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Does learning in statistics get deeper or shallower?

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Abstract

Purpose – While the natural expectation is that students seek greater depth of learning as they develop intellectually during their studies, some research calls this into question and even suggests that student learning can become shallower from year to year. The present study aims to investigate the relative depth of students' learning at different stages of their undergraduate studies by comparing second-year with third-year students in two statistics units.

Design/methodology/approach – A survey was conducted using Biggs's Study Process Questionnaire. The survey results were used to compare second- and third-year groups, as well as to investigate other variables by comparing the performances of: international and domestic students, male and female students, students who worked and those who did not work, and students who intended to register for a higher degree and those who did not.

Findings – Significant differences in approaches were found between male and female students; and between students who intended to enrol in a higher degree and those who did not.

Research limitations/implications – Characteristics of the learning and teaching environment, including quality of teaching, were not investigated in this study. These and the possibility of students' mixed approaches to learning depending on the unit of study might have significant impact on the results. Additionally, this study is specific to one Sydney university; therefore the results might not be generalisable.

Originality/value – The findings from this study provide evidence that there is no significant difference between second and third year; or in international and local students' approaches to learning in statistics.

Keywords Learning, Statistics, Education, Students

Paper type Research paper

1. Introduction

There are many research papers addressing the question of university students' approaches to learning (Biggs, 1987b; Kember and Gow, 1991; Kember, 2000; Cooper, 2004; Bilgin and Crowe, 2008). A few research articles focusing on the learning approaches of students in statistics have also appeared (Gordon, 1995; Bilgin and Crowe, 2008), but these studies either included only one cohort of students or had small sample sizes. The present study aims to examine statistics students' approaches to learning over time in two large, and generally similar, statistics units.

A number of researchers have identified two different levels of learning among university students (Biggs, 2003; Ramsden, 2003; Marton and Säljö, 1976; Entwistle and Ramsden, 1983), sometimes referred to as "surface" and "deep" learning. At the

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surface level learning is viewed in simple quantitative terms, as an accumulation of facts through memorisation. At this level some researchers also point to a lack of engagement, where the student's only aim is to pass with the minimum effort. At the higher or deeper level, on the other hand, learning involves a process of understanding or of grasping the meaning of the learned material, in the sense that the learner is able to benefit from what is learned by seeing how it can be applied in different contexts, possibly with a view to acquiring further information or understanding in those contexts. Biggs (2003) suggests that "[t]he low cognitive level of engagement deriving from the surface approach yields fragmented outcomes that do not convey the meaning of the encounter, whereas the deep approach yields the meaning at least as the student construes it" (p. 13).

Also relevant to the present study is a further dimension of learning which Biggs (2003) adds to the "surface" and "deep" levels, namely, an "achievement approach", where the student's main aim is to obtain the highest possible grade, regardless of how interesting they find the subject of study.

Learning approaches have been measured quantitatively by using questionnaires, for example Biggs's well-known Study Process Questionnaire (SPQ) (Biggs, 1987a), which is being used in the present study. Other questionnaires are Entwistle's Approaches to Studying Inventory (ASI) (Entwistle and Ramsden, 1983) and the Approaches and Study Skills Inventory for Students (ASSIST) (Tait *et al.*, 1998). Qualitative studies also exist in the literature, where researchers have analysed interviews with students using various methods of analysis – for example, the phenomenographic method of Marton and Booth (1997, p. 14) – to draw conclusions about their learning approaches.

Researchers have pointed out that teaching methods and methods of assessment can influence the way students approach their learning. Ramsden (2003) argues that "[t]he same student learns differently in different situations" (p. 49); in other words, students are capable of using both surface and deep approaches to their learning. Other studies show how different teaching methods might encourage one approach over the other (Säljö, 1981; Trigwell and Prosser, 1991; Trigwell *et al.*, 1999).

A number of researchers have compared student learning along demographic lines (Marton and Säljö, 1976; Biggs, 2003; Entwistle and Ramsden, 1983); by looking at possible differences between: students from different cultural backgrounds (Kember, 2000; Ling *et al.*, 2005; Leung *et al.*, 2006); male and female students (Regan and Regan, 1995; Baykan and Nacar, 2007); and students at different stages of their university studies (Watkins and Hattie, 1985; Biggs, 1987b; Kember, 2000; Zeegers, 2001).

1.1 Aims

We might expect students to become less surface oriented in their learning as their university studies progress, but Biggs *et al.* (2001) have warned of an alarming tendency for students to become more surface oriented over the course of their studies, asserting that:

> A particularly depressing finding is that most students in most undergraduate courses become increasingly surface and decreasingly deep in their orientation to learning. There are however exceptions; students with aspirations for graduate study do not show this pattern in their chosen area of study, nor do students taught using problem-based learning, who become increasingly deep, and less surface, in their orientations (Biggs *et al.*, 2001, p. 138).

A primary purpose of our study is to determine whether statistics students' learning approaches change over the course of their studies and, if so, in what direction.

We undertook this study in a large metropolitan university – Macquarie University in Sydney, Australia. In 2008 this university was going through a structural change, specifically moving from a divisional structure to a faculty structure. Due to this change, its department of statistics was moved from the Division of Economic and Financial Studies (which became the Faculty of Business and Economics [FBE]) to the Faculty of Science. The department is one of the largest statistics departments in Australia, with 24 full-time equivalent staff, and is responsible for a full range of statistics units from first-year undergraduate to Masters courses.

Two large-enrolment statistics units form the context of this study. These units were at second-year and at third-year level, where the second-year unit is a prerequisite for the third-year unit. More than half the students enrolled in these units were FBE students who chose these units as their elective units. For students majoring in statistics, who formed around a quarter of the study population, these were core units. The units involved four hours of face-to-face teaching (three hours of lectures in large groups and a one-hour small-group practical or tutorial) with additional online communication through a learning management system. Lecturers and tutors were available for consultation with students every week up until the final exams.

The present study compares students at the two different levels. The fact that students from the earlier year flow into the later year will make it possible to follow up with a further, longitudinal study in due course. Another advantage of choosing these two units for the study was that both have large enrolments, making it possible to obtain large sample sizes. Further advantages were that the teaching teams for the two units tend to coordinate their activities, and they use very similar methods of teaching as well as similar methods of assessment (comprising a mid-semester test, a final exam and electronic multiple-choice quizzes). These similarities meant that any observed changes in learning approaches shown by students in the two years could fairly confidently be attributed to changes in the students' own attitudes to learning over time, rather than being attributable to differing teaching approaches or other extraneous factors.

The study set out to survey the students using Biggs's Study Process Questionnaire (SPQ) (1987a, b) and included a demographic survey developed in-house, so that in addition to comparing second- with third-year statistics students' approaches to learning, we would be able to compare the learning approaches of domestic and international students, male and female students, part-time-employed students and students not in the workforce, and students who intended to proceed to a higher degree in statistics and those who did not. A further aim of the study was to establish whether there is a relationship between students' learning approaches and their grades for the unit of study.

2. Method

Biggs's SPQ is a self-reporting survey aimed at identifying students' approaches to learning. It consists of 42 items on six subscales, with seven items on each subscale. Each item elicits a response from the student on a scale ranging from 1 ("This item is never or only rarely true of me") to 5 ("This item is always or almost always true of me"). Three of the six subscales deal with learning strategies (namely, deep, surface and achieving strategies – DS, SS and AS respectively) and three with learning

motives (deep, surface and achieving motives, or DM, SM and AM). In addition, each student gets a Surface Approach, a Deep Approach and an Achieving Approach score, calculated by adding their surface strategy and surface motive scores (= Surface Approach score), their deep strategy and deep motive scores (= Deep Approach score), and so on. These learning approaches are not mutually exclusive. For example, a student could have high scores in all approaches. A fuller explanation of what the categories mean is provided in Biggs (1987a).

The SPQ and demographic surveys were conducted for both the second-year and third-year student groups during the tenth teaching week of the second semester of 2008. For logistical reasons the second-year survey was conducted during the practical sessions for the unit, all five of which were on the same day, while the third-year survey was conducted during the unit's lecture period. To eliminate any possible bias caused by the presence of the researcher – who was also the course lecturer – she removed herself from the class after giving a short introduction inviting students to participate, and the survey was conducted by a research assistant, employed to oversee the process.

2.1 Participants

There were 490 students enrolled in the second-year unit (Operations Research I), 323 of whom participated in the study – a 66 per cent response rate. Of the 145 students enrolled in the third-year unit (Operations Research II), 59 – or 41 per cent – participated. The difference in response rate was most likely due to the attendance patterns of the students (that is, attendance at the practical sessions was compulsory for the second-year students and attendance at lectures was not monitored for the third-year students). Therefore 382 of the combined enrolments participated. One second-year participant whose responses were clearly facetious was excluded from the analysis. Four students who answered six or less of the 42 questions were dropped from the study; and one student was given only a surface approach score, since they failed to respond to any "achieving" items and offered only three responses to "deep" items. The age of the students (in years) was calculated by subtracting their birthday from the survey day, and then dividing it by 365.25. The students' achievements were represented by their standard numerical grade (SNG) for the unit.

2.2 Procedures and statistical analysis

Motive and strategy scores for each student were calculated by totalling their scores under each of those headings. Some students did not answer all the SPQ questions, so to keep the maximum number of students within the study, a method of adjusting motive and strategy scores was developed for this survey. Thus an adjusted subscale score (ASS) was generated by calculating a student's average score in a subscale (that is, by dividing their total score under that subscale by the number of questions answered and then multiplying the result by 7, since there were seven items for each subscale). For example, a student who answered five questions in a subscale and scored 15 would get an ASS of 21 ($15/5 = 3 \times 7 = 21$), creating a reasonable comparison between this student's responses and those of students who had answered all questions. For students who answered all seven questions in a subscale, their adjusted and observed subscale scores would be the same.

Learning approach scores were calculated on the basis of adjusted subscale scores. Mean scores for motive and strategy approaches were then compared across different

demographic groups – in particular, groups defined by gender, country of birth and unit studied. Depending on the number of groups, either ANOVA or *t*-tests were used to compare the mean scores of approaches and subscales to test the hypothesis that students' approaches to learning were the same between the groups versus the hypothesis that students' approaches to learning were different between groups. The correlations between age, standard numerical grades, motives, strategies and approaches scores were calculated using Spearman's rho.

3. Results

The sample was more or less evenly divided between male (49.5 per cent) and female (50.5 per cent) participants. This split was not significantly different in the two units ($\chi^2 = 0.008, p = 0.931$). The average age of students in this study was approximately 22 (std = 1.9) years, with females having a slightly lower average age, by less than a year. Most students were under 27, apart from two males who were 28 and 30. The average age in the third-year unit was ten months higher than that in the second-year unit (22.8 years compared with 22 years). Of the students 90 per cent identified themselves as international students and 10 per cent as domestic. Although there was a higher proportion of domestic students in the third-year unit (17 per cent), than in the second-year unit (9 per cent), the difference was not significant ($\chi^2 = 3.78, p = 0.052$). More than 97 per cent of the students were studying full time and there was no significant difference between the proportion of full-time students in the two units (97 per cent compared with 98 per cent, $\chi^2 = 0.273, p = 0.601$). Of the students 42 per cent had part-time employment outside the university, with no significant difference between the two units in this regard ($\chi^2 = 0.407, p = 0.524$). On average, third-year students reported working three hours longer in outside employment per week than the second-year students ($t_{151} = 1.836, p = 0.068$).

3.1 Differences between the second- and third-year students

No significant differences between the means of Motive, Strategy and Approach scores were found between students studying the second- and third-year units. None of the means within each subscale was more than one point different from the others, while the variability in the Deep Motive scores was even lower than in the other subscales. This suggests that students' approaches to learning in statistics do not become increasingly surface or decreasingly deep from the second year to the third year of their studies.

3.2 Differences between the international and domestic students

A comparison was made between the motive, strategy and approach scores of students who identified themselves as international students as against those who identified themselves as domestic. Although there was no significant difference between the means of motive and strategy scores by country of birth ($p > 0.05$), international students had slightly higher mean scores for all subcategories except Deep Motive (where the domestic students (23.3) had a 0.1 higher score than international students (23.2)). This shows that international students use all the strategies and motives to improve their learning compared to domestic students. The lower variability in the Deep Motive scores compared to the other subscales is an indication of the similarities of the domestic and international students in this subscale.

The highest scores for both domestic and international students were for Surface Approach (where there was also the lowest variability or the highest similarity between domestic and international students). These were followed by Deep Approach scores (with a slightly higher variability). Achieving Approach scores were lower than other Approach scores, and although domestic students' scores here were more than two points higher than those of international students, this was not a statistically significant difference ($p = 0.06$), while variability was the highest for this approach.

Given the multicultural nature of Australian society, a significant number of the domestic students in the study came from non-English speaking backgrounds – a factor that may be as likely to influence a student's approach to learning as their country of origin. In addition to asking students about their nationality, the demographic survey also asked whether English was their first language. Although students whose first language was not English had higher mean scores for all Motive and Strategy scores except Deep Strategy, a comparison between the mean Motive and Strategy scores of these students and those whose first language was English showed no significant difference between the groups ($p > 0.05$). Approaches were not significantly different either. These findings provide evidence towards the similarity of learning approaches of domestic students regardless of their first language (that is, English or not).

3.3 Differences between the male and female students

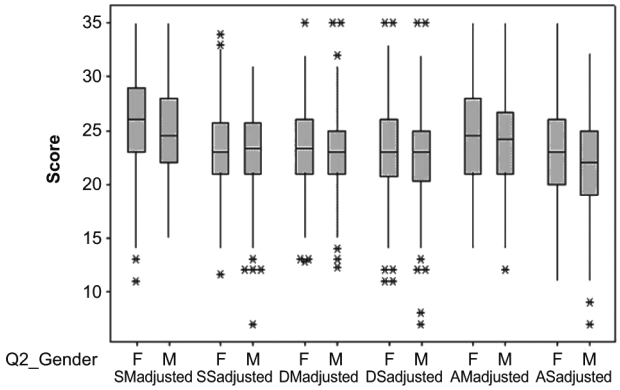
The mean scores for Surface Motive ($p = 0.009$) and Achieving Strategy ($p = 0.018$) were significantly higher for female students, in other words, on average female students used more Surface Motive and Achieving Strategies compared to their male counterparts. Although the means of other subscales were not significantly different by gender ($p > 0.05$), female students had either roughly equal or slightly higher mean scores for the subcategories. The comparative box plot in Figure 1 shows the distribution of Motive and Strategy scores by gender for the three dimensions of the SPQ.

The distribution of the Approaches scores is shown in the comparative box plot in Figure 1. Although the medians were very similar for all three approaches, the means of Surface (male = 47.9, female = 49.3; $p = 0.045$) and Achieving Approaches (male = 45.8, female = 47.5; $p = 0.044$) scores were significantly higher for female students. This can be interpreted as females being more goal oriented, that is, to pass the unit and achieve the highest possible grade.

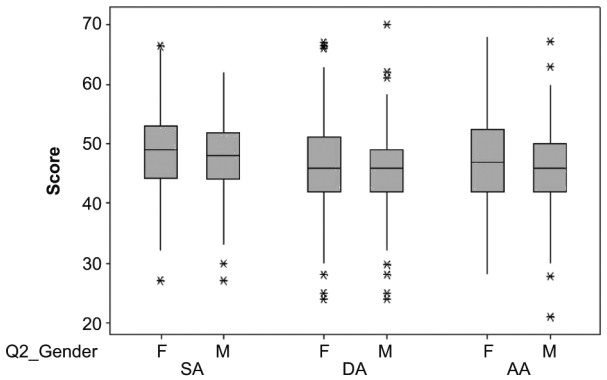
3.4 Differences between the students who were employed and those who were not

Although the mean scores for Motive, Strategy and Approaches were not significantly different relative to work commitments ($p > 0.05$), students with a job had slightly higher mean scores for four of the six Motive and Strategy categories. Surface Approach had the highest mean for both working and non-working students, 48.5 and 48.7 respectively.

While students in the third-year cohort were working three hours longer than those in the second-year cohort, there did not appear to be any significant relation between scores on each of the scales and the number of hours of employment. However, we found a small but significant negative correlation between the number of hours worked in each week and Achieving Approach scores (Spearman's rho = -0.181, $p = 0.031$). This implies that when the working hours increase then the Achieving Approach scores decrease.



(a) Motive and Strategy scores by gender



(b) Approaches scores by gender

Note: M = Male; F = Female

Figure 1.
Distribution of motive, strategy and approaches scores by gender

3.5 The differences between students enrolled in different degrees

The degrees for which participants were enrolled were grouped into four categories: accounting (56 per cent), statistics (20 per cent), other (20 per cent) and missing (4 per cent). The "other" category included students who were enrolled in different double degrees (such as BA Economics and Applied Finance) and various single degrees (for example BA Applied Finance), where there were one or two students for each different degree. To be able to analyse the data these were aggregated into the "other" category. An ANOVA test showed that the means of the Motive, Strategy and Approaches scores were not significantly different relative to the degree for which students were enrolled ($p > 0.05$).

3.6 Differences between the students who did and did not intend to enrol in a higher degree

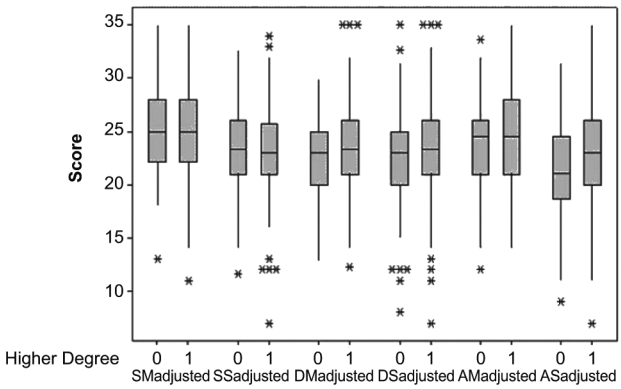
The mean scores for Deep Motive, Deep Strategy, Achieving Motive and Achieving Strategy were higher for the students who intended to enrol in a higher degree, and

significantly higher for Deep Motive ($p = 0.005$) and Achieving Strategy ($p = 0.0003$). The distributions of scores are represented in the comparative boxplots in Figure 2.

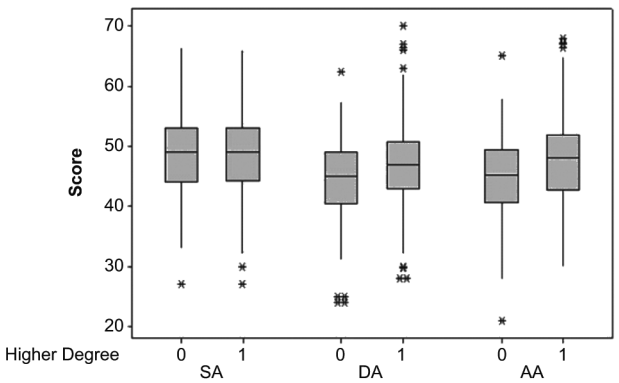
Figure 2 displays the distribution of Approaches scores according to intention to enrol in a higher degree. The mean scores for Deep ($p = 0.009$) and Achieving ($p = 0.001$) Approaches were significantly higher for students who intended to enrol in a higher degree – by 2.1 and 2.9 points, respectively. Therefore we can conclude that the intention to enrol in a higher degree provides an incentive for students to use Achieving and Deep Approaches to their learning in statistics.

3.7 The relationship between the motives, strategies, approaches, age and SNG

Although the magnitudes of correlations were small, age was negatively correlated with students' overall unit grades (SNG) as well as with their strategies, motives and approaches scores. The significant correlations were between age and SNG



(a) Motive and Strategy scores by intention to enrol in a higher degree



(b) Approaches scores by intention to enrol in a higher degree

Note: 0 = No; 1 = Yes

Figure 2.
Distribution of motive, strategy and approaches scores by intention to enrol in a higher degree

(Spearman's rho $= -0.147, p = 0.005$); Surface Approach (Spearman's rho $= -0.116$, $p = 0.029$) and Achieving Approach (Spearman's rho $= -0.110, p = 0.040$). The older the students were in the data set, the lower their SNGs, Surface and Achieving Approaches scores were.

While Standard Numerical Grade (SNG) was negatively correlated with age, there was a significant positive correlation between SNG and scores for Surface Strategy (Spearman's rh $= 0.126$, $p = 0.018$), Deep Strategy (Spearman's rho $= 0.139$, $p = 0.009$), Achieving Motive (Spearman's rho $= 0.239$, $p < 0.01$), Deep Approach (Spearman's rho $= 0.135$, $p = 0.012$) and Achieving Approach (Spearman's rho $= 0.191, p = 0.0004$).

A multiple regression model was developed, where SNG was predicted with the significant factors (gender and intention to enrol in a higher degree) and all three approaches scores (Surface, Deep and Achieving) to further investigate the significance of each predictor by controlling for the contribution of the other predictors. The results of this full model showed that only Achieving Approach was significant ($p = 0.034$) for predicting the SNG. Exclusion of two factors (gender and intention to enrol in a higher degree) increased the significance of Achieving Approach ($p = 0.027$), while Surface and Deep Approaches continued to be insignificant. For this reduced model, we found that for a one-unit increase in the Achieving Approach, the SNG increased by 0.32 units. Although not significant, it was interesting to note that the coefficient for the Deep Approach was negative (for a one-unit increase in the DA, the SNG decreased by 0.03) and the coefficient for the Surface Approach was positive (for a one-unit increase in Surface Approach the SNG increased by 0.08).

We could interpret these results to mean that the mature students were not aiming just to pass the unit and have high grades but were more oriented towards deep learning of the contents. Although gender and intention to enrol in a higher degree were significant predictors of SNG, when learning approaches were incorporated into the prediction they became insignificant. The only significant predictor of SNG for this group of students was their Achieving Approaches scores: the higher their Achieving Approaches scores, the higher their grades.

3.8 The relationship between the types of Motives, Strategies and Approaches

The correlations between strategy and motive scores for each of the three learning approaches were positive and highly significant ($p < 0.01$). All subscale scores indicated that students' motives and strategies were aligned, with a particularly strong correlation between Deep Motive and Deep Strategy scores (Spearman's rho $= 0.461, p < 0.01$). All of the Approach scores showed significant positive correlations with one another. The highest correlation was between Deep and Achieving Approach (Spearman's rho $= 0.633, p < 0.01$), and the lowest was between Deep and Surface Approach (Spearman's rho $= 0.353, p < 0.01$), while the correlation between Surface and Achieving Approach was somewhere in between (Spearman's rho $= 0.438, p < 0.01$).

It is not possible to separate students into groups based solely on their learning approaches, since highly significant positive correlations between different approaches and strategies provide evidence of mixed approaches to learning (instead of using one pure approach). If students had a high Deep Approach score, we might expect them to have low Surface Approach scores – but in this data set it is clear that if students were

high in one approach score, they were also high on other approach score (that is, a mixed approach to learning).

4. Limitations of the current study

There are a number of considerations which should be kept in mind in considering the previous results:

- While students' demographic characteristics may be related to their learning approaches, the way we identify demographic groups could make a significant difference to the results produced by a survey. For example, we might define an international student simply according to nationality, or we might define them according to whether their culture and language differ from those of the greater part of the local population – a choice that could have a significant impact on survey results.
- Students might change their approach to learning from unit to unit. For example, their use of a Deep or Surface Approach in a subject might depend on how much they like that subject; or they might employ a particular approach because of time pressure, such as using a Surface Approach because of a shortage of time (Ramsden, 1984). A change in their time pressures might also lead to a shift in their approach midway through a unit. Alternatively, the same student might use different approaches simultaneously (Marton and Säljö, 1984; Bilgin and Crowe, 2008). Qualitative data are likely to help here, by providing information about whether, when and why students might change their approach.
- The way a unit is organised might impact on students' learning approaches. For example, too many assessment tasks might encourage students to employ a Surface Approach.
- The quality of lecturing might affect students' approaches to learning. But how is this to be measured? Again, qualitative data may help to determine the impact of a lecturer's style or capacity for communication on students' approaches to learning.
- This research was undertaken in one urban university in Sydney; therefore the results might not be generalisable, given the specific nature of teaching and learning and the student body in this particular university.

5. Conclusion

This investigation showed that students' approaches to learning in two statistics units were not significantly different at second- and third-year levels of study; nor did they differ significantly between domestic and international students; nor between students who worked and students who did not work; nor between students enrolled in different degrees.

There were significant differences, however, between students who intended to enrol in a higher degree and those who did not. Deep Motive, Deep Approach, Achieving Strategy and Achieving Approach scores were significantly higher among those students intending to proceed to a higher degree. There were also significant differences between female and male students, the former having significantly higher Surface Motive, Surface Approach, Achieving Strategy and Achieving Approach scores. Finally, and interestingly, the standard numerical grades of students were

positively correlated with Deep and Achieving Approaches as well as with Surface and Deep Strategies and Achieving Motive.

This was a cross-sectional study where two groups of students at different levels of study were surveyed and compared. A longitudinal study where the same students are surveyed in consecutive years as second- and third-years in lower- and higher-level courses in the same discipline (such as statistics) would provide the best way of further investigating and assessing the results of the present study, particularly since this would allow for controlling for differences between individual students. A larger-scale study involving more than one institution and/or more than one discipline, and possibly including institutions in different countries, could yield generalisable results that would be of interest across the higher education sector.

References

Baykan, Z. and Nacar, M. (2007), "Learning styles of first year medical students attending Erciyes University in Kayseri, Turkey", *Advances in Physiology Education*, Vol. 31, pp. 158-60.

Biggs, J.B. (1987a), *Study Process Questionnaire Manual*, Australian Council for Educational Research, Melbourne.

Biggs, J.B. (1987b), *Student Approaches to Learning and Studying*, Australian Council for Educational Research, Melbourne.

Biggs, J.B. (2003), *Teaching for Quality Learning*, Open University Press, Buckingham.

Biggs, J., Kember, D. and Leung, D.Y.P. (2001), "The revised two-factor Study Process Questionnaire: R-SPQ-2F", *British Journal of Educational Psychology*, Vol. 71, pp. 133-49.

Bilgin, A.A.B. and Crowe, S. (2008), "Approaches to learning in statistics", *Asian Social Science*, Vol. 4 No. 3, pp. 37-43, available at: www.ccsenet.org/journal.html (accessed 22 February 2009).

Cooper, B.J. (2004), "The enigma of the Chinese learner", *Accounting Education*, Vol. 13 No. 3, pp. 289-310.

Entwistle, N.J. and Ramsden, P. (1983), *Understanding Student Learning*, Croom Helm, London and Canberra.

Gordon, S. (1995), "A theoretical approach to understanding learners of statistics", *Journal of Statistical Education*, Vol. 3 No. 3, pp. 1-16.

Kember, D. (2000), "Misconceptions about the learning approaches, motivation and study practices of Asian students", *Higher Education*, Vol. 40, pp. 99-121.

Kember, D. and Gow, L. (1991), "A challenge to the anecdotal stereotype of the Asian student", *Studies in Higher Education*, Vol. 16 No. 2, pp. 117-28.

Leung, M.Y., Li, J., Fang, Z., Lu, X. and Lu, M. (2006), "Learning approaches of construction engineering students: a comparative study between Hong Kong and mainland China", *Journal for Education in the Built Environment*, Vol. 1 No. 1, pp. 112-31.

Ling, P., Arger, G., Filonenko, I., Chua, H. and Yin, C. (2005), "Approaches to study: a comparison of Malaysian and Australian students", in Brew, A. and Asmar, C. (Eds), *Higher Education in a Changing World, Proceedings of the 2005 HERDSA Annual Conference in Sydney, 3-6 July 2005*, Higher Education Research and Development Society of Australasia, Milperra, pp. 276-86.

Marton, F. and Booth, S. (1997), *Learning and Awareness*, Lawrence Erlbaum Associates, Mahwah, NJ.

Marton, F. and Säljö, R. (1976), "On qualitative difference in learning: I. Outcome and process", *British Journal of Educational Psychology*, Vol. 46, pp. 4-11.

Marton, F. and Säljö, R. (1984), "Approaches to learning", in Marton, F., Hounsell, D. and Entwistle, N. (Eds), *The Experience of Learning*, Scottish Academic Press, Edinburgh, pp. 39-58.

Ramsden, P. (1984), "The context of learning in academic departments", in Marton, F., Hounsell, D. and Entwistle, N. (Eds), *The Experience of Learning*, Scottish Academic Press, Edinburgh, pp. 198-216.

Ramsden, P. (2003), *Learning to Teach in Higher Education*, Routledge, London.

Regan, J. and Regan, L. (1995), "Changes in university students' study processes during the first year of their undergraduate courses in relation to age, gender and faculty", in Jeffery, P.L. (Ed.), *Proceedings of 25th Annual Conference of the Australian Association for Research in Education, 26-30 November*, available at: www.aare.edu.au/95pap/regal95057.txt (accessed 30 June 2010).

Säljö, R. (1981), "Learning approach and outcome: some empirical observations", *Instructional Science*, Vol. 10 No. 1, pp. 47-65.

Tait, H., Entwistle, N.J. and McCune, V. (1998), "ASSIST: a reconceptualisation of the approaches to study inventory", in Rust, C. (Ed.), *Improving Students as Learners*, Oxford Centre for Staff and Learning Development, Oxford Brookes University, Oxford, pp. 262-71.

Trigwell, K. and Prosser, M. (1991), "Improving the quality of student learning: the influence of learning context and student approaches to learning on learning outcomes", *Higher Education*, Vol. 22 No. 3, pp. 251-66.

Trigwell, K., Prosser, M. and Waterhouse, F. (1999), "Relations between teachers' approaches to teaching and students' approaches to learning", *Higher Education*, Vol. 37, pp. 57-70.

Watkins, D. and Hattie, J. (1985), "A longitudinal study of the approaches to learning of Australian tertiary students", *Human Learning*, Vol. 4, pp. 127-41.

Zeegers, P. (2001), "Approaches to learning in science: a longitudinal study", *British Journal of Educational Psychology*, Vol. 71, pp. 115-32.

Further reading

Australian Academy of Science (2006), *Mathematics and Statistics: Critical Skills for Australia's Future*, available at: www.review.ms.unimelb.edu.au/Report.html (accessed 16 June).

Brookfield, S.D. (1995), *Becoming a Critically Reflective Teacher*, Jossey-Bass, San Francisco, CA.

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