

# Learning and Its Implications for Teaching: Two Case Studies from Canadian and Hong Kong Schools

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Do Hong Kong students dislike innovations and want to be taught? Traditional opinions suggest that they do, although there is accumulating evidence to show that students in Anglo-Chinese schools are not particularly predisposed to that expository, didactic mode of teaching. Most of them do like innovations. They prefer their classrooms to be different from what they are, and they should learn much better under innovative than under expository teaching. In the present paper, the author, with two case studies put forward, attempted to show that prior knowledge and learning environment in fact have a sound effect on the learning approach. The results showed that before discussion, students in Hong Kong tended to be more "surface" in their learning strategies as compared to their Canadian counterparts. With the introduction of innovative measures of teaching into the Hong Kong classrooms, it was possible to change students' conception from a lower ordered to a higher ordered one. This throws light on local educators in the teaching and learning of complicated scientific concepts.

香港學生究竟是否傾向傳統授課方法呢? 很多人都認為如此, 但也有研究指出, 英文中學的學生, 並沒有特別傾向傳統的教學法。其實, 大部份的學生比較喜歡新式的學生為本位的教學法。他們期望有不同的課堂氣氛, 使他們在新教學法中, 學習效果有所提高, 在本文中, 作者嘗試將兩個個案研究配合, 顯示學生在前的知識概念及學習環境對學習取向有很大的影響。在課堂討論前, 香港學生與加拿大學生的比較, 較傾向於採用表面取向。但在課堂採用新教學法後, 結果顯示香港學生的知識概念由低層次被提升至高層次水平。此結果對於本地教育學者在教授及學習複雜理科概念的問題上, 有一定的啟示。

## Introduction and Literature Review

Understanding how students learn is achieved by research methods that conceptualize the student in the context of the classroom, school, or tertiary institution (Biggs & Watkins, 1993). A consequence of this position is that the student's perspective is important.

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This paper is an extension of the joint article "Who benefits from mastery learning?" with Professor John B. Biggs, Department of Education, University of Hong Kong, presented at the ninth Annual Conference of the Hong Kong Educational Research Association, Hong Kong, November, 1992.

I am indebted to Wong Wing-wai, my former Biology colleague and current Guidance Master at Po Leung Kuk Lee Shing Pik College, who interviewed students on their responses to mastery learning teaching strategies, and for suggesting some of the arguments in this paper.

I am grateful to Professor John B. Biggs, Department of Education, University of Hong Kong, Pokfulam Road, Hong Kong, who directed me to the research reported in paper in the Hong Kong context, and Professor Gaalen L. Erickson, Department of Mathematics and Science Education, University of British Columbia, Vancouver, Canada, who permitted me to use one of his graduate classes for this research.

Researches into student learning have shifted in recent years to focus on the learner himself/herself, with emphasis on his/her responses to the learning materials, and this shift of focus has important implications for teaching. Along with this trend of development, two main approaches to learning are discerned: surface and deep (Biggs, 1987; Marton, Hounsell, & Entwistle, 1984). The concept has two dimensions: a predisposition to approach learning tasks in a deep or surface way, and the "on-line" processing strategies, classifiable as surface or deep, that a student actually uses in handling a particular task (Lai & Biggs, 1994). Marton and Saljo (1976) called easily testable particulars of the learning materials the "signs" of learning. If the learner only concentrates on and reproduces these signs of learning without integration, he/she definitely engages in a "surface" approach of learning, as opposed to a "deep" approach. In the latter, the learner should seek meaning from what the signs signify (Marton & Saljo, 1976).

With this in mind, it is idealistic that school learning should prepare students for a "deep" rather than a "surface" approach to learning. However, it is clear that students' learning theories are constructed

from the context in which they learn. If students perceive school learning as unrelated to their goals and experience, or worse still, as beyond their ability, they will resort to the rote learning strategy so as to secure a pass. In this way, students just focus on discrete aspects of the learning materials, such as the actual words, without paying attention to the actual meaning involved. It has been found empirically that the learning outcome of such an approach is rich in minor detail, but usually irrelevant to the question or is structurally impoverished. This, being in SOLO terms, is usually no more than multistructural (Biggs, 1979; Watkins, 1983).

On the other hand, if school learning is delivered in such a way that it relates to students' prior experience and knowledge, students will hopefully employ the deep approach. They will start to construct meaning from the learning materials by integrating the task components. Learning, in this sense, is a means to enrich their experience and is therefore rewarding. The outcome of learning is likely to be at least relational and possibly extended abstract, in SOLO terms.

The present study is designed to see how the outcomes of learning in SOLO terms are related to approaches to learning by comparing two independent case studies in Canada and Hong Kong. The purpose of this is to show how the difference in outcome of learning of the two groups is related to the learning context. In addition, it is unquestionable that surface approaches lead to what many would regard as undesirable outcomes of learning, whereas deep approaches lead to desirable ones. In view of this, it is desirable that all aspects of teaching should help learners to engage in deep rather than surface approaches to learning. With this in mind, it would be appropriate for the author to include a discussion of a small-scale investigation conducted in Hong Kong which looked into students' thinking. In particular, this will focus particularly on the notion of extracting, confronting, and progressing from lower order conceptions to higher order conceptions as measured in SOLO terms. Lybeck (1981) gives an excellent example of how a group of students, by learning about each other's ways of thinking, functioned together on a higher conceptual level than any of the individuals singly did.

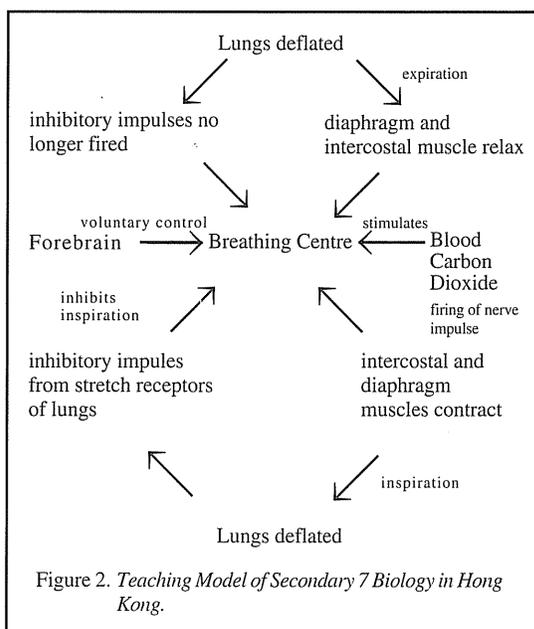
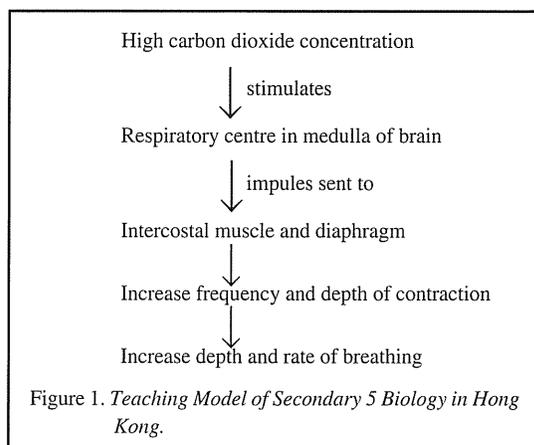
## The Present Study

### Case Study One: Canadian Context

#### Subjects

The participants in this study were a group of graduate students and their professor in a graduate

course (science education) at a Canadian University. The author introduced two models of breathing in class. They are illustrated in Figures 1 and 2.



#### Treatment

The author presented the two models one by one, starting with the simple one. Before the presentation, the author stressed that these two models were taught in Secondary 5 and 7 Biology in Hong Kong high schools. The first model emphasized that 'high' carbon dioxide concentration will stimulate the respiratory centre in the medulla oblongata of the brain which subsequently initiates a series of activities in the effectors (intercostal muscles and diaphragm), resulting in faster and deeper breathing.

In the second model, a few more steps were introduced in comparison to the previous model: lung inflation, stretch receptors on lung, inhibitory impulses from stretch receptors, expiration and so on.

Participants were then asked to discuss these models in groups of two and then each group was asked to 'construct' their own models. After the discussion, representatives from each group were asked to come out to present their own models. These models are displayed in Figures 3 to 5.

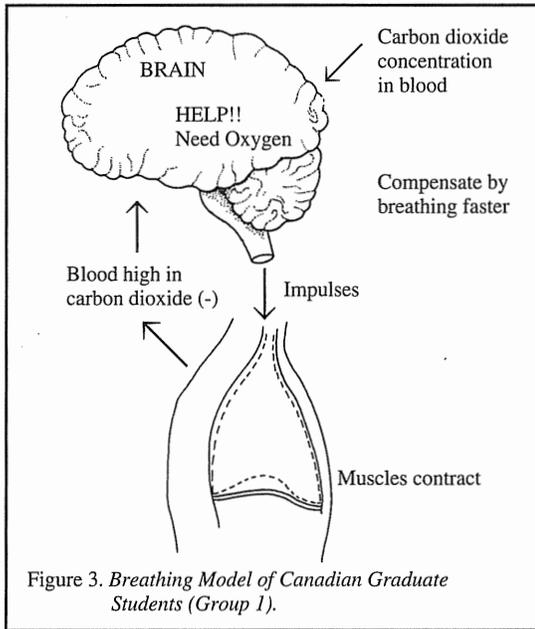


Figure 3. Breathing Model of Canadian Graduate Students (Group 1).

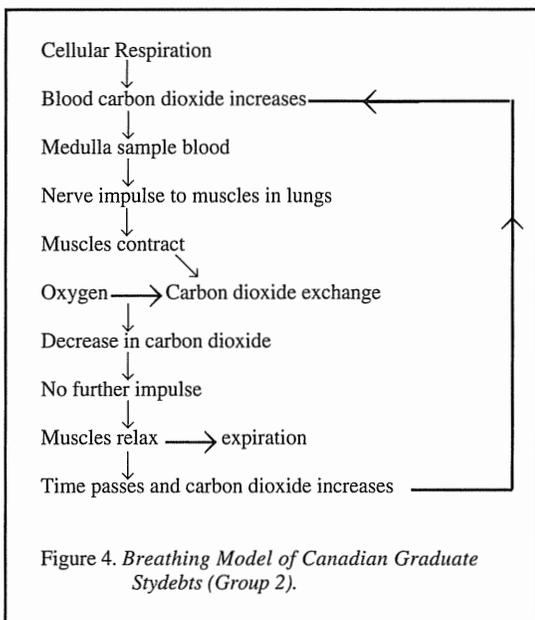


Figure 4. Breathing Model of Canadian Graduate Stydebts (Group 2).

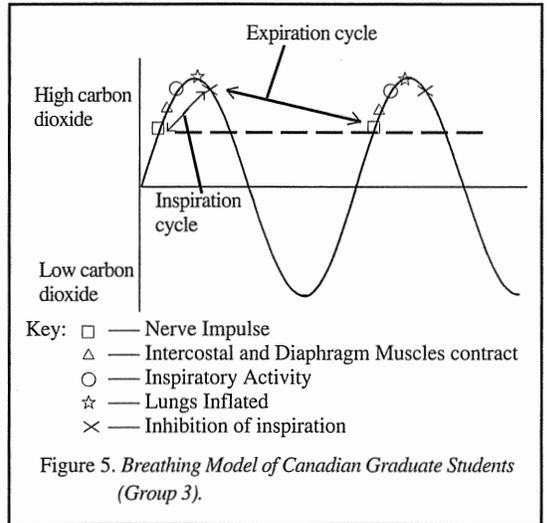


Figure 5. Breathing Model of Canadian Graduate Students (Group 3).

### Instrument

In order to assess the outcomes of learning as are explicated in the various figures, a model which describes increasing competence of learning was selected. Biggs & Collis (1982) did in fact show that students learn quite a wide range of materials in stages of ascending complexity, which is common across different subject curricula. This conception led to the formulation of the "SOLO taxonomy", SOLO representing Structure of the Observed Learning Outcome. The instrument is useful for developing the criterion-referencing assessment which is the basis of school-based curriculum development (Biggs, 1989). This taxonomy enables the assessor to identify different stages at which a student is operating in his/her learning process. The stages involve the following:

- attempt to approach the task, but the response is in no way related to the question (*pre-structural*)
- one (*unistructural*), then several (*multistructural*) aspects of the learning task are addressed, but no attempt has been made to link them up
- several aspects of the task are brought out and integrated into a coherent whole (*relational*)
- the coherent whole is further developed into an abstract level (*extended abstract*).

The SOLO taxonomy, based on the structural complexity of the responses implicit in the different breathing models, was used as a qualitative interpretative instrument. In other words, this was an indication of the level of the structural complexity of the content of the responses, and hence provided a qualitative measurement of the learning outcomes. From

these outcomes, it is possible to relate them to different approaches to learning, which have been labelled as surface or deep approaches.

## Results

According to the SOLO levels, the models shown in Figures 3 to 5 can be analyzed on this hierarchical scale as follows:

### *Model 3*

It extracts one relevant fact, and is therefore unistructural. Members of the group had linked breathing only to inspiration. This partial account cannot be called a complete explanation.

### *Model 4*

It contains several relevant facts. Members of the group somehow tried to relate breathing to inspiration and expiration. Attempts had been fostered to integrate the parts together into a coherent whole. The response was classified as relational.

### *Model 5*

It employs a higher-order principle involving graphical interpretation of the teaching models delineated in figures 1 and 2, which is related not only to the given concept of an increased carbon dioxide concentration on breathing rate, but also to the phase change of the breathing cycle. This abstract level of phase change, not made explicit in the teaching models, was brought out by members of the group. They were thinking more abstractly than the others and therefore, the response was classified as the extended abstract level in SOLO terms.

## Case Study Two: Hong Kong Context

### *Subjects*

The study was completed by the author in 1990 with a group of secondary 7 Biology students in a Hong Kong secondary school. Within this group of students, half of them were secondary 5 repeaters and all of them were internal students, promoted from secondary 5 of the same school. They have been used to the expository didactic teaching style for many years.

### *Treatment*

The author employed two forty-minute periods for the study. During the first period, the teacher introduced the topic on the control of ventilation from the textbook. The students were then asked to form groups of their own choice. This was done spontaneously, as these students usually sat at the same bench in the laboratory. During the group discussion, stu-

dents were asked to relate the present model with the one that was presented in secondary 5. Then, they were asked to present their model to the class at the end of the two periods. During the second period, students were asked to comment on each others' models. Interactive questions arose among students. They were allowed to make their ways of thinking about the content explicit. It was hoped by doing that, students would be able to reflect on each other's way of thinking about a concrete problem. Finally, they were asked to revise their models.

### *Introduction by teacher*

The teacher began the class by introducing the model on the control of ventilation in the textbook. The model is displayed in Figure 2.

Then, the teacher proceeded to explain this model and challenge the students by some questions (the dialogues were recorded in Cantonese and are translated here):

"Model 2 states that carbon dioxide from respiratory activity will be sensed by the breathing centre that will initiate inspiration. As the lung is inflated, inhibitory signal will be sent to the inspiratory centre to stop inspiration and initiate expiration. As the lungs are deflated, inhibitory impulses are no longer fired, and inspiratory activity starts again cyclically."

"Please relate this model to the one taught in secondary 5 (see Figure 1), relating carbon dioxide concentration to breathing rate."

"How does a change in the carbon dioxide concentration lead to a change in breathing rate and depth?"

### *Discussion in class*

Students were then asked to form groups to discuss for a period, during which two different models emerged. These are displayed in Figures 6 and 7.

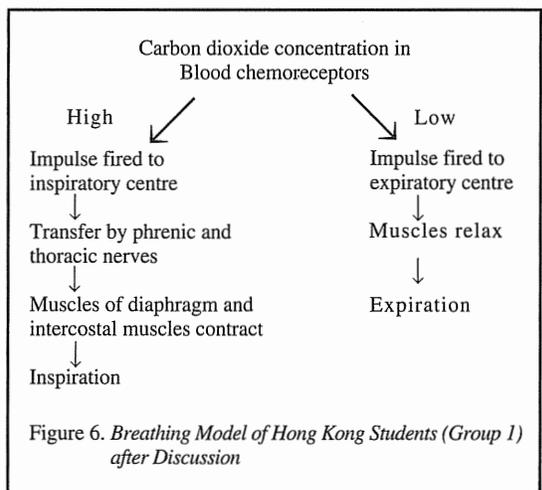
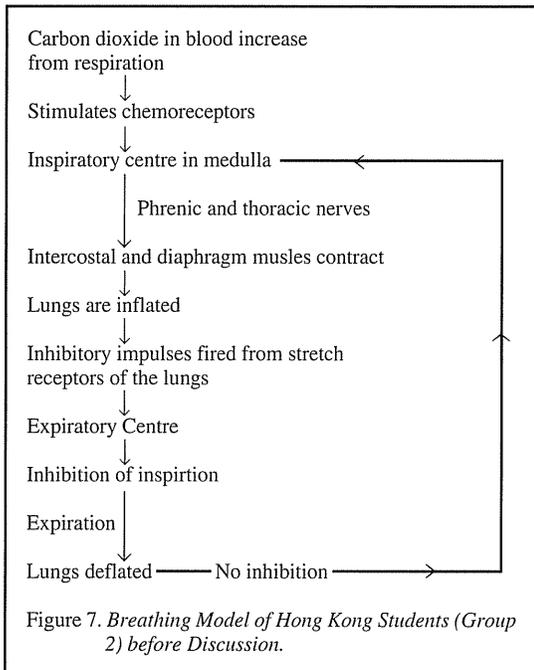


Figure 6. Breathing Model of Hong Kong Students (Group 1) after Discussion



One member of the group (the group which gave the model in Figure 6) told us that he recalled from memory vividly that the secondary 5 model (see Figure 1) read like this:

“An increase in carbon dioxide concentration will be sensed by the respiratory centre of the medulla, which in turn will send impulse to the intercostal muscle and diaphragm to increase the depth and rate of breathing.”

According to this student, he found it very difficult to integrate this concept into the existing teaching model (see Figure 2) for this model contained a lot of details. He went on to explain that he focused on the literal meaning of the individual parts at first. Later on, he sorted out the information and came up with the existing model. Then questions were raised by other students after they had examined this model (see Figure 6) for some time:

“Does high concentration of carbon dioxide only lead to inspiration?”

For the above question, the student emphasized the word ‘high.’ This elicited responses from the first student:

“High carbon dioxide concentration will lead to inspiration. As the person breathes in, oxygen in the air will diffuse into blood to lower the carbon dioxide concentration.”

This stimulated a query from other members of the class:

“Is carbon dioxide alone sufficient enough to cause ventilation?”

With this challenge, the first student suddenly realized that there might be something wrong with his concept of ventilation. The teacher, at this stage,

entered into the discussion by asking the following question:

“Do you still remember the resuscitation apparatus? What is the composition of the gas necessary to revive the victim?”

Dialogue among members of the class resumed:

Student: “It contains a lot of oxygen gas and a small amount of carbon dioxide.”

Teacher: “What is the use of carbon dioxide?”

Student: “It stimulates the respiratory act.”

Teacher: “What kind of respiratory act? Inspiration or expiration?”

Student: “Inspiration. Ah! I understand.”

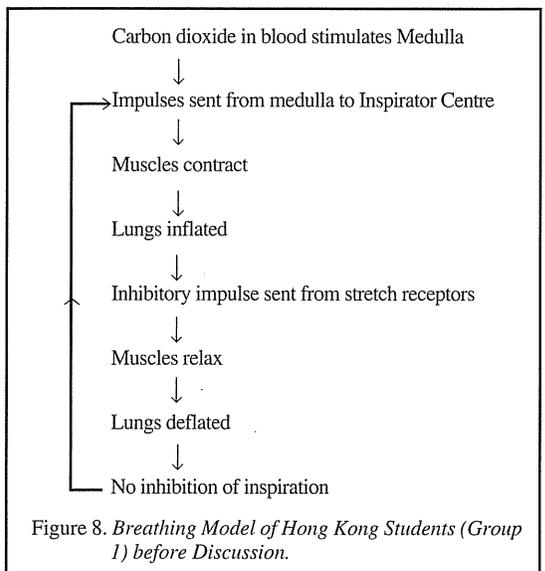
Through this interaction between student and student, student and teacher, the first student finally realized that the presence of carbon dioxide itself, not necessarily of a high concentration, is basically enough for stimulating the respiratory act. He told us that his misconception arose from the grade 5 model in which he associated the prior knowledge that only an increase in carbon dioxide concentration can stimulate breathing, which was implied in his group model (see Figure 6).

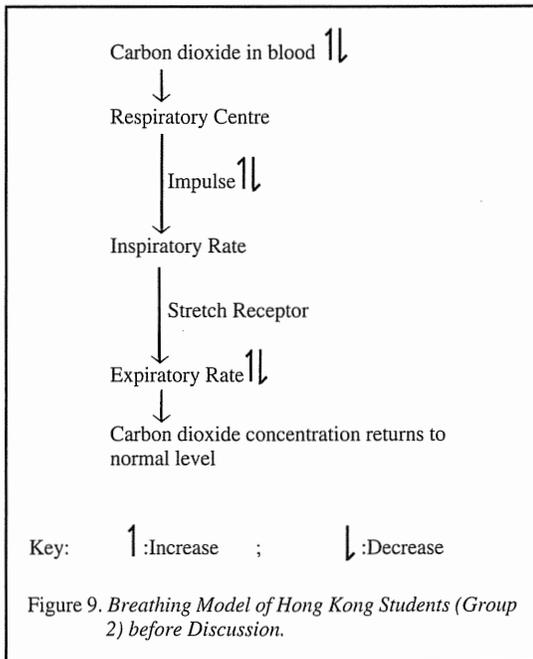
After the clarification of this point, students from other groups asked questions on the model in Figure 6 again:

“By looking at your model, it seems to me that inspiration will lead to a drop of carbon dioxide concentration.”

Through discussion, cognitive restructuring enables students to see the problems from new perspectives, to develop relationships between new and previously learned information.

After discussion in class, group members were asked to present their revised models. These are illustrated in Figures 8 and 9.





## Results

According to the SOLO levels, the models in Figures 6 and 7 before discussion and models in Figures 8 and 9 after discussion can be analyzed on this hierarchical scale.

### *Model in Figure 6*

It states that only high blood carbon dioxide concentration leads to inspiration and low blood carbon dioxide concentration leads to expiration. It illustrates an inadequate or non-existent structural link between response and the original teaching models, and hence is prestructural.

### *Model in Figure 7*

It relates carbon dioxide concentration (only an increase) to inspiration and expiration. Thus, most or all of the various aspects of the situation are tied together with a relating concept, and is relational. The explanation, however, is valid only for the given teaching models.

### *Model in Figure 8*

This shows great improvement to the previous model (see Figure 6) before the discussion. It tends to relate blood carbon dioxide concentration to inspiration and expiration. It is a coherent whole, and is hence relational.

### *Model in Figure 9*

The model uses a higher order principle, relating change in carbon dioxide concentration to breathing rate, which is not made explicit in the

teaching models. The students of this group were thinking more abstractly than the others, and, as an extended response, This model is more abstract than the teaching models which only state that carbon dioxide concentration can affect breathing rate and depth, without referring to the change of carbon dioxide concentration.

## Conclusions and Discussion

The above data support the research findings that there are two main approaches to learning: surface and deep. Within the context of the present study, the SOLO levels of the Hong Kong group before class discussion were no more than the multistructural level, which was a result of surface approach to learning (Biggs, 1979; Watkins, 1983). This takes place when students perceive school learning as disintegrated and is totally irrelevant to their goals and aspirations, or otherwise detached from their everyday experience. The conjecture fits exactly into the teaching and learning situation in Hong Kong, which is examination oriented. Being geared towards good examination results, assignments and test drilling are believed to be the means of obtaining a good performance in public examination. In junior high schools, most teachers even distribute notes with blanks for students to fill in. Examination papers will usually be set in accordance with questions taught in worksheets, thus directing student responses to a lower SOLO level, emphasizing rote learning without understanding. Hence, this group of students, being promoted from the junior secondary level of this school, were used to the expository teaching style and mechanical assessment system. Therefore, we can relate approach to learning to factors such as teaching style and the assessment system. Some years ago, mastery learning was used by the author to teach biology to secondary three classes. The data of the Hong Kong version of learning for mastery showed that deep and surface biased learners increasingly diverged in both performance and attitude, with surface learners doing better from unit to unit, and deep learners worse. The results also suggested that mastery learning promotes the engagement of a study approach characterized by a narrow focus on detail that is likely to be tested, which is then rote learned (Lai & Biggs, 1994). Hence, we can see that rote-memorisation teaching or learning strategy somehow bars students from innovative thoughts, which should be discouraged by all means. The above argument is further strengthened by the comparative data in the Canadian context. Since the graduate students in Canada

were not under the examination context and expository teaching style, they 'constructed' their own models by bringing in relevant background information to the setting. Many of them even expressed that their prior knowledge -- first aid training, influenced their model formulation. By examining the SOLO level of the groups, the outcome of the response was at least at the relational level, which might be considered to be associated with a deep approach. In this approach, learners concentrate on the meaning of the learning task; they integrate the task components, both with each other and with other tasks -- not necessarily school tasks. In this case, it was their personal experience of first aid training in everyday life. Hence, in this mode of enquiry, learning is seen as a possibility of enriching one's experience. By comparing the SOLO levels of the responses of the Hong Kong group and the Canadian group before discussion, it is obvious that the SOLO levels of Canadian group were higher, indicating a 'deeper' approach to learning initially.

In addition, when the study was extended by including students from the Hong Kong group to engage in active group learning, through the processes of student displaying and discussing their models, they seemed to be able to change from lower order conceptions to higher order conceptions, as evidenced by the increase in the structural complexity of the models (see Figures 8 and 9) in SOLO terms after discussion.

Two issues in particular require further research. The present results suggest that students do not come into the learning environment empty minded. An interesting feature of some of this work is the role of prior knowledge in making sense of the nature of the task, and also of the models actually generated. Students bring to a task quite a variety of prior knowledge which influences in important ways the actual responses elicited. It may be appropriate for researchers to further probe into the prior knowledge of learners, and to see how this can be integrated into teaching materials. Most assessment systems in Hong Kong are norm-referencing, in which students have to be assessed rigidly, with little flexibility given. This is especially applicable to science subjects at the secondary levels, where students are assessed by questions that ask for right or wrong answers.

Another issue which needs further investigation is how to relate the SOLO taxonomy to Marton's notion of "conceptions" (1981). In this way, qualitatively different ideas about the learning materials held by the learners can be further identi-

fied, so that the conceptual change and cognitive restructuring that learners have undergone can be traced stepwise.

It is inappropriate here to elaborate this phenomenographic approach (Marton, 1981). The point is simply that the present results call the examination-oriented approach into question as a teaching strategy especially when learning is only quantitatively conceived. In that sense, the examination-oriented approach is likely to result in lower cognitive level approaches and outcomes, and to turn off or discourage the more promising or deep learners. Therefore, it may be the right moment for local teacher educators and principals to consider instilling the idea of 'innovative' teaching into their classrooms, so as to foster a better learning environment for our new and energetic generations.

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