An application of student learner profiling: comparison of students in different degree programs

Elizabeth May, Charlotte Taylor, Mary Peat, Anne M. Barko and **Rosanne Quinnell,** School of Biological Sciences, The University of Sydney, Australia
lizmay@bio.usyd.edu.au

Abstract: *The ability to profile students by assessing their approaches to study and conceptions of discipline is valuable for educators at all levels. Detailed analysis of these factors has been undertaken in science disciplines at the University of Sydney to (i) determine the academic profiles of students in the cohorts we teach; and (ii) determine whether our teaching practices and the learning environment we provide stimulate the development of the student profiles we regard as desirable in a science graduate and, ultimately, in the professional scientist. At tertiary level, this analysis is complicated by the various degree programs that intersect in compulsory or service units of study, particularly at the first year level, and it is therefore essential that we understand the extent to which we are serving students in all degree programs. Our first year biology classes are large (up to 1500) and the unit Concepts in Biology (semester 1) is both a pre-requisite for further study in Biology and a compulsory service course for a range of degree programs (e.g. Medical Biotechnology, Pharmacy, Nutrition). We performed a cluster analysis on survey data combining measures of student approaches to study, conceptions of biology and performance in assessment after completing one semester of biology and examined the proportions of students in each of four clusters: two 'positive' (deep achievers and enthusiastic achievers) and two with less desirable profiles (surface strategists and neutral). Chi-squared analysis indicated no significant difference in distribution of students enrolled in Arts, Science and Pharmacy between the four clusters ($p = 0.104$). A significant difference was, however, detected at the level of science degree program ($p < 0.002$), with the Bachelor of Science (Marine) and Bachelor of Science contributing most to the difference. Implications of our analysis and further applications of learner profiling for informing improvements in science curricula, teaching and assessment will be discussed.*

Introduction

An important criterion in profiling the learner attributes of students has been determining whether students profess to taking a *deep* or *surface* approach to their learning (e.g., Biggs 1987; Holschuh 2000; Chin and Brown 2000; Cuneo and Harnish 2002; Case and Marshall 2004; Wilson and Fowler 2005). Adoption of a *deep* approach to learning is considered by university teachers to be a desirable learner attribute (Percy and Salter 1976), although the difficulty of formally assessing such an attribute, and, moreover, rewarding students who exhibit the attribute can create situations in which assessment strategies reward *surface* learners equally well (Biggs 1987; Entwistle Hanley and Hounsell 1979) and indeed students have been reported to adopt more of a *surface* approach as they proceed through a degree program (Biggs 1987).

The technique of cluster analysis, a form of multivariate analysis, which characterizes groups of students based on an intersecting suite of student attributes, has been used in a variety of educational studies to profile the characteristics of students (e.g., Hazel, Prosser and Trigwell 2002; Boughan 1998; Lawless and Kulikowich 1996). We have recently developed a survey instrument that combines analysis of student approaches to learning with a novel survey to ascertain students' conceptions of biology as a discipline, and have used cluster analysis to characterize groups of students with shared combinations of attributes (Quinnell, May, Taylor and Peat 2003; Quinnell, May, Peat and Taylor 2005). The survey instrument also allows us to incorporate students' response to our curriculum and their end-of-semester performance in assessment tasks into our classification of learner profiles. The conceptions of biology survey was devised using the template of the conceptions of mathematics survey of Crawford, Gordon, Nicholas and Prosser (1998).

First year biology teaching at the University of Sydney is governed by a very broad client base. Our first year biology classes are large (up to 1500) and the unit of study Concepts in Biology (semester 1) is both a prerequisite for further study in biology and a compulsory service course for a range of degree programs (e.g., Medical Biotechnology, Pharmacy, Nutrition). Thus this unit of study functions as a service unit to a number of undergraduate degree programs and as a core unit for biology degree students to provide the background for progression into second and third year biology units. We were interested to learn how students from different faculties and degree programs were represented in the various learner profile clusters. Identifying and encouraging the development of desirable profiles should lead to more successful student outcomes in all years of tertiary study and ultimately provide appropriate strategies that students can carry into a science career. On a pragmatic level, we are keen to retain students with positive learner profiles in our biology streams.

Macbean (2004) reported significant differences in both approach to study and conceptions of mathematics between physics students and biochemistry students taking mathematics as a service course, albeit enrolled in different mathematics streams based on differences in prerequisites for the two cohorts. The physics students took a more *meaning* orientation (= *deep* approach) to studying mathematics than did the biochemistry students, and this correlated with less tendency to have *fragmented* conceptions of mathematics. Skogsberg and Clump (2003) found that psychology majors in a US university scored highly on the *deep* approach subscales of the revised two-factor Study Process Questionnaire (Biggs, Kember and Leung 2002).

Analysis of our 2001 student cohort in a first-year biology unit of study indicated four significant clusters, each with different learning strategies and student attribute profiles. The profiles divided into two ‘positive’ clusters (*deep achievers* and *enthusiastic achievers*) and two with less desirable characteristics (*surface strategists* and *neutral*). Students comprising the two positive clusters have profiles that we would most like to retain in the discipline, as both incorporate, to varying degrees, successful performance and desirable conceptions of the discipline. Success in these cohorts is characterized by not only good marks but also by evidence of positive engagement with the curriculum. The two positive clusters represented 36% of the student cohort in 2001.

The diversity of our student intake into first year biology inevitably means that a variety of learner profiles will be evident. We were interested in examining the distribution of learner profiles both between faculties and among the various Science degree programs to determine if any faculties or programs fare better than others in terms of their representation in the ‘positive’ learner profile clusters.

Materials and methods

Students enrolled in first-year biology at The University of Sydney were surveyed at the beginning of their first semester of biology study (Survey 1) and again at the end of the fourteen-week semester (Survey 2). The survey instrument included a *Conceptions of Biology Questionnaire (*CBQ*)*, a *Study Process Questionnaire* (SPQ) and, for Survey 2, a *Unit Evaluation Questionnaire* (UEQ). Thus Survey 1 assessed students as close as possible to their departure from secondary education and their entry into tertiary biology, and Survey 2 assessed students after one semester of tertiary biology. Here we examine the data obtained from the end-of-semester survey to compare student cohorts from different degree programs and faculties.

The *Conceptions of Biology Questionnaire* was adapted from the instrument used to assess conceptions of mathematics (Crawford et al. 1998). This included Likert-scale items on two sub-scales: *fragmented* conceptions of biology (10 items) and *cohesive* conceptions of biology (10 items). This was the first time, to our knowledge, that a *Conceptions of Biology Questionnaire* had been designed and used, so the data from Survey 1 were analyzed to test the reliability of the conceptions of biology items and to determine how they factored with the *SPQ* sub-scales (Quinnell et al. 2005). This analysis highlighted misalignment of the *fragmented* and *cohesive* sub-scale items and these were reworded for inclusion in Survey 2.

Survey 2 assessed a student's conception of the biology science discipline after taking a tertiary biology course. A student who agrees with statements such as *"For me, Biology is just the study of facts"* and *"Biology is just about figuring out how living systems work"* would score highly on the *fragmented* sub-scale. A student who agrees with statements such as *"Biologists have devised a set of theories over many years to help investigate and explain matters in the living world"* and *"Biology allows predictions to be made about everyday life and situations"* would score highly on the *cohesive* sub-scale. The full list of items in the *Conceptions of Biology Questionnaire* is given in Quinnell et al. (2005).

The *Study Process Questionnaire* (SPQ) was based on that of Biggs (1987) and modified for use in biology. We scored students on a *surface* approach to study sub-scale (14 items) and a *deep* approach to study sub-scale (14 items). Items assessing approaches to studying biology were included in the survey administered at the end of semester to determine a student's approach to learning after taking a tertiary biology course. The full list of items in the *Study Process Questionnaire* is given in Quinnell et al. (2005).

The *Unit Evaluation Questionnaire* administered as part of Survey 2 comprised five sub-scales that measured students' perceptions of the quality of teaching (*good teaching*), whether goals were set and communicated for the unit of study (*clear goals*), whether the workload was suitable (*appropriate workload*), whether assessment tasks encouraged *deep* learning practices (*appropriate assessment*), and whether the unit included a suitable level of independent study (*independence*).

Likert-scale responses to survey items were scored on a five-point scale and sub-scale scores were calculated as averages of scale item scores. Statistical analyses of all responses were performed using Statistical Package for the Social Sciences (SPSS) software. Cluster analysis incorporated survey data and information on individual performance, as measured by final grade, to identify sub-groups of students with shared characteristics. The end-of-semester survey data were sorted by faculty and degree and subjected to chi-squared analysis to determine the representation of different cohorts of students in each cluster. The surveys were administered with permission from the University of Sydney Human Research Ethics Committee.

Results

The data from the survey administered after one semester of biology included the students' final grade and resolved the cohort into four student clusters. The cluster analysis presented here (Table 1) used individual student response scores for each sub-scale variable and compared them with the mean values for the cohort. Each cluster represents a group of students who scored similarly on all sub-scales. The values in Table 1 are a measure of the number of standard deviations the cluster score is from the mean value for the whole cohort. Values are only indicated for those sub-scales showing significant deviation from the mean ($> |0.3|$).

The clearest outcomes are those in which scores for complementary sub-scales load inversely, *e.g.* a positive score for *deep* approach and negative score for *surface* approach would mean the students in the group clearly demonstrate one approach while rejecting the other. Such clear alignment was evident in Cluster 3 only and represents a desirable learner profile. The data enabled us to characterize the clusters as representing four specific learner profiles: *neutral, surface strategists, deep achievers* and *enthusiastic achievers*.

Students in the *neutral* cluster scored just above average for *fragmented* conception but close to average for other sub-scales (*i.e.,* values non-significant).

Surface strategists scored above average for *surface* approach to study, well below average for *deep* approach to study and are average performers (i.e., performance value non-significant) in summative assessment tasks. These students represent 'strategists' as they are passing (average performance) despite adopting what we would regard as a less-than-desirable approach to study. Their responses to the UEQ were very negative.

Deep achievers are students who scored above average for *deep* approach to study, which was complemented by a very significant below average score for *surface* approach and *fragmented* conception. In concert with above average performance, this represents a highly desirable student learner profile. Their responses to the UEQ were very positive.

Enthusiastic achievers are above-average performers who reject (i.e., score below average for) *fragmented* conception. They had average scores for both *surface* and *deep* approach. (Their score for *cohesive* conception was just below significance at 0.27.)

Table 1. Cluster analysis of student survey responses (*Conceptions of Biology Questionnaire, Study Process Questionnaire, Unit Evaluation Questionnaire)* and final mark at the end of first semester tertiary biology.

Variable	Sub-scale	End of semester student profiles			
		Cluster 1 n = 144 50%	Cluster 2 n = 38 13%	Cluster 3 n = 33 11%	Cluster 4 n = 70 25%
Approach to studying	Surface		0.31	-1.35	
	Deep		-1.07	0.61	
Conception of biology	Fragmented	0.31		-0.72	-0.35
	Cohesive		-0.66		
Unit Evaluation Questionnaire	Workload suitable		-0.67	1.37	
	Unit goals set clearly		-0.93	1.14	-0.30
	Teaching was good quality		-1.10	0.88	
	Assessment encouraged deep learning		-0.97	0.82	0.40
	Independence level suitable	0.51	-1.16		-0.52
Performance	Final mark	-0.35		0.53	0.45
Profile		neutral	surface strategists	deep achievers	enthusiastic achievers

Values above 0.3 indicate students in the cluster scored significantly above the mean on the specified sub-scale; values below -0.3 indicate students in the cluster scored significantly below the mean on the specified sub-scale. (Where no value appears the value was < |0.3| i.e., no significant deviation from the cohort mean for that sub-scale)

The distribution of the four clusters between the faculties of Pharmacy, Science and Arts (Figure 1) was examined using chi-squared analysis (Table 2) to determine if the percentage of students from each faculty in each cluster matched that of the whole cohort. The only significant deviation from the expected distribution was in the *deep achiever* cluster (p = 0.042). Pharmacy students were not represented at all in this cluster but were over-represented in the *enthusiastic achievers* cluster. However, when the two 'positive' clusters were pooled, the overall distribution of Pharmacy students was not significantly different from expected (p = 0.757).

Table 2: Distribution of students from Arts, Science and Pharmacy between the four end-of-semester clusters.

	Cluster								
	1: neutral		2: surface strategists		3: deep achievers		4: enthusiastic achievers		Faculty total
Faculty	obs	(exp)	obs	(exp)	obs	(exp)	obs	(exp)	
Arts faculty	8	(6.0)	2	(3.1)	2	(1.6)	2	(3.4)	**14**
Science faculty	84	(84.3)	41	(42.9)	27	(22.2)	45	(47.5)	**197**
Pharmacy	18	(19.7)	13	(10.0)	0	(5.2)	15	(11.1)	**46**
Cluster total	**110**		**56**		**29**		**62**		**257**
Expected %	24.125		42.80		21.79		11.28		
probability	0.6640		0.5137		**0.0422**		0.3555		
Are faculties equally represented in the cluster?	yes		yes		no		yes		

Probability in bold indicates a significant deviation from the expected distribution.

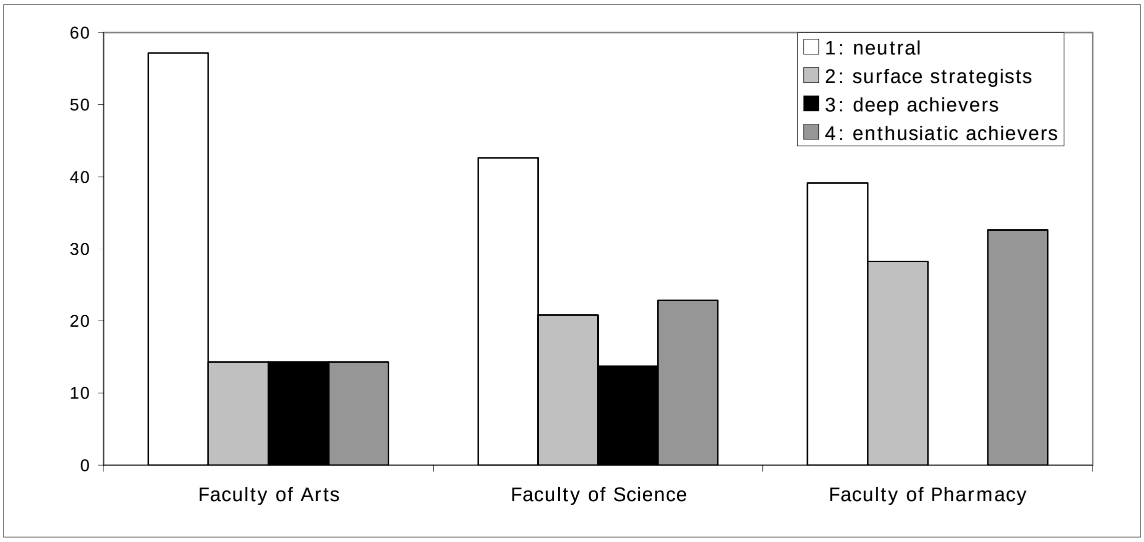

Figure 1. Distribution of students in end-of-semester learner profile clusters within the faculties of Arts, Science and Pharmacy.

We were interested to discover whether students in different Science degree programs were represented equally between the different learner profile clusters. The observed distribution (Figure 2) deviated significantly from the expected distribution across the whole cohort ($p = 0.0017$) and analysis of the distribution within each degree code revealed that the difference was due to skewed representation in the BSc (Marine) and BSc degree students. BSc (Marine) students had significantly higher numbers in the *neutral* cluster and BSc had fewer *surface strategists* and more *deep achievers* than other degree cohorts.

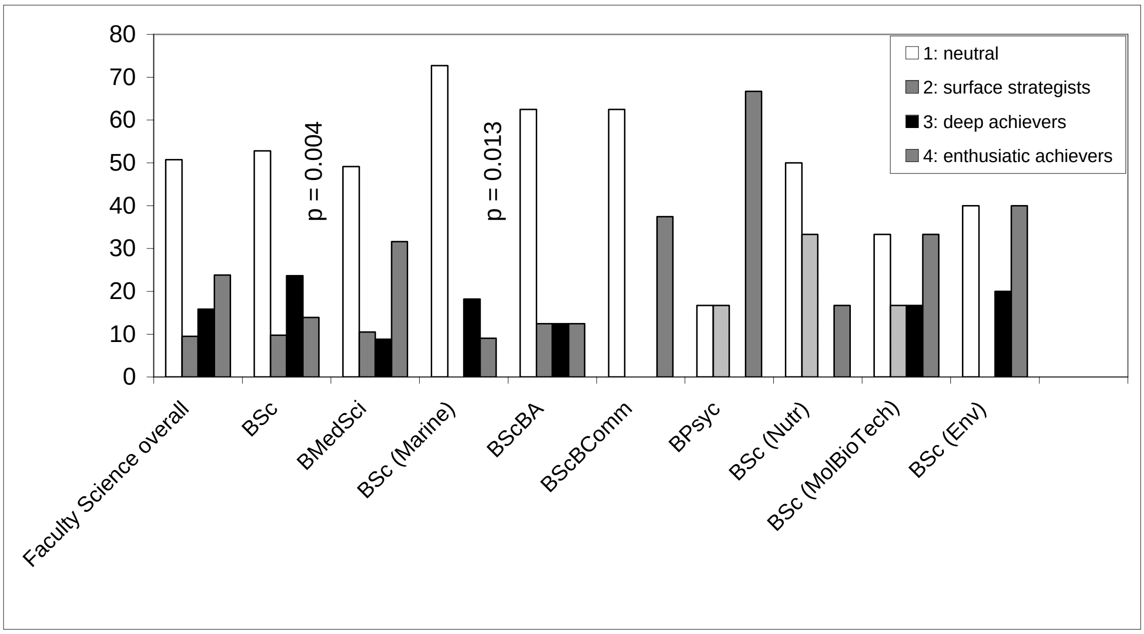

Figure 2. Percentage distribution of students between learner profile clusters within each Science degree cohort. There is a significant difference between degree programs in how students sort into the four learner profiles identified by cluster analysis. ($p = 0.0017$). p values on the graph indicate individual degree cohorts that deviated significantly. (Degrees with zero percentages were non-significant due to small number of students.)

Discussion

Our approach to determining learner profiles is based on a combination of information about students' approaches to study, conceptions of discipline, engagement with curriculum and academic performance. This provides a rich measure that informs us about the learner attributes students are bringing to their tertiary studies and how the different variables making up their profile correlate with each other.

We have used survey data to determine learner profiles at the end of a semester of biology and examine possible differences between cohorts of students in different degrees and faculties. We have identified a combination of positive learning strategies and conceptions of biology that we would desire in a graduate, and a biology graduate in particular. Our concern has been that the requirement to provide service teaching and core teaching to a diverse mix of students may result in skewed outcomes for students in different faculties. We have developed a curriculum, using a diverse range of both delivery and assessment strategies, which we believe provides a satisfactory course of biology study for all types of students. Approximately 20% of our first year biology cohort proceeds to second and third year biology. It is significant to us that our science students are engaging with the course and, in so doing, are achieving an outcome that should facilitate success if they proceed to further biology study. However, we need to be sensitive to needs of all students in first year biology.

Our ability to probe survey data showed that, while students in Arts, Science and Pharmacy were similarly distributed between the two 'positive' and two 'negative' learner profile clusters, there were no *deep achievers* in the Pharmacy cohort in the 2001 first year biology class. It is currently not possible to determine any reason or correlate for this. Motivation may play some part: Skogsberg and Clump (2003) found that psychology majors in a US university scored highly on the *deep* approach subscales of the revised two factor Study Process Questionnaire (Biggs et al. 2002) and suggested their primary motivation for learning lay in the students' perception of the intrinsic value of the information they were learning. The class included students both with and without a high school (HSC) biology background and their distribution between faculties was not known. It is possible that students with HSC Biology background would enter university with an established *cohesive* conception of the discipline. Future studies including information about each student's background in biology may clarify this. Such an analysis would also shed light on whether the conceptual frameworks of HSC and tertiary biology teaching are aligned.

The preponderance of *deep achievers* in our BSc students is intriguing and may reflect either an existing trend in students or the fact that we are scientists teaching science. However, we do not appear to be particularly disadvantaging any other cohort, as for the most part the distribution within faculties and other degree programs is not significantly different to that of the three faculties combined.

Future applications of learner profiling

We are currently analysing our complete dataset to examine if and how the learner profiles of our students change after a course in biology, by using survey data collected from students at the beginning of semester and data from the same students collected at the end of semester. We have developed two models for tracking shifts in individual learner profiles and are currently comparing the power of each model to assess the dynamics of the changes.

We might consider we are doing well to encourage the *deep achievers* in the BSc program. We intend to survey student cohorts longitudinally throughout their degree program to determine if the students with positive learner profiles progress to second and third year biology, and to further examine if and how their profiles shift through different stages of the biology curriculum.

Our approach will also allow us to examine the learner profiles of students at the transition from high school to tertiary study within a discipline area and to track changes in learner profiles throughout a biology degree program. This will shed light on the impact of the change to the syllabus of the NSW HSC (2000) and indeed changes that may occur in our own curriculum in first year biology and beyond.

Clearly we can continue using this profiling tool to monitor how well we are serving our students whilst meeting our obligations as a service provider to the broad spectrum of faculty and degree courses to which we cater now and in the future.

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