Abstract

This paper focuses on the Key Learning Area of Science and reports on the preliminary findings of research into the continuum of Science teaching from Kindergarten to Year 10. Experience working with both primary and secondary preservice and inservice teachers has revealed interesting similarities and differences in the teaching of Science to children. A comparison will be made between the intended science curriculum (based on syllabus documents) and the implemented curriculum and methods of teaching (from in-school data collection and teacher interviews in a secondary school and its main feeder primary schools).

Introduction

Context and background for the research

The purpose of this case study is to develop a picture of the science that is taught in a cluster of primary schools and its alignment with the subsequent secondary school science program. Two key roles of the Science and Technology K-6 syllabus are to:

- ...prepare students for life in the 21st Century and,
- ...provide background for the study in two of the eight Key Learning Areas in the secondary curriculum - Science and technology (Board of studies, 1991).

As such there should be a correlation between the programs of Science studied in primary and secondary schools. The Science stages 4-5 syllabus (Board of Studies, 1998:43) states that "Consultation with primary schools provides information on the Science and Technology experiences of students during stage 3 and assists teachers in providing a smooth transition to students". It also acknowledges that students will begin stage 4 with a variety of experiences and knowledge.

Teachers of stages 4-5 have been provided with an overview of stage 3 outcomes in the new syllabus, however the K-6 syllabus contains no information on the 7-10 syllabus. A second set of outcomes and related indicators have been produced for the K-6 syllabus that are more general than the previous ones (Board of Studies, 2000a). Presumably teacher consultation with secondary schools would provide information on the subsequent Science experiences in years 7-10 and assist teachers in preparing students for secondary school Science.

This study resulted from the following observations that were made by the researcher during primary and secondary school science teaching experience:

- Teachers of primary and secondary school science had little if any communication, therefore the two courses were being planned and taught independently.
- Similar activities featured in both primary and secondary school science programs, that is, they were selected for reasons other than children's development levels.
- Primary science activity books (texts) often included those that were a regular part of secondary school science programs.
- Pre-service primary teachers expressed concern re determining knowledge and understandings content from the syllabus (outcomes were too general).
Inservice secondary teachers generally perceive that little if any science is taught in primary schools, therefore they should assume virtually no pre-existing knowledge and understandings of major science content areas and component concepts.

The study aims to provide a research base to assist the schools in this cluster to enhance the alignment between the stages in K-10 science. This should result in primary school science experiences providing children with the knowledge and understanding, skills and motivation to ready them for secondary science. Further the secondary school science experiences should be able to build on students prior learning eliminating needless repetition and gaps in the learning program.

**Significance of this research**

This research is important for a number of reasons:

- It seeks to promote partnerships between primary and secondary science teachers to facilitate the reality of a K-12 curriculum.
- Research of this nature has scope for influencing the quality of the continuum of science teaching and learning in schools.

The results of this research will have implications for both inservice and preservice teacher education and future curriculum development.

**Limitations to this study**

The study involves a small sample comprising one secondary school and four of its main feeder primary schools. This sample size is limited and the findings would need to be ratified through further studies across a wider population.

The structured interviews with teachers is to assist in the interpretation of the written science programs, however, the information that can be gathered in a 30 minute interview is finite. Observations within each of the schools to enable a first hand view of the activities that students were engaged in would reveal further the nature of science within the sample schools.

The willingness of schools to participate in research of this nature (that may be viewed as evaluative) could influence the acquired sample population possibly resulting in bias.

This paper presents preliminary findings of content analysis (Borg and Gall, 1989) of the syllabus documents and is therefore limited by a review of the intended curriculum only. The intended curriculum may differ from the actual curriculum - that which is implemented in schools resulting from teacher interpretation and local conditions influencing science teaching and learning. The value of this study rests with the completion of the second, critical phase of analysis of school science programs and teacher interviews.

**Research questions**

1. To what degree (if any) does the content and experiences (knowledge and understandings, skills, values and attitudes) of the K-6 Science syllabus align with the subsequent Stage 4-5 (7-10) Science syllabus content?
2. To what degree (if any) does the content and experiences of the K-6 Science syllabus prepare students for the subsequent Stage 4-5 (7-10) Science syllabus content?
3. To what degree (if any) does the content and experiences of the Stage 4-5 (7-10) syllabus build on the prior learning in K-6 Science?

Literature review

This section has not been included.

The method

Phase 1

Curriculum mapping and content analysis part 1 (syllabus documents)

The documents included: - in this analysis were:

- Science and Technology K-6 Syllabus and Support Document (Board of Studies, 1991). The content (knowledge and understandings) outcomes (10-11) were analysed for the main content areas and concepts to be covered across K-6.
- Science stages 4-5 Syllabus (Board of Studies 1998).

Data relating to the content of the intended science curriculum for primary and secondary schools was established by content analysis and curriculum mapping of the Stage 1-3 (Board of Studies, 1991) and Stages 4-5 (Board of Studies, 1998) syllabus documents. The analyses and mapping will ultimately include knowledge and understandings, skills, and values and attitudes for both stages 1-3 and 4-5. This paper deals with the knowledge and understandings section only. The Science Stage 6 Support Document (Board of Studies, 2000b) includes a continuum of learning from stages 1-3 to stage 6 for Prescribed focus areas, and Domains including Skills and Values and Attitudes.

A grid was developed to map the content (knowledge and understandings) onto. The diverse structural organisation of the K-6 and Stage 4-5 syllabi required the adoption of a common framework for mapping curriculum content. The vertical axis included major content areas, which were based on the five strands from the National curriculum profile (Curriculum Corporation, 1994). The four conceptual strands (Earth and space, Energy and change, Life and living and Natural and processed materials) were used as they reflect the traditional Science areas of study: Biology, Chemistry, Earth Science and Physics. The component organisers for each strand provided smaller categories for grouping content which was facilitated by descriptions in relevant documents (Curriculum Corporation, 1994a; 1994b; Deleuil and Malcolm, 1994). The process strand, whilst overlapping with skills was included to illustrate the nature of the planned science experiences for each of the 5 stages from K-10.

The horizontal axis of the curriculum-mapping grid included the stages from Stage 1 to stage 5. Early stage one was not included because it is a category that was introduced in the revised outcomes and indicators document (Board of Studies, 2000a) but did not exist in the previous (Board of studies, 1991) syllabus. Implementation of the new outcomes is not mandatory, individual schools are to decide if and how they should be used. The outcomes contained in this recent document are fewer and consequently more general than those in the original 1991 syllabus. For these reasons this document was excluded from the content analysis.
The K-6 (stages 1-3) and Stages 4-5 (7-10) syllabus documents were analysed in the following ways:

1. Syllabus Aims were compared.
2. Organisation of the Science content was compared.
3. The Outcomes were transferred onto the curriculum-mapping grid, then summarised into condensed statements reflecting the key concepts and emphasis for each section. Keywords were also highlighted (Appendix 1).
4. A summary grid was produced from the original grid to indicate areas that were not represented across all stages.
5. Scientific terms were counted from the summary grid to indicate the degree of explicitness of Science content.

Analysis of the syllabus documents was intended to answer the following questions:

- What is the overall intent of science K-12?
- How are the syllabus documents organised?
- What concepts are covered by each stage?
- What emphasis is placed on each content area?
- What scientific terms are introduced?

**Further analyses:**

Further analyses in this phase will include:

- Science K-6 syllabus and support document. Analysis of Learning Processes, Skills and Values and Attitudes outcomes (Board of Studies, 1991: 12-17). Analysis of the Units of work contained in this document may give more insight into suggested learning experiences relating to each of the content areas.
- Science and Technology K-6 Outcomes and Indicators (Board of Studies, 1999b). The indicators will be analysed to break down the content within the main content areas. In other words to identify the component concepts that the syllabus committee intended to be studied at each stage. Whilst the outcomes are general, the indicators provide examples of activities that children may engage in to demonstrate achievement of the outcomes. Looking at each of these may provide more information as to the intended learning experiences.

**Phase 2**

**Curriculum mapping and Content Analysis part 2 (school science programs)**

The content of the actual curriculum taught in schools will be determined from similar content analysis of Science programs obtained from the sample schools. These will not only be mapped against the major content areas, but will also be contrasted with the results of the syllabus analysis from phase 1.

**Structured interviews of science teachers**

Selected teachers involved with teaching the science programs will be asked to participate in a structured interview (30 minutes long) to discuss the nature of science experiences in their school or year level taught. This will provide information not contained in the written science programs such as:
• time spent on topics
• description of science themes or content areas
• experiences provided to students
• reasons topics or concepts were or were not included in science programs.
• the sequence in which topics are usually presented
• the implications for K-10 science teaching and learning

**Sampling methods used and samples obtained**

One secondary school and five of its surrounding primary schools were approached for inclusion in this study. The secondary school was chosen for convenience by the researcher. The primary schools were selected because they provided the majority of year 7 students for the local secondary school. The five primary schools were geographically close to the secondary school and all schools in this cluster were located in similar socio-economic areas. The secondary school is a large, co-educational comprehensive school and the primary schools are medium sized co-educational comprehensive schools.

Science programs will be requested from each of the schools in the cluster. Interviews with science teachers will be sought from 2-3 teachers in each school including the head teacher science in the secondary school.

**Secondary school sample**

The Science Head Teacher will be asked to provide copies of the school science programs from 7-10 (stages 4-5). This person may also be one of the teachers interviewed. One or two classroom teachers will be interviewed about the science program (30 minutes per person).

**Primary school sample**

Selected teachers involved with teaching Science will be asked to participate in a structured interview. (One to two teachers from each school, 30 minutes per person). One of the above teachers will also be asked to assist the researcher to obtain a copy of their school's stages 1 - 3 (K-6) Science programs.

The sampling period will be between the 18th November 2000 and the 18th of December 2001.

**Instruments used**

**Semi structured interviews**

Semi-structured interviews will be used as they are generally the most appropriate for interview studies in education and provide objectivity and depth, whilst permitting the gathering of valuable data about teacher's opinions that may not be obtainable by other approaches (Borg & Gall, 1989). Interviews will be tape recorded to reduce interviewer bias towards data selection, enable more thorough studying of the interview through play back and to speed up the interview process through eliminating note taking (Borg & Gall, 1989).

**Ethical principles observed in this study**

Macquarie University Ethics Review Committee (Human research) and the Department of School Education Strategic Research Directorate procedures will be followed to ensure informed consent and ethical protection of the subjects involved.
The methods for ensuring the privacy of the participants

The following measures will be taken to ensure the anonymity of participating schools and teachers:

• Schools will not be directly named or referred to within the project. Schools will be labeled as secondary ABC, primary 1, 2, 3, 4, and 5. Any identifying features of schools e.g. school logos, contact details or names, will be removed from obtained science programs prior to inclusion in appendices or sample references within written papers or subsequent articles.
• No teacher or principal will be directly named or referred to within the project. Teachers will be labeled as teacher i), ii), iii), etc from school Secondary ABC, P1, P2, P3, P4 or P5.
• Interview transcripts will not contain any identification of teachers involved and transcribed data only will be referred to within the project.

Results and discussion

Note: these findings are preliminary only and may change as a result of further data collection.

Overall intent of Science K-10

The Science and Technology K-6 syllabus aims to develop students' competence, confidence and responsibility to enrich:

• their views of themselves, society, environment and the future and
• their enthusiasm for further learning (Board of Studies, 1991:7).

This is achieved through studies of the world around them in a broad framework with general rather than explicit content.

The Stage 4-5 Science syllabus aims to provide learning experiences that will assist students in developing:

• scientific knowledge and skills about phenomena within and beyond their experiences,
• appreciation of science as a human activity and apply science to an understanding of their world,
• positive values and attitudes about themselves, others, learning, science and the environment (Board of Studies, 1998: 8).

This is achieved through studies of broad areas of science that relate to general scientific principles encompassing Biology, Chemistry, Physics and Geology that enable students to apply science to the world around them. The content is explicitly stated and related to everyday life.

Implications

The K-6 syllabus if far more general and open ended than the 7-10 syllabus. This means that actual syllabus content may differ from the intended syllabus content due to the individual school or teacher's interpretations. Consequently children in schools within the same cluster may differ considerably or little in their learning experiences depending on
chooses or emphases taken by teachers. As children from several schools comprise the feeder population for one secondary school, children may (and likely do) enter the same secondary school with varied science backgrounds. This is not the fault of primary teachers; it is the nature of the primary school curriculum as dictated by a generalist syllabus. The existence of this trend increases the need for greater communication between primary schools and their related secondary schools in order to address this issue. An increase in awareness of the primary school curriculum by its subsequent secondary teachers and visa versa would assist in the overall science learning of the students involved.

Organisation of syllabus documents

The two syllabus documents structurally differ in the arrangement of objectives, outcomes and content. The K-6 Science and Technology syllabus is organised by 6 content strands and 3 learning processes accompanied by values and attitudes that cut across these areas.

- Content strands - Built environments, Information and communication, Living things, Physical phenomena, Products and services, the earth and its surroundings.

The 7-10 Science syllabus is organised by 3 major areas: Contexts, Prescribed Focus areas and Domains.

- Contexts - and are determined by the school or teacher. These are based on one of the following categories: motivation, conceptual meaning, communication skills, scientific literacy or personal and societal power.
- Prescribed focus areas - History of Science, Nature and Practice of Science, Applications and uses of Science, Implications for society and the environment and Current issues, research and development.
- Domains integrate knowledge and understanding, skills, values and attitudes are comprised of:
  - Knowledge and understanding - subdivided into: Models, theories and laws, Systems and structures and Interactions)
  - Skills - subdivided into: Planning investigations, conducting investigations, communicating information and understanding, Develop scientific thinking and problem-solving techniques and Working individually in teams), and
  - Values and attitudes.

Implications

The K-6 syllabus is simpler in its structure than the current 7-10 syllabus. Secondary teachers are currently grappling with the change in emphasis from the previous process based syllabus to the new more knowledge-based syllabus that is designed to be taught in contextual framework. Both primary and secondary preservice teachers first and foremost are concerned with the content knowledge and understandings that they will be responsible for teaching. Once established, such content can be taught in a variety of frameworks, e.g. topic of theme based, integrated with other KLA's or taught separately.

One of the aims of the curriculum mapping exercise was to separate the basic Science content areas and component major Science concepts from the encompassing syllabus structure. This would enable both primary and secondary teachers to quickly identify the content and concept areas that are to be emphasised in the stages for which they are responsible for teaching. A simple grid containing the major concept areas for each stage of Science teaching and learning may assist both teachers and resource developers to ensure
that the content and experiences proposed or utilised are appropriate for students learning in particular stages.

**Concepts covered by each stage**

The topics and concepts covered by each stage will be summarised and tabulated. The extract below provides and example of the information revealed by this process.

**Table 1 - Extract of summarised curriculum-mapping grid**

<table>
<thead>
<tr>
<th>Content strand: Life and Living</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organiser</strong></td>
</tr>
<tr>
<td><strong>Living together</strong></td>
</tr>
<tr>
<td><strong>Structure and function</strong></td>
</tr>
<tr>
<td><strong>Biodiversity, change and</strong></td>
</tr>
</tbody>
</table>
Firstly differences can be seen in the emphasis of content areas across the stages. For example:

- Stage one does not involve the idea of organisms living together, focusing instead on the general characteristics of living things, similarities and differences between various types and changes relating to seasonal variations.
- Stage two emphasises the dependence on other living things and the environment for survival and changes that occur in organisms during their lifetimes and consequent changes in needs.
- Stage 3 considers the human impact on the balance of nature and variations within species. (One would assume this requires some preliminary ideas about classification, although this is not explicitly stated). This stage also introduces at a rudimentary level, the idea of evolution in relation to changes in groups of organisms over long periods of time.

Stages two and three do not include specific references to structure and function of living things. Nor do they include references to the human body. However, the content strand components outlined in the K-6 Science and Technology syllabus states "the human body as a complex system" (Board of Studies 1991: 20). This suggests that there was an intention to include some treatment of human body systems in primary Science. The content strand descriptors were not included in the curriculum-mapping grid because they were not written as stage statement and it was assumed that these would be encompassed by the outcomes.

- Stage 4 includes specific concepts to be studied relating to organisms living together (adaptations, food chains & webs, photosynthesis & respiration). The cell is introduced as the basic unit of structure and function and is related including cell parts, unicellular and multicellular organisms and the beneficial & harmful effects of microorganisms. Cell specialisation and organs & systems are studies for a range of multi-cellular organisms including ways the materials are acquired for photosynthesis & respiration. Specific humans body systems are listed as well as nutritional requirements. Structural features are used as the basis for classification using simple
keys, as well as methods of food production or consumption. Simple reproduction is introduced via cell division in unicellular organisms.

- Stage 5 builds on the impact of humans on the environment through studying the biotic & abiotic features of the local environment, the cycling of materials and methods for conserving, protecting & maintaining environmental quality. The theme of structure & function continues with the cell theory focusing on how systems provide for the needs of cells, coordination systems and malfunctions relating to infectious and non-infectious diseases. The role of cell division in the growth, repair & reproduction of organisms is also included. The Watson & Crick DNA model is introduced along with its role in controlling organism features through the inheritance of genes and chromosomes and the role of mutations in the theory of evolution and natural selection.

**Implications**

Quite obviously the stage 4-5 syllabus content is much more explicit that the K-6 content. The stage 5 content builds directly on the stage 4 content. Whilst the stage 1-3 content may be considered to be assumed knowledge for the stage 4-5 syllabus - this cannot be taken for granted with such a loose framework of general rather than explicit content at the primary level. This also raises problems for primary teachers making decisions about what specific content areas should be taught at the primary level. Many primary Science teachers do not have a Science background which often results in a lack of confidence about scientific knowledge (ASTEC, 1997). A syllabus that listed the basic knowledge and understandings to be included in each content area may assist primary teachers in choosing Science activities and experiences.

**Scientific terms introduced**

This section is not included.

**Continuation of research**

The continuation of the process of curriculum mapping and content analysis will reveal further the intended curriculum in the major content areas. This will be able to be compared and contrasted with the actual curricula that are being implemented into schools through and analysis of school science programs. Mapping of the school science programs will also identify areas common to primary school curricula and areas that may be overlooked. It will also indicate areas of overlap with the secondary school syllabus content that may affect (positively or negatively) the learning of science in High School.

Teacher interviews with primary teachers will reveal how they deal with a generalist syllabus including factors affecting their selection of subject matter and class activities. Interviews with secondary teachers will reveal the methods used to determine student prior learning from stages 1-3 (and related experiences outside school) and how they cater for this in their teaching practice.
References


