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A COMPARATIVE STUDY OF STUDENTS' LEARNING STRATEGIES IN CHEMISTRY

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INTRODUCTION

A child in Singapore has to live with the prospect of facing many examinations. The Singapore education system places a high credit on examinations and certification. Singapore students are impressed upon by both teachers and parents that examinations are selection mechanism and they have to acquire minimum qualifications before they get to advance to the next stage of their education for more qualifications. Hence students are fraught with constant test anxiety and competitiveness.

The Education Minister of Singapore, Mr Lee Yock Suan revealed in the Straits Times, dated 17 September 1992, the education plan for young Singaporeans in preparation for the 21st Century. He said that children would become independent learners and problem solvers if they learn how to seek for new information, think critically and show initiative.

Critical thinking requires careful analysis and judgement of facts and information. One needs to be in the Analysis level and above of Bloom's taxonomy in order to reach this stage of thinking. One needs to systematically process given information before coming to any conclusion. Students therefore must be taught to adopt a useful approach for meaningful learning. They will not be able to develop critical thinking if they continue to use strategies that involve only rote learning. Hence, a knowledge of learning strategies generally used by our students will enable us, teachers, to design instructional programmes to improve students' ways of learning and critical thinking.

The aim of this study is to determine if there are any differences in the strategies used in the learning of Chemistry by the academically more able and the academically less able Secondary Three Express stream students.

THEORETICAL BACKGROUND

Research into learning strategies employed by students have been extensively carried out throughout the years as it has become a subject of great interest to teachers and others involved in education. What are learning strategies?

> *"Learning strategies involve the strategies for comprehending and recalling information as well as strategies for retrieval and utilization of learned information during tests/examinations" (Chang,1989).*

Students approach their learning in qualitatively distinct ways and this leads to different outcomes in learning (Biggs 1987, Marton and Saljo, 1976). As a result of a series of factor analyses of secondary and tertiary samples of students' questionnaire responses (Biggs, 1987), three approaches of learning were identified. These approaches are Surface, Deep and Achieving. Each approach of learning comprises a motive

component and a strategy component. For instance, the Surface Approach consists of the Surface Motive and the Surface Strategy.

The Surface Approach

The Surface Motive is basically instrumental or extrinsic. The student's main goal is to meet requirements without putting in much effort; studying thus becomes a balance between working too hard, and failing on the other. The resulting strategies (Surface Strategies) manifested by this motive are essentially reproductive. The students concentrate on the surface features of learning and not on the meanings or implications of what is learned. In other words, the students target to learn bare essentials and reproduce through rote learning.

The Deep Approach

The Deep Motive is basically intrinsic. The strategies (Deep Strategies) employed are reading widely, understanding, using and extending acquired knowledge, relating content to personally meaningful contexts, relating new knowledge to previous relevant knowledge, theorising about what is learned, and deriving extensions and exceptions.

The Achieving Approach

The Achieving Motive is based on competition and ego-enhancement that goes with motivation in obtaining high grades. The strategies (Achieving Strategies) that go with achievement motivation comprise those organisational behaviours that characterise the model student, such as keeping clear notes, planning optimal use of time and other "study skills".

A Comparison of the Approaches

Affectively, the Deep Approach leads to task involvement and to satisfying outcomes, whereas the Surface Approach is frequently alienating even when used successfully, leaving the student anxious about the outcomes and resentful of the time taken. The Achieving Approach is different from Deep and Surface Approaches in that the latter refer to the kinds of cognitve processes used when engaging the task (meaning or rote learning), whereas the former refers to arranging the context for carrying out the task. While Deep and Surface are mutually exclusive, an Achieving Approach may be linked to either: one can rote learn in an organised or unorganised way. Surface-achieving is the approach adopted by students who want to obtain high grades and think that the way to do so is by using Surface Strategy; they frequently find, however, that it is not the case. Deep-achieving, on the other hand, is characteristic of many of the better students.

Some Research Findings

A few studies on students' learning strategies were recently carried out in Singapore.

Chang (1989) studied the learning strategies employed by 234 Secondary Four Express and Normal stream students in English and Mathematics. She found that Express stream students (147) adopted a deeper and a more reflective approach in their learning than the Normal stream students (87). The Express stream students also used more effective strategies such as checking what they remember after reading each chapter/topic, checking main headings and writing a summary after every lesson/topic etc.

A few years later, Chang (1992) extended her previous study (1989) by investigating the dominant approach used by 1393 Secondary Two students, Secondary Four students and Junior College/Pre-University Three students in learning Languages, Social Sciences, Mathematics and Sciences. It was found that despite heavy emphasis on learning for examinations, students were able to resist the temptation to adopt a pure Surface Approach in their learning.

In the same year, Chin and Tsu (1992) investigated the learning strategies employed by 142 Secondary Three Express (69) and Normal (73) stream students in learning Chemistry. They found that Express stream students placed more importance on understanding the meaning of chemical terms than the Normal stream students. Contrary to Chang's finding (1989), the Normal stream students used more frequently the strategy of writing down a summary after each chapter studied while the Express stream students practised more frequently the strategy of memorising definitions, rules and formulas in Chemistry.

METHOD

Instrument

A questionnaire consisting of 18 items of learning strategies in Chemistry was constructed. The items in the questionnaire were classified into three categories as defined by Biggs (1987), namely Surface Strategy (Items 1 to 5), Achieving Strategy (Items 6 to 10) and Deep Strategy (Items 11 to 18). Students were requested to rate each item on a 5-point Likert scale. A score of 5 indicates a strategy always or almost always used, 4 indicates a strategy frequently used, 3 indicates a strategy used half the time, 2 indicates a strategy sometimes used and 1 indicates rare or no usage of the strategy rated. The 18 items are shown in Table 1. The time allocated for the administration of the questionnaire was 15 minutes.

Sample

Two hundred and fifteen Secondary Three Express stream students from seven classes of a local school participated in this study. The students were classified as weak (academically less able), average and good (academically more able) using their Secondary Two General Science Examinations marks. Those who scored 55 and less are academically less able, those who scored 70 and above are academically more able and those who scored between 56 and 69 inclusive are the average students. Out of 215 students, 68 were weak, 70 were average and 78 were good students.

RESULTS AND DISCUSSION

Three sets of mean and standard deviation scores were computed and tabulated. The first set represents the means and standard deviations of the three types of learning strategies for the whole group of students (Table 1). The second set represents the means and standard deviations of the three types of learning strategies for the good and weak students (Table 2). The third set represents the means and standard deviations of each of the 18 items for the good and weak students (Table 3). T-tests were employed to find out if the two groups of students, good and weak, had any significant differences in their usage of learning strategies.

Table 1 Means and Standard Deviations of the Whole Group of Students for the Three Types of Learning Strategies

Learning Strategies	Mean (S.D.)	No. of Observations
Surface (Items 1 to 5)	2.49 (0.74)	213
Achieving (Items 6 to 10)	3.53 (0.81)	214
Deep (Items 11 to 18)	3.08 (0.73)	211

The mean scores of the group of students for the three types of learning strategies (Surface, Achieving and Deep) as shown in Table 1 indicate that, generally, the whole group of students prefer the use of Achieving Strategies to learn Chemistry. It is also evident that there is a difference in the use of the Achieving Strategies between the good and weak students (Table 2).

As shown in Table 3, only 6 out of 18 items of the questionnaire reflected some significant differences between the mean scores of the good and weak students. Both good and weak students seemed to be practising the learning strategies to a similar extent as indicated by 12 insignificant mean differences. This result was expected as the two groups of students were from

the Express stream. The 12 out of 18 means consist of 2 Surface (Items 2 & 5), 3 Achieving (Items 6,9 & 10) and 7 Deep Strategies (Items 11, 12, 13, 14, 15, 16 & 18).

Table 2 Means and Standard Deviations of the Good and Weak Students for the Three Types of Learning Strategies

Learning Strategies	Good Students		Weak Students	
	Mean (S.D.)	No. of observations	Mean (S.D.)	No. of observations
Surface (Items 1 to 5)	2.36 (0.75)	76	2.80 (0.73)	67
Achieving (Items 6 to 10)	3.71 (0.80)	78	3.39* (0.88)	67
Deep (Items 11 to 18)	3.16 (0.76)	76	2.95 (0.76)	66

* $p < 0.01$

However, the mean results of the good students for the Achieving Strategies (Items 6 to 10) were unanimously more than 3.5 when compared with the mean results for the other strategies (Table 3). As discussed earlier, the means of the good and weak students for the Achieving Strategies was significantly different. This confirmed that the good students tended to adopt Achieving Strategies more than the weak students. In contrast, the weak students were more likely to use rote learning (Table 3: Items 1 & 3) in learning Chemistry as they found it "better to learn just the facts and details about a Chemistry topic rather than understand all about it " and that "the only way to learn Chemistry is to memorise it by heart ". In addition, the means for Item 4 in Table 3 indicate that in learning Chemistry the weak students would do only enough work to guarantee themselves a pass in the subject. It was quite obvious that the weak students lacked motivation in studying the subject and were rote learning to pass the subject.

The means for Items 11 and 14 in Table 3 were quite low indicating that both groups of students did not often read widely on Chemistry. Reading widely on Chemistry is crucial in the development of critical thinking in students and students should be encouraged to engage in this activity more often.

The good students tended to be more reflective (deep) in their learning as indicated by the means for Item 17 (Table 3). The good students were likely to use Chemistry practical lessons to understand chemical concepts. It was heartening to know that these students were trying to integrate theory into practice, which is the way Chemistry should be studied. Thus, these students were more likely to treat practical lessons more seriously than the weak students. This difference was most probably due to the good students being more motivated and

TABLE 3 Means and Standard Deviations of the Good and Weak Students for the 18 items

No.	Learning Strategies in Chemistry	Mean (S.D.) Good students (N = 78)	Weak students (N = 67)
1.	I find it better to learn just the facts and details about a Chemistry topic than understand all about it.	2.33 (1.32)	2.75 (1.31)*
2.	When the lesson is too hard to understand, I memorise everything.	2.65 (1.30)	3.02 (1.29)
3.	I find that the only way to learn Chemistry is to learn it by heart.	2.43 (1.23)	3.02 (1.20)**
4.	In learning Chemistry, I work things so that I do only enough to make sure that I pass.	1.80 (1.26)	2.28(1.27)*
5.	I don't spend time on learning things that I know won't be asked in the exams.	2.55 (1.23)	2.94 (1.36)
6.	I work solidly throughout the term and revise regularly when the exams are near.	3.64 (1.09)	3.48 (1.04)
7.	I do all of my assignments as soon as they are given to me.	3.86 (1.11)	3.40 (1.14)*
8.	After a test/when a test is returned, I go over it carefully correcting all errors and understanding why I made the original mistakes.	3.78 (1.03)	3.15 (1.23)**
9.	I read all the references and things that my teacher says we should.	3.68 (1.13)	3.58 (1.17)
10.	I organise my work in neat steps to help me learn better.	3.65 (0.97)	3.33 (1.22)
11.	I read reference books /magazines related to Chemistry other than my textbooks to get a deeper understanding of chemical concepts taught in class.	2.78 (1.23)	2.60 (1.28)
12.	I try to understand how to derive a chemical principle, law or formula before accepting it.	3.41 (1.30)	3.16 (1.23)
13.	I turn an explanation/argument over in my mind a few times before accepting it.	3.35 (1.02)	3.03 (1.23)
14.	I spend a great deal of my free time finding out more about interesting topics which have been discussed in the Chemistry class.	2.43 (1.09)	2.33 (1.17)
15.	I pose questions to myself after every lesson/topic to check my understanding.	2.86 (1.17)	2.81 (1.22)
16.	I relate what I learn in a new topic to what I have already learnt in previous topics.	3.24 (1.08)	3.03 (1.13)
17.	I use my Chemistry practical lessons to help me understand chemical concepts.	3.92 (0.92)	3.34 (1.10)**
18.	While I am studying Chemistry, I often think of how useful the material that I am learning would be in real life.	3.18 (1.28)	3.22 (1.32)

* $p < 0.05$
** $p < 0.01$

interested in the subject as compared to the weak students.

For the Achieving Strategies, the means for Items 7 and 8 (Table 3) are significantly different. The good students displayed a tendency to do all assignments as soon as they got them. The good students were also more likely to go over test questions carefully correcting all errors and understanding why they made the mistakes. These study skills seemed to be used less often by the weak students.

IMPLICATIONS FOR TEACHING CHEMISTRY

The results of the study have some important implications for the teaching of Chemistry.

Teaching Effective Learning Strategies

Rote learning (Surface Strategy) was preferred by the weak students in learning Chemistry (Table 3: Item 3). Changing a student's approach to studying Chemistry may also involve changing his or her motivation to study the subject if the appropriate motivation is not already present. An intervention programme may be necessary to decrease surface and increase deep approaches in learning Chemistry. Such intervention programmes to decrease surface and increase deep approaches to the academic tasks have proven to be successful (Peterson, 1988, Biggs & Rihn, 1984). Teachers are encouraged to teach and reinforce the use of Achieving and Deep Strategies in their instruction by showing examples of how to effectively learn Chemistry.

Providing Feedback on Assignments/Tests

The weak students seem to take their assignments and tests lightly. It is suggested that answers to a test paper should be discussed adequately with students so that their understanding of concepts is enhanced and they realize what their weaknesses are in that content area or topic. This type of feedback should be continuously given to students, especially to the weak students.

Developing Wide Reading Habit

As a response towards the results of Items 11 and 14 (Table 3) that both groups of students seldom referred to references other than textbooks, it is suggested that assignments or worksheets given to students require them to look up other books besides their textbooks for answers. In other words, the students should not be spoon-fed all the time. Schools should also buy relevant books/magazines on Chemistry that students can read for wider knowledge and greater understanding especially the good students. Teachers should encourage them to often read these materials and perhaps have discussions with students on topics that interest the students. Students may also write summaries on

materials that they have read and share ideas amongst themselves. In this way, students will pick up the habit of reading widely and acquire the necessary skills to seek for information. Reading will also help students learn how scientists actually work and how useful Chemistry is to our lives.

Practical Work

At Secondary Three level, little emphasis is placed on practical work. Thus students, especially the weak ones, do not treat the practical lessons seriously. The Chemistry course for the Secondary Three level should be structured in such a way that students will sit for a test or examination on practical work that they have done throughout the year. The practical test/examination should incorporate questions that require students to know their content knowledge well to pass the test/examination. Thus the practical lessons must be carefully planned such that the students can see the link between theory and practical work. In this way, the students will value more the time they spend in the laboratory. Also, teachers should stress the importance of practical lessons right from the beginning when Chemistry is introduced to the students and reinforce this throughout the year.

CONCLUSION

The results of this study show some significant differences in the usage of learning strategies between the academically more able (good) and less able (weak) students in learning Chemistry. Both groups of students, good and weak, preferred the use of Achieving Strategies. However, the weak students tended to use more rote learning. To help the weak students learn effectively, teachers should equip themselves with adequate knowledge and experiences for teaching effective learning strategies: Achieving and Deep Strategies. In other words, teaching effective learning strategies for learning Chemistry should be part of Chemistry teaching. If possible teachers should expose students to the application and importance of Chemistry in our daily lives to boost interest and motivation in students to learn Chemistry especially the weak students.

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