Effect of Interactions between Demographic Variables and Learning Traits on International Students' Performance

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Abstract:

This research study investigated approaches by international students from vastly different educational, cultural and linguistic backgrounds to learning and their academic performance in Foundation Studies (FS) at RMIT University. This paper explores the effect of the interactions between various demographic variables and learning traits on students' performance under Traditional method of Teaching and Learning (TTL) and Problem Based method of Learning (PBL). Most universities around the world run Foundation Programs (FPs) as a bridging course between high/secondary schools and undergraduate studies with the aim of improving the quality of international student intakes for university undergraduate studies. Discipline-based and lecture dominated TTL is gradually giving way to PBL in many universities. This research study addresses the question 'Are there different teaching and learning techniques more appropriate to international students studying in an English dominated study environment?'. The effects of the magnitude of interactions between demographic variables and learning traits on students' performance have been discussed at length. The magnitude of the effect of the treatment was calculated by using effect size calculations. Effect sizes were calculated by using Cohen's *d* with Hedges g correction. Interesting effects were observed on students' performance due to the interaction between demographic variables and learning traits.

This research study raises interesting and challenging questions about the provision of teaching and learning practices, which may enhance international students' learning.

Introduction

The study investigated the effect of the magnitude of interactions of demographic variables and learning traits on international students' performance in Foundation Studies (FS) in two different methods of teaching and learning. The four demographic variables in this study were gender, age, prior qualification and medium of instruction in prior education before joining FS. The learning traits include *introvert/extrovert*, *intuitive/sensing*, *thinking/feeling* and *perceiving/judging* on four learning style dimensions. The two methods of teaching and learning were Traditional Teaching and Learning (TTL) and Problem-Based Learning (PBL).

FS is an accredited program offered to international students for their tertiary education in Australian universities (RMIT, 2006). On successful completion of FS, students have various pathways to continue their education in tertiary education. International education not only provides universities with revenue but also brings in cultural contributors to Australian society and the higher education sector. At the same time international education is important to international students themselves as well as their own families and nations (Deumert, Marginson, Nyland, Ramia, & Sawir, 2005). It is in this context that the researcher finds the FS program at RMIT to be of great importance. It is an opportunity for RMIT as well, to groom a group of international students each year in its own cultural conventions and educational ethos. It is an avenue for sowing the seeds of

student- centred education for a group of future tertiary students at RMIT in each year. It makes learning more enjoyable, effective and stress free for both students and teachers at the tertiary level.

After FS most of the Biology students go for higher studies in Health Sciences. Medical schools both in Australia and overseas have shifted their paradigm from TTL to PBL. In Australia, PBL was introduced in 1978 at the medical school of University of Newcastle, NSW (Schmidt, 1998). It has since been introduced in most other medical schools in Australia. The department of Education and Children's Services in South Australia has introduced PBL in primary and secondary schools (Hollands, 2005). In PBL, learners are progressively given more and more responsibility for their own education and become increasingly independent of the teacher for their education (Barrows, 1985). PBL is an instructional method that challenges students to learn how to learn, work cooperatively in groups to seek solutions to real world problems (Duch & Norton, 1992). In PBL, students act as professionals and confront problems as they occur and need to determine the best solution possible. An important feature of PBL is that it is a student-centred approach of learning. Students learn to determine what they need to know. The emphasis is that the acquisition of information and skills by students depends on students' abilities to identify their educational needs, best manner of learning, pace of learning and their ability to evaluate their learning (Barrows & Tamblyn, 1980). Student-centred learning describes ways of *thinking* about learning and teaching that emphasises student responsibility for such activities as planning learning, interacting with teachers and other students,

researching and assessing learning (Cannon, 2000). I was curious to find out whether the Biology students in FS are comfortable in the PBL method.

The literature reviewed emphasised that students' learning style preferences are important as well as other factors like learning environment and interest in the course of study. Academic achievement requires the ability to deal with concepts and ideas deeply, which should favour people with *introvert* characteristics. On this ground, it has been predicted that *introverts* perform higher than *extroverts* in academic performance (Myers & McCaulley, 1985). Time bound tests put *intuitors* at an advantage due to the fact that *sensing* types tend to read test questions several times before answering them (Myers, 1980). If memorization and recall were important, *sensing* types tend to perform higher and if analysis was required *intuitive* students had an advantage (Wankat & Oreoviez, 1993). These predictions have been verified in the field of engineering (O'Brien, Bernold, & Akroyd, 1998) and (Felder, Felder, & Dietz, 2002). In these studies among engineering students showed that *introverts*, *intuitors* and *judgers* generally outperformed their *extrovert*, *sensing* and *perceiving* counterparts. A longitudinal study conducted among Canadian engineering students had claimed that male students with preferences for *introversion*, *intuition*, *thinking* and *judging* were found to be more likely to succeed in the first year engineering curriculum than were their *extrovert*, *sensing*, *feeling* and *perceiving* counterpart (Rosati, 1997). However, a previous study in 1993 claimed that among the male students at the lower end of academic performance, *sensing* students were more likely to complete the course successfully (Rosati, 1993).

In a study conducted at the University of Sydney, NSW students' learning styles were investigated by using Paragon Learning Style Inventory (PLSI) and checked their effect on academic performance of first year chemistry undergraduate students. The study showed that *introvert* students perform higher than *extrovert* students and *thinkers* perform higher than *feelers* (Yeung, Read, & Schmid, 2005). The same study had shown no significant relationship between academic performance scores and learning styles on *sensing*/*intuitive* or *judging*/*perceiving* dimensions (Yeung, Read, & Schmid, 2005).

The PLSI is a self-administered inventory based on the personality test called MBTI, which in turn is based on Jung's theory of personality (Yeung, Read, & Schmid, 2005). Shindler and Yang in 2002 developed this instrument and it has shown excellent reliability and stability (Shindler, 2002). John Schindler felt that the MBTI was not suitable for young students owing to the language and structure of the questions. This led to the development of a modified version of MBTI that suits students aged 9-20 years as well as adults for an assessment of learning styles. It was developed specifically for use in educational settings and has been previously used in determining the learning styles of tertiary students (Yeung & Read, 2006).

Foundation students at RMIT are all international students and the majority has difficulties studying in English as the major mode of communication during their first year in Australia. Hence it was felt that the PLSI was the most suitable instrument to determine their learning styles. Furthermore the easy self-assessed scoring system facilitated a reliable classification for educational purposes.

The PLSI uses Jungian/Myers-Briggs dimensions, *Extroversion*/*Introversion*, *Sensing*/*Intuiting*, *Thinking*/*Feeling* and *Judging*/*Perceiving*. Sixteen Learning Style Types (LST) are formed from these four dimensions. This inventory has 48 questions with two answers numbered 'a' and 'b'. Students can choose either 'a' or 'b'.

Research Participants

The participants of this research were 116 Foundation International Biology students during 2003-2006 academic years at RMIT. Among them 49 were male and 67 were female students. In relation to age 98 students were below 20 years and 18 students were 21-27 years. Among the participants 108 students completed secondary school education and 8 students completed their tertiary education from their respective countries. On the basis of the language of instruction in their prior qualifications, 53 students studied in English and 63 students studied in languages other than English.

Procedure

In each academic year there were two intakes of students of FS at RMIT, one in February and the second in June. The February intake was designated as *Group 1* and the June intake was designated as *Group 2* and the data collection was carried out in the second semester of each intake.

The demographic data for each student were gathered by using a questionnaire. This was followed by administering the Paragon Learning Style Inventory (PLSI) (Schindler,

2003) to measure students' approaches to learning. All students were given a copy of the questionnaire and were given 30-40 minutes to go through each item and mark their preferences. Each student's learning style was identified by the researcher after analysing these questionnaires. The students were then provided the identified learning style together with the characteristics of all 16 learning styles and the occupational trends of the 16 types.

The next phase of the research investigated students' performance in Biology. Group 1 of 2003 was taught Topic 1 in the Biology syllabus in TTL. A test was conducted after the TTL and it will hereafter be referred to as Test 1. The same students were facilitated by the researcher to learn Topic 2 in the Biology course by PBL method. For this purpose, the eighteen students of Group 1 were divided into 3 small groups, and each group was seated separately in the same classroom. Each small group consisted of six students and a Case Study in the form of an analysis worksheet was given to each student by the researcher. The case was prepared in such a way that students could derive the required learning issues from Topic 2 after group discussions and deliberation about the case. The case was designed in three sections. After each section, there was a discussion time of about 10 minutes in which students within a group could identify and come to a common consensus about the key information, the problem mentioned, the hypotheses and rationale of the hypotheses. Each student wrote this information in the given space of the worksheet. In this group discussion the researcher was the facilitator and encouraged each student to participate actively. Then students in each group read and discussed the second section of the case. More information was added and hypotheses and rationale

were added or modified according to the student reflection and deliberation about the case. The same process was continued with the third and fourth section. At the end of the three sections, students were able to derive the learning issues and each group identified a few learning issues. The researcher checked the learning issues derived by each group and made sure that all the required learning issues were covered. For this exercise two periods of approximately 50 minutes were used. The next two biology periods were used for collecting information about the learning issues and organising them by referring to library books, journals, videocassettes and Internet facilities. This section was conducted at RMIT library. Each group undertook the task separately. This information gathering session was used to build on existing knowledge of each group to enable them to solve the problems in the case study and learning issues. In this process students worked as a team helping each other to find the solutions for most of the learning issues. The researcher was helping and guiding the students to gather information at the appropriate level. The next two Biology classes were used for the presentation, discussion and deliberation by each group. At the end of the session all learning issues were summarised by the students and the researcher made sure that all the required information at the appropriate level was discussed and explained. The next Biology period was used for conducting a test, which will hereafter be called Test 2**.**

The same process was undertaken with Group 2 of 2003. However, the PBL method was used for Topic 1 and Topic 2 was taught by TTL method. The researcher prepared another PBL case study for Topic 1, so that students could derive all of the required learning issues for this topic. The same process was repeated in 2004 and 2006 using the

same case studies and the same tests. The Table 1 represents this procedure in chronological order.

Table 1 **Research design for investigating students' performance**

2003	Group 1	Topic 1 by TTL	Test 1
		Topic 2 by PBL	Test 2
	Group 2	Topic 1 by PBL	Test 1
		Topic 2 by TTL	Test 2
2004	Group 1	Topic 1 by TTL	Test 1
		Topic 2 by PBL	Test 2
	Group 2	Topic 1 by PBL	Test 1
		Topic 2 by TTL	Test 2
2005	Group 1	Topic 1 by TTL	Test 1
		Topic 2 by PBL	Test 2
	Group 2	Topic 1 by PBL	Test 1
		Topic 2 by TTL	Test 2
2006	Group 1	Topic 1 by TTL	Test 1
		Topic 2 by PBL	Test 2
	Group 2	Topic 1 by PBL	Test 1
		Topic 2 by TTL	Test 2

Note: Topics 1 and 2 were two of the ten topics in semester 2 of FS.

The researcher marked both Test 1 and Test 2 and the results were given to each student. Students were given a chance to go through their scripts and identify their strengths and weaknesses in these particular learning areas.

While observing the discussions, deliberations and presentations by the students during the PBL sessions, the researcher rated each student's participation using the rating scale

Students' Participation in Group Discussion (SPGD). At the end of the whole PBL process, students were given a chance to evaluate themselves by using the rating scale Students' Self Evaluation (SSE).

Analysis

Having carried out an analysis of means and variations as well as the magnitude of these variations, the researcher went on to analyse these variables in greater depth by investigating the effect of two independent variables at a time, on a third dependent variable in order to determine whether the two independent variables influenced one another in their effect on the third. Owing to the many variables and interactions possible, this resulted in the investigation of numerous combinations of variables in their influence on each other. This was done by constructing line graphs on SPSS and noting observed trends and interactions.

Line graphs were constructed for investigating the interaction of the four demographic fixed subject variables gender, age group, prior qualification and language of instruction of prior education with the four pairs of learning style traits and their combined effect on performance in TTL, PBL, SPGD and SSE scores. This was done by placing a learning style trait pair on the category axis and plotting separate lines for each group of the demographic variable against scores on each of the assessments. This resulted in 64 graphs that showed some very interesting trends for each group along a learning style dimension.

Each graph had a learning style dimension on the horizontal axis indicating two learning traits. Performance level on one of the assessments was shown on the vertical axis. Two separate coloured lines showed the performance of students grouped according to a demographic variable. These lines showed some clear trends in many cases. In some cases the two lines ran parallel to each other, while in other cases they were inclined to each other in varying degrees and in yet other cases they intersected each other and crossed over.

Parallel lines upwards or downwards indicate ‘no interaction’ between the categorizing variable on the horizontal axis and demographic variables. However, such graphs do indicate that one level of a variable displays a higher score than the other level. Non-parallel lines with differing slopes indicate the presence of interaction and it can be seen that the greater the difference in slope, the greater the degree of interaction. Effect size calculations were employed to provide a quantitative measure to the varying degrees of interaction, referred to hereafter as the ‘magnitude of interaction’. The effect size provides information about how much change is evident across all studies and for subsets of studies (Glass, McGaw, & Smith, 1981). As this study involved existing class groups or demographic groups and did not control for variables, the comparison was often between groups of unequal sizes. Hence effect size was deemed to be the appropriate measure in this situation. Effect size is a measure of the strength of the relationship between two variables and uses standard deviation to contextualize the difference in means. The advantage of effect size over statistical significance is that it is independent of sample size.

Some representative graphs are shown below. Figure 1 shows a graph where the lines appear to be parallel indicating no interaction.

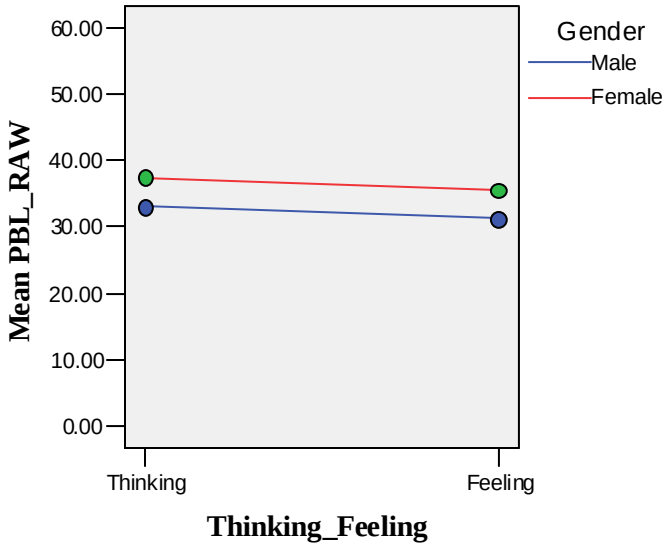

Figure 1 Interaction between gender and *thinking/feeling* traits on PBL

Figure 2 shows a graph with non-parallel lines indicating there is some interaction between gender and the *perceiving/judging* learning traits.

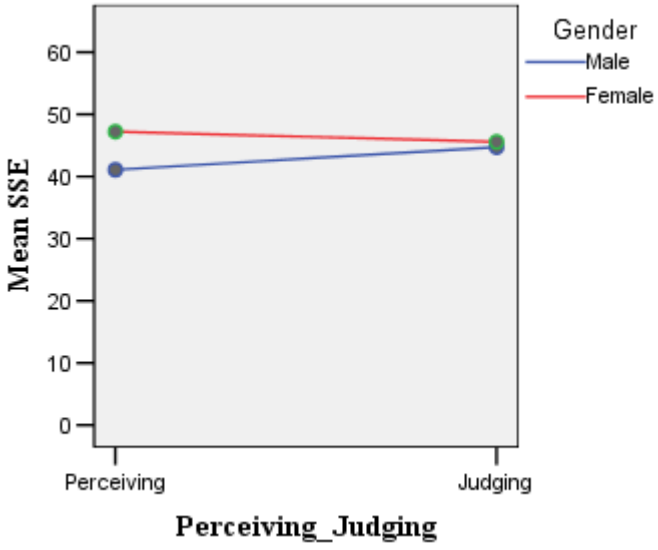

Figure 2 Interaction between gender and *perceiving/judging* traits on SSE

When the lines on a graph cross as shown in Figure 3, the performance trends were reversed. In this graph, the male *introvert* students scored higher than the male *extrovert* students however in the case of the female students, the reverse was observed.

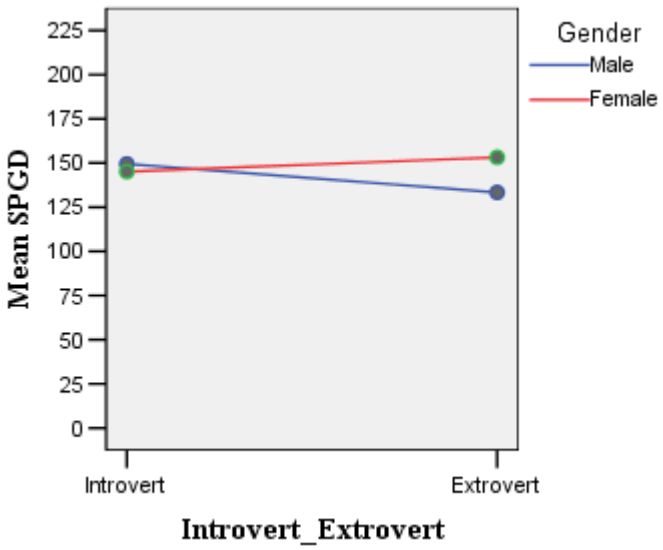

Figure 3 Interaction between gender and *introvert/extrovert* traits on SPGD

The endpoints of the lines indicate the mean score of a subgroup of students grouped according to the learning style traits as well as the demographic variable concerned. For example in Figure 2, the endpoints of the blue line representing male students denote the mean score on the SSE test for male *perceiving* learners and male *judging* learners. These means were calculated on SPSS and the difference in means between the endpoints of the two lines on each learning trait end was determined and the effect sizes were calculated using Coe's effect size calculator spreadsheet (Coe, 2006).

The effect sizes of the difference between the two pairs of endpoints at each learning style trait were calculated. The magnitude of the interaction was defined as the difference between these two effect sizes. When the lines cross over, the differences between the two endpoints were added together to represent the true difference.

Descriptors for magnitudes of effect sizes from very small (Izard, 2004) small, medium and large (Cohen, 1969) are used for the analysis. An effect size of ≥ 0.8 has been classified as *large*, any value ≥ 0.5 and < 0.8 as *medium*, a value ≥ 0.2 and < 0.5 as *small* and anything < 0.2 as *very small* or negligible. In effect this provides an assigned range on either side of the endpoints for decimal rounding. For example any effect size from 0.45 to 0.74 is the assigned range for *medium* effect size. The researcher has also used a visual pointer to these effect sizes by colour coded highlighting. Any *large* effect has been highlighted in red, a *medium* effect in yellow, a *small* effect in green and a *very small* effect size has been highlighted in blue. The Table 2 is given as a representation to show the interaction between two independent variables on performance.

Table 2 Interaction between gender & *Perceiving*/*Judging* learning traits

Assess	*Group 1*	*Group 2*	**Effect Size*	**Difference in Effect Sizes*	**Magnitude of Interaction*
TTL	Fem Perc	Male Perc	0.52	0.15 in favour of Perc	*Small*
	Fem Judg	Male Judg	0.37		
PBL	Fem Perc	Male Perc	0.43	0.10 in favour of Perc	*Very small*
	Fem Judg	Male Judg	0.33		
SPGD	Fem Perc	Male Perc	0.32	0.20 in favour of Perc	*Small*
	Fem Judg	Male Judg	0.12		
SSE	Fem Perc	Male Perc	0.79	0.66 in favour of Perc	*Medium*
	Fem Judg	Male Judg	0.13		

* ***Large*** ***Medium*** ***Small*** ***Very small.***

For analysis purposes 16 such tables showing interactions between demographic variables and learning style traits were generated corresponding to the 64 line graphs.

Results

Some interesting results emerged as a result of the analysis of these 16 tables and 64 line graphs and these are summarized below in Table 3. There were varying levels of interactions between the variables ranging from *very small* to *large*. The calculation and interpretation of the magnitude of interaction between gender and the *introvert/extrovert* learning style traits is described as a representative sample of the analysis involved.

Table 3 Interaction between demographic variables and learning style traits

Subject Variables	*Dependent variables*	*Learning style traits*			
		I / E	*N / S*	*T / F*	*P / J*
		Magnitude of interaction			
Gender	TTL	*small*	*very small*	*very small*	*small*
	PBL	*medium*	*small*	*none*	*very small*
	SPGD	*medium*	*very small*	*small*	*small*
	SSE	*small*	*small*	*small*	*medium*
Age group	TTL	*medium*	*large*	*small*	*large*
	PBL	*very small*	*very small*	*very small*	*small*
	SPGD	*small*	*small*	*very small*	none
	SSE	*small*	*medium*	*large*	*small*
Prior Qualification	TTL	none	*medium*	*large*	*large*
	PBL	*small*	*small*	*small*	*small*
	SPGD	*small*	*large*	*large*	*small*
	SSE	*very small*	*large*	*medium*	*small*
Language of Instruction of Prior education	TTL	*small*	*small*	*very small*	*large*
	PBL	*medium*	*small*	*very small*	*large*
	SPGD	*small*	*small*	*small*	*medium*
	SSE	*medium*	*medium*	*small*	*small*

The interaction analysis between gender and the learning style traits indicated that there was a *small* (0.28) interaction between gender and *introvert/extrovert* traits on TTL. This was due to the *small* (0.22) effect size of the difference in means between the male and female *extrovert* students and the *medium* (0.50) effect size of the difference in means of the male and female *introvert* students. The magnitude of interaction between gender and *introvert/extrovert* traits on PBL was found to be *medium* (0.59) and this was due to the *very small* (0.04) and *medium* (0.63) effect sizes of the difference in means between the two groups. In the case of SPGD, the magnitude of interaction was found to be *medium*

(0.69) and this was due to the *very small* (0.12) and *medium* (0.57) effect sizes of the difference in means between male and female *introverts* and male and female *extroverts* together with the fact that the lines crossed over. On the SSE, the magnitude of interaction was *small* (0.15). This value was obtained as a result of the *small* (0.26) effect size of the difference of means between the male and female *introverts* and the *small* (0.41) effect size of the difference in means between the male and female *extroverts*.

The results suggested that there was a clear interaction between gender and the *introvert/extrovert* learning traits. This showed that the extroverts were possibly contributing to the difference in performance between the genders. Similarly it was observed that the difference between male and female *intuitive* students was more pronounced than the difference between the male and female *sensing* students, on PBL, SPGD and SSE. The trend was reversed on TTL. Thus the *intuitive* trait might also have contributed to the difference in performance between the genders especially under Problem- Based method of learning. The analysis of interaction between gender and the *thinking/feeling* learning traits showed that the thinking learners might have contributed to the difference in performance between the genders especially in the case of Problem-Based method of learning and the male thinking students might need more support in PBL. It was noted that the difference between the male and female *perceiving* students was greater than the difference between the male and female *judging* students and the difference was more pronounced on TTL and SSE while on PBL and SPGD, the difference was relatively smaller. Thus the *perceiving* trait could also have been contributing to the difference in performance between the genders.

The results of analysis of interaction between age and learning style traits also displayed some trends. It was observed that being an *extrovert* mature age student could contribute to the difference in performance on TTL. Hence the mature age *extrovert* students might need extra support in learning under TTL. The interactions were *small* or *very small* under PBL. This suggests that mature age *extroverts* scored higher under PBL compared with TTL. It was also observed that the *intuitive* trait could contribute to the difference in performance between normal and mature age students on TTL. The normal age *intuitive* students scored much higher than their counterparts and it suggests that all *sensing* students and mature age *intuitive* students might need extra support for learning under TTL. Once more the difference was less pronounced under PBL with the exception of the SSE where crossing over of the line graphs in a trend reversal showed a medium interaction. This suggests that the mature age *intuitive* students scored higher on self evaluation. There was little interaction between age and the *thinking/feeling* traits except on the SSE, which again showed a reversal of general trend due to the mature age *feelers* scoring higher. The difference between the age groups was also more pronounced in the case of the *perceivers* compared to the *judgers* on all but the SPGD. Results of analysis of interaction between age and the *perceiving/judging* traits indicated that the *perceiving* trait might have been contributing to the difference between the age groups as the normal age *perceiving* students scored higher than other students on all but the SSE on which the mature age *perceiving* students scored higher. Thus teachers need to be aware of the needs of mature age *extrovert*, *intuitive* or *perceiving* students.

It was seen that there was very little interaction between prior qualification and the *introvert/extrovert* learning traits. The slight differences that became apparent seem to point towards *introverts* showing greater ability to cope with and overcome any difficulties and reduce the difference in performance. There was considerable interaction observed between prior qualification and the *intuitive/sensing* traits. On all assessments the difference between school and tertiary qualified students was greater among the *intuitive* learners than among the *sensing* learners. In fact the trend was reversed in the case of *sensing* learners on the SPGD and SSE. This indicated that the *sensing* learners seemed to be able to overcome the difference exhibited between school and tertiary qualified students, to a certain extent, while the difference was more pronounced for the *intuitive* students.

There was also a considerable interaction observed between prior qualification and the *thinking*/*feeling* traits. The difference between the school qualified and tertiary qualified students was far more pronounced in the case of *feeling* students compared to *thinking* students. Thus the *feeling* trait may have contributed to the difference between the performance of school and tertiary qualified students. Hence the tertiary qualified *feeling* students might need more support under both methods of teaching. However it was noted that the tertiary qualified *thinking* students were more confident in their self evaluation. The *perceiving/judging* traits also seemed to interact considerably with prior qualification. The difference in performance by prior qualification was far more pronounced in the case of *perceivers* compared to *judgers* the greatest difference being apparent on TTL. Notably, on PBL contrary to the general trend, the tertiary qualified

perceiving students scored higher. The *judgers* seemed more capable of overcoming any existing difficulties and reducing this gap in performance levels. Thus the point for consideration here would be that tertiary qualified students were very few and would naturally be mature age as well as changing their fields of study. Thus it would appear that *extrovert*, *intuitive*, *feeling* and *perceiving* students in this group would probably need extra support.

Thus the analysis of interaction between language of instruction of prior education and learning traits indicated that the *introvert/extrovert* traits clearly had some interaction with the language of instruction. The difference in performance between the two groups was more pronounced among the *extrovert* students, the *introverts* seeming to cope better. Furthermore in PBL it was noted that *introvert* students with language of instruction was not English, overcame their shortcomings in language proficiency to a larger extent than the *extrovert* students. On TTL *intuitive* students with other languages of instruction scored higher than all others. However, on PBL the *intuitive* students with English as the language of instruction scored higher. This showed that all *sensing* students and *intuitive* students with other languages of instruction need more support. The *thinking/feeling* traits did not seem to interact much with language of instruction. However, the very slight difference was in favour of *thinkers* who appeared better able to overcome any difficulties in language proficiency. The *perceiving/judging* trait on the other hand had a very definite interaction with language of instruction of prior education. The general trend was reversed in the case of *perceivers* on all four assessments in that among the *perceivers*, students with other languages of instruction scored higher than

students with English as language of instruction. On the other hand among *judgers*, the reverse was the case on all four assessments. This showed that while *judgers* have emerged as higher scorers in other analyses, the *perceivers* seem to cope better with any language related difficulties. Thus *perceiving* learners might have contributed to reducing the overall difference in performance between the two groups with English and other languages as the language of instruction.

Findings and Recommendations

International students in any university in developed countries come from different educational, social and cultural backgrounds. They would have been exposed to varying teaching and learning environments depending on the educational systems in their respective countries. While they might have been highly successful under those systems, very often they find themselves out of their depth when faced with unfamiliar teaching and learning situations and very different educational expectations. This in turn can lead to frustration especially when some of their peers appear to be coping with the situation. Hence the classroom situation should accommodate the needs of students from various educational backgrounds. Based on the findings of this research in preparing students by FS and other transitional programs for educational pathways in Health Sciences and other Biological sciences, it will be advantageous to use a mix of traditional and Problem-Based methods in teaching Biology. Further, teachers should be aware of interactions between the demographic variables and learning style traits and their effect on performance in Biology.

Teachers and lecturers should keep in mind that gender and learning style traits do have a combined effect on performance in Biology and on PBL in particular. Thus it would be in the interest of achieving effective teaching and learning, to be aware of students' learning style preferences and to cater for activities to suit the various characteristics of the learners in the classroom. Hence, on the basis of the results of this research, male *extrovert* students, male *intuitive* students, male *thinking* students and male *perceiving* students should be catered for in the teaching and learning situation. Male *extroverts* and male *thinkers* might need more support on Problem-Based learning. *Extroverts* students are impatient with long slow jobs, prefer to communicate by talking rather than writing and like to learn a new task by talking it through with someone (Shindler, 2003). Hence by promoting co-operative learning, group work, giving opportunities for asking questions and expressing their ideas, *extroverts* can be accommodated well in a classroom situation. More facilitation might be needed in self-directed learning involving referring relevant resources, integrating old and new knowledge, understanding the learning issues and attaining appropriate level of knowledge. *Thinkers* are good at putting things in logical order, have a talent for analysing a problem, respond more to people's ideas rather than their feelings, tend to be firm, tough-minded and may hurt people's feelings without knowing it (Shindler, 2003). Hence *thinking* students might excel in the problem-solving and logical reasoning aspects of PBL. However, they might need more facilitation in group-oriented activities. This can be done by giving them concrete and regular feedback, convincing them of the necessity for accommodating the feelings of other students and valuing their logical input. Male *intuitive* and male *perceiving* students are two other groups that were found to need support under both methods of learning.

Intuitive students are aware of new challenges and possibilities, focus on how things could be improved, dislike doing the same thing repeatedly, work in bursts of energy powered by enthusiasm with slack periods in between, may leap to conclusions quickly and follow their inspiration and hunches (Shindler, 2003). These students could be supported in their learning process by giving an overall picture of the task without overemphasizing details, providing individual attention when necessary and ensuring a mix of both traditional and Problem-Based methods of teaching. *Perceiving* students often do things at the last minute and perform well under pressure of a deadline, adapt well to changing situations and use lists as reminders of all the things they have to do (Shindler, 2003). The performance of these students could be enhanced by providing clear written assignment guidelines and time frames for completion. They might need some help to make decisions and avoid postponing unpleasant jobs.

All tertiary qualified students in this study are mature aged and scored higher on PBL than TTL. However, all mature aged students are not tertiary qualified. The interaction analysis further showed that though mature age students scored higher in PBL than TTL, normal age students scored higher than mature age students in both TTL and PBL. The interview analysis indicated that mature age students had personal problems in attending classes regularly as they had to support themselves. That was not the case for the majority of normal age international students as they were usually financially supported. The interview analysis also showed that most of the students preferred the traditional method of teaching and learning compared to the Problem-Based method of learning. However, mature age students often had difficulties keeping pace with the regular activities like

note taking, class exercises, practical activities and written submissions of assignments as expected in the traditional method of learning. It was noted that incorporating self paced activities and Problem-Based method of learning into the curriculum could benefit mature age students. Further, in higher education students are required to use more student-centred and analytical approaches to learning. FS is a bridging program that prepares students for higher education. Hence it is recommended that a combination of traditional and Problem-Based methods of teaching and learning should be encouraged in Biology in FS.

International students often have languages other than English as language of instruction in their prior education. Comparisons between the performance of students with English as the language of instruction in their prior qualification and their counterparts with other languages of instruction, had shown that the difference in performance between the two groups was greater in PBL, although the difference was *small*. Hence it is recommended that students from other language backgrounds who have completed their education in other languages might need more facilitation to overcome their language difficulties in self-directed, student-centred PBL activities. Further interaction analysis showed that *extroverts* with other languages of instruction need more support under both methods of learning. *Sensing* students with other languages of instruction seemed to need more support to perform better in written tests, while they performed well in PBL group activities. On the other hand *intuitive* students with other languages of instruction might need more support in group participation while they performed relatively better on the written tests. Another interesting observation was that *perceiving* students with other

languages of instruction actually scored higher than their counterparts with English as language of instruction reversing the general trend on all four assessments. This suggests that *judging* students with other languages of instruction need more support on language issues. Hence it is recommended that teachers should encourage *extrovert, intuitive, sensing* and *judging* students from other language backgrounds to use support facilities provided by most universities to improve their language, writing, presentation and communication skills.

The researcher feels that it will be advantageous to determine the student learning styles at the beginning of any program using the PLSI. In addition, it would also be in the interest of good teaching and learning for teachers to be aware of their own learning style traits so that they will be in a position to accommodate and enhance the learning processes of the students with different learning styles without being affected by their own preferences.

Lastly, researcher recommends the use of instruments like SPGD and SSE for assessment purposes to measure students' participation in PBL activities. This will provide a systematic feed back to the facilitator to identify the individual learning differences of students and provide appropriate support.

Conclusion

This research is unique in many respects owing to its topic, participants and methodology. While there have been numerous studies involving the effect of learning style traits on academic performance, to the knowledge of the researcher, no study has been done among international students. Secondly, this is the only study, also to the best of the researcher's knowledge to compare the traditional and Problem-Based methods of teaching and learning among international Biology students. Thirdly, the participants of the study are FS students in a bridging course between school and university, which also adds to the uniqueness of the results. The results of the study have thrown light on many factors that affect performance in Biology under two methods of teaching and the many interactions among these factors. These findings can be of benefit to all Biology teachers and lecturers, to other Biology educators, administrators and authors as well as to all practitioners of Problem-Based teaching and learning.

In the light of the many trends observed in this study, which involved a relatively small sample of international students, there is need for research on a much larger scale in order to ensure that conclusions might be generalised to other contexts. The trends and interactions that have emerged as the result of this study open up avenues for further research to investigate these trends in greater depth with larger samples or through longitudinal studies. The study replicated in other universities or other countries might lead to greater insights into the influence of student approaches to learning and other student characteristics on academic performance under the traditional and Problem-Based method of teaching and learning.

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