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CURRICULUM REFORMS IN A CHANGING EDUCATION SYSTEM: A CASE OF A PHYSICS CURRICULUM PACKAGE IN SINGAPORE

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ABSTRACT

This paper focuses on the design of a Physics curriculum package that is currently in use in a significant number of Singapore secondary schools. It traces the evolution of the Singapore Education System from the survival-driven phase (1965-1978) to the efficiency-driven phase (1979-1990) to the current ability-driven education phase. The impact of these changes in the evolution of the Singapore Education System on curriculum planning and development from the predominantly social reconstructionist conception of curriculum to the academic rationalist, humanistic and cognitive conceptions will be discussed.

The Physics curriculum package being examined is designed to infuse the three major educational initiatives, namely, Information Technology, National Education and Thinking launched in 1997. Of special mention in the package is the incorporation of the 'edutainment' framework into the disciplinary-knowledge approach used in the design of the textbooks. This 'edutainment' framework seeks to present Physics as a body of content knowledge of high educational value in an entertaining way. Besides giving a description, an analysis and an evaluation of the various components of the Physics curriculum package will be made from the learner's perspective. The paper concludes with the need to incorporate some other initiatives from the teacher's perspective to improve the Physics curriculum package.

EVOLUTION OF THE SINGAPORE EDUCATION SYSTEM

Singapore is located between latitudes 1°09'N and 1°29'N and longitudes 103°36'E and 104°25'E, approximately 137 kilometres north of the Equator. It is a small country with a land area of 647.5 km^{2}. (http://www.sg/flavour/profile/Land/land.htm) and as of June 1999, its multi-racial population was about 3.2 million people, of which 77% were Chinese, 14% were Malays, 8% were Indians and 1% were other minority races (http://www.sg/flavour/profile/People/popula.htm). It gained self-rule in 1959 and independence in 1965. Since independence, the government of Singapore has made it clear that its approach to education would be in terms of the political, social and economic needs of the country (Wong, 1974). The book *Evolution of Educational Excellence: 25 years of Education in the Republic of Singapore,* published in 1990, traces the historical account of four major educational reforms from 1965 to 1990 which can be broadly divided into two phases:

Phase 1: Survival-Driven Education (1965 – 1978)

The focus during that period was on mass-education, bilingual education, social cohesion and national identity as Singapore strived to survive and thrived as a young nation. When Singapore gained self-rule in 1959, schooling was used in post-colonial Singapore as an instrument of social reconstruction. The early 1960s were characterised by a programme of rapid quantitative expansion of educational facilities and a high increase in student enrolment. This was followed by a period of qualitative consolidation in the shift from academic to technical education to provide a manpower base for industrialisation. The policy of bilingualism was for all children to learn English and a mother tongue. The learning of English was seen not only as an important window to the knowledge, technology and expertise of the modern world but also as a means to break communication and racial barriers essential to the nation building. Planning for education and, more specifically curriculum, was centrally directed and largely based on the social reconstructionist conception to meet the demands of an economy undergoing rapid and structural changes, bearing in mind the ethnic, cultural and linguistic sensitivities of the various races. The academic rationalist conception of the curriculum though important was not the main focus then. This is evident in the curriculum materials and textbooks being left almost entirely to the commercial publishers to provide.

Phase 2: Efficiency-Driven Education (1979 – 1990)

As Singapore became more affluent, the education system entered a new phase of development, characterised by efforts to rectify deficiencies in the system as well as to fine-tune the system to meet national goals and the varied individual needs of students within the system. In 1979, a review committee chaired by Dr Goh Keng Swee, the then deputy Prime Minister who also assumed the concurrent post of Minister of Education in the same year, identified two major deficiencies in the system; namely, the ineffective bilingual policy and the problem of high education wastage in the system. In the wake of the Goh Report (1979), the New Education System (NES) was introduced in February 1979 with reforms in four broad areas; namely, the structure, the curriculum, the organisation and procedure within the Education Ministry and the management of schools (Yip, Eng, Yap, Lim, Gopinathan, Ang, & Yeoh, 1990).

The focus on ability-based streaming formed the backbone of the new structure. Greater autonomy for schools and the provision of quality curriculum packages led to the setting up of a centralised curriculum development institute in 1980 known as the Curriculum Development Institute of Singapore (CDIS). Curriculum had progressed beyond the social reconstructionist conception towards both academic rationalist conception and to a lesser extent the humanistic conception.

THREE RECENT MAJOR EDUCATIONAL INITIATIVES

1997 can be viewed as a watershed year in the history of the education system in Singapore. To prepare the young for the 21st century with its knowledge-based economy driven by the twin forces of globalisation and the breakneck speed of advancement in Information Technology, three major educational initiatives were launched. On 28 April 1997, the Masterplan for Information Technology (IT) in Education was launched by the Minister of Education, Rear Admiral Teo Chee Hean, with the underlying philosophy that IT-based teaching and learning strategies would facilitate the development of skills required for the future workforce (http://www1.moe.edu.sg/press/1997/pr01597.htm).

To develop national cohesion and to cultivate the instincts for survival and confidence in the future, National Education, also known as citizenship education was launched on 17 May 1997 by the Deputy Prime Minister, Brigadier-General Lee Hsien Loong (http://www1.moe.edu.sg/press/1997/pr01797.htm). The Prime Minister of Singapore, Mr Goh Chok Tong in a speech to the 7th International Conference on Thinking on 2 June 1997 held in Singapore, launched his vision for meeting the challenges of the 21st century. (http://www.moe.edu.sg/abtmoe/pa/contact/vol10/pers.htm). This vision is encapsulated in four words, "Thinking Schools, Learning Nation" (TSLN). The Prime Minister emphasised that the concept of Thinking Schools is central to this vision. In his own words, the Prime Minister said:

> THINKING SCHOOLS will also redefine the role of teachers. Every school must be a model learning organisation. Teachers and Principals will constantly look out for new ideas and practices, and continuously refresh their own knowledge. Teaching will itself be a learning profession, like any other knowledge-based profession of the future. We will take this into account in *reviewing our school curriculum [italics added]*. Teachers must be given time to reflect, learn and keep up-to-date. Then teachers will be able to *make the textbooks and the Internet relevant to their students [italics added]*, relating what is learnt to current events and issues.

In response to the Prime Minister's vision of TSLN, an inaugural workplan seminar on "Education in Schools-Developing Thinking Schools" was launched on Saturday, 5th September 1998. At the workplan seminar, the Minister of Education, Rear Admiral Teo Chee Hean, challenged the educationists and policy planners to adopt an ability-driven strategic approach in policy planning and practice. He pointed out that the focus in the ability-driven education is on the development and maximal harnessing of the pupils' different talents and abilities.

(http://www1.moe.edu.sg/press/1998/5sep98.htm).

Critical reviews were undertaken by many practitioners from a wide cross-section of the educational institutions to see how best the current education system can be modified or refined to achieve the TSLN vision. One of the significant outcomes of the reviews was in the content reduction of the curriculum to free time for the inclusion of new formal and informal curriculum components such as the Thinking Programme, IT-based teaching and learning, National Education and Project Work. Of special interest is project work whose aim is to foster qualities such as curiosity, creativity and enterprise, nurture critical skills for the information age, cultivate habits of self-directed enquiry, and encourage students to explore the inter-relationships of subject-specific knowledge (Ministry of Education, 1999/2000).

CURRENT CURRICULUM PLANNING & DEVELOPMENT IN THE SINGAPORE EDUCATION SYSTEM

Walker's (1990) definition of curriculum as "the content and purpose of an educational program together with their organization" fits in closely to the curriculum found in the Singapore Education System (p.5). In 1996, there was a re-organisation in Ministry of Education and one of the major changes was the merging of the Curriculum Planning Division (CPD) with the Curriculum Development Institute of Singapore (CDIS) to form the Curriculum Planning and Development Division (CPDD). A significant number of curriculum writers from CDIS were also transferred to the newly-formed Educational Technology Division (ETD) to reflect the growing importance of IT in Education.

Within the framework of Singapore's education policy, the CPDD mission is to provide a balanced curriculum that will develop pupils into well-adjusted, cultured and healthy individuals; informed, thinking and creative persons, and responsible, moral citizens who can contribute to the well-being of the nation (http://www1.moe.edu.sg/cpdd.htm). Under the ability-driven education paradigm, curriculum has progressed beyond the social reconstructionist, academic rationalist, humanistic conceptions to include the cognitive processes conception whose principal purpose is to equip students with the necessary skills or processes to help them learn how to learn. T**he functions of the** Curriculum Planning and Development Division (CPDD) can be briefly summarized as follows:

1. Design, review and revise syllabuses and monitor their implementation
2. Design and develop instructional packages for selected subjects
3. Monitor and appraise the teaching and learning of curriculum subjects
4. Monitor and provide training in the effective use of instructional materials
5. Disseminate information regarding teaching strategies and act as change agents and facilitators of effective, innovative ideas
6. Take charge of special curriculum programmes, international science programmes, etc.
7. Promote the integration of information technology (IT) into the curriculum
8. Develop and monitor media resource libraries and reading programmes in schools
9. Review, inspect and authorise textbooks and supplementary materials
10. Supervise the Ministry of Education language centers
11. Take charge of the library for HQ officers
12. Provide specialist advice to other Divisions, Ministries and private publishers on matters related to the curriculum

IMPACT OF THE TSLN VISION ON THE UNIVERSITY OF CAMBRIDGE & LONDON EXAMINATION SYNDICATE (UCLES)

Since colonial times and until recently, Singapore relies heavily on the University of Cambridge & London Examination Syndicate (UCLES) for both the GCE 'O' GCE 'N' and GCE 'A' Level Examinations needs. The reasons are two-fold:

1. Unlike other countries such as Malaysia, the population of Singapore is small Hence, there is no economy of scale to set aside limited resources to conduct these three national examinations.

2. Since the University of Cambridge London Examination Syndicate (UCLES) is recognized worldwide, it is beneficial for our students' educational qualifications to be certified by UCLES. This will put them in good stead to proceed overseas for further degrees.

In the light of the TSLN vision, the CPDD has taken the lead role in the drawing up of new syllabuses to incorporate the three major educational initiatives. In 1998, CPDD conducted a syllabus review for subjects at all levels to reduce the content in order to incorporate thinking skills, national education and information technology. The various stakeholders from the schools and the tertiary institutions were invited by CPDD to be members of the various review committees to ensure continuity in the spiral curricula from primary to tertiary levels. A spiral curriculum is one where the totality of the learning experiences for each child is designed to be sequential and cumulative over a longitudinal period of time. At each level of the child's learning, there is a state of cognitive readiness to be considered whereby learning in the earlier years are reinforced in the later years in that each topic and related concepts are re-visited at a higher cognitive level. Cognitive readiness (Ausubel, 1968) in the developmental sense is a function of general cognitive maturity which in turn is largely related to the age level of the child. For the GCE 'O', 'N' and 'A' Level Examinations, these revised syllabuses with content reduction and the incorporation of major educational initiatives were sent to UCLES for their feedback and endorsement. These new syllabuses are currently being implemented with effect from January 2001 for all subjects.

THE PHYSICS CURRICULUM PACKAGE IN FOCUS

The Physics curriculum package consists of two textbooks, two workbooks, three practical books and the teacher resources. Of the package, the focus will be on the textbooks as they contain the recent educational initiatives that are aligned with the TSLN vision. The titles of these two upper secondary textbooks targeted at 15 to 16 years old students are:

1. *Physics: A Course for 'O' Level (2nd Edition)* for the Pure Physics Course

2. *Comprehensive Physics for 'O' Level Science (2nd Edition)* for the Science (Physics) Course

Textbook Design

The disciplinary-knowledge approach is used in the design of the textbooks whose content coverage in terms of breadth and depth is based on the new UCLES syllabuses. Compared to other widely used Physics textbooks such as *Physics* by Abbot first published in 1963, these two textbooks use the "edutainment" framework to minimise the undesirable perception of Physics as a body of "cold and hard" facts in these Physics textbooks. The "edutainment" framework seeks to present Physics as a body of content knowledge of high educational value in an entertaining way through the use of numerous motivational features designed to make the study of Physics an enjoyable educational experience for students. In this 'edutainment' framework for the textbooks, the key content and pedagogical features are as follows:

1. Introduction Page

A typical unit begins with a large colourful representative photographs to give a visual introduction to the unit title accompanied by a table containing the learning outcomes and an advance organiser in the form of a few general statements.

(a) Learning outcomes

The learning outcomes are based on the behavioural objectives approach. The educational objectives are stated in specific observable behavioural terms that serve as goals that can be measured and evaluated accurately (Hogben, 1972). These learning outcomes, also known as instructional objectives allow both the teachers and students to focus in the attainment of a specific array of behaviors (Eisner, 1969). The learning outcomes which are learner centred are drawn from the new UCLES Physics syllabuses.

a. Advance organizer

Advanced organisers in the form of a few general statements are presented to sensitise the students to some important aspects of the topic before they proceed to read the unit. In the epigraph to his book, *Educational Psychology: A Cognitive View*, Ausubel (1968) made this statement, " If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (p.iv). Ausubel's idea of having an advance organiser is to activate the student's prior knowledge to help bridge the gap between knowledge they already possess and new knowledge to be learnt. Advanced organizer is fundamentally an instructional strategy - a small part of Ausubel's assimilation theory of learning (Novak, 1998).

2. Body Text

Besides having full color photographs, clear annotated diagrams and taking care of the language appropriateness and style, the body text also contains the following:

(a) Quick facts

These are key points presented in boxes at the beginning of each section that are related to the learning outcomes to provide a quick overview of the section. It can also be used for quick revision before a test or examination.

(b) Worked examples

Worked examples are designed specifically to show students how to apply concepts/principles in problem solving. The examples are carefully chosen, bearing in mind that the students might be novices in problem solving. Worked examples are powerful instructional devices that provide an expert's problem-solving model for the learner to study and emulate. Research studies by cognitive psychologists have shown that the use of worked examples were effective for skills acquisition in problem solving especially in early stages of skill development (Atkinson, Derry, Renkl, & Wortham, 2000).

(c) Self-assessment questions (SAQs)

These are short questions that use the cognitive psychology to reinforce the learning of key concepts and principles. Most learning theories are in agreement that learning is effective only when it is accompanied by reinforcement (Bloom, 1982). These reinforcement questions are set at the end of each section to enable students to reflect and process what they have just learned. They require the students to do more than recall the facts. The questions promote thinking and the application of facts.

(d) Experiments (including IT laboratories) & home-based activities

Historically, the knowledge of Physics is created from experimentation rather than a set of propositions. Experiments and home-based activities provide students with the experiential knowledge that will help them to understand and apply the concepts/principles they acquire in theory. The use of IT hardware in the form of dataloggers and software such as Science Workshop, Data Studio and spreadsheet allows students to appreciate the power of IT in collecting, processing and plotting data accurately and quickly with the help of computers.

(e) Web Activities

Computers are the latest in a continuing technological evolution that is helping to improve the means by which teachers teach and students learn. It enhances the quality of education. Suitable web activities in the form of animations, applets and other applications such as "Crocodile Clips" serve as powerful teaching and learning tools. Suitable websites allow learning to go beyond the confines of the classroom into what is commonly known as 'borderless' learning to further explore and enrich the students' knowledge. One example taken from Unit 16 on Sound of the textbook *Physics: A Course for 'O' Level (2nd edition)* is

> *The following website simulates the use of ultrasound imaging as a technique used to "see" the inside of an object,*

<http://www.explorescience.com/activities/Activity_page.cfm?ActivityID=43>

(Chew, Leong & Chow 2000, p.249)

a. **Physics gossips**

These are interesting anecdotes placed at the end of some major sections of the unit as a motivational element by presenting the "lighter" and human side of Physics. In this way, Physics will be made more palatable and not be seen as hard facts. An example taken from Unit 5 on Turning Effect of Forces of the textbook *Comprehensive Physics for 'O' Level Science (2nd edition)* is as follows:

It was recorded that Archimedes made the following statement:

Give me a place to stand and I will move the Earth ! Archimedes was explaining to his friends that he could apply the law of levers (an extension of the Principle of Moments) to move any weight. He was carried away by the power of the argument when he suggested that, were there another earth, he would go there and lift our own planet from it. Do you think he knew the mass of the Earth when he made the wild claim ? had he known that the mass of the Earth is 6×10^{24} kg 6 followed by twenty-four zeros), he would have had to eat his own words.

(Chew & Leong 2000, p.72)

b. **Do you know?**

With regards to the value of intellectual curiosity, Paul (1999, p. 9) commented that

> *intellectual curiosity is an important trait of mind,….After all, intellectual curiosity is not a thing in itself, valuable in itself. It is valuable because it can lead to knowledge, understanding, and insight, because it can help broaden, deepen, sharpen our minds, making us better, more humane, more richly endowed persons.*

The feature "Do you know?" is designed specifically to promote intellectual curiosity. These are interesting facts pitched at a greater depth to spark off interest among learners to seek knowledge beyond the textbook. An example taken from Unit 6 on Work, Energy & Power of the textbook *Comprehensive Physics for 'O' Level Science (2nd edition)* is as follows:

Do you know

that recycling aluminium, the metal that is used in soft-drink cans, uses only 5% of the energy that would be required to produce it from the raw ore ? A large percentage of solid waste is paper ?, If recycled, it requires only about one-quarter of the energy needed to produce paper from wood pulp ?

(Chew & Leong 2000, p.97)

c. Physics Puzzles

These are problems to challenge students to engage in productive thinking in line with what Treffinger (1993) defined as productive thinking which focused on several important operations or processes:

- gathering, organising and analyzing information;
- generating ideas;
- refining and testing ideas;
- making inferences, deductions, choices and decisions;
- finding and solving problems;
- continuously monitoring, reflecting, and evaluating;
- implementing decisions and action plans

An example of a puzzle taken from Unit 6 on Work, Energy & Power of the textbook *Comprehensive Physics for 'O' Level Science (2nd edition)* to promote productive thinking is given below:

> *Combining the two formulae $V = IR$ and $P = VI$, we get two other formulae $P = V^2/R$ and $P = I^2R$. It seems that, according to the formula $P = V^2/R$, the smaller the resistance, the larger the power loss is, but according to the formula $P = I^2R$,, the larger the resistance, the larger the power loss is. Now, which is correct? Can both be correct?*

(Chew & Leong 2000, p.274)

(i) Thinking Room

This is a special feature to promote reflective thinking by introducing interesting real life problems for the students to solve them. John Dewey (1859-1952) who is regarded as America's most important philosopher and a leading educational theorist, asserted that unless the student had an opportunity to use the information in problem solving and action, the information is lifeless and unlikely to remain to be committed to memory. He sees the human being as an inquiring organism who is by nature stimulated cognitively through the process of problem solving which will in turn lead to meaningful experiential learning (Phillips & Soltis, 1985). An example of a Thinking Room which seeks to develop creative problem-solving is taken from Unit 2 on Speed, velocity and Acceleration of the textbook *Physics: A Course for 'O' Level (2nd edition)*:

> *Imagine the following scenario: During a public display at the East Coast beach where the weather was clear with a strong sea breeze, a thin parachutist jumped out from a hovering aircraft at high altitude. He was followed closely by a fat parachutist who jumped two to three seconds after him. Due to a technical fault, the thin parachutist had difficulty opening the parachute. He frantically signalled to the fat parachutist for help. What is the best possible solution to save the life of the thin parachutist?*

(Chew, Leong & Chow 2000, p.32)

(j) Concept maps

These are pictorial summaries (Novak, 1991) to show the relationships between the various quantities in

Physics. Pictorial summaries show the students how knowledge can be organized and presented in meaningful ways to give insights into the subject matter. Novak (1991) found that when students gained skill and experience in constructing concept maps, they began to report that they were learning how to learn. They were becoming better at meaningful learning and found that they can reduce or eliminate the need for rote learning. In other words, concept maps played a key role as a tool to represent knowledge held by the learner, or the structure of knowledge in any subject matter domain. An example of a simple concept map, taken from Unit 3 on Forces of the textbook *Physics: A Course for 'O' Level (2nd edition)* is given in Appendix 1.

a. **National Education Activities**

National education activities serve to stimulate students to conduct some basic literature research and appreciate or apply physics concepts to the challenges and constraints facing Singapore. Where possible, these activities serve to build a sense of confidence and belonging to the country. An example taken from Unit 2 on Speed, Velocity and Acceleration of the textbook *Comprehensive Physics for 'O' Level Science (2nd edition)* is as follows :

> *Visit the school library or the community library and look up books about the Singapore Armed Forces (SAF). Find out about the capabilities of fighter jets, missiles, ships and armoured vehicles used by the SAF. In particular, find out about the speed and range of these equipment.*
>
> *(Chew & Leong 2000, p.3)*

2. **Exercises**

Educational psychologists have shown that a powerful way to engage students cognitively is to get them to process information. This is the reason for the provision at the end of every unit an exercise at the end of every unit. The exercises comprise a variety of questions ranging from multiple-choice questions, simple structured questions to past year questions culled from a few examination boards. The questions allow students to assess themselves on their understanding of the concepts and principles. Answers are also provided for immediate self-evaluation.

Workbook Design

Besides the unit exercises provided in the textbook, workbooks are also made available to give students the opportunity to master the scientific knowledge and skills. Foundational questions are classified into unit exercises that correspond to the units in the textbook for formative assessment. The worksheets in the workbook are deliberately kept short to allow the students to encode knowledge and skills through the combination of listening to the teacher during the lessons and practising the problems set in the worksheet. In addition, enrichment puzzles are also provided to re-package the homework in a creative way to motivate the students and enhance learning. Trial examination papers are provided for summative assessment to prepare the students for their school-based or national examinations.

Practical Book Design

The practical books are designed to equip students with both the practical and thinking skills. The great importance of science practical in the development process skills (practical and thinking skills) can be summarized by these words: "I hear, I forget; I see, I remember; I do, I understand". Besides the experiments, there is a section on skills build-up that seeks to address the need that practical skills used in experiments are made of a composite of multiple skills. These skills build-up exercises can be done any time during the school year. It is especially meaningful if these exercises are done after the students have shown that they do not possess such skills. To let students practise their skills, two practice exercises are included just before the actual experiments. In addition, there are also introductory notes on the safety procedures, instruments used in practical work, two simple activities for enrichment purposes and an answer booklet containing the solutions to the practical questions.

Teacher's Resources

To facilitate the teachers using this Physics package, the teacher's resources contain the following components:

1. ***Scheme of Work***

   There are 4 terms of ten weeks each for the secondary schools in Singapore per calendar year. A suggested scheme of work detailing the weekly topics (both theory and practical with National Education, Information Technology and Thinking activities incorporated where appropriate) is provided to help teachers achieve the learning outcomes listed in the syllabus.

2. ***Solutions to the questions/exercises in the textbook/workbook.***

   A handbook containing suggested solutions to the Self-assessment Questions, Puzzles, Thinking Room and Exercises in the textbook as well as Exercises and Enrichment Puzzles to the workbook are provided as a guide to the teachers using the physics package.

a. CDROM and Dedicated Website (http://www.teol.com.sg)

To optimize the curriculum time allocated for the teaching of physics, a customized teacher-centred CDROM is currently being produced to empower the teacher as a powerful pedagogical tool. In addition, a dedicated website containing all the URLs in the textbook arranged according to the units is provided for online learning and teaching. With regards to the integrating of IT in schools, Tapscott (1999, p. 48) made the following points on educating the net generation: "*The ultimate interactive learning environment is the internet itself…. The digital media is causing educators and students alike to shift to new ways of thinking about teaching and learning*".

Tapscott (1999. pp. 48 - 51) went on to list the following eight shifts of interactive learning:

i. From linear to hypermedia learning
ii. From instruction to construction and discovery
iii. From teacher-centred to learner-centred education
iv. From absorbing material to learning how to navigate and how to learn
v. From school to lifelong learning
vi. From one-size-fits-all to customised learning
vii. From learning as torture to learning as fun
viii. From the teacher as transmitter to the teacher as facilitator

THE WAY FORWARD

This Physics curriculum package is comprehensive in having both the print and non-print content and pedagogical components for both students and teachers. However, there is still room for improvement because the components in the physics package are designed from the learner's perspective. There is a need to incorporate the following initiatives from the teacher's perspective:

1. **Supplementing the teacher resources with a teacher handbook that contains the constructivist teaching & learning strategies**

The traditional view of teaching and learning is that the learner can acquire every established fact, skill, concept and word of wisdom taught to them by the teacher. Teachers are mediators between scientific knowledge and student understanding (Clements & Battista, 1990). The constructivist view of learning and teaching, however, emphasizes that learners actively create or construct their own knowledge and meanings. Besides the personal construction of knowledge, social interaction is also important as human experiences always include interaction with others. Students want to have their experiential reality confirmed by others and also want to know what others think (von Glaserfeld, 1989).

One useful strategy in the constructivist approach is for teachers to use group learning whereby students are given the opportunities in class to solve a given problem (Stanbridge, 1990). Students work in pairs to solve the problem. Each pair shares their constructs with another pair. The teacher-centred approaches of either " pouring in " or "pasting over" new knowledge is now replaced by the student-centred approach of "processing through" new knowledge in the constructivist approach. A teacher handbook containing the various teaching and learning strategies will definitely be a very useful resource for the package.

2. Building a learning community of physics teachers

According to the book *The Fifth Discipline: The Art & Practice of The Learning Organisation* by Peter M. Senge (1990), the missing dimensions in the Physics curriculum package are the building up of a shared vision and team learning, two of the four core disciplines in the building of a learning organisation. Most physics teachers upon graduation from their pre-service courses are left very much on their own to upgrade themselves through in-service courses and the annual Science Teachers Association of Singapore (STAS) workshops. There is generally a lack of networking with other physics teachers outside their own schools. In recent years, though the cluster concept of grouping a few schools within the same zone is a positive step in fostering networking amongst physics teachers within the cluster, there is still a need to develop a shared vision of building a learning community of physics teachers beyond the confines of the schools and even clusters for greater team learning. This shared vision of building a learning community of physics teachers amongst schools at the national level is currently being spearheaded by the authors of this physics curriculum package with inputs from experienced physics teacher educators at the National Institute of Education. The strategy adopted by the physics authors involves the planning of regular Physics Education Seminars. The aim of the seminar is two-fold:

a. To allow the authors and the experienced physics teacher educators from the National Institute Education to share with the physics school teachers the latest research findings on physics education.

b. To provide a platform for networking among a greater pool of physics teachers.

CONCLUSION

Since independence in 1965, curriculum reforms in Singapore have been driven largely by the country's need to remain economically competitive in a world where the only constant is change. Yet, Singapore has to be mindful of the need to ensure national cohesion. This explains why curriculum planning, development and implementation in

Singapore are centrally directed using the four orientations of social reconstructionist, academic rationalist, humanistic and cognitive conceptions as the framework to achieve a fine balance.

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Appendix 1

Concept Map on Forces

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