

Research Article

Academic Achievement of International Biological Science Students Under Two Teaching Regimes

Varughese Kuzhumannil Varughese

School of Life and Physical Sciences, College of Science, Engineering and Health, RMIT University, Melbourne, Australia.

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Abstract

Most developed societies have become increasingly multicultural and as such their educational institutions are required to educate increasingly diverse student cohorts. International students differ greatly in their education and language backgrounds and tend to fall into different age groups as well. It is a challenging task to accommodate all individual differences and optimise the learning environment. This study investigates the impact of students' background on academic achievement scores in Biology. Differences in academic achievement scores of a group of international students in two teaching and learning practices were compared by student background. Effect size calculation using Cohen's d with Hedges' g correction was used to determine the magnitude of difference in performance. The results were observed to vary from very small to large. Recommendations to improve the learning experience of students from diverse backgrounds have been made in the light of these findings.

Keywords: Teaching and learning practices, international students, magnitude of difference, effect size

Introduction

Globalisation and advancements in technology have changed the outlook of education. Most developed societies have become increasingly multicultural. Universities all over the world are in the process of rapid change and they are being required to educate students from an increasing variety of backgrounds, despite decreasing government funding. The student cohorts have become increasingly diverse since the 1990s (McInnis, James and McNaught, 1995). Since 2000 this increase has been almost explosive. On the one hand economic empowerment of the middle class in developing nations has allowed an influx of international students into educational institutions in the developed countries such as USA, UK and Australia. On the other hand universities faced with reduced government funding have expanded their market overseas with a view to attracting fee paying international students. Multicultural education is an approach to teaching and learning that is based on democratic values and beliefs. It affirms cultural pluralism within culturally diverse societies. It is based on the assumption that the primary goal of public education is to foster the intellectual, social and personal development of virtually all students to their highest potential (Bennett, 1999).

This study investigated the effect of students' backgrounds on academic achievement (scores or marks) under two methods of teaching and learning. The participants of this study were international Biology students in Foundation Studies (FS) at the Royal Melbourne Institute of Technology (RMIT) University, Australia. FS is an accredited program offered only to international students and is recognised for entry to diploma and degree programs by Australian universities, Tertiary and Further Education (TAFE) colleges and higher education institutions elsewhere (RMIT, 2006). The students differ greatly in their educational and language backgrounds and often they belong to different age groups. The purpose of this study was twofold. Firstly, to

determine the degree of heterogeneity among the students and secondly how elements of that heterogeneity affected their academic achievement scores under two different methods of teaching and learning.

It is a challenging task to accommodate all individual differences, optimise the learning environment and engage and support students together effectively (Felder, 1993). The two methods used in this study were Traditional Teaching and Learning (TTL) and Problem-Based learning (PBL). It is well established that students' individual differences influence both their learning and their academic achievement (Riding, 2005). A study conducted at the RMIT University showed that the magnitudes of differences in performance by students' approaches to learning in two pedagogical environments varied from *small* to *medium* (Varughese and Fehring, 2009). An understanding about the magnitudes of differences in performance by students' approaches to learning helps to optimise the learning environment.

Most of the Biology FS students proceed with their higher education in Health Science areas. Health education in Australian universities is increasingly using the Problem-Based method of teaching and learning. It is in this context that this study seeks to examine whether international students from different age groups and vastly different educational and language backgrounds are able to learn successfully under the PBL method. An important feature of PBL is that it is a student-centred approach of learning. In this method, students learn to determine what they need to know. Student-centred learning describes ways of thinking about learning and teaching that emphasises student responsibility for such activities (Cannon, 2000). In PBL, teachers may have a role for preparing appropriate learning tasks, learning resources and evaluation materials that reflect their particular experience and knowledge. However, these materials serve as guides and resources to be used while students take responsibility for their own learning (Barrows and Tamblyn, 1980).

Methods

Research Participants

The participants of this research were 116 FS international students at RMIT over four academic years. There were two intakes in each year with an average of 14 Biology students in each intake. The first intake runs from January to November consisting of two 18-week semesters with five contact hours per week for Biology. The first semester for this intake runs from February to June and the second semester from July to November each year. The second intake runs from June to January and consists of two 14-week semesters with six contact hours each. The first semester for the second intake ran from June to September and the second semester from October to January of the following year.

Data Collection

The data collection commenced after obtaining the ethics approval from Human Research Ethics Committee (HRESC) of RMIT. The data were collected by using a questionnaire. This questionnaire consisted of seven items. They were name of the student, student number, gender, age group, nationality, prior education qualification and language of instruction in prior education. Name and student number were included in the questionnaire to identify each student at any time during the course of the research. The nationality was included to determine students' heterogeneity in terms of their cultural background. The age of each student was collected by using a scale with four age groups namely 18–20 yrs, 21–23 yrs, 24–26 yrs and 27+ yrs. The gender, age group, prior education qualification and language of instruction in prior education were used for comparative studies with reference to each student's academic achievement score in both TTL and PBL.

Of the ten topics in semester 2, one topic (Topic 1) was taught under the TTL method and the second topic (Topic 2) was taught under PBL method for the intake one (*Group 1*) of each year. For the intake two (*Group 2*) of each year, Topic 1 was taught under PBL method and Topic 2 was taught under TTL method. At the end of each topic a test was conducted to assess students' understanding in these particular areas. The test that was given after the TTL method of teaching was named the TTL test and the test after the PBL method of teaching was called the PBL test for the analysis purpose. Thus each participant took both TTL and PBL tests.

Each test consisted of two sections (A and B). Section A of each test consisted of 20 multiple-choice questions worth 20 marks. Section B of both tests consisted of four short questions worth 10 marks each. Hence the total mark for each test was 60. The learning issues in Topic 1 were in essence; DNA, RNA, genes, chromosomes, genotype, phenotype, significance of meiosis in variation, monohybrid cross, dihybrid cross, polygenic inheritance and pedigree analysis. The learning issues of Topic 2 were mutation, types of mutations, diseases such as Sickle cell anemia, Cystic fibrosis, Down syndrome as examples of diseases caused by various types of mutations and protein synthesis (Varughese, 2004).

Procedure for the Study

The *Group 1* of 2003 was taught Topic 1 in TTL. In the TTL method students were taught by using the traditional lecture format, including lecturing with the aid of lecture slides, lecture notes and white board. Students took notes and answered structured questions. A test was conducted after the TTL to assess students' understanding of this topic. The same students were facilitated by the researcher to learn Topic 2 by PBL method. For this purpose, the students of *Group 1* were divided into small groups, and each group was seated separately in the same classroom. A case study in the form of an analysis worksheet was given to each student of all the groups 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 students' reflections and deliberations about the case.

The same process was continued with the third section. At the end of the third section, students were able to derive the learning issues and each group identified a number of 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 facilitated the students for gathering 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 summarized by the students and the researcher made sure that all the required information at the appropriate level was discussed and explained. A test was conducted after the PBL to assess students' understanding of this topic.

The same process was undertaken with Group 2. However, the PBL method 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 in Group 2 could derive all of the required learning issues for this topic. The same process was done in all four academic years. The researcher marked both TTL and PBL tests of each group.

Data Analysis

Analyses were carried out using the statistical package SPSS 13.0 and MS Excel spreadsheets. This included preliminary analyses of frequencies of data grouped according to students' backgrounds. The magnitudes of differences in academic achievement scores by students' background were determined by using effect size calculations. Effect sizes were calculated by using Cohen's *d* (Cohen, 1988) with Hedges *g* correction (Hedges and Olkin, 1985). Coe's spreadsheet (Coe, 2006) was used for the purpose. Effect size measures the treatment effect (Glass, McGaw and Smith, 1981). Descriptors for magnitudes of effect sizes include *small*, *medium*, *large* (Cohen, 1988) and *very small* (Izard, 2004). 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.

Results and Discussion

Surveys were compiled and the total participants ($n = 116$) included 49 male and 67 female students from 27 countries. Of the four categories of age groups, the majority of students belonged to the '18–20 years' category. The remaining three age groupings combined had just 18 students. Owing to this unequal distribution, another two-category grouping was devised for age group classifying the 18–20 year olds as 'normal age' ($n = 98$) and all the other groups together as 'mature age' ($n = 18$). Prior qualifications of students were also grouped into four categories. Of the participants, 47 had completed Yr 11 or equivalent and 61 had completed Yr 12. Two participants were repeating FS and 6 were graduates with university degrees prior to joining FS. Once again for better comparison and more meaningful analysis the students were grouped according to their prior qualification, into two categories as 'school qualified' and 'tertiary qualified'. All participants with Yr 11 and 12 qualifications were grouped as school qualified and the others were grouped as tertiary qualified. Of the participants 53 had completed their prior education with English as the language of instruction while the remaining 63 had other languages as the language of instruction. The magnitude of difference in academic achievement scores between TTL and PBL is as shown in Table 1.

Table 1 The magnitude of difference in academic achievement scores between TTL* and PBL**

	n	Mean	sd	pooled sd	Means diff	Effect size
TTL	116	35.21	11.65			
				12.28	0.52	0.04
PBL	116	34.69	12.87			

*TTL: Traditional Teaching and Learning. **PBL: Problem-Based Learning

The magnitude of difference in academic achievement scores between TTL and PBL was found to be *very small*. This suggested that teaching method had no significant effect on students' achievement scores in this survey. The magnitudes of differences in academic achievement scores by students' background in two teaching and learning practices in Biology were measured by effect size calculations. The results are given in Table 2.

Table 2 Magnitudes of differences in academic achievement scores (marks) by students' background

		n	Mean	sd	pooled sd	Means diff	Effect size
TTL	Male	49	32.63	12.10	11.49	-4.47	-0.39
	Female	67	37.10	11.02			
PBL	Male	49	32.16	13.46	12.74	-4.38	-0.34
	Female	67	36.54	12.19			
TTL	Normal age*	98	36.20	10.87	11.46	6.37	0.55
	Mature age*	18	29.83	14.38			
PBL	Normal age†	98	35.30	12.70	12.85	3.88	0.30
	Mature age††	18	31.42	13.67			
TTL	Sch quali*	108	35.89	11.19	11.42	9.89	0.86
	Tert quali**	08	26.00	14.53			
PBL	Sch quali*	108	34.90	12.76	12.90	2.96	0.23
	Tert quali**	08	31.94	14.92			
TTL	English	53	35.86	12.11	11.68	1.19	0.10
	Other	63	34.67	11.31			
PBL	English	53	36.08	12.77	12.86	2.55	0.20
	Other	63	33.53	12.94			

*School qualified: Students who completed Yr 11 or Yr 12

**Tertiary qualified: Students who completed any tertiary education

† Normal age: Age between 18yr – 20yrs

†† Mature age: 21 yrs and above

In this study, cohorts of FS biology students over a period of four academic years were monitored. Statistical inference is a strategy for estimating population values from a representative sample. Since this research already used population values statistical significance is not considered necessary. Effect size was deemed to be the best measure in comparing groups that are not controlled for variables or equal in number. Effect size is a way of quantifying the difference between two groups using the standard deviation to contextualize the difference in means (Cohen, 1988). When looking at the difference between two groups, it is a measure of 'how big the difference is', rather than significant differences indicated by inferential tests. The sample groups in the whole population of FS Biology students were not equal in numbers. Therefore effect size calculation was used to determine the magnitude of difference in performance between groups under TTL and PBL.

The analysis of the magnitude of difference on the basis of gender showed a *small* effect size in favour of female students. This translated to higher achievement scores of female

students in both TTL and PBL. Male students generally need more facilitation in both TTL and PBL. There was a *medium* effect size displayed in the difference between normal age and mature age students' achievement scores on TTL, with the 'normal' age students gaining greater scores. However, it was found to be a *small* effect size for PBL in favour of the normal age students, suggesting that mature age students improved their achievement score in PBL. The magnitude of difference in achievement scores was found to be *large* on TTL and *small* on PBL in favour of school qualified students. It indicated that tertiary qualified students, who are also mature aged, improved their scores on PBL. The magnitude of difference in achievement scores was found to be *very small* on TTL and *small* on PBL, favouring students who had experienced English as language of instruction in their prior education. This indicated that students with other languages of instruction in their prior education need more facilitation in student-centered PBL modes of delivery. They appear more comfortable in a TTL mode of learning, likely benefiting from additional support and facilitation from teachers. Overall, this study emphasized the potential that different teaching and learning practices may impact differently on international students, who are from different backgrounds and are learning in English language dominated learning environments.

Recommendations for Teaching and Learning

Teachers of international students in tertiary education (including foundation level) may use this study as a basis to develop more effective teaching and learning in (at least) biological subject areas. It is first important to raise awareness that international students in any university in developed countries will come from different educational and language backgrounds, and represent different age groups. 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, age and language 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.

Conclusions

Students that have excelled educationally in their own countries and gone on to study abroad have been reported as only mediocre or even failures when they enrol with foreign universities and there are implicit assumptions that international students perform less in conventional structures (Morrison *et al.*, 2005), although the empirical evidence for this in the literature is equivocal, and varies greatly between studies and geographically. Morrison *et al.* (2005) are a useful insight in to UK education and they concluded from a literature review that international students in the UK achieved fewer 'good' degrees (first or upper second class honours) than UK counterparts, but with regional variations in terms of the learner origins. Performance of international students has been measured in terms of both their experience and also on their outcomes (i.e. attainment; Leonard *et al.*, 2003). For many students it is their primary goal to gain a (good) qualification.

This research study investigated international students' backgrounds and their effects on academic achievement scores under two different methods of teaching and learning. The effects were measured by effect size calculations. The magnitudes of differences in means of achievement scores between pairs of variables such as male/female, normal age/mature age, school qualified/tertiary qualified and English as the language of instruction/other languages as language of instruction were found to vary from *small* to *large* in TTL and PBL. Although

the results are modest the study underlines the need for using different teaching and learning practices for international students studying in English dominated study environments. Although some trends were observed in students' achievement scores, studies with larger numbers of students are needed to generalize the conclusions. However, this study recommends the use of both TTL and PBL in bridging programs like FS, so that international students from various educational and language backgrounds, and different age groups could get enough space to build confidence and prepare themselves for their further education in English dominated study environments.

It is clear that the term 'international student' encompasses a wide range of cultures and experiences. Other comparisons of specific ethnicity of learners provides different information. For example, Hinkel (1999) explored objectivity and credibility of written assessments in US institutions. It was concluded that native (US) students presented more objective views, approaching topics from more balanced perspectives and supported these views with appropriate evidence to ensure credibility. In contrast, Chinese students scored lower as they were considered 'more vague' than native learners, provided less [credible] evidence and lacked persuasive reasoning in their arguments. This underlines need to understand the nature of learner cohorts and direct support at many levels (individual, groups, courses etc.). A wider view of the learners' experiences may also include their acclimatisation to the country/ institution, for example how individuals settle or exhibit 'culture shock' (see Furnham 1997).

Communicating author

Dr. Varughese Kuzhumannil Varughese, School of Life and Physical Sciences, College of Science, Engineering and Health, RMIT University, Melbourne, Australia.

Tel: 61-3-9925-8378 Fax: 61-3-9925-4144

E-mail: varughese.varughese@rmit.edu.au

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