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Analyzing the Hong Kong Junior Secondary Science Syllabus Using the Concept of Curriculum Orientations

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This article reports a critical examination of the design of the new junior secondary science curriculum in Hong Kong. Five orientations to science curriculum are identified and discussed: academic, cognitive processes, society-centered, humanistic, and technological. Arguments for integrating all curriculum orientations within a science curriculum are presented. Using the five curriculum orientations as analytical tools, the content of the new junior secondary science syllabus designed by the Curriculum Development Council (1998) is examined. The analysis covers the curriculum intentions, curriculum content and organization, teaching methods, learning activities, and instructional assessment. The results show that the new syllabus is dominated by the academic and cognitive processes orientations but neglects the humanistic, society-centered, and technological orientations. Directions for improving the design of the science curriculum are suggested.

Key words: curriculum design; curriculum orientations; science education

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Introduction

Recently, the Hong Kong junior secondary science syllabus has been revised by the Curriculum Development Council (CDC, 1998). The new syllabus was circulated to schools for comments in January 1997 and a full-scale implementation of it by all secondary schools is set for the academic year beginning in September 2000. The syllabus has far-reaching effects on science education in Hong Kong. It not only serves as the intended science curriculum to be implemented in classrooms but also as a blueprint for textbook writers to develop their products. Because our science teachers stick very closely to textbooks, the CDC syllabus has great impact on science teaching and learning.

The CDC Science Subject Committee (1998) collected 172 science teachers' views on the new syllabus. Unfortunately, teachers' comments and the CDC reactions mainly focused on the selection and organization of its curriculum content. Many teachers suggested that the content should be reduced. However, it is important to note that a science curriculum is more than a collection of subject matter topics. Kirkham (1989) reminded us that:

> The content of school science courses is important. Without the content it could not be called science. But science education is not just about purveying ideas, it is about making the world in which we live better understood, appreciated, and enjoyed. (Kirkham, 1989, p. 146)

Actually, the same subject matter topic, such as acids and alkalis, may be taught in different ways so that students attain different sets of learning objectives (Roberts & Orpwood, 1979, 1982). In addition to content, curriculum designers have to make decisions about other curriculum elements, such as the curriculum intent, teaching methods and assessment strategies. All these decisions are largely influenced by the curriculum orientations of the designers (Cheung, 2000; Miller, 1983), which are the essence of curriculum design.

A curriculum orientation may be defined as a set of beliefs about the

intent, content, organization, teaching methods, learning activities and instructional assessment of a curriculum. A designer's curriculum orientation is shaped by his/her background, culture, experiences, priorities, and conceptions of curriculum, teaching and learning. The purpose of this article is to delineate five orientations to science curriculum that currently prevail in the literature and to analyze the new junior science syllabus (CDC, 1998) using the five orientations as analytical tools. While only the junior secondary science syllabus is content-analyzed in this article, the five curriculum orientations can be applied to examine other science curricula. I hope that my findings would stimulate public debate about science education in Hong Kong.

The article is organized in three parts. It starts with an analysis of the characteristics of the five curriculum orientations in science education, focusing on their recommendations of the intentions, contents, learning activities and assessment strategies for school science. It then goes on to present arguments for combining these five curriculum orientations together in a curriculum to promote scientific literacy. Finally, the curriculum orientations of the new junior secondary science syllabus are identified and discussed.

Five Orientations to Science Curriculum

Curriculum design is a complex process of conceptualizing and organizing the various elements of curriculum into a coherent pattern (Print, 1993). The elements include curriculum intent (aims, goals and objectives), content, learning activities, and assessment. Different conceptualizations and organizations of these curriculum elements will result in dissimilar curriculum designs. Based on an extensive review of the research literature on science goals, content, teaching, and learning (e.g., Bybee & DeBoer, 1994; Harms & Yager, 1981; Prosser, Trigwell & Taylor, 1994; Roberts, 1995; Watts & Bentley, 1994), as well as research literature on curriculum orientations (e.g., Eisner & Vallance, 1974; Kemmis, Cole & Suggett, 1983; Klein, 1986; McNeil, 1996; Miller, 1983), five dominant orientations to science curriculum are identified in the present study. The salient features of these five curriculum orientations are summarized in Table 1.

Table 1 Curriculum orientations in science education

Orientation	Assumption	Curriculum Intent	Curriculum Content	Curriculum Organization	Teaching-learning strategy	Assessment
Academic Curriculum	Science is discipline knowledge	Understand science subject matter. Prepare students for advanced study of science. Focus on cognitive learning objectives	Factual and theoretical knowledge that reflects the structure of a science discipline such as chemistry, biology, and physics	The logical structure of a science discipline. Science concepts as the curriculum organizer.	Didactic. Students listen to teacher talk, read text, memorize laws and formulae, answer factual questions, watch demonstrations, and practice laboratory skills.	Students' mastery of scientific knowledge.
Cognitive Processes Curriculum	Science is a process of inquiry.	Teach students how to learn science. Develop essential inquiry skills.	Scientific methods. Science process skills such as observing, hypothesizing, and measuring. General inquiry processes such as problem solving, use of evidence, and analytical reasoning.	Process-led modules.	Laboratory-centered, experimental, process approach. Investigations and simulated research activities. Students learn scientific concepts by discovery.	Students' acquisition of science process skills. Correct use of scientific methods.
Society-centered Curriculum	Science is a tool for improving our society.	Help students to become socially responsible citizens who contribute to the development of society. Understand science-related societal issues.	Science-based real-world problems such as genetic engineering, ozone depletion and energy shortage. Emphasize applications of science to societal problems, environmental concepts, ethics, values, decision making, multidisciplinary studies, and careers in scientific fields.	Contemporary societal issues as the curriculum organizer.	An issue-based approach. Action oriented. Multidisciplinary approach. Cooperative activities. Investigations to find out the interconnectedness of events, people and scientific phenomena. Decision-making exercises involving scientific knowledge in a social context. Use of community resources.	The effectiveness of students to use scientific knowledge to interpret societal problems. Ability to make well-reasoned decisions. Recognize the limited role of scientific knowledge in making decisions about societal matters.
Humanistic Curriculum	Science is a human form of knowledge and a tool for personal development.	Prepare students to utilize science for improving their own lives and for coping with an increasingly technological world. Understand the human nature of science. Integration of affective, cognitive and psychomotor objectives.	Select topics that students enjoy. Scientific knowledge that is seen as useful in everyday life. Applied science topics such as food chemistry. History of science. Implications of scientific advances for individuals.	Student needs and interests as the curriculum organizer. A flexible framework that allows individual students to select the order of learning.	Student-centered. Classroom as a joyful and facilitating environment. A constructivist view of learning. Contextual learning and storyline approach. Use of illustrations and explanations that involve feeling and emotion. Narrative lab reports.	Students' personal satisfaction, self-confidence, moral character and intellectual growth. Students' abilities to use science experiences to interpret and solve personal problems.
Technological Curriculum	Technology is a connector between science and society.	Understand the technological aspects of science. Develop abilities of technological design and of locating and analyzing technology-related information.	Select contents based on the predetermined objectives. Contents focus on scientific knowledge in a technological context, technological designs, careers in technology, and the effects of technology on society.	The logical order of learning objectives as the curriculum organizer.	Student learning must occur in systematic ways. Use of programmed instruction, mastery learning and instructional technologies such as computer, film, television, and lab equipment.	Students' abilities to apply scientific knowledge to the complex technological aspects of everyday life. Competence in handling information technology.

The five curriculum orientations are internally consistent and conceptually distinct. They represent different value positions, providing alternative prescriptions for the intent, content, organization, teaching methods, learning activities, and instructional assessment of a science curriculum. Each curriculum orientation has its own history and literature. The key assumption embedded within each orientation is also shown in Table 1. It is worth noting that most of the science curricula that have been designed for use in secondary schools reflect one or more of the five orientations in different degrees. "Pure" forms are seldom found. These orientations are presented in their pure form for purposes of clarity only. A summary of each orientation is given below.

Academic Curriculum

This is the oldest and most widely used curriculum orientation in secondary school science. Advocates of this orientation believe that science is discipline knowledge and content is more important than process. The science curriculum aims at developing students' rational thinking through the study of various science disciplines such as physics, chemistry, and biology. Every science discipline emphasizes rigorous intellectual training. Teachers are an authority in a particular science discipline and students are required to understand important scientific facts, principles, laws, and theories. Students are expected to think like professional physicists, chemists, or biologists. The significant intellectual achievements of great scientists are treated like the grammar and syntax of the scientific disciplines and thus are selected as the essential content of school science. Traditional topics are taught at the secondary level and are mainly selected on the basis of the structures of scientific knowledge (Raven, 1970). For each science discipline, the curriculum content is organized on the basis of the logical relationships between scientific concepts. For example, the secondary 4-5 physics curriculum in Hong Kong is entirely devoted to the following six theoretical

topics: optics; heat; mechanics; waves; electricity, magnetism and electronics; and atomic physics (Curriculum Development Council, 1993). Chemistry teaching often starts with atomic structure, goes on to discuss the periodic table, chemical bonding, and so forth. In the academic orientation, students usually play a passive role in their learning process. Laboratories are primarily used as a place to illustrate, demonstrate, or verify known concepts and laws. Traditional assessment methods, such as multiple-choice questions and short essays, are popular. Students are tested for acquisition of what is known in science, and the assessment results are mainly used for judging whether individual students are allowed to pursue more advanced study of science.

Cognitive Processes Curriculum

Unlike the academic orientation, this orientation emphasizes science processes rather than contents. Wellington (1989, p. 15) summarized five arguments that most science educators put forward for a process-led science curriculum:

1 The content-led approach has failed.
2 'Science for all abilities' necessitates a process-based curriculum.
3 The information explosion has made the teaching of facts highly questionable.
4 Scientific facts date too quickly to form the basis for science education.
5 Skills, particularly transferable skills, are more relevant to pupils than knowledge.

The cognitive processes orientation is based on the inductive empiricist view of science (Finley, 1983). The process enthusiasts believe that there is a so-called scientific method, and students best learn science by behaving as professional scientists, engaging in hands-on laboratory work. Thus, this curriculum orientation stresses the importance of training students in scientific enquiry. Students must act as problem-solving scientists and are ex-

pected to acquire transferable scientific process skills such as defining problems, making observations, forming hypotheses, controlling variables, performing experiments, and analyzing data. The teaching of these science processes should precede instruction of scientific conceptual knowledge, and observation should be the first science process taught because it is the basis for the hierarchy of science processes (Finley, 1983). Students are required to understand the nature of scientific inquiry and essential procedural concepts such as reliability and validity. They must also master some general inquiry processes such as use of evidence, logical and analytical reasoning, and decision making. Because teachers have to teach the processes of science overtly (Screen, 1986), science teaching must take place in a laboratory and provide students with opportunities to participate in actual or simulated scientific investigations. Teachers allocate a considerable amount of lesson time for students to complete investigation planning tasks, data collecting tasks, and data processing tasks (Tobin, 1986). They also encourage students to infer scientific concepts and laws through discovery from laboratory activities. Teachers usually assess their students' performance in science investigations by observations, practical tests, or written reports. Questions are set in such a way that students are not required to recall factual knowledge to answer them (Mannering, 1990). The process approach to school science education received widespread support in the 1980s (Wellington, 1989). Examples of a process-based science curriculum include the *Warwick Process Science* (Screen, 1986) and *Science — A Process Approach* (AAAS, 1970).

Society-Centered Curriculum

This orientation views the school science curriculum as a vehicle for facilitating social change. Adherents of the society-centered curriculum believe that school science has meaning only in a social context (Carin, 1971). Science education should try to empower students to build a better world and to promote active citizenship. An issues approach to science teaching is recommended (Harding & Donaldson, 1986; Hofstein & Yager,

1982; Watts et al., 1997). The curriculum content is typified by contentious, science-related societal issues such as genetic manipulation, use of food additives, acid rain, animal transplants, fertility treatments, nuclear energy, water pollution, worldwide starvation, safety of herbicides, effects of tobacco, waste disposal, and population growth. The science curriculum emphasizes 'real life' problem-solving and the integrative nature of the knowledge base (Watts et al., 1997).

For this curriculum orientation, school science is usually presented as a questioning process (Harding & Donaldson, 1986). The curriculum content is organized into modules and progression through the modules is guided by asking questions. Teachers are expected to teach science subject matter beyond facts and concepts and lift it up to the values level (Harmin, Kirschenbaum & Simon, 1970). Decision-making is an essential part of the curriculum; students must take decisions about what information they need and how they use it. Students are provided with learning opportunities to critically analyze important societal issues, weigh alternatives, and make decisions. They not only study the social and economic issues arising from the applications of scientific knowledge, but also need to understand how society has affected the developments of science. Students often engage in action projects and simulations that emphasize collaborative work, group experiences, and development of students' critical consciousness and sense of social responsibility. To assess student performance, a teacher usually looks for evidence of students' contribution to action and their critical responses to a particular science-based societal issue. Students are often not competitively graded, and peer assessment is also a commonplace. The project Chemistry in the Community (American Chemical Society, 1998) is a good example of a society-centered curriculum; real-life chemically related societal issues, such as water quality, conservation of chemical resources and global warming, serve as the organizers for the chemistry curriculum and its sequence. Other examples are: *Science in Society Project* (Lewis, 1978), *Event-Centred-Learning* (Watts et al., 1997), and *Chemistry from Issues Project* (Harding & Donaldson, 1986).

Humanistic Curriculum

This orientation to curriculum is based on humanistic psychology (Bybee & Welch, 1972). Rutherford (1972) asserted that a humanistic science course must meet the following three criteria:

> (1) the content of the course must make substantial connections with the humanities as such; (2) it must focus on the human factor in science; and (3) the course itself must be humanely taught. (p. 57)

The major premise of the humanistic orientation is that students should be the crucial source of all science curricula. Proponents of this student-centered approach to curriculum design are self-actualizers who believe that the function of the school science curriculum is to provide each individual student with intrinsically rewarding experiences that contribute to personal liberation and development (McNeil, 1996; Moheno, 1993). The curriculum helps students realize the important role science plays in their personal lives and attempts to integrate their affective domain (emotions, attitudes, values) with the cognitive domain (intellectual knowledge and abilities). The curriculum content emphasizes the needs, interests and emotions of students so that they are better equipped to take decisions about science-related matters that affect their personal or economic well-being. Topics focus on things that are seen as useful in everyday living, such as electricity in the home (e.g., the workings of the telephone and electric iron), disease prevention, consumer science, and food hygiene. More examples of science topics based on students' everyday experiences and concerns can be found in the Salters' project (Campbell et al., 1990).

This curriculum orientation emphasizes student-centeredness and experience-based learning. Humanistic science teachers pay attention to students' prior knowledge (Laverty & McGarvey, 1991). They try to present materials imaginatively to facilitate student learning and prefer interdisciplinary teaching rather than rigid subject differentiation. Every student is an active constructor of knowledge through experience and opportunities to

discover and inquire. There must be opportunities for students to pursue their own learning projects. Humanistic science teachers like to use a historical approach to science teaching, popular science stories, and context-based learning activities (Stinner, 1995), as well as anthropomorphic and animistic explanations (Watts & Bentley, 1994). To show that science learning is fun and rewarding, teachers also like to teach scientific concepts through drama even though traditional science topics such as safety in the laboratory, electricity and magnetism (Hicks & Stone, 1986), and fermentation (Campbell et al., 1988) are involved. Alternative assessment methods, such as portfolio, direct observation, self-assessment and peer assessment, are preferred to traditional objective tests. Humanistic science educators believe that, in addition to students' intellectual achievements, their personal growth and satisfaction and appreciation of the role of human factor in scientific development should also be assessed.

Technological Curriculum

Supporters of this orientation believe that technology, such as medicine, transport, building, armament and communication, should serve as a connector between science and society. George (1981) argued that "the impact of science on our lives is felt through technology rather than directly through pure science" (p. 25). Science is the knowledge base for technology, but technology provides tools and techniques for science. Because science and technology cannot exist independently, students best learn science through teaching of scientific concepts in a technological context (Dreyfus, 1987). Thus, the technological orientation is characterized by an emphasis on applications of science in various technologies and industries. For example, biology students should be able to describe cloning methods and their use in agriculture. Furthermore, students are expected to develop abilities of technological design and to become competent users of information technology. This orientation to curriculum has been heavily influenced by behaviorism (Eisner & Vallance, 1974; McNeil, 1996).

Proponents of the technological orientation strongly believe that good teaching requires getting science subject matter across to students efficiently and effectively. Thus, curriculum designers stress systematic planning and focus on finding efficient means to a set of predetermined learning objectives. All the intended learning objectives must be written in operational terms. The organization of curriculum content is governed by the logical sequence of the objectives. Technological science curricula recommend teachers to use teaching strategies such as computer assisted instruction (Good & Berger, 1998; Marsh & Kumar, 1992) and mastery learning (Hashim & Chan, 1997). Teachers teach by small steps and manipulate the power of reinforcement. Traditional objective tests are often used to assess student performance.

Integrating Multiple Curriculum Orientations to Promote Scientific Literacy

Because each curriculum orientation has its advantageous characteristics, it is difficult for any curriculum designer to justify the selection of only one of the five orientations as the sole basis for a science curriculum. As Jackson (1992) pointed out, "Who calls oneself a new humanist or a self-actualizer or a social reconstructionist or an academic rationalist? The answer is no one does" (p. 17). Goodlad and Su (1992) also said, "In practice, virtually all patterns of organizing curricula are hybrid, especially in the rhetoric of documents developed at the societal and institutional levels of planning" (p. 338).

The concept of curriculum orientations is closely related to scientific literacy. A number of educators have argued that a multi-oriented science curriculum is essential for promoting scientific literacy (Kirkham, 1989; Millar, 1996; Roberts, 1983, 1995; Staver & Bay, 1987). For example, Roberts (1983) explained the meaning of scientific literacy as follows:

> In discussing goals of science education programs, many professionals now use the term "scientific literacy" to represent comprehensive, balanced and

> composite goal statements which cover all curriculum emphases for science education. That is, in the usage of such people, "scientific literacy" is not a narrow or specific kind of goal, on the order of a single curriculum emphasis. (p. 15).

Although Roberts (1983) did not use the concept of curriculum orientations, he emphasized that "balance is extremely important in the goals set for school science programs" (p. 34). Furthermore, a cluster of curriculum orientations has been used to underpin some recent prominent science reforms in the world, such as the *Project 2061* (AAAS, 1989, 1998) and the *National Science Education Standards* (National Research Council, 1996). The *Science-Technology-Society* (STS) approach recommended by many science educators is also a multi-oriented curriculum design. Roberts (1995), for example, analyzed the *National Science Education Standards* in the USA and concluded:

> Probably most important, though, is the observation that no one of these [curriculum emphases] is any more correct or true or right than any of the others. Each expresses a valid facet or aspect of science as a human endeavor. Each is therefore readily defensible, and certainly no one curriculum emphasis could be defended as the basis for national standards for science education for all students. (p. 77)

The five orientations to science curriculum are conceptually conflicting, but research by Cheung and Ng (in press) has confirmed that in a teacher's belief system the specific curriculum orientations actually cluster together to form a curriculum meta-orientation. Based on the five distinct curriculum orientations (Table 1), they developed a 33-item Science Curriculum Orientation Inventory. Data were collected from 810 science teachers in Hong Kong. They found that teachers valued all the five curriculum orientations. Teachers also showed no significant change in beliefs about any of the five orientations after they gained more teaching experience. However, the more experienced a science teacher was, the wider was the

gap between his/her beliefs about the cognitive processes and humanistic orientations. Furthermore, a confirmatory factor analysis of the teacher responses to the inventory indicated that science teachers' beliefs about curriculum design had a hierarchical structure; the five distinct curriculum orientations were positively correlated, forming a second-order curriculum meta-orientation construct. In other words, the five curriculum orientations in science education are mutually complementary rather than mutually exclusive. The eclectic nature of teachers' beliefs about curriculum design implies that a CDC science syllabus that has been designed on the basis of only a few curriculum orientations is not likely to receive enthusiastic teacher support. To promote scientific literacy in Hong Kong and to cater for teachers' beliefs about curriculum design, all the five orientations must be embedded within the new CDC junior secondary science syllabus.

The Curriculum Orientations of the New Science Syllabus

Curriculum Intent

The CDC (1998) recommends the new science syllabus for use in secondary 1 to 3. In the introduction section of the syllabus, the CDC states explicitly that "the primary aim of science education at the junior secondary level is to ensure that students develop the necessary scientific and technological knowledge and skills to live and work in the 21st century" (p. 2). Six broad aims are specified, which generate 26 general objectives. These 26 general objectives are divided into six groups: (1) knowledge and understanding, (2) scientific method and problem solving skills, (3) laboratory techniques, (4) communication skills, (5) decision making skills, and (6) attitude. A content analysis of the 26 general objectives revealed that 12 objectives focus on development of science process skills.

The 26 general objectives result in a total of 248 specific objectives. The emphasis on clear, predetermined learning objectives in the whole science syllabus implies that the CDC probably used Tyler's (1949) rationale for curriculum planning or other objectives models of curriculum planning

(Posner, 1998; Print, 1993). Thus, the overall design of the syllabus seems to have been affected by the technological orientation to curriculum.

Table 2 Example learning objectives from the new science syllabus

Curriculum Orientation	Example Objective
Academic	• Be able to distinguish the different forms of energy. • Be able to describe the water cycle. • Acquire some knowledge about the menstrual cycle.
Cognitive Processes	• Be able to design and perform an experiment to purify water. • Acquire skills in filtration, distillation and evaporation. • Be able to control variables to make experiments valid.
Society-Centered	• Show concern for pollution problems arising from the generation of electricity. • Show concern for the water pollution problem and demonstrate commitment to the reduction of water pollution in daily life. • Acquire some knowledge about some causes of the thinning of the ozone layer and its effects on us.
Humanistic	• Be aware of the danger of overloading in the use of universal adaptors. • Be able to take appropriate safety precautions when using fuels. • Appreciate some practical uses of lenses in our daily life.
Technological	• Develop an interest and enjoyment in studying the marvels of science and technology. • Appreciate that the advances in science and technology have brought man beyond the limits of our planet. • Recognize the advantages of using space shuttles in space programs.

However, although the 248 specific objectives cover all the five curriculum orientations (see Table 2), most of them actually reflect the academic orientation or the cognitive processes orientation. Relatively few

objectives stress the link of science to technological applications, societal issues, and the daily experiences of students. Also, students' abilities to undertake technological design, to find ways to solve science-related societal problems, and to retrieve and analyze science-related information through information technology are not emphasized. Thus, the curriculum intent of the new syllabus is largely academic and process-oriented but overlooks the humanistic, society-centered, and technological orientations.

Curriculum Content

The content of the new science syllabus (CDC, 1998) covers 15 topics: Introducing Science; Looking at Living Things; Cells and Human Reproduction; Energy; The Wonderful Solvent — Water; Matter as Particles; Living Things and Air; Making Use of Electricity; Space Travel; Common Acids and Alkalis; Sensing the Environment; A Healthy Body; Metals; Materials of the Modern World; and Light, Colours and Beyond. The syllabus is basically a subject matter core design (Ornstein & Hunkins, 1998); more difficult contents are put in the extension.

The curriculum orientation of the core contents is predominantly academic. For example, the topic "Matter as Particles" requires students to learn the three states of matter, the particle theory, and abstract concepts such as gas pressure and density. All the core contents are academic except "Applications of thermal expansion & contraction in everyday life" (CDC, 1998, p. 62). In their evaluation report, the CDC Science Subject Committee (1998) also reported:

> Unit 6 "Matter as Particles" is the only topic that is not interesting and difficult for the students, but this is an area dealing with the fundamental properties of matter and its omission is considered highly undesirable by the Subject Committee and is therefore retained in the revised syllabus. (p. 41)

The above quotation suggests that the Subject Committee did not realize that the same topic, like "Matter as Particles", could be oriented towards different learning objectives, curriculum organization, teaching methods or

assessment strategies. The academic orientation is not a must even though the title of a particular topic sounds very traditional. Unfortunately, the Subject Committee did not explore other alternative designs. The topic "Energy" has also been designed on the basis of the academic orientation. Energy shortage, for example, is not used as the main theme. Relationship between energy and students' daily life is not emphasized. Further examples of reliance of the academic orientation are found in such topics as Living Things and Air, Making Use of Electricity, and Metals.

Contents related to other curriculum orientations are also incorporated into the new science syllabus but only as a secondary or minor addition to the academic orientation. The humanistic contents include the following: household electricity; safety in handling acids; choice of utensils for cooking acidic food; everyday uses of acids, alkalis and neutralization; solvent-sniffing; a healthy body; and effects of cholesterol. Examples of content promoting values education are: causes of acid rain and its effects on the environment; noise pollution; effects of alcohol; disposal of used metals; disposal of plastics; and the influence of increasing use of radio waves on our society. There are also a few technological science topics in the new syllabus, such as a space journey and optical fibres. However, a lot of the humanistic, societal or technological science contents are treated as extensions in the syllabus. Examples include air pollution index, cost of electricity, abortion, working principle of common electrical appliances, the impact of space programmes on man, social issues in test-tube babies, preventive measures against acid rain, oral health, defects of the eye, design of a lighting system for a room, the effects of ultra-violet radiation on man, and the thinning of the ozone layer. Because these important topics are extensions of the core science subject matter, it is very likely that if instructional time grows short, teachers would set aside these "extras" to lecture the so-called "real science". Therefore, "STS-type" topics appear to play only a supporting role in the new syllabus.

Furthermore, according to George (1981), "the basic laws of science are universal, but the applications of science and technology are intensely

nationalistic" (p. 24). This suggests that the innovative topic entitled "Space Travel" might not be appropriate for science students in Hong Kong. The topic is hardly relevant to our local situations and student needs. Attempts should have been made by the CDC to select application-led topics that can promote student understanding of Hong Kong's issues in technology (e.g., our successes and failures) as well as Hong Kong's contributions to science and technology.

Curriculum Organization

The content of the new science syllabus is organized into 15 units. Science concepts rather than societal issues, personal problems or technological applications are the building blocks of the whole curriculum (see CDC, 1998, p. 7). The organization of subject matter within each unit is also based on the academic orientation. In the unit "Common Acids and Alkalis," for example, the sequence of teaching points builds systematically from the definitions of acids and alkalis towards pH scale and neutralization. Societal issues (e.g., acid rain) or personal health problems (e.g., use of antacid tablets to treat stomachache) are not used as organizing centers. Further examples are found in the units Matter as Particles, Living Things and Air, Making Use of Electricity, and Sensing the Environment.

Obviously, the CDC Science Subject Committee relied on the traditional structure of science to organize the content. Some committee members probably believe that students need to master a lot of subject matter background before they can competently learn the industrial applications or social implications — a sequence supported by the academic orientation.

Teaching Methods and Learning Activities

Each unit of the new syllabus provides a range of learning activities, some involving laboratory work, some using library search, and some requiring group discussion. The most obvious difference between the old and the revised science syllabuses is that laboratory activities are shifted from simply

demonstrating or verifying known scientific facts and principles to providing students with opportunities to develop inquiry skills and to engage in investigations — the essence of the cognitive processes orientation. Ten process skills are identified by the CDC (1998): observing closely and carefully, classifying, measuring, handling equipment and apparatus properly, communicating, inferring, predicting, proposing hypotheses, interpreting data, and controlling variables. The CDC delineates these 10 process skills using a total of four pages and recommends the following teaching strategy:

> In the teaching and learning of the above skills, efforts should initially be directed at teaching explicitly each of the skills through the use of appropriate activities, and then finally helping students integrate some or all of these skills in experimenting and carrying out investigations. (CDC, 1998, p. 16)

Learning activities related to process skills are coded in every unit in the syllabus. The particular process skills to be developed through the learning activities are also summarized at the end of each unit. However, other important skills (e.g., to retrieve relevant scientific data from the Internet, to find ways to solve science-related societal problems in Hong Kong) are not emphasized.

The CDC also briefly explains how teachers should guide students to design scientific investigations. Eighteen learning activities focusing on investigations are coded in the syllabus (see Table 3). The CDC (1998) emphasizes that the investigations "should involve a fairly genuine form of 'experimenting', including proposing questions or hypotheses for investigating, and devising ways to find answers" (p. 26). Although the CDC recommends students to plan their own investigations, it does not advise how teachers can take students' interests and needs into account to promote student-centered scientific investigations.

Table 3 Science investigations coded in the new science syllabus

1.	Design and carry out a fair test.
2.	Design experiments to purify muddy water.
3.	Perform purification experiments of students' own design.
4.	Investigate the factors affecting the rate of evaporation.
5.	Investigate the factors affecting the rate of dissolving.
6.	Perform a fair test to find the best solvent for an oil stain on a cloth.
7.	Fair tests to find out which brand of snacks contains the greatest amount of energy.
8.	Investigate the necessary conditions for photosynthesis: carbon dioxide, light and chlorophyll.
9.	Design a circuit to test for insulators and conductors.
10.	Carry out fair tests to investigate factors affecting the resistance of a wire.
11.	Make the fastest "balloon rocket".
12.	Design an experiment to find out the strength of vinegar needed to preserve fruits at room temperature for at least a month.
13.	Design an experiment to find out the effect of different pH on the prevention of apple browning.
14.	Design experiments to investigate the preservative effect of sorbic acid (or other preservatives) on fresh bread from the bakery.
15.	Compare the strength of concrete and reinforced concrete/plywood and wood.
16.	Design a device to help a dentist see the back of your teeth.
17.	Design a device to help a child to see over a tall fence.
18.	Design a lighting system for a restaurant with due consideration for the preferences of the target customers.

Thus, information about teaching and learning activities presented in the new syllabus is mainly process-oriented. Learning activities relating to other curriculum orientations are relatively rare. As examples, the CDC (1998) recommends students to read stories of how scientists make inventions or discoveries, to debate whether EM radiation affects our health, to measure blood pressure, to watch video on "test-tube" babies and debate on the related social issues such as selective breeding, to make decisions about

ways to reduce energy consumption, to design a device to help a dentist see the back of a tooth, and to conduct library search on uses of optical fibres in telecommunication and medicine. Supporters of the humanistic, society-centered or technological orientations certainly want to include more of these types of learning activities. The CDC (1998) emphasized the cognitive processes orientation, possibly because it was a reaction against a content-dominated transmission model of science teaching. However, criticisms of process skills as a basis for designing a science curriculum are commonplace in the literature. Two such criticisms are shown below:

> Clearly process science alone is not science, otherwise 'science' would automatically lead to new discovery and knowledge every time it was used. (Kirkham, 1989, p. 144)

> It cannot be doubted that a content-led approach with an over-emphasis on inert knowledge, difficult abstractions and factual recall has failed. But ...a swing to an over-emphasis on processes and skills is equally undesirable and just as likely to fail as its content-biased equivalent. (Wellington, 1989, p. 18)

Instructional Assessment

The CDC (1998) recommends teachers to use a variety of assessment methods such as oral questioning, direct observation, written assignment, practical test, paper-and-pencil test, project work and questionnaire. According to the CDC (1998), "Assessment should be designed to find out whether students are achieving the objectives set" (p. 127). Methods are suggested to assess students' knowledge, understanding, science process skills and attitudes, but assessment of students' communication skills, decision making skills, self-learning, self-confidence, understanding of technological applications of science, ability to analyze science-based societal issues, ability to solve personal problems and so forth are not mentioned. This implies that the CDC has paid more attention to the academic and cognitive processes orientations than the other three curriculum orientations. Although the CDC (1998) points out that the learning objectives

should provide a basis for student assessment, it has not considered all types of learning objectives described in the syllabus.

Conclusions

Learning scientific principles and skills has long been the focus of junior secondary science education in Hong Kong, but not enough attention has been given to other important aspects of school science, even though the syllabus has recently been revised. In this article, I applied the concept of curriculum orientations to reveal the limitations inherent in the design of the new junior secondary science syllabus (CDC, 1998). Five orientations to science curriculum were identified and discussed in the article. Analyses of the design of all the essential curriculum elements in the new science syllabus indicated that it is dominated by the academic and cognitive processes orientations but neglects the humanistic, society-centered, and technological orientations. Consequently, school science is mainly presented as abstract, boring, difficult and theoretical concepts as well as a set of process skills that are claimed to be applicable unproblematically to all scientific investigations. Although the new syllabus has included more societal issues and applications of science than the old syllabus (CDC, 1986), the curriculum still seems cold, remote and irrelevant to students' lives.

The findings of this study are of direct concern to those educators who want to eradicate scientific illiteracy in Hong Kong. To design a high-quality science syllabus, the CDC must take the five curriculum orientations into account. A better balance among those five curriculum orientations in the revised science syllabus (CDC, 1998) is urgently needed in order to promote scientific literacy in Hong Kong. We need to inject more human, societal, and technological elements into the syllabus so that students perceive science learning as relevant and meaningful. Because each unit is a building block of the whole syllabus and has its intent, content, organization, teaching methods, learning activities and instructional assessment, a better balance among the five orientations must be built into every unit. Hong Kong teachers are psychologically ready to adopt a science syllabus with

multiple curriculum orientations (Cheung & Ng, in press), but whether the CDC can design a holistic science curriculum that combines the advantageous features of the five curriculum orientations remains to be seen. Furthermore, the percentage of each curriculum orientation in a syllabus should vary with grade levels. The National Science Teachers Association in the United States, for example, has recommended that about 37% of instructional time should be spent on process skills in sixth grade, but the percentage should decrease quite linearly as students move to the twelfth grade (Staver & Bay, 1987). Such a recommendation might not be applicable to Hong Kong and further research on the percentages of curriculum orientations is needed. Thus, the challenge for science curriculum designers and textbook writers in Hong Kong is to integrate those five curriculum orientations within each of the 15 units in the syllabus and to establish an appropriate balance among them.

While the junior secondary science syllabus was analyzed in this study, the five curriculum orientations can be easily applied to evaluate other CDC science syllabuses as well. Findings generated by the content analysis of a science syllabus will be particularly useful when used in conjunction with other curriculum evaluation checklists (e.g., Pratt, 1994). The information summarized in Table 1 can also serve as a conceptual framework enabling Hong Kong teachers to design school-based multi-oriented science curricula.

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