A Comparison of First Year Statistics Units' Content and Contexts in a Multinational Study, with a Case Study for the Validation of ASSIST in Australia

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Abstract The study of statistics has become widespread throughout many degrees around the world in many universities, as the emphasis on evidence-based decision making has gained momentum in the business world. Students' approaches to their learning bear significant weight over the skills and understanding that students acquire during their studies. Three distinct learning approaches have been identified by researchers over the last three decades: deep, surface (British Journal of Educational Psychology 46:115–127, 1976) and strategic (Educational Research Journal 5:18–28, 1990). The discrepancy between desired learning outcomes and the aptitude and skills that students of statistics acquire (e.g. International Statistical Review 63:25–34, 1995) is well documented but the underlying reasons for choosing different learning approaches in statistics has only been investigated in limited studies and only from the perspective of a student's demographics. It is therefore important to understand how unit and student characteristics might encourage students to utilise certain approaches, especially students who do not major in statistics.

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The aims of the current chapter are therefore to provide a brief review of learning approaches, a detailed description of the multinational study and validation of the Approaches and Study Skills Inventory for Students (ASSIST) as a measure of the learning approaches utilised by a cohort of Australian students of statistics.

Keywords Learning approaches • Statistics education • Multinational • ASSIST

1 Introduction

The study of statistics has become an integral feature of tertiary education across multiple disciplines, and in many countries. Despite this, there is often a discrepancy between the learning outcomes desired by educators and the aptitude and skills that students of statistics acquire (Garfield 1995). The economic and cultural globalisation of higher education necessitates that students be proficient in their understanding and application of these statistical skills as the pressure for individual institutions to meet international standards increases (Marginson and Van der Wende 2007). In addition it has been documented that many developed countries will face shortages of graduates from mathematical and statistical sciences (Australian Academy of Science 2006). The primary reason for including statistics into curricula is to enable students to make judgments about data, or about data interpretation, using multiple tools (Gal and Garfield 1997; Cobanovic 2002). It is therefore imperative for research to determine the nature of barriers faced by students, especially students who do not major in statistics, and potential attenuating or accentuating variables within these relationships. Barriers faced by students may include their approach to learning, which may in turn be correlated with their success in a statistics course.

There have been a vast number of research projects carried out to understand the underlying reasons for different ways of learning (termed approaches). Although earlier research was mainly qualitative, later both qualitative and quantitative research followed. Marton and Saljo (1976a, b) first asked participants to memorise passages, finding that some students tended to focus on the general meaning of the passage, and others on specific words. Inferring from this evidence of a greater discrepancy in students' approach to learning, they asked these students open-ended questions, such as "What do you mean by 'learning'?" They found evidence for two distinct approaches that students possessed towards learning which were clearly associated with differences in the levels of understanding achieved: deep and surface. The concept of learning approaches now entails both a student's motives for learning and their resulting strategies for achieving this learning, and generally identifies a third approach termed strategic (achievement) (Biggs 1990). Students adopting deep approaches do so in order to understand and internalise concepts for later use, and therefore often interact more critically with subject content and endeavour to relate these concepts back to their prior knowledge and experience (Ramsden 1992). In contrast, those adopting a surface approach do not personally engage with the learning process, and focus on memorisation of concepts without attempting to relate them first (Marton and Saljo 1976a). The focus on evaluation

and assessment within learning institutions has been seen to produce the third type of learner: individuals adopting strategic approaches in an endeavour to maximise their marks and comply with academic requirements rather than to holistically understand course materials (Biggs 1987; Entwistle 1991; Tait and Entwistle 1996).

The aim of this chapter is to describe the multinational project designed to explore characteristics of students' learning approaches across three countries and then to validate the ASSIST survey tool as being a good measure of students' learning approaches for the Australian data only. Providing a context we describe the similarities and differences between three first year service statistics units (courses) on which data are currently being collected. We restrict our examination to the contents being covered and the learning environments. The learning environments of the units being studied will be used for analysis in the second stage of this research as predictors of the students' learning approaches. We also describe the survey tools used in the project. To validate ASSIST in the Australian data, we apply factor analysis to determine whether the factors identified load appropriately according to the ASSIST model. Validation of ASSIST in the Argentinian and Italian data and other stages of this project are beyond the scope of this chapter.

The ethical aspects of this research were approved by Macquarie University Human Ethics Committee (Reference Number 5201100809) in 2011.

2 The Multinational Learning Approaches Project

The approaches to learning have been researched in Australian Universities, and the existence of these same three approaches is now well established (Scouller 1998; Bilgin 2010). The cultural background of students has been the focus of considerable enquiry in Australia (Ballard and Clanchy 1984; Donald and Jackling 2007; Kember 2000; Kember and Gow 1991); possibly because of a reasonably large proportion of (predominantly Asian) international enrolments.

In Italy, the Bologna process identified the need for "lifelong learning" practices, similar to the concept of the deep approach to learning, and caused an intense reform of Italian tertiary education (Jakobi and Rusconi 2009). Considering its relevance, the approaches to learning theory has yet to be well established in any Italian University to the authors' knowledge.

Salim (2006) established that the three approaches to learning also exist within Argentinian students, and found that students adopting achievement approaches had significantly higher grades than those adopting deep approaches. It was suggested that the large percentage of students adopting achievement and surface approaches was due to the focus of tertiary education in the sample being for job opportunities rather than a desire to learn more, as well as the structure of the course in rewarding this approach (Salim 2006). However, this sample was of biochemistry students, and was deliberately selected to over-represent both academically successful students and those who had failed repeatedly. A similar pattern may not exist for students studying statistics rather than a content-based subject, as success is contingent upon the thorough understanding of both practice and theory.

This multinational study is the first of its kind (to the authors' knowledge) that aims to explore the utilisation of learning approaches in statistical education and compare these findings in a multinational setting, not just looking at the student characteristics but also course characteristics.

The core research team (the first five authors of this chapter) for this study was formed in 2010 in Ljubljana, Slovenia during the Eighth International Conference on Teaching Statistics (ICOTS), "Data and context in statistics education: Towards an evidence-based society", after one of the team member's presentation on learning approaches. The team developed a research framework until 2011, and then started collecting data from students in Australia, Italy and Argentina. Since then two researchers from Turkey joined our research group and have surveyed around 500 students in six different universities in Turkey. In addition, one researcher from Vietnam who has surveyed nearly 700 students in his university has also joined the project. For the future we aim to add researchers from North America and Africa to our research team so that we can cover all continents except Antarctica. A main aim is to shed light on the factors underlying students' choice of different learning approaches in statistics units, so that we can better inform educators of statistics to be aware of these factors when they are designing their curriculum. Of course we would also like to provide guidelines to creating better statistical learning environments for all so that the societies we live in become more statistically literate.

Our research project has three stages. Stage one will cover understanding the learning context and unit contents as well as student characteristics by data collection from the students and from the course coordinators. We will document similarities and differences between unit characteristics: the content—what has been taught and how the units are delivered. We will also need to test the validity of ASSIST in each country to ensure that we are using a reliable tool. This is important before we can use ASSIST to identify learning approaches of students in these three countries. After validating ASSIST we will start developing models to identify characteristics of students and units for different learning approaches (stage two). Finally stage three will involve providing resources and recommendations for statistics educators on statistical units' designs, which enable deep approaches to learning. We envisage this study is a long-term study and expect to move to second stage within 12 months.

2.1 The Approaches and Study Skills Inventory for Students

The Approaches and Study Skills Inventory for Students (ASSIST) (Tait et al. 1998) was developed to assess students' approaches to learning across the three types using a five-point Likert scale for 52 statements relevant to learning. ASSIST aims to offer a mechanism through which educators and researchers across countries and disciplines can gain an understanding of the approaches utilised by students, and potentially the influence of contextual and personal variables on these approaches.

ASSIST has three parts. Part A includes six statements to describe "what is learning?" in students' eyes. Part B consists of 52 statements which are used to

identify the learning approaches of students. Finally, Part C of the survey helps researchers to identify student preferences for different types of courses and teaching, that support understanding (related to deep approach) or that transmit information (related to a surface approach). This is done by using eight statements together with a question asking students how well they think they have been doing their assessed work so far. This survey tool is publicly available (Centre for Research on Learning and Instruction 1997), although it can only be used where the educational language is English. Therefore the core authors translated the survey into Italian and Spanish for the purpose of this study. The validation of ASSIST has been reported for UK data by Entwistle et al. (2000) and for Egyptian data by Gadelrab (2011). In Ireland, ASSIST has been used to assess students' learning approaches for accounting and science students (Byrne et al. 2002, 2010). As such it is of interest to validate ASSIST on the data from each country in this project.

2.2 The Demographic Survey

An additional survey was also developed to gather information regarding the demographics of students (e.g. gender, age, language spoken at home, their parents' educational background), the students' official university identification number (Student ID) so that it was possible to access their official final grade for the unit, their educational background (e.g. where they completed high school, what kind of high school they attended), their current circumstances (e.g. where they live, whether they work) and their future educational plans (e.g. whether they intend to enrol a higher degree). Finally after providing a brief description of the three learning approaches (deep, surface and strategic), the survey asked students to identify their learning approach for the statistics unit they were studying and write a few sentences regarding why they used this specific approach in this statistics unit. The full demographic survey used in Australia is provided in the Appendix. In Italy and Argentina minor modifications were made to the demographic survey to address differences in high school and tertiary education systems.

To be able to have an acceptable assessment of students' learning approaches in statistics, we surveyed our students towards the end of their study period so that they had been exposed to almost all of the concepts to be covered in the semester. By this time they would have been assessed in some aspects of their learning and they would have been given feedback on their assessment tasks.

2.3 The Learning Environment and Unit Characteristics in Three Countries

The characteristics of three first year statistics units offered in Italy to Psychology students, in Argentina to Agricultural Engineering and Environmental Sciences students and in Australia to mainly Business students will be compared in this section.

The characteristics are based on 2011 offerings of these units since the data collection from the students started in 2011.

In Australia, the focus of the research was on an introductory statistics unit within Macquarie University. Although not compulsory for all students, many degrees in the University have this unit as a prerequisite for further study, including Bachelor of Applied Finance, Bachelor of Business Administration, Bachelor of Economics, Bachelor of Marketing and Media, Bachelor of Biodiversity and Conservation, Bachelor of Marine Science and Bachelor of Medical Sciences (Macquarie University 2012a). Since there is no assumed knowledge, the course begins with an introduction to variable types, study designs and the relationship between a sample and population. Graphical and descriptive statistics are covered in detail, followed by probability and sampling distributions. Hypothesis testing and confidence intervals are a main focus of this course which includes methods for known and unknown variances. The second half of the course explores the concepts and applications of correlation and regression, which is followed by categorical data analysis. The final week is dedicated to the review of all the contents covered and a reminder of how the topics relate to each other.

The unit teaching team for 2011 consisted of three academic staff members, all with more than 10 years of experience, from the Department of Statistics. The teaching team was headed by a Senior Lecturer. There were more than 900 student enrolments which necessitated four lecture streams, each 2 h a week for 13 weeks. One of them was taken by the lecturer in charge, two of them by one academic staff member and the final one by the other academic staff member. The largest lecture class size within this course consisted of 334 seats tiered theatre.

As well as attending a 2 h lecture each week, students were required to attend a 1 h tutorial and a 1 h practical (both with up to 50 students per group) each week. Tutorials involved guided problem solving using pen and paper and manual calculations. Practicals helped students to learn how to solve these problems using a statistical software package. Both tutorials and practical classes started in the second week and continued until the last week. They were mainly run by higher degree students (i.e. Ph.D., Honours). In second semester 2011, there were nine tutors running 23 tutorial classes and seven practical demonstrators running 23 practical classes. Consultation times were offered by all academic staff in the department and covered most hours between 9 am and 5 pm each working day.

Assessments for the unit included online quizzes (15 %), three group-based assignments each worth 5 %, a class test run under exam conditions organised during tutorials just before the midsemester break (15 %), and a final examination worth 55 % (Table 1). Unless students were able to prove through a special consideration application (Macquarie University 2012b) that serious and unavoidable disruption to their studies resulted from an event or set of circumstances (i.e. illness) that prevented them from being able to sit the final exam on the allocated date and time, students were not given an opportunity to attempt to pass the examination again.

The course of interest in Italy was an introductory statistics course for psychology students of the University of Florence. Students are introduced to the concept of measurement and introductory statistics using examples and data from

Table 1 Assessment characteristics of units in Australia, Italy and Argentina

Country	Australia	Italy	Argentina
Online quizzes[a]	9 (15 %)	–	–
Assignments or quizzes[a]	3 (15 %)	1 (10 %)	2–12 (10 %)
Written exam[a]	2 (15 and 55 %)	1 (70 %)	2 (40–50 %)
Oral exam[a]	–	1 (20 %)	–
Attempts allowed for exams	1 with justification	5 no justification	4 no justification

[a]The numbers represent how many and the percentage means the weighting of the assessment tasks towards the final grade

Table 2 Face-to-face hours per semester in Australia, Italy and Argentina

Country	Australia	Italy	Argentina
Number of students	970	400	450
The lecture class sizes (seats available)	334, 320, 250, 216	250, 250	115, 115, 115, 110
Teaching team (lecturer + tutor + demonstrator)	4+9+7	4	4+8
Total face-to-face lecture hours per semester	26	40	32
Maximum number of students per tutorial	50	120	36
Total face-to-face tutorial hours per semester	12	20	42
Maximum number of students per practical	80	–	36
Total face-to-face practical hours per semester	12	–	6
Total face-to-face hours per semester	50	60	80

psychological literature and research. The course is designed to provide students with sufficient theoretical and practical knowledge of descriptive statistics and probability theory to then study hypothesis testing and confidence intervals, as well as descriptive statistics and other inferential statistical analyses. This course is compulsory for first year students. There were 400 students in the course in 2011 (Table 2). As with the Australian course, the teaching required a team effort and was headed by a senior lecturer with more than 10 years of experience. The teaching team consisted of only two academics who ran all of the lectures and tutorials. The course runs for 10 weeks, and consists of one 4 h lecture and one 2 h tutorial (with students working in groups) each week. The largest lecture class size within this course consisted of 250 seats (i.e. maximum number of students could be 250 but it is possible that there were less number of students in any given week in any given lecture time). Consultation hours were also offered to students for one-on-one help with exercises. Classes were based around the discussion of theoretical issues, followed by practical examples and exercises undertaken with pen and paper, rather than using computer packages in tutorials. The assessment for this course consisted of a group report (10 %), an ungraded assignment for providing students with formative feedback, and written (70 %) and oral (20 %) final examinations (Table 1). The tasks in these examinations consisted of solving problems (numerical answers) and open-ended questions in which students had to apply and explain concepts

acquired during the course. In contrast to the Australian sample, students were allowed to sit the examination up to five times in the year.

The sample chosen in Argentina was from a general statistics unit which is compulsory for students studying towards Agricultural Engineering or Environmental Sciences Degrees. As for the Australian and Italian first year units the teaching team in 2011 consisted of several academic staff members and the team was headed by a Senior Lecturer with more than 10 years of experience. There were 450 students in the course in 2011. The course ran for 16 weeks, and consisted of one 2 h lecture per week, one 3 h tutorial (with up to 36 students per group) a week and two practicals a term. The largest lecture class size within this course consisted of 115 students. The first half of the course covered topics related to descriptive statistics, probability and random variables (particularly binomial and normal variables). The second half of the course introduced sampling distributions, hypothesis testing and confidence intervals for the mean and mean differences. In the final weeks of the semester, simple linear regression and categorical data analysis were taught.

The performance of the students was assessed through continuous evaluation (with assignments that were submitted in every class) and two midterm tests (four or five problem-solving exercises). If the students gained 70 % or above in the midterm tests, then they passed the course, they did not need to sit a separate final exam. If their performance during the semester fell below 40 %, then they failed the unit and they were not allowed to sit the final exam. Students with intermediate performances—achievement between 40 and 70 %—were required to sit a final, integrated examination, which consisted of multiple choice questions (Table 1). These students were given four attempts to sit the final examination.

The total face-to-face contact hours during the semester for the three learning environments are provided in Table 2. While Australian students had 50 h total face-to-face contact with academics, half of these were with junior academics (i.e. current higher degree students), and all contact hours in Italy (60 h per semester) and in Argentina (80 h per semester) with academic staff members. Future work will explore whether this aspect of the units had any relationship with students' learning approaches and success in statistics.

3 Validation of ASSIST in the Australian Data

3.1 Data Collection in Australia

In Australia in the second semester of 2011, students were surveyed in week 13 in their practical classes. Unfortunately, the practical attendance by that time was very low. Instead of 50 enrolled students per practical class, on average there were no more than 10 students in each class. Dr. Bilgin went to each practical class, introduced the study to students and distributed the survey forms. She left the class and surveys were collected by practical demonstrators. Although the total number of

enrolments for the unit was close to 1,000, due to the drop in the practical class attendance, only 68 students returned a completed survey. This is not surprising in Australian higher education institutions. Students are usually asked to complete surveys all through the semester such as Learner Evaluation of Unit, Learner Evaluation of Teacher and educational research undertaken by academics or higher degree students. For a recent study, Dr. Bilgin only managed to get 4.9 % response rate from 10,000 randomly selected local students for an online survey after two reminders.

To be able to achieve a reasonable number of student responses for the two surveys, we repeated the survey in first and second semesters in 2012. At the time of writing, the data for the second semester 2012 was in paper form and not available for analysis. In total, we had 68 responses in 2011 and 67 responses in 2012 available for analysis. These 135 responses were used in factor analysis to verify the factorial structure of ASSIST in the Australian cohort.

3.2 Participants in Australia

The sample was evenly split between male (48.9 %) and female (51.1 %) participants. The average age of students was 21 (SD = 5.4) years. Ninety-three per cent of the students were aged 26 years or younger. One in five students identified themselves as international students (19.8 %). The international students were mainly from China (35 %) and other Asian countries (54 %). Although only 20 % of the students were international students, 52 % of sampled students indicated that they spoke a language other than English at home and only 59 % of the students stated that English is their first language. One-third of the students completed secondary education through a private or independent high school, and a further 18.5 % in Catholic high schools, while nearly half of the students (49 %) graduated from a government high school (including selective high schools—only 5 %). Forty per cent of the students attended coaching for more than 30 h in a year prior to starting university. For nearly 40 % of students (39 %) neither parent had a university degree, while one-third had both parents with a university degree (29 %), 13 % only the father and 13 % only the mother had a university degree. Only a few students did not know whether either of their parents had a university degree (6 %). The majority of the students lived with their parents (63.6 %), others lived in shared accommodation (14.4 %), with partner/husband/wife (8.3 %), alone (7.6 %), residential college (1.5 %) or in other accommodation (4.5 %). Sixty-one per cent of the students had a job during their studies where they worked from 3 h per week to 60 h per week. On average they worked 17.2 (SD = 12.6) hours each week.

Two-thirds of students indicated that they liked studying in general however, only 52 % of students stated that they liked studying mathematics in their high school years. The percentage of students who considered statistics to be useful for their future work (55 %) was slightly lower than the percentage of students who intended to enrol in a higher degree after completing their current degree (64 %).

Their self-identified learning approaches were for deep, surface and strategic approaches, 33 %, 44 % and 23 % respectively. The higher percentage of surface approach and the lower percentage of deep approach might be due to students' immaturity at university studies. Seventy-six per cent of the students provided an explanation for why they had chosen a certain learning approach to study their current statistics units.

Deep and surface approaches consist of four subscales each with four statements; therefore if a student chooses the highest possible value for each statement, the highest possible score for deep and surface approaches are 80. The strategic approach consists of five subscales each with four statements; therefore if a student chooses the highest possible value for each statement, the highest possible score for the strategic approach is 100. The mean deep, surface and strategic approach scores for the 135 students were 55.2 (SD = 10.4), 52.6 (SD = 11.7) and 68.1 (SD = 13.4), respectively. To be able to graphically display all three learning approaches so that they are comparable, scores were standardised prior to creating the boxplot in Fig. 1.

Figure 1a clearly shows that the distributions of the three learning approaches scores were very similar for this sample. Although there did not seem to be any relationship between surface and deep approaches and between surface and strategic approaches, it is visible in Fig. 1b that deep and strategic approaches had a positive linear relationship and they were significantly correlated with each other (Pearson correlation coefficient = 0.715, $p < 0.0001$), while the correlation between deep and surface (Pearson correlation coefficient = 0.03, $p = 0.73$) and surface and strategic (Pearson correlation coefficient = −0.01, $p = 0.89$) approaches were insignificant.

3.3 In Students Words

We have used word clouds to identify student stated reasons for choosing certain learning approaches in their statistical learning (Figs. 2, 3 and 4). We found relevant quotes for most observed words from students' responses to provide students' perspectives. There were 42, 37 and 24 student responses to open-ended questions on why they have chosen surface, deep and strategic approaches to their learning, respectively.

While the students' explanations for choosing a surface approach to their learning in statistics ranged from (Fig. 2):

> I have other important subjects to focus on at the moment, and only really need to pass stats.
>
> Only need to pass this unit for science-only need some key information for science tests.

to,

> I find it easier to cope with statistics by focusing on what I have learned each week and sometimes I find it difficult relating different week's information to each other.
>
> I like to be told exactly what to learn and where to find it. I don't think creative thinking in stats (for me anyway) will give me good marks

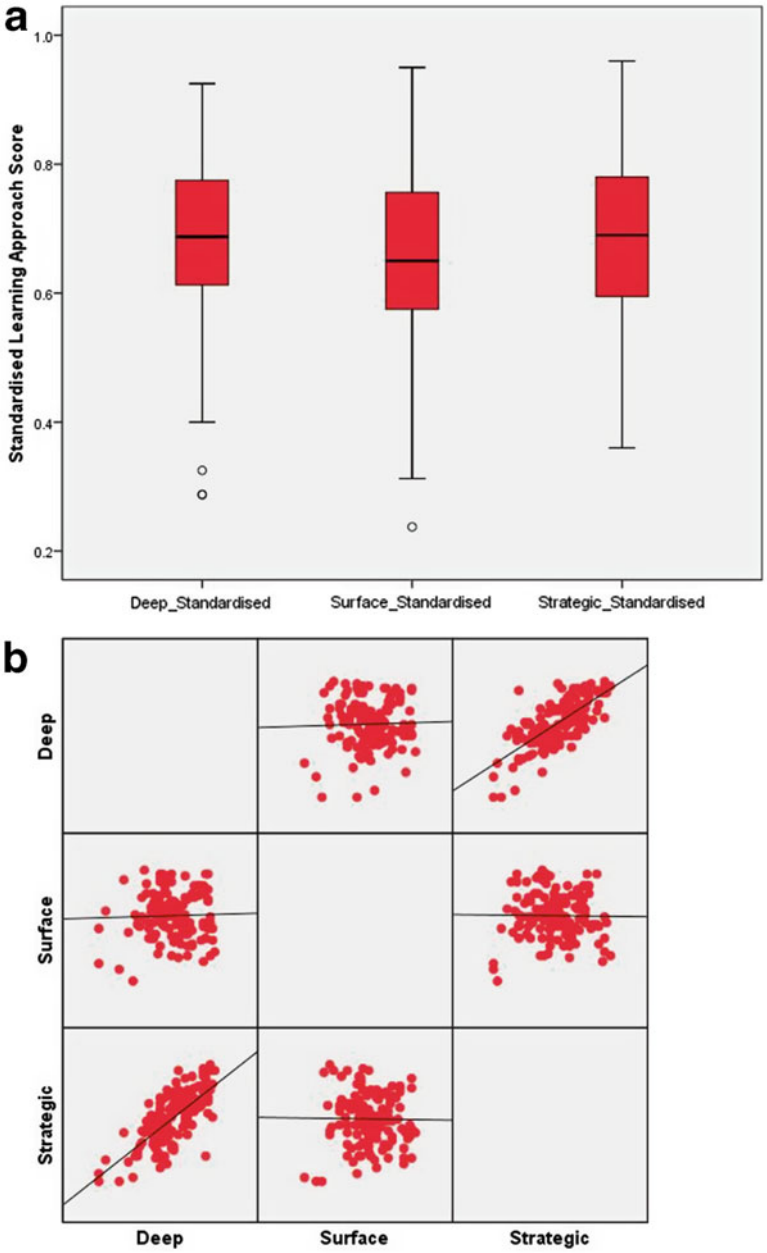

Fig. 1 Standardised learning approaches scores distribution and their relationships with each other for the Australian data set

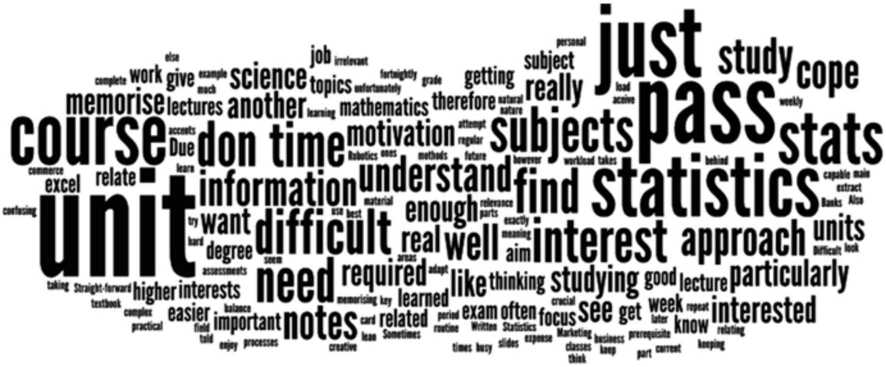

Fig. 2 Word cloud for surface learning approaches

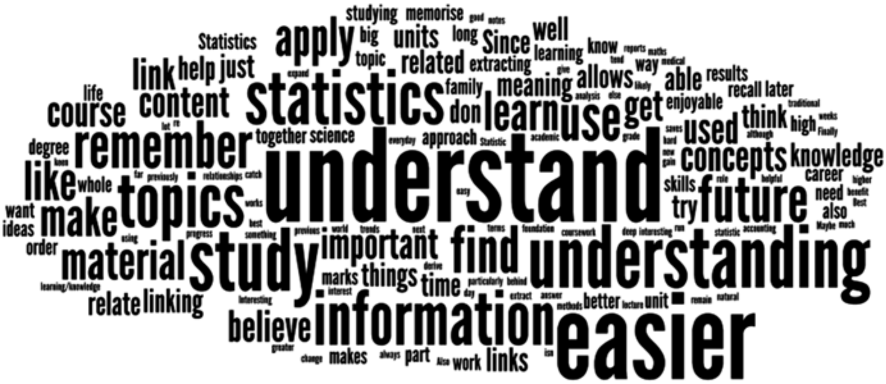

Fig. 3 Word cloud for deep learning approaches

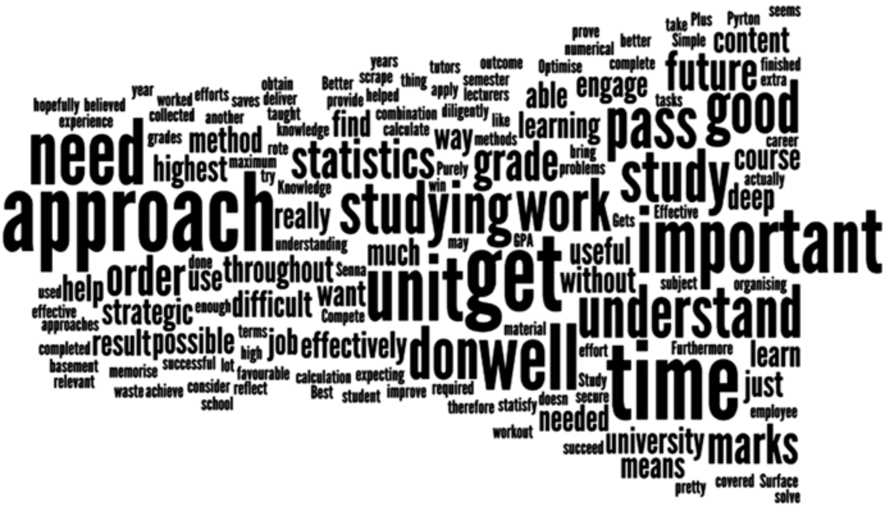

Fig. 4 Word cloud for strategic learning approaches

The reasons for them choosing a deep approach to their learning in statistics were more in line with the definition of the deep approach (Fig. 3), i.e. to understand and internalise the concepts:

> Understanding and linking concepts makes it easier for me to recall things, and to derive anything else. I'm more likely to remember something if I think it is meaningful.
>
> It's easy to remember things if you understand them in your own context link them and draw relationships between each other. It saves time and tends to stay in the memory longer.
>
> That is how I like to approach everything, the joy of learning.
>
> Because it's important I can apply my statistical analysis skills to other units now and in the future. Statistic has a big role in science (doing a medical science degree).
>
> If you extract meaning from what you are learning then it is much easier to understand.

Finally, the strategic approach to learning in statistics appears to have been made for obvious (strategic) decisions:

> I use this approach because without organising time diligently then I find it difficult to complete tasks and study. Furthermore, studying effectively means I don't waste time.
>
> Optimise the time then the work is finished and completed. Study method means all content is covered.
>
> Simple. Effective. Gets the job done. I don't have time to engage in the work. Plus, there is way too much content to engage with
>
> This was the approach was taught and used throughout my high school years. I believed it has worked for me which is why I continue to use it in university.
>
> The grade is really important to me as I need to get a really good grade as I'm a sponsored student. And the approach can help me to succeed in this unit.

In summary students stated that their main reason for choosing a surface approach was because their only aim was to pass the unit and the unit was potentially difficult for them to pass. Others wanted to understand the content of the unit because that made it easier for them to remember and relate what they have learnt to their future studies therefore they are choosing deep approach to their learning. The remaining students pointed out that they do not have enough time to use any other approach than a strategic approach in order to get high grades which was very important to them.

3.4 Exploratory Factor Analysis of the ASSIST Model

The purpose of carrying out an exploratory factor analysis on the learning approaches data was to reveal the underlying relationship between the three learning approaches (i.e. factors) and the component subscales of ASSIST without any prespecifications and restrictions on cross-loadings. The method used here involved a principal components method (PCA) for performing the exploratory factor analysis. We wish to validate ASSIST for the sample of Australian statistics students.

Component subscales loading high on the learning approach they represent with minimal cross-loadings are an indication of the good discriminant validity of the factors, and thereby reinforce that the ASSIST subscales efficiently measure the individual learning approaches of the Australian first year statistics students.

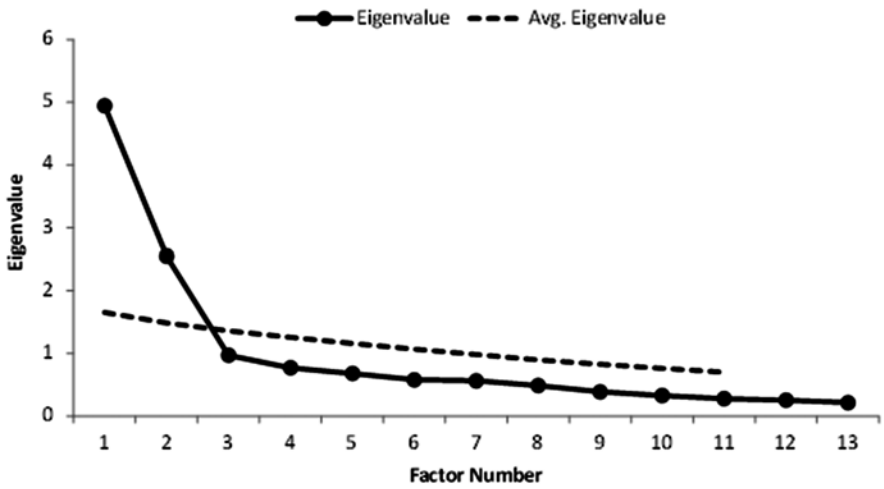

Fig. 5 Scree plot for the Australian data set

We began by examining the correlations between 13 subscales and found that most of the correlations were greater than 0.3 except for the correlations between surface approach subscales, and either deep or strategic approach subscales. The statements relating to the surface approach had weak correlations with the other two learning approaches. The value of the determinant was 0.002, which is small, but still acceptable since it is not zero and hence the correlation matrix can be inversed. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for this data set was 0.835, which is much great than required minimum (0.5) to be able to apply factor analysis. Furthermore, Bartlett's test of sphericity returned a highly significant p-value (<0.001), meaning that the off-diagonal entries in the correlation matrix were significantly greater than zero. Based on these findings, it can be concluded that it is worthwhile to carry out an exploratory factor analysis.

To decide how many factors to extract we used three measures:

1. A rule of thumb is to extract the factors where the eigenvalues are approximately greater than 1. The first four eigenvalues for this data set were 4.946, 2.550, 0.970 and 0.770 which suggests the extraction of two or three factors.
2. As a visual guide, we examined the scree plot (Fig. 5, solid line) to decide how many factors to extract. The elbow appears to be at the third factor, suggesting retention of two or maybe three factors.
3. We also applied the so-called "parallel procedure" first introduced by Horn (1965). In short, this procedure uses Monte Carlo simulation to generate eigenvalues a large number of times on the same sample size as the data set, averages them, and compares the actual eigenvalues to these standards. The cut-off is set where the average eigenvalue exceeds the actual eigenvalue, i.e. the variance is greater than the average variance in random samples. In our case, with $n=135$ and $p=13$, the first four average eigenvalues are as follows: 1.654, 1.487, 1.360 and 1.255. Our third actual eigenvalue was 0.970 and the third average eigenvalue

Table 3 Rotated component matrix

	Components		
	1 (Deep)	2 (Strategic)	3 (Surface)
ST: Organised studying	0.431	0.744	–0.021
ST: Time management	0.233	0.865	–0.006
ST: Alertness to assessment demands	0.532	0.358	0.111
ST: Achieving	0.412	0.774	–0.041
ST: Monitoring effectiveness	0.607	0.447	0.012
SU: Lack of purpose	0.113	–0.320	0.720
SU: Unrelated memorising	–0.060	0.063	0.879
SU: Syllabus-boundness	0.023	–0.002	0.787
SU: Fear of failure	0.036	0.117	0.774
D: Seeking meaning	0.772	0.256	–0.013
D: Relating ideas	0.785	0.123	–0.004
D: Use of evidence	0.799	0.166	0.085
D: Interest in ideas	0.607	0.420	–0.025

of 1.360 from the simulation is slightly exceeding this. As the cross-over point (Fig. 5, dashed line versus solid line) is closer to the third eigenvalue, the method of the parallel procedure argues for the extraction of three factors.

While, strictly speaking, the first two guidelines suggest the extraction of two factors only, we know that these guidelines are very rough and the third eigenvalue of 0.970 was very close to the cut-off value of 1. Lastly, the results of the parallel procedure also support the extraction of three factors rather than two.

The PCA approach explained nearly 65 % of the variation with three factors extracted and it is worthwhile to note that the first two factors only accounted for 47 % of the variance. As such, our decision to extract three factors appears further justified. The factor analysis distinctly separated the component subscales of the three learning approaches with most of them having a positive loading of above 0.7, although some subscales ("alertness to assessment demands" and "monitoring effectiveness") appeared to have some overlap between the strategic and deep approaches by loading more strongly on the deep approach (Table 3). It is interesting to note that these two subscales were also found to have inappropriate loadings in a research project that aimed to validate ASSIST on a sample of Norwegian undergraduate students (Diseth 2001). Diseth (2001, p. 382) argues that the subscale "alertness to assessment demands", which includes items focusing on the utilisation of feedback, is less applicable to the Norwegian sample as Norwegian students get little feedback during the semester and it more relates to studies beyond the first year. With regard to the subscale "monitoring effectiveness", Diseth (2001) notes that it is a related subscale, which might not be applicable in all contexts as is the case with the Norwegian sample, and it might be more relevant to graduate studies as noted by Entwistle et al. (2000 as cited in Diseth 2001). These arguments are likely to hold in relation to the factor analysis carried out on the Australian first year statistics students. Furthermore, the fact that unrotated loadings (not presented) of these two subscales were greater than 0.7 on the strategic approach supports the theoretical argument that they are primarily related to the strategic approach.

In summary, the exploratory factor analysis appears to validate the ASSIST model by loading appropriately onto the correct component for all but a couple of subscales.

4 Conclusion

The study of statistics has become widespread throughout many degrees in Australian universities, such that many statistical courses are now prerequisites for further study. The use of surface approaches within statistical study could be considered detrimental to both the student and the field, as only deep approaches award students with sufficient knowledge to progress and be capable of future statistical enquiry. However, to date there have been few empirical studies exploring the relationship between learning approaches and course outcomes in statistics courses. It would be of interest to determine if these relationships differ within students who are progressing towards a degree other than statistics, such as in psychology, biology, agricultural engineering or accounting, where statistical knowledge is essential but often overlooked. Comparisons of course characteristics and student demographics across countries might allow educators to gain a better understanding of the influence of contextual (i.e. course related) and demographic (i.e. personal) variables on students' learning approaches.

Research concerning individual characteristics of students and their relationship to learning approaches has limited applicability for academic reform, and therefore there is greater need for clarification of the role played by dynamic factors. As such, extensive tutoring prior to university entry (i.e. high school years), hours of work undertaken that is unrelated to what has been studied, language of education (i.e. native or second language) and features of the courses are of particular interest. It has been found that previous experiences and predispositions to learning shape a student's approach to learning in tertiary settings, with students who have come to rely on surface approaches preferring university materials that allow surface learning (Entwistle 1991). It would be of interest to determine how preparation for high school completion examinations, a set of examinations largely focused around content memorisation, prior to university admission would be related to the learning approaches subsequently utilised. The relationship between a student's hours of paid work and their learning approaches has also been of interest to researchers. Zhang (2000) found that work experience was positively associated with deep and achieving approaches, and negatively with surface approach. However this result may only hold for work relevant to the student's study, and could otherwise detract from the student's ability to utilise deep approaches to learning. Further work is therefore warranted to measure the hours a student works, the necessity of this work, and its relation to their learning at university, to shed light on this matter.

The comparison of the three units offered in Australia, Italy and Argentina, and the educational systems of the countries in which they are taught, offers researchers a perspective through which contextual and contents of the first year statistics units are taught. Along with demographic variables, these context variables might be able

to give us an indication why students of statistics are using certain learning approaches in their studies.

Several differences documented here might help us to identify relationships between these variables and learning approaches. Practical classes, statistical packages and online resources are used in teaching the Australian sample, and it is of interest as to how these additions to statistical teaching may alter the approaches used by students. In light of the big push to Massive Online Open Courses (MOOCs), the findings might be of interest to the wider educational community.

The impact of class sizes could also prove to be important as the Argentinian classes consisted of far fewer students than were in both the Italian and Australian samples. The assessment styles of the three groups were similar in terms of their mix of intermittent assignments, group work and examinations, but with more emphasis given to the final examination in the Italian and during semester assessments in the Argentinian samples. In addition, more opportunities were given to students to pass the final examination without justifying why they should be given a second chance to sit it in Italy and Argentina. Using one-to-one oral final examination is unheard of in the undergraduate Australian higher education environment; due to the large numbers of enrolled students, it seems an unlikely option for future Australian undergraduate education.

By using the 135 responses from the Australian students, we were able to verify that ASSIST was a valid measure of students' learning approaches (deep, surface and strategic). We are applying similar analysis to Italian and Argentinian data sets to verify the effectiveness of the translated versions of ASSIST. The results will be presented in future publications.

We acknowledge that the Australian sample might be biased due to the timing of data collection and because we were unable to reach a reasonable proportion of students. Nevertheless, even with this small sample we were able to show the validity of ASSIST in this sample which may be useful for future Australian studies. In the future we might be able to increase response rates by surveying students in the middle of their studies and by utilising online tools.

A comprehensive study of the learning approaches utilised by students in (at least) these three countries, Australia, Italy and Argentina, as well as identifying the relationships between the learning approaches and student background variables and features of the learning environment, will potentially provide avenues for academic reform in statistics education by highlighting the needs for curriculum changes.

5 Note

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This chapter is refereed.

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Appendix: Demographic Survey Used in Australia

Department of Statistics
Learning Approaches in Statistics Demographic Survey

Welcome to the **Multinational study on learning approaches variability of university students in Statistics courses research**. As a lecturer in the department of statistics, I would like to better understand our students' approaches to learning. This survey is used to collect demographic information as well as information on your approach to learning. Please complete the questions below, either by writing your answer or ticking the appropriate option. Any confidential information pertaining to individuals will not be released to anybody outside the research team. Only the aggregated results will be presented and/or published.

Thank you very much for taking the time to read this information

---

Student ID: _____

Q1. What is your birth date? _____/____/_____

Q2. What gender are you? ❍ Female ❍ Male

Q3. Are you an international student? ❍ Yes ❍ No

1. If yes, which country do you come from? _____
2. How many years have you lived in Australia? _____

Q4. Do you speak another language at home? ❍ Yes ❍ No
If yes, which language do you speak? _____

Q5. Is English your first language? ❍Yes ❍No
If no, what is your first language? _____

Q6. In which degree are you enrolled? _____

Q7. Which year did you finish high school? _____

Q8. What type of high school did you attend before university?
❍ Government ❍ Private/Independent ❍ Catholic system
❍ Government Selective ❍ Other, please specify_____

Q9. Where did you complete your schooling?
❍ Sydney region ❍ Overseas - South East Asia
❍ Other Australian capital/major city ❍ Overseas – Other (please specify below)
❍ Rural Australian school _____

Q10. Did you attend coaching for more than 30 hours in a year before you came to university (i.e. preparation for HSC)? O Yes O No

Q11. What was your university admission mark (ATAR in Australia) (if applicable)?

_____

Q12. Do either of your parents have a university degree?
O Yes, both O Yes, only my mother O Yes, only my father O No O Don't know

Q13. What are your current living arrangements?
O With parents O Alone
O With husband/wife/partner O Residential college
O Shared accommodation O Other _____

Q14. Are you a full-time or part time student? O Full time O Part time

Q15. Is this your first, second, third, fourth or more year at the university?
O (1) O (2) O (3) O (4) O More _____

Q16. How many units of study are you taking this semester?
O (1) O (2) O (3) O (4) O (5)

Q17. Will you have a job during semester? O Yes O No
If yes, please answer the following questions.
a. Do you have to work to support yourself? O Yes O No
b. Will this job be on campus? O Yes O No
c. Will you be using what you are learning or learnt at university for your work? O Yes O No
d. How many hours per week will you work (on average)? _____
e. Do you think that work will negatively impact on your learning? O Yes O No

Q18. Do you like studying? O Yes O No

Q19. Did you like studying mathematics in high school? O Yes O No

Q20. Do you consider statistics useful for your future work? O Yes O No

Q21. Do you consider enrolling in a higher degree after completing your Bachelor degree? O Yes O No

Q22. Which grade do you expect to achieve for this unit?

O HD or D O Credit O Pass O Fail

Q23. Why have you chosen to study this statistic unit?

Q24. Is there anything else that you would like to add?

_____
_____
_____
_____
_____

Q25. Please read the information provided below before you answer parts a and b.

Possible Approaches to Learning	Deep Approach	Surface Approach	Strategic Approach
What might be related to each	The intention is to extract meaning from what is learnt and relate ideas to prior learning. The course topics are linked to each other as well as linking to prior learning.	The intention is to cope with the task at hand. The course topics seems unrelated to each other. Memorise certain bits to answer questions in assessment tasks.	The intention is to achieve the highest possible grades by using organised study methods and good time-management. Monitor your study effectiveness to optimise the time to study.
a) Which learning approach would you place yourself in Statistics Unit that you are studying? (Tick One box on the right)			
b) Why do you use this approach in this Statistics unit? (Please write a few sentences)			

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