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Personal Observations of Student-centred Learning: The Laboratory Experience

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In 1923, the respected biochemist and philosopher of science Haldane stated, "It is the whole business of the university teacher to induce people to think[1]." The laboratory class is a marvellous medium to encourage this and to help students construct knowledge. The environment is intrinsically student-centred: the student performs the experiments and interprets the results. On occasion, students need to work in small groups, either because of the complexity of the experiment or the availability of the equipment. In so doing, laboratory classes promote peer learning, teamwork and interpersonal skills. In addition, many of the experiments are problem-based in design which should help students understand concepts and theories[2]. However, perhaps the strongest motivating factor in favour of the laboratory class as a learning environment is the fact that students get to create things; and quite frankly, creating things is fun.

It is perplexing, therefore, to witness the laboratory class failing to realise its potential. This issue is pretty much universal in higher education. In Britain, Byers recently commented, "All too often students see laboratory work as a form of assessment rather than as an opportunity to learn[3]." I believe that the problem is indeed an issue of motivation. However, the issue of motivating students is not unique to the laboratory setting. Thus rather than focussing on the laboratory, I wish to use the example of the laboratory class as a device to discuss the wider issue of inducing students to think.

We need to first consider what we want students to learn. de Bono wrote, "It must be more important to be skilled in thinking than to be stuffed with facts[4]." In the context of science education, Biggs stated, "Rote learning scientific formulae may be one of the things scientists do, but it is not the way scientists think[5]." Some students believe that in science there are right answers to everything and that the mastery of a particular body of scientific knowledge allows one to become an expert in the field. It is partly this belief that leads to public misconceptions about what science can and cannot do. My own philosophy of the goal of science education is certainly not original; but in my mind, rather than purely adding to a student's existing store of knowledge, we should be promoting science education as a way of thinking[6].

Consequently if we are to help students learn, we need to understand how students learn. We need to predicate our teaching on enabling learning to happen. The

1. Haldane, J.B.S. (1923). *Daedalus, or Science and the Future.* London: Kegan Paul, Trench, Trubner. This paper was read before the Cambridge Heretics, a radical freethinking society established in 1909 and dedicated, *inter alia*, to the open discussion of religious matters.
2. The laboratory class provides perhaps some of the earliest examples of problem-based learning. In fact, von Liebig at the University of Giessen in Germany first introduced laboratory classes for general student use as early as the 1820s.
3. Byers, W. (2002). 'Promoting Active Learning through Small Group Laboratory Classes'. *University Chemistry Education*. Vol. 6, pp. 28–34.
4. de Bono, Edward. (1967). *The Five Day Course in Thinking*. London: Penguin.
5. Biggs, J.B. (1989). 'Approaches to the Enhancement of Tertiary Teaching'. *Higher Education Research and Development.* Vol. 8, No. 1, pp. 7–25.
6. Kuhn, D. (1993). 'Science as Argument: Implications for Teaching and Learning Scientific Thinking'. *Science Education*. Vol. 77, No. 3, pp. 319–337.

literature on how people learn is vast, but perhaps the most influential and accessible theories of learning, and one that certainly strikes a chord with me, is that of constructivism[7]. Constructivism can be summarised in the phrase: "Knowledge is constructed in the mind of the learner[8]." When we teach, we need to remember that the new facts that we propound do not become directly incorporated into the mind of the student without processing; they have to be fitted into the existing structures and schemata already in the mind of the student. For the learner faced with new information, the only thing that matters is whether the knowledge constructed from this information functions satisfactorily in the context in which it arises.

Thus, individuals may construct different images of reality from the same information, since each is incorporating the new information into a unique set of mental images. This of course explains why students frequently seem to misunderstand completely or fail to remember new concepts that we introduce to them. If we are to enable students to learn, we must accept that we cannot brilliantly transfer into the minds of our students, what we have in our own minds. As a guide to help teachers teach, Ausubel stated that:

> If I had to reduce all of educational psychology to 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[9].

In applying these ideas to science teaching, it is worthwhile considering that our minds do not contain reality itself, but models of reality that we have constructed. It is important to impress upon students, who can appear to be unaware of the fact, that their concepts of, for instance, atoms and molecules, are only models. Simple models of reality provide a strong framework for a student to incorporate new ideas and so construct a more complex model. It maybe that the final model that we wish our students to understand will require us to help students construct several intermediate models.

Of course the ability of a student to construct a new model of reality is influenced not only by their prior knowledge, but also by the level of intellectual development that the individual has reached. Piaget[7], the author of constructivism, gave a useful scheme of intellectual development. His research showed that children progress from 'pre-operational thought' to 'concrete operational thought' and finally through to 'formal operational thought'. The last two levels are relevant to higher education. Concrete operational thinkers argue from concrete examples; typically, they can describe without explaining, and give examples but not general definitions derived from these examples. Formal operational thinkers, in contrast, can follow a formal argument, can set up hypotheses, and are comfortable with hypothetico-deductive reasoning[10].

However, it is perhaps not the progression of intellectual development that is relevant to higher education, but the fact that students will revert to concrete operational thought whenever they encounter a new area[11]. Before one can reason with hypotheses and deductions based on experience, there must be a sound descriptive base that has been put in order. The problem for teachers is that we are frequently expounding to students new topics with which we are very familiar (and consequently operate in formal operational mode) whereas the students are struggling to understand them in concrete operational mode, and necessarily resort to rote learning. If a student remains a concrete operational thinker within a particular topic, it is difficult (although not impossible) for that student to see the inter-connectivity between different topics that a complete understanding of a science demands.

Traditionally, laboratory experiments have been essentially expository-type exercises. Unfortunately, most students try to keep the time they think about practical work to a minimum. The basic design of a laboratory experiment is one where the students are asked to follow a set of instructions, a recipe if you will. This enables the students to complete an experiment without ever thinking about what they are doing, thus militating against any meaningful learning taking place. It is widely appreciated that there is a need for an inquiry-type dimension to the laboratory experiment. A few innovations have been introduced to the laboratory setting. These include pre-laboratory

7. Piaget, J. (1926). *La représentation du monde chez l'enfant*, Paris: Librairie Félix Alcan. Translated as *The Child's Conception of the World* by Tomlinson, J. & Tomlinson, A. (1929). London: Kegan Paul, Trench, Trubner.

8. Bodner, G.M. (1986). 'Constructivism: A Theory of Knowledge'. *Journal of Chemical Ed*ucation. Vol. 63, pp. 873–878.

9. Ausubel, D.P. (1986). *Educational Psychology: A Cognitive View*. New York: Rinehart and Winston, Inc.

10. For example, we can consider gravity. People have always known that what goes up must come down. Concrete operational thinkers can describe the force of attraction between objects and of course give diverse examples. However, prior to the publication of Newton's *Principia Mathematica*, we did not have a working hypothesis for why the apple falls from the tree towards the Earth; instead it was considered a Law of Nature. In developing his theory of gravitation, Newton asked why do objects fall towards the Earth. It is the asking of this question that contrasts the concrete with the formal operational thinker. The brilliance of Newton's theory was not that it explained why objects, like the apple, fall towards the Earth, but that it explained the ocean tides, why the Moon orbits the Earth and why the Planets orbit the Sun.

11. Bailey, P.D. & Garratt, J. (2002). 'Chemical Education: Theory and Practice'. *University Chemistry Education*. Vol. 6, pp. 39–57.

exercises[12] to encourage students to think about the experiment they are about to perform, and post-laboratory exercises[13] to facilitate reflection and promote consolidation of learning.

In this article, I would like to concentrate on my experiences within the laboratory class. It would be remiss of me not to mention at least a couple of issues that relate directly to my experiences in Singapore. The laboratory classes at NUS are blessed by Teaching Assistants, who at least in my experience, are diligent and hard working. However, this diligence can sometimes play into the hands of students who are trying to minimise their own diligence. By and large, experiments work and students know they work. Some students, on realising that an experiment is failing, will not attempt to discover the reason behind this, but instead expect the Teaching Assistants to fix the experiment. Some Teaching Assistants themselves compound this issue by standing over the students and stopping an experiment if they see that the data coming out are going awry. It took me awhile to realise what was happening for the *lingua franca* between the majority of the teaching assistants and the majority of the students is Chinese of which I have no understanding. An issue that was my responsibility, and the effects of which are completely opposed to my teaching philosophy, is that I allowed the students to write laboratory reports after class. Frequently, the experiments are classics of their type and detailed descriptions of the theory and the results that one might expect can be found in standard textbooks. It is singularly difficult to motivate students to rediscover this knowledge for themselves, rather than copy it verbatim from a textbook. I will not be allowing this practice to be repeated in future classes I supervise.

Within the laboratory class, it was clear that if I wanted any meaningful learning to take place, I had to become directly involved in the learning process. So I employed Socratic questioning. For me, this method works because in questioning the students, I gain an insight into their current level of knowledge from which I can then help guide the students construct the necessary more complex model they require to understand the concept at hand. It also allows me to help the students identify the fundamental principles and the links between diverse concepts. For the student, I believe it helps build confidence. I can introduce concepts at a rate dependent on the student's ability, and thus, the student feels inclined to venture into areas of higher understanding where such a student may have been embarrassed to venture in a tutorial setting with that student's peers looking on. In increasing the student–teacher interaction, the student gets full and appropriate feedback. I find that after helping a student construct the requisite knowledge, that student is inclined to ask questions about their newfound knowledge. This has the additional benefit of highlighting any misconceptions I may have introduced. If feedback to these questions is given appropriately with the proper encouragement, then that student's confidence and motivation is increased. However, I would not like to give the impression that this method is some sort of panacea. For instance, I was fortunate that the class sizes were small. This is not the norm. Many laboratory classes can number a hundred or more and then the attention that one can give individual students is limited and the method of teaching would need to be modified.

I have been rather liberal in my use of quotations during this discourse. However, I hope that they have been useful in illuminating the concepts that I have introduced and my thinking concerning teaching. In conclusion, I would like to leave you with a final quotation that returns us to why, how and what we are trying to teach to our students. In 1929, the eminent philosopher and mathematician Whitehead turned his thoughts to education and wrote:

> In my own work at universities I have been much struck by the paralysis of thought induced in pupils by the aimless accumulation of precise knowledge, inert and unutilised. It should be the chief aim of the university professor to exhibit himself in his true character—that is as an ignorant man thinking, actively utilising this small share of knowledge. In a sense, knowledge shrinks as wisdom grows: for details are swallowed up in principles. The details of knowledge which are important will be picked up *ad hoc* in each avocation of life, but the habit of the active utilisation of well-understood principles is the final possession of wisdom[14].

It is clear that motivating students to think has been an elusive goal of educators for a very long time. ■

12. Johnstone, A.H.; Sleet, R.J. & Vianna, J.F. (1994). 'An Information Processing Model of Learning: Its Application to an Undergraduate Laboratory Course in Chemistry'. *Studies in Higher Education*. Vol. 19, pp. 77–88.

13. Johnstone, A.H. (1997). 'Chemical Education, Science or Alchemy?'. *Journal of Chemical Education*. Vol. 74, pp. 262–268. Ditzier, M.A. & Ricci, R.W. (1994). 'Discover Chemistry: Balancing Creativity and Structure.' *Journal of Chemical Education*. Vol. 71, pp. 685–688.

14. Whitehead, A.N. (1929). *The Aims of Education and Other Essays*. New York: Macmillan. The chapter, 'The Rhythmic Claims of Freedom and Discipline', from which the quotation was lifted was originally published in the Hibbert Journal.

Learning and **Coping** as **Dental Students**

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Structure of Dental Undergraduate Programme

The Faculty of Dentistry provides a four-year undergraduate dental course leading to the Bachelor of Dental Surgery (BDS) degree. The selection of candidates for the course is stringent and those seeking admission require good grades in Chemistry, either Biology or Physics, and a third subject at the Singapore-Cambridge 'A' levels General Certificate of Examination. The candidates are also required to have good grades for their General Paper and second language as well as the Scholastic Aptitude Test. There is also a manual dexterity test and an interview for candidates who are short-listed for the course.

The BDS course comprises two pre-clinical and two clinical years. In the pre-clinical years (Year 1 & 2), dental undergraduates share some common core subjects with medical students such as Anatomy, Biochemistry, Physiology, Dental Anatomy & Histology, Pharmacology, Microbiology (including Immunology) and Pathology. This is to ensure dental students acquire the essential basic science knowledge needed for clinical practice. They also receive extensive pre-clinical training in dentistry. The methods of instruction include lectures, tutorials, seminars, laboratory sessions and technique work.

In the clinical years (Year 3 & 4), students manage and treat their own patients under supervision. It is here that they apply the theory and skills acquired previously in the various disciplines. The programme is rigorous with comprehensive didactic and clinical sessions. A multidisciplinary approach to solving problems is emphasised, thus encouraging the undergraduates to integrate and fully understand management and treatment modalities. Courses such as General Practice Management, Behavioural Science and Problem-based Learning (PBL) have been added to the curriculum to prepare the student for the demands of clinical practice upon graduation.

The dental curriculum is competency-based, with emphasis in imparting basic skills essential to the practice of dentistry. The didactic programme teaches relevant knowledge and skills necessary to train a competent general dental practitioner. Clinical competency tests have replaced the schedule-based clinical assessment. A student will sign up for competency tests for different procedures after he or she has adequate exposure to basic clinical competency. This will allow the more clinically-competent students to progress at a faster rate. At the same time, students who may need remedial help can be identified.

Since dental students have to accomplish so much in such limited time, it is important for them to be able to learn effectively and efficiently. They spend many hours taking part in clinics and attending didactic sessions, approximately 40 hours a week in the faculty, and even longer hours in the laboratory after school, preparing for their clinical cases. The aim of this preliminary study was to investigate the students' perception of the effectiveness of teaching methods, the teaching staff and how they cope with the pressures of their dental education.

Subjects and Methods

During March 2003, a questionnaire was distributed to 48 clinical year students (15 Year 3 and 33 Year 4) who were assured that their responses would be kept anonymous and confidential. This questionnaire assessed, on a 4-point Likert scale, the methods of teaching that they found effective, their methods of learning, the people that support their learning, their time for social activities and how they coped with the pressures of their studies.

Results

A total of 37 students (11 Year 3 and 22 Year 4) completed the questionnaire giving a response rate of 77%.

1. Helpful teaching methods

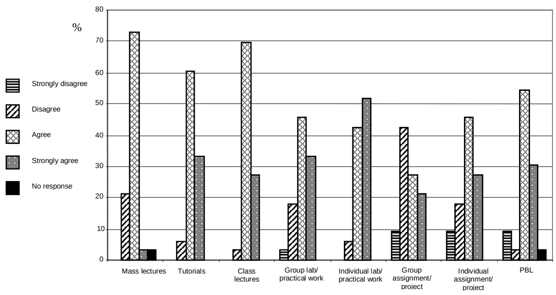
More than 75% of the dental students agreed that mass lectures, tutorials and class lectures were helpful teaching methods in their learning process. A mixed response of agreement was found for group projects/

assignments. A high proportion agreed that individual and group laboratory/practical work was helpful. About 85% of the students agreed that PBL was helpful.

Table 1. Helpful teaching methods

Teaching Methods	N=33				
	Strongly disagree %	Disagree %	Agree %	Strongly agree %	No response %
Mass Lectures	0	21.2	72.7	3.0	3.0
Tutorials	0	6.1	60.6	33.3	0
Class lectures	0	3.0	69.7	27.3	0
Group lab/practical work	3.0	18.2	45.5	33.3	0
Individual lab/practical work	0	6.1	42.4	51.5	0
Group assignment/project	9.1	42.4	27.3	21.2	0
Individual assignment/project	9.1	18.2	45.5	27.3	0
PBL	9.1	3.0	54.5	30.3	3.0

Figure 1. Helpful teaching methods



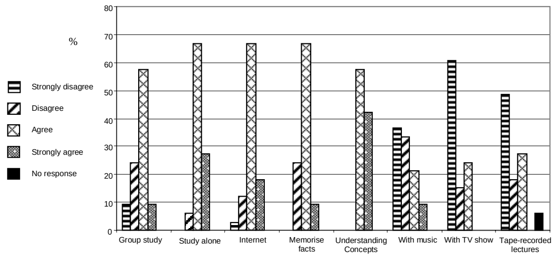
2. Effective study methods

Slightly more than two-thirds of the students found that group study was an effective method in their learning. 94% preferred to study alone. The use of internet was found to be an effective study tool in 85% of the sample. All the dental students in this sample agreed that understanding concepts was important for effective studying. The need to memorise facts was found to be an effective study method in 75% of the students. About one-third of the sample found that studying with music or TV on to be effective. Less than a third of the sample agreed that tape-recorded lectures were effective in their learning.

Table 2. Effective study methods

Study Methods	N=33				
	Strongly disagree %	Disagree %	Agree %	Strongly agree %	No response %
Group study	9.1	24.2	57.6	9.1	0
Study alone	0	6.1	66.7	27.3	0
Internet	3.0	12.1	66.7	18.2	0
Memorise facts	0	24.2	66.7	9.1	0
Understand concepts	0	0	57.6	42.4	0
With music	36.4	33.3	21.2	9.1	0
With TV show	60.6	15.2	24.2	0	0
Tape-recorded lectures	48.5	18.2	27.3	0	6.1

Figure 2. Effective study methods



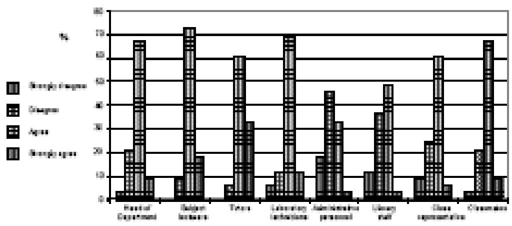
3. People who are helpful in learning process

Subject lecturers and tutors were found to be most helpful in the learning process by the dental students. Laboratory technicians were also found to be helpful as reflected by the 82% response rate. Head of department was found to be helpful in 75% of the sample. Classmates (76%) and representatives (67%) were also found to be helpful people. Library staff and administrative personnel played a lesser role in assisting the learning process.

Table 3. People who are helpful in learning process

People	N=33			
	Strongly disagree %	Disagree %	Agree %	Strongly agree %
Head of department	3.0	21.2	66.7	9.1
Subject lecturers	0	9.1	72.7	18.2
Tutors	0	6.1	60.6	33.3
Laboratory technicians	6.1	12.1	69.7	12.1
Administrative personnel	18.2	45.5	33.3	3.0
Library staff	12.1	36.4	48.5	3.0
Class representative	9.1	24.2	60.6	6.1
Classmates	3.0	21.2	66.7	9.1

Figure 3. People who are helpful in learning process



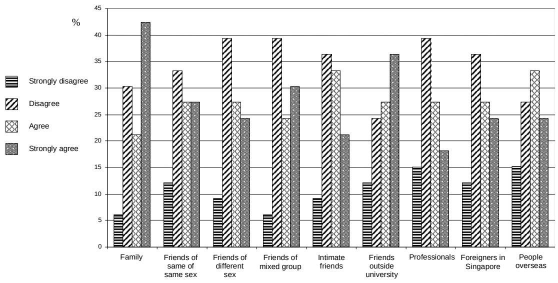
4. Spending less time with family and friends

About two-thirds of the students agreed that they had less time for family and friends outside university. Slightly more than half of the students agreed that they spent less time with friends of either or both sexes, foreigners in Singapore and people overseas.

Table 4. Spending less time with family and friends

Spending less time with	N=33			
	Strongly disagree %	**Disagree %**	**Agree %**	**Strongly agree %**
Family	6.1	30.3	21.2	42.4
Friends of same sex	12.1	33.3	27.3	27.3
Friends of different sex	9.1	39.4	27.3	24.2
Friends of mixed group	6.1	39.4	27.3	24.2
Intimate friend	9.1	36.4	33.3	21.2
Friends outside university	12.1	24.2	27.3	36.4
Professionals	15.1	39.4	27.3	18.2
Foreigners in Singapore	12.1	36.4	27.3	24.2
People overseas	15.2	27.3	33.3	24.2

Figure 4. Spending less time with family and friends



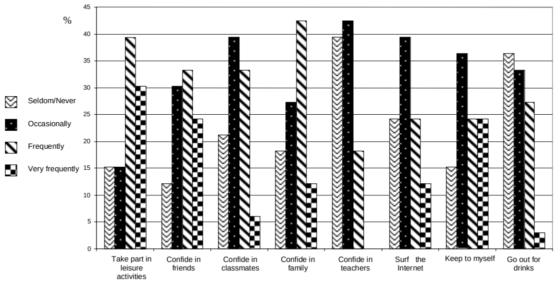
5. <u>Coping with pressures</u>

More than two-thirds of the students coped with pressures of student life by taking part in leisure activities such as sports and movies. Majority of the students preferred to confide in their family and friends when under stress. The students were more likely to confide in their friends outside university than their classmates. The majority of the students (82%) would not confide with the teachers. A minority of the students (30%) would go out for drinks with their friends as a means of stress relief.

Table 5. Coping with pressures

Coping with pressures	N=33			
	Strongly disagree %	**Disagree %**	**Agree %**	**Strongly agree %**
Take part in leisure activities	15.2	15.2	39.3	30.3
Confide in friends	12.1	30.3	33.3	24.2
Confide in classmates	21.2	39.4	33.3	6.1
Confide in family	18.2	27.3	42.4	12.1
Confide in teachers	39.4	42.4	18.2	0
Surf the Internet	24.2	39.4	24.2	12.1
Keep to myself	15.2	36.4	24.2	24.2
Go out for drinks	36.4	33.3	27.3	3.0

Figure 5. Coping with pressures



Discussion

The teaching methods that dental students found most helpful were lectures and tutorials. These results suggest that the students in this sample had not totally steered away from the influence of the pre-university educational system that is very much a teacher-centred approach rather than student-centred. However, a majority of the students (85%) found Problem-based Learning to be effective in helping them to learn. This finding is indicative of the educational value to the students with the introduction of PBL modules into the dental curriculum to complement the traditional teaching methods. The dental course is compact and rigorous with new clinical and scientific information being introduced daily. Thus it was not surprising to find that the dental students still preferred the top down approach in their learning as it would reduce the time needed to gather and assimilate relevant information at the expense of appreciating the learning process of attaining knowledge.

Group assignment/project was not found to be a teaching method that was as effective as group or individual lab/practical work. This could be due to the fact that dental training is very much a practical course that requires hands-on approach in the learning. It could be speculated that group assignment/projects that were didactic or research in nature were not valued as much as practical training by the students. The assumption made was that the dental students considered group assignments/projects to be a separate entity from PBL when answering the questionnaire. Moreover, there is currently no peer appraisal system in the evaluation of dental students. As such, group assignments/projects that did not have an impact on the overall performance rating would be considered less useful. The nature of dentistry is one that requires independent practical training. Thus it was not surprising to find that teaching methods that require individual ownership of the training and performance to be considered highly useful by dental students.

A majority of the dental students preferred to either study alone or in groups. These findings suggest that both independent and interdependent learning played an important role in the learning process despite the fact that the nature of dental training could be individualistic at most times. The competitive nature of the dental course could also motivate students to study alone. Further investigation will be necessary to determine whether independent or interdependent learning is more effective and constructive during the course of training. A majority of the students found that memorising facts was also a helpful study method.

This finding was typical with any medical or dental training whereby certain basic clinical or scientific information must be committed to memory for efficient clinical application. In addition, all students in this survey agreed that understanding concepts was important to help them study. This finding might be reflective of a level of maturity in the thinking of these students. More information will be needed to find out if understanding concepts is able to better assist in memorising factual information at university level of education.

Subject lecturers and tutors were most influential in helping the students to learn. In the present dental curriculum, heads of department are also involved in teaching both didactic and clinical subjects. Lesser teaching contact time could be a possible reason for the perceived lesser attention felt by the students given to them by the heads of department. Two-thirds of the sample agreed that classmates were helpful in the course of learning. This finding reflected the need of interdependent learning among the students. However, which aspect of the learning process dental students need to rely on one another will require further investigation. Laboratory technicians were also found to be helpful by the students. As mentioned previously, a significant part of the dental curriculum consists of practical training that includes laboratory work. Thus this finding validated the importance of having quality dental technicians to assist the students in their learning process. Administrative personnel and library staff had lesser influence on the learning process. However, this finding does not mean that they are not important. It might merely indicate that the students had lesser contact with these people who did not have a clear and immediate educational impact on their learning process.

Dental students generally agreed that they spent less time with family and friends outside dentistry. This was to be expected due to the long hours of the dental course. Staying in student hostels might also contribute to the lesser time spent with family. However, slightly more than half of the students did not find that the educational process had reduced their contact time with friends, presumably within the same course. This finding reflected the close-knit environment unique to the dental course.

Two important finding with regards to how dental students cope with pressures was that 82% of the students would occasionally or seldom/never confide their problems to the teachers and 48% would frequently keep the problems to themselves. These findings could mean that dental teachers were approachable and effective for educational purposes only. Further investigation will be required to determine the perception of dental students towards their teachers' ability to help them cope with pressures from other aspects of life that may affect their educational performance. In addition, a great proportion of dental students would rather confide their problems to friends unrelated to the dental course. This might be indicative of the highly competitive nature of the local dental undergraduate programme.

One of the limitations of this study was the small sample size. As such, the use of statistical analysis would not be meaningful and appropriate. The sample included only students in the clinical years. A larger sample consisting of both pre-clinical and clinical students is necessary for future studies. However, this study has provided a broad spectrum of potential areas for future educational research in dentistry. Greater refinement of the questionnaires that address specific issues of the dental education is proposed.

Conclusions

The following conclusions could be drawn from this study:

- Lectures and tutorials were preferred teaching methods.
- PBL was found to be helpful in the learning process.
- Individual/group, practical/lab work was more helpful than group assignment/project.
- A majority of the dental students studied in groups or alone.
- Understanding concepts was unanimously agreed to be helpful in the learning.
- Subject lecturers and tutors were most helpful in the learning process.
- Dental students spent less time with family and friends outside dentistry.
- Dental students rather confide in family/friends than lecturers/classmates.

Dental education is both science and art amalgamated into a rigorous course that requires clinical proficiency and discipline from dental students through both didactic and practical training. The final outcome of the dental course is to produce clinically competent dentists who are independent performers, critical thinkers and long-term learners. A successful dental curriculum will need to address the many facets of the course that will impact the learning process. ■

Decoding the **DNA** of **NUS Students:** A **Survey** of **Student Learning Habits**

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Introduction

One key thrust of NUS is to provide quality education and foster a community that is passionate about learning and discovery. To achieve this, it is essential that we understand NUS students better. Hence, we conducted a brief survey on the learning habits of NUS students and focused on:

- pre-university educational preparedness
- learning habits before and after entering NUS

During Semester 2 of Academic Year 2002/03, the survey was administrated online using the Integrated Virtual Learning Environment (IVLE) website of a freshman undergraduate module, *CS 1102 Data Structures and Algorithms*, which had an enrolment of more than 500 students. The survey, which we call *GEL* analysis, focused on three aspects:

- **G**eneral background
- **E**ducational background
- **L**earning/studying habits before and after entering NUS

Results

The **G**—General Background

A total of 195 students responded to the survey, of which about 73% were male students. Although the gender composition of students in the course was equal among males and females, we conjectured that the higher male response rate was due to higher web usage habits among male students.

Based on the **G** of the students, we were able to divide them into two groups with regards to their pre-university education experience:

- British (Br) systems (mainly Singapore)
- Non-British (NBr) systems (including China, Vietnam, Indonesia, etc.)

We also noted that those from non-British systems had spent less than 5 years in Singapore, with the majority of them having spent less than 2 years here.

The **E**—Educational Background

One of our goals was to link the **E** of the students with their preparedness for university education. It was found that most (about 60%) of those from the Br systems did not feel prepared while most (about 62%) from the NBr systems felt prepared for education in NUS. The students from the NBr systems were also found to have significantly higher grade expectations than those from Br systems, with about 69% expecting a grade of A and above for those from NBr systems compared to about 32% from the Br systems (p-value = 0.001 using Fisher's exact test with a bonferroni correction).

The **L—**Learning Habits

To further analyse the **L**, we considered three factors:

- study environments
- study habits
- study materials

In considering the preferred study environment, it was found that about 50% of the students preferred studying alone, and about 46% preferred to study with a friend or an informal study group. The majority (more than 75%) of the students indicated that they preferred to

Figure 1: Rankings of study materials before and after entering NUS

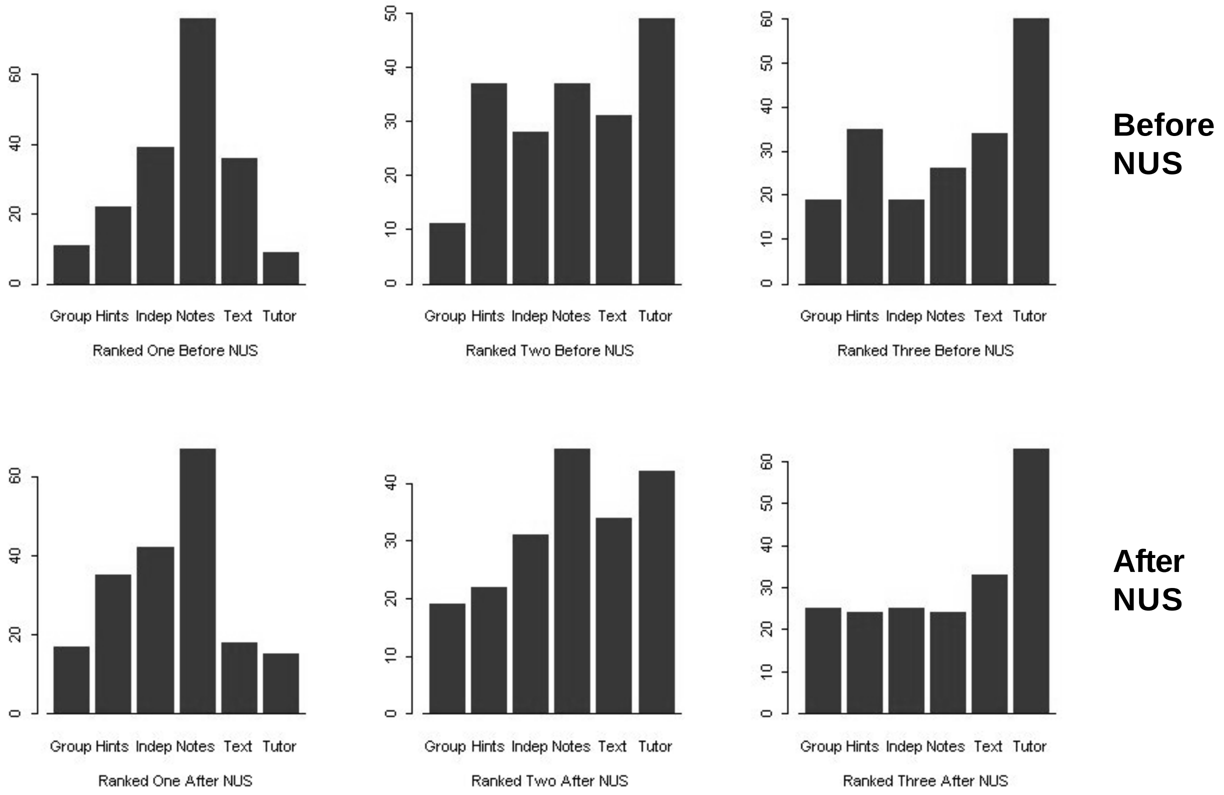
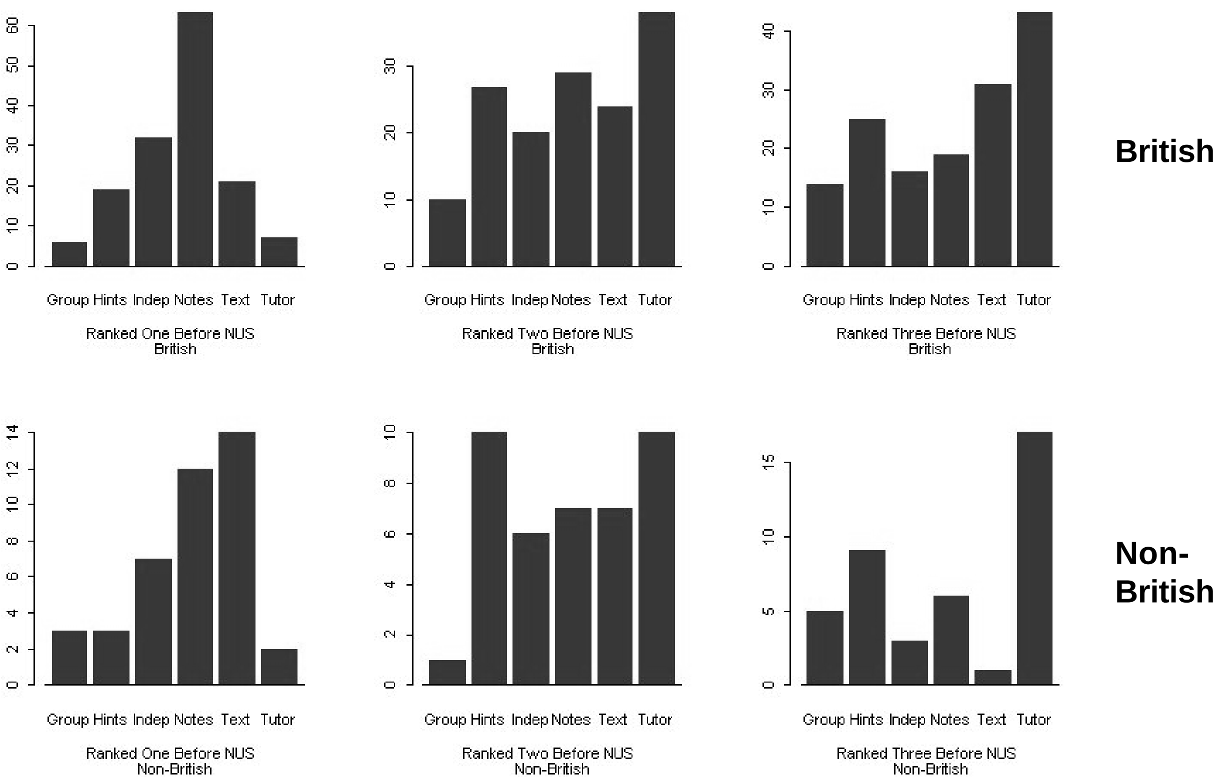


Figure 2: Rankings of materials (A) before and (B) after entering NUS, stratified according to the students' pre-university educational systems

A. Before NUS



B. After NUS

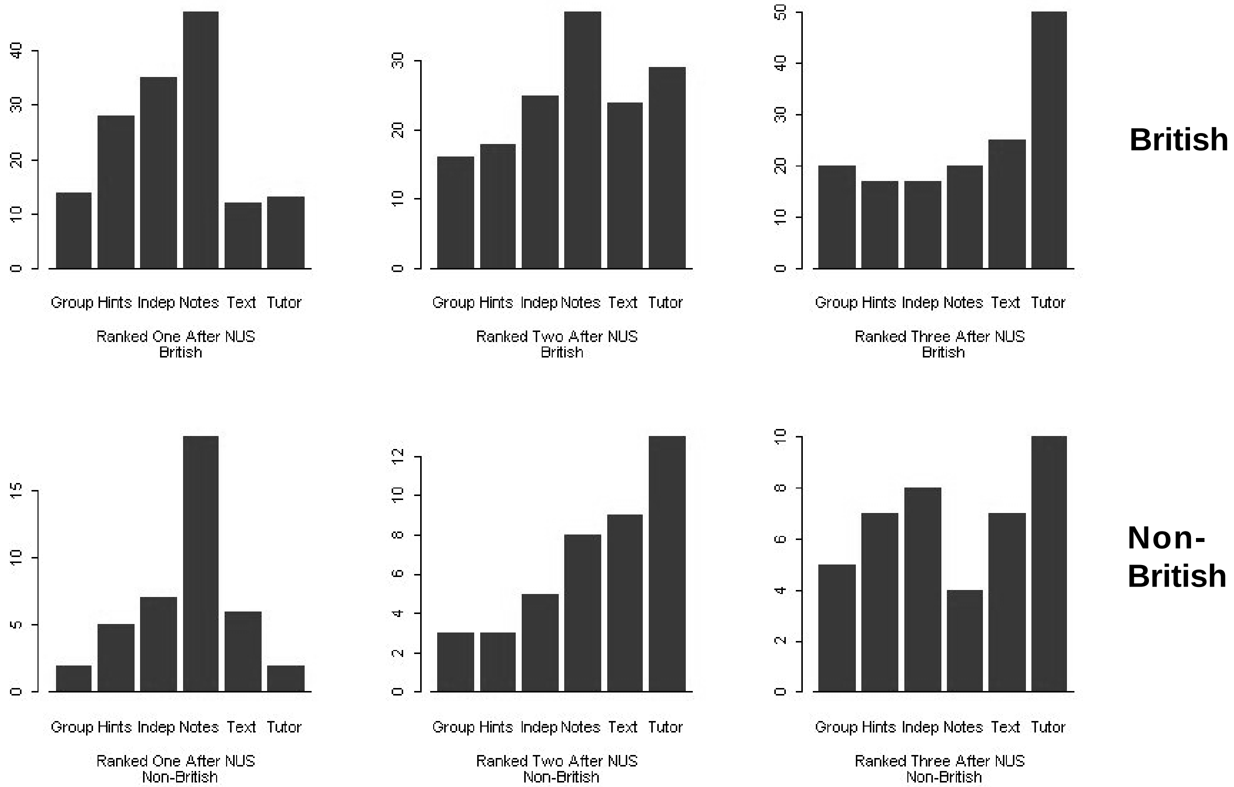


Table 1: Summary of GEL analysis of NUS students

Student Characteristic/Attitudes	Br System	NBr System
Pre-university education: preparedness for NUS	Felt unprepared	Felt prepared
Grade expectations	Low	High
Study environment	Independent Friends Study groups	Independent Friends Study groups
Study habits	Changed	Changed
Study materials (before NUS)	Lecture notes Independent study	Lecture notes Textbooks
Study materials (after NUS)	Mixture	Mixture

study at home or in the library, while a few (about 20%) of them mentioned that it all depended on their moods and offered a combination of home and/or library and/or classroom.

With regards to study habits, we found that the individual study habits of most students have changed since entering NUS.

As for the study materials, the majority of the students gave the highest rank to 'lecture notes' as being the most useful both before and after entering NUS, as shown in Figure 1. Besides 'lecture notes', other study materials which were perceived to be useful are 'textbooks', 'tutors' and 'hints', but it seemed that the reliance on 'hints' reduced after the students had entered NUS. It should to be noted that 'group discussion' was consistently given low ranking by the students and this could be attributed to the fact that they were in a computer science class (data not shown).

To further analyse the study materials, we stratified the students according to their pre-university educational system (i.e. the Br and NBr systems) as shown in Figure 2.

As demonstrated in Figure 2, before entering NUS, students from the Br systems tended to rely heavily on 'lecture notes' and 'independent study', while those from the NBr systems relied more on 'lecture notes' and 'textbooks'. However, this seemed to have changed when they entered NUS, as students from both the Br and NBr systems relied on a wider mix of study materials although 'lecture notes' were still highly regarded.

DNA Connectedness

From this brief survey, the one obvious difference we have observed was in the students' perception towards university education and their own abilities from different educational systems (i.e. the Br and NBr systems). Those from the NBr systems tended to be more confident in both their feeling of preparedness for tertiary education and how well they would perform compared to their fellow students from the Br systems. Hence, teachers must keep these varying perceptions in mind and tailor their teaching approach according to the students' educational backgrounds. In other regards, such as study methods and materials, there were no significant differences between students from the Br and NBr systems. In conclusion, our brief survey has revealed that the educational background of a student contributes to the heterogeneity of a class. ■

The **Role** of **Proper Questions**

Dr Wang Wenge
Department of Physics

The problem I was interested in exploring was the influence of different kinds of questions on the students' behaviour. By carrying out an investigation, I obtained some understanding of how to encourage students to think critically and ask their own questions.

In 2001, I performed two experiments, denoted by S1 and S2 as described below, to study how students responded when asked different types of questions. About seventy students at Level 2 were involved in the two experiments. Since there are many concepts in physics that are not easy to understand for students, I selected two such concepts for the two experiments. The process of the experiments and the results are as follows.

S1 consisted of two steps. First, various aspects of a concept were explained; most of the students responded by just accepting what was taught without any queries. Next, the students were questioned about how the concept taught is possibly related to other concept(s); the students thought for a while and a few subsequently offered their answers.

It was observed that most of the students did not find it easy to grasp the spirit of the concept although they could repeat most of its properties and relate it to other concept(s). Upon further analysis, I realised that the students did not understand why the concept had been introduced, (i.e. the situation in which the concept had been introduced). Such knowledge is extremely important for one to understand difficult concepts. These observations prompted me to conduct the second experiment.

S2 consisted of three steps:

1. I explained to the students the background knowledge, in particular, an old theory, which are useful in introducing the concept.
2. I presented some new phenomena that could not be explained by the old theory, then, asked the students: "How would you improve the theory to explain the new phenomena?" The students responded by giving some suggestions.

3. I followed up on the students' suggestions and discussed the possible results. Finally, I introduced the concept. The students responded by raising more suggestions. Then, some of the students even began asking why some of the suggestions could not work.

The teaching method used in S2 was successful in arousing the students' curiosity about the phenomena surrounding the concept and helping them to understand why a new concept had to be introduced in the face of unexplained phenomena. It is important for students to cultivate such knowledge and ability if they wish to pursue a career in research. The S2 method also challenges the lecturer: the lecturer must have wide-ranging knowledge and a strong analytical ability to cope with the students' suggestions in Step 3. Note that the lecturer should not just declare that a student's suggestion as unfeasible; instead, he/she must take the time to explain why it cannot work.

To conclude, I wish to highlight that both S1 and S2 have their own advantages and one should not simply assume that S2 is better than S1 by the experiments explained above. S1 may be better for explaining concepts that are not counterintuitive because it is more systematic than S2 and takes less time. In contrast, S2 is suitable for explaining concepts that seem counterintuitive, or not obvious at the first sight. ■

CDTL

The Centre for Development of Teaching and Learning (CDTL) engages in a wide range of activities to promote good teaching and learning at the National University of Singapore, including professional development, teaching and learning support, research on educational issues, and instructional design and development.

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