things we wanted to be taught.*

   *You get to talk to a scientist...to really understand.*

A range of tools were used by students to create presentations to communicate their findings. These included student generated videos (within groups) reporting on their inquiry investigations, Glogster which allowed students to create virtual posters including audio, video, text, hyperlinks, and images, and share their creations, and Google Docs PowerPoint, which enabled them to share, create, collaborate, edit and publish presentations online as well as to access from anywhere at any time. Students indicated that:

   *We repeated filming the videos several times, reviewed them until we were happy with the content. The reviewing helped because you could see what had been improved.

   It’s [Glogster] good as you can pop in videos and stuff, do all sorts of pictures, music, animated effects.*

Moodle discussion forums and Wallwisher allowed exploration and sharing of ideas by providing new spaces for learning that allow time to think and plan, with an opportunity to revisit and reflect on emerging ideas at any time and from anywhere. Moodle discussion forums enabled clarifications, summarising knowledge and identification of ‘next steps’ for student learning. Use of such discussion forums required a new culture for learning communities, as students are required to learn to trust by having the confidence to share their own thoughts as well as to learn how to think and talk critically in a group.
You can chat and research about the question in your group and also it is in a safe environment. I didn’t know some of the students in my group and I wouldn’t feel comfortable about going round to their place, but it was good to chat to them on-line.

Mr J helps us as individuals using the Moodle, he doesn’t tell us the answer, he just makes you think about it, he gives you pointers to the next stages of your thinking, it’s personal, related to you.

Mobile devices, as well as providing access to online information searches, were instrumental in the collection and analysis of data in ways that “mirror” authentic scientific inquiry. Mobile devices assisted in developing critical observation skills by allowing students to record an inquiry and identify patterns in the data, share observations, ask, review and then ask further questions.

Students commented:

It helps a lot if you are watching a [cell phone] video, you take it in more... and you remember it better.

You can actually see what we were learning and doing.

And from a teacher:

By initially allowing the use of phones in class I effectively gave them the understanding that it is Ok to use their phones to help their learning, this had a twofold effect in that classroom misuse of the phones was no longer an issue.

So a range of technologies were used across the school case studies to support student inquiries by accessing information, collaborating, co-constructing and sharing their ideas.

2. Traditional school curriculum, time frame, assessment and physical structures inhibit the potential of an e-networked inquiry approach to learning.

Although in some schools unreliable technologies presented a challenge, the more significant challenges faced were about the rules of time and curriculum. A teacher’s comment exemplifies this:

Inquiry takes some time to do, it’s not something that can be done in a lesson, it’s something that needs to be built. Also the students need to learn the skills of inquiry, it’s not something that’s innate... That creates an issue with assessment, our tests are knowledge-based, they don’t acknowledge the fact my students had spent two extra weeks doing inquiry.
As this quote highlights, a school environment that adopts a prescriptive science curriculum with pressure from the management on staff for the timely coverage and assessment of pre-identified topics, inhibits and devalues the development of inquiry teaching and learning skills and processes. The project found that teachers needed time to consider and plan for e-networked supported science learning that went beyond the rote learning or mere learning of facts in order that students learn to value inquiry processes such as exploring, collaborating, creating and communicating ideas. They needed “sandpit and reflection time” (Otrel-Cass, Cowie & Khoo, 2011) to try out new ideas, trial the use of e-network tools and learn where and when to use these tools appropriately as well as support their students learning to use these tools in their inquiry venture. Teachers also needed time for reflecting and evaluating the fit between the tools used and the inquiry process and goals supported in the classroom, and then to refine both the process and tools adopted in their practice.

Student reflections on the classroom structures, and the extent to which the e-networked tools supported their inquiry learning process, need to be articulated to assist teachers in refining their e-networked supported practices. For example student comments included:

*The technology helped my communication because it was easy to post questions and see posts of all the answers and any questions and get information back quickly.*

*I think you need a mixture and just occasionally bring in the technologies because sometimes it can be really effective, but I think that it’s often not that efficient.*

*If it’s an interesting topic then sweet as they will go and do it, but if not then it’s tough. We need to get given some basic knowledge and then we can take it from there.*

*We were kind of just given the laptops and told to go find stuff. I think for the amount of time we spent on the computers we didn’t actually learn a lot. If we were given specific questions to research and study we would have learnt quite a bit more.*

The students not only become familiar with using a tool(s) but also in developing their awareness and skills for engaging meaningfully in the inquiry process. To achieve this, reflection time for teachers and students was essential to enhance pedagogical and learning awareness for integrating e-networked tools in the inquiry process.

The school infrastructure of hardware, software and systems was a frustration for both teachers and students in schools where it did not fully support the types of network supported inquiry learning the teacher was trying to implement. One student commented that:

*Things seemed to take a long time when we were using the computers, the ones in class took so long to log on. For the amount of time we spent on the computers I don’t think we learnt a lot.*
In some instances, a teacher recounts how the outcome of the structural inadequacies was positive:

We were frustrated by the unreliable school network, inadequate equipment and access to a school online portal such as Moodle. So we re-evaluated and utilised what we had available, which were phones and digital cameras. This worked well as the students were able to use an everyday item that they are familiar with and create and learn in their own unique way.

When the infrastructure was supportive, teachers found that unanticipated explorations and outcomes occurred:

For the higher level class, where access to electronic media was pretty much the norm, access to online resources from home was easy for this cohort, their knowledge of online applications was high, hence the development by one group of their own web site, they also worked through as a class their own Facebook page they had set up to discuss school things.

Both the school academic structures of curricula and assessment (rules), and the available technologies (affordances), shaped the patterns of interaction within the classes and within the groups, and influenced to a significant extent the nature of the inquiry process.

3. Teachers developed confidence over time to implement an inquiry approach in their classroom and permit students to have more control over their own learning.

Over the two years of the project we found that teachers became increasingly comfortable with implementing an inquiry approach in their classroom. This developed as a result of time spent studying, discussing and reflecting on the nature of inquiry both individually and as a part of the research group, but also from classroom experimentation, which for some teachers was initially quite tentative.

As a teacher, the initial letting go of the control of the students learning was the biggest hurdle. This was overcome by the initial group planning and brainstorming that set the context and direction of the inquiry.

One teacher commented that there were some areas in which it was useful for the expertise to reside with the students rather than with the teacher:

Over the period of the project I became a lot more aware of the benefit of allowing students to learn both individually and collectively in an environment that they were very
familiar with. By not being the expert in the electronic medium, the students were able to show me the different aspects they both were familiar with and those that they had discovered along the way.

For all classes, the development of an inquiry approach was a journey shared by both the teacher and the students over time. For example, one teacher, after establishing Wallwisher as the medium for inter group communication, found that:

the students were quickly taken away from their teacher pleasing roles to that of being the expert amongst their peers. During these times the learning was very evident.

Student reflections on their experiences throughout the project, as they recognized the benefits of an inquiry style of learning, became a source of encouragement for the teachers. For example, students commented that:

I have become better at independent learning and now find it easier to research by myself.

Listening to my group’s conversation and adding my input and discussing it improved my overall learning.

Having to find information and present it in our own way was fun and challenging, it was good because we had new ways to teach which weren’t boring.

I reckon we developed independent research skills because of the technology; instead of the teacher telling us exactly what to do and what the answers were, we figured it out for ourselves.

As a key member of the inquiry learning classroom community, the teacher’s understanding of the nature of inquiry, and their attitude toward the rules that exist between the teacher and students within that community, strongly influence the nature of inquiry that is implemented in a classroom.

4. Students need support in developing inquiry learning skills such as goal setting, self management, and presenting and communicating their inquiry learning outcomes when transitioning from a more teacher directed approach to their learning.

The student who reflected that ‘There were not enough guidelines to tell us what we need to know’ represented the feelings of many students in the initial stages of the implementation of an inquiry approach. Other students, in reflecting on the early stages of the project, more explicitly stated:
We could have been given specific things to learn and to do, because we didn’t really know what we were doing at the beginning.

At the beginning there was just too much stuff it was like brain fuzz, if it had been broken down into smaller bits it would have been easier.

Other students recognized that they needed assistance with management skills throughout the task:

If we had been given a time frame as well would have been good, because some groups were like so far ahead and some were so far behind, like ‘you have till the end of this lesson to complete this task’

There was some frustration by the students throughout the tasks because the teacher was not being directive:

At the end of a section we should get a sheet from the teacher telling us what will be on the test. I’m not very visual and he gave us too much stuff all at once, so he should tell us more. I asked him if he could just tell us what’s on the test, and the rest of the class said ‘that’s what he’s doing’, but I said we need it on paper, written down

In some lessons we needed a bit more direction because sometimes we were just sitting around looking on wallwisher and things cause we didn’t really know what we should do next.

It took a long time to put the powerpoint together and if we were doing things the old way we could have learnt more in that time.

There were also specific skills that the teachers realized were necessary in order for the students to be successful:

I realized it was important to allow groups to work at own speed, let them establish their milestones and how long to reach them.

The students need help to establish an end goal for each working group, set these tasks so they are achievable but also so that they extend the learning.

A number of teachers found that the students required a scaffolding approach, not only in relation to the content and their self management skills, but also for the technologies they were using. They realized that because inquiry learning is not entirely unstructured, students needed assistance with developing a structure:
Significant scaffolding was required prior to any inquiry learning elements being introduced. This had its own difficulties as again depending on the students focus/experiences/ attitudes and abilities meant a differentiated approach was needed.

The next stage was to allow the students an opportunity to become comfortable with the resources that we had available. This started by the use of simple recordings with their phones of tasks they undertook in class as I scaffold their learning. A learning method that allowed the students to share and replay their learning was a concept I discovered by default but embraced as a unique learning tool. The reluctant students were now recording their activities, commenting on these activities and sharing their new found knowledge with others.

The teachers realized that there was a balance to be optimized between structure and scaffolding, and student ownership and direction of their own inquiry and learning. This balance varied between different year groups, but also in some classes it varied between the groups within the class. It required some time for the teachers to get to know their students well enough to achieve this balance.

**Parallels and Implications**

This project indicated that e-networks can support teachers and students in an inquiry approach to learning in which scaffolding and guidance is provided by the teacher, and groups of students decide on the issues they pursue, the data they collect and the outcomes they generate. Given the similar classroom processes, there are clear lessons here for technology education where students often work in groups, they decide on the problems to be addressed and through a process of design, collect information and data to produce an informed solution. The major implications are:

- Teachers need time to think and prepare for e-network supported student engagement that goes beyond learning facts, but also students learning what it means to collaborate, explore, create and share technological ideas.
- Students must be carefully scaffolded in developing the skills necessary for them to effectively engage in e-networked design learning – sometimes in the technological skills needed, but also in collaboration and self management skills.
- Teachers should share (and maybe negotiate) goals and guidelines on working collaboratively in design projects so students can align their learning goals and values accordingly.
- Time is also needed for students to explore and use networked technologies.
- Teachers need to be made aware that there is a spectrum of types of design learning, from very open and student directed to more teacher directed, and movement along the spectrum is facilitated by experience and the nature of the students.
• Current curriculum and assessment structures need to be developed to facilitate more design and inquiry teaching and learning approaches
• Consideration needs to be given to how to adapt assessments to acknowledge the skills and learning developed through design learning.
• Current school policies and management structures will need to be revisited if teaching and learning is to thrive in a school environment that values an e-networked supported student centred learning approach.

References


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