



## Peer Assisted Study Sessions (PASS) in first year chemistry and statistics courses: insights and evaluations

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### Introduction

First level Science students are faced with a bewildering array of courses at university, many of them with densely structured, modular, and multi-streamed curricula. While such curricula are designed to give students the advantage of studying a large number of topics in separate modules within the one course structure, they also have the potential to alienate rather than engage students. This is especially so if students lack the ability to interpret confusing messages concerning learning requirements. Any lack of coherence between teaching, learning and assessment may be exacerbated if there is non-alignment between student learning and progressive assessment. If students lack an overarching perspective of the critical appraisal inherent in the discipline, they may be forced to adopt a surface learning approach, especially if they have done so in the past.

Students' prior educational experiences are known to influence their current conceptions of learning (Marton and Saljo 1997). However, while students' approaches to learning can be influenced by their perceptions of the teaching and learning environments (Biggs 1999b), assessment criteria (Laurillard 1997), or motivation and anxiety levels (Fransson 1977), their learning orientations may be positively re-directed. This can be achieved if they are encouraged to become personally involved with their own learning (Beaty, Gibbs and Morgan 1997); for example, by increasing students' level of learning related activity with the coursework (Biggs 1999a).

To provide an active learning environment which can also support the alignment of learning objectives and assessment with student learning, peer assisted study sessions (PASS) have been introduced into the curricula of eleven first level courses within the Faculty of Biological and Chemical Sciences. The aim of this paper is to discuss features, or insights, that have been identified as contributing to the successful implementation of PASS in chemistry and statistics, and to evaluate the effect of PASS on student performance and subsequent recruitment into the discipline.

### Rationale: The PASS Model

The essence of PASS pedagogy, not unlike Supplemental Instruction, is designing well-organised study sessions consisting of small groups of first year students who undertake self-directed learning (Martin and Arendale 1993). These hour-long, weekly, voluntarily attended study sessions are facilitated by two, course competent second or third year undergraduate student leaders. PASS is a mainstream service: it pro-actively targets large, high-risk, first year courses rather than reactively assisting high-risk students.

The aim of these sessions is to create a collaborative learning environment where students can integrate traditional methods of teaching with learning from student centred discussions in a relaxed yet intellectually stimulating environment. Students are thus able to admit ignorance and misconceptions, and seek information, advice and remediation, without fear of jeopardising their academic outcome (Bulmer and Miller 2003).



The PASS paradigm epitomizes a social constructivist mode of education whereby small groups of students interact to explore concepts and values inherent in the discipline (Topping 1998). An important consideration is that students' knowledge constructs are mediated by interactions with more competent peers who are at a level of understanding just beyond that of the students themselves, so that learning can occur within a student's 'zone of proximal development' (Vygotsky 1978).

By learning with supportive mentors, students gain confidence in their own ability to practise within the discipline and are thus encouraged to take control of their own learning (Ramsden 1992). The rationale of the PASS learning model is that it allows leaders to align student learning with progressive assessment, as it provides the scaffold within which leaders can design student-directed study activities that target course learning objectives, for any instructional mode of learning.

## Method

First level chemistry (CHEM1012) and statistics (STAT1201) courses during 2003 were selected to evaluate the effect of PASS attendance on student performance and attrition, and also on recruitment of students into second and third year Chemistry courses. Overall, 84% of chemistry students were enrolled in a science-based degree program. Student outcomes were recorded for chemistry from 1999 to 2003 and for statistics in 2003. Student OP (Overall Position) ratings, or university entrance scores, were recorded for each student; OP1 is the highest rating, OP25 the lowest. For science students, the lowest rating is OP8, for applied science students, the lowest rating is OP16.

### Quantitative evaluation

PASS leaders recorded the attendance of students in weekly attendance rolls and numbers were checked and verified against figures collected by supervising coordinators. Individual student attendances were entered into student academic profiles on a database that contained OP (overall position) ratings, all progressive assessment marks and final course grades.

### Qualitative evaluation

The Chemistry department commissioned a survey from the Tertiary Education Development Institute, of students who were enrolled in the second level chemistry course CHEM2041 in 2002. Students participating in the survey were given written questionnaires preceded by interviews in smaller focus groups, regarding the origin of their current views of proceeding with chemistry (Smith and Bath 2002). Of interest was the perceived impact of PASS on students' future study and work intentions, and their perceptions of chemistry; in particular whether attending PASS had any effect on changing their intentions to continue studying chemistry after first year.

### Teaching and learning modes and assessment

For CHEM1012, there are three streams of 36 lectures supported by ten PASS sessions each semester. Assessment comprises a final MCQ exam (60%), five laboratory practicals (20%), and four progressive computer generated tests (CMTs) (20%). Each CMT is a set of twelve questions randomly and uniquely generated from a lecturer devised testbank comprising mostly MCQs, but also a limited number of short, numerical answer questions. Approximately 5,000 tests are generated and marked by the system each semester. Students are notified of the release and return dates for each test and can download and work on each set for up to one week, with the help of peers and any resource material provided in PASS.

For STAT1201, there are two streams of 36 lectures and ten practicals supported by ten PASS sessions each semester. Assessment comprises a computer based final exam (44%), a library skills based journal article review (10%), a project (individual or group) presented as a journal article (25%), a laboratory book (practical problem solving) (10%), a computer based mid-semester test (10%), and a statistically relevant photograph, or poem, or art competition (1%).



## Results and evaluation

### Quantitative: Chemistry course

Table 1 is a profile of Chemistry 1A (CH112/CHEM1012) student numbers, attrition rates and student performance in first semester from 1999 to 2003. Although enrolment numbers are commonly >1 000, attrition rates due to student drop-out have remained relatively constant, from 3.1% to 4.3%. The primary concern in 1999-2000 was a relatively high failure/pass conceded (grades 1-3) rate of 15-16%, with concurrent low student retention rates. Consequently, a pilot PASS program began in 2001 with groups meeting only every second week; since then, session frequency has increased to weekly, in alignment with other PASS programs.

Since 2000, there has generally been a fall in the number of students with grades 1-3, viz. a 10.1% drop between 1999 and 2003. Concurrently, there has been an increase in the number of students attaining grades 4 and 5 in 2001 (7%-8%) and grades 6 and 7 in 2002 and 2003 (8%-11%). From 1999 to 2003, the Grade Point Average (GPA) has increased from 4.34 to 4.91, and mean CMT and MCQ results have increased by an average of 8.4% and 3.8%, respectively.

Table 1. CHEM112/1012 student enrolment, assessment and performance

Category	1999	2000	2001 #	2002	2003
No. enrolled	1279	1066	1040	1118	1131
% Attrition	4.3*	3.1*	3.9	3.7	3.8
% grades 1-3	15.2*	16.0*	6.7	11.4	5.1
% grades 4-5	61.8*	62.7*	70.5	62.5	62.0
% grades 6-7	18.7*	18.2*	18.8	22.4	29.1
GPA	4.34	4.34	4.63	4.61	4.91
% Practical	92.3	93.7	88.8	91.9	92.0
% CMT	71.6	72.4	76.0	75.5	80.0
% MCQ	52.1	50.4	50.2	52.1	55.9
% Total	63.9*	63.5*	63.1	64.8	67.9

\* amended to align with 2001-2003 marking scheme # pilot PASS program

Table 2 presents evidence relating to the effect on student performance for students attending PASS. Data were generated from the 2003 CHEM1012 student cohort who had completed assessment (1089 students). Students were divided into four groups: those that had never attended PASS (0 PASS), those who had attended only intermittently (1-4 PASS), those who had attended regularly (5+ PASS), and all students who had completed assessment (all students).

Table 2. Effect of PASS attendance on student performance: CHEM1012, 2003

Category	% Mean result for each category			
	All students	0 PASS	1-4 PASS	5+ PASS
Practical	92.0	90.6	92.3	93.2
CMT	80.0	74.3	76.8	83.9
MCQ	55.9	50.2	50.3	61
Total	67.9	63.1	64.1	71.8
Grade	4.91	4.51	4.57	5.29
OP	4.5*	5.3*	5.0*	3.9*

\*OP range for all students was 1 to 16

There is strong evidence that students who regularly attended PASS demonstrated improved performance, not due to higher OP students self-selecting to attend PASS, as there is very little difference between the mean OP of students in each category. While the class averages in Table 1 showed overall elevated student performance after the introduction of the PASS program in 2001, the progressive (CMT) and final (MCQ) assessment results in Table 2 each showed an average rise in both CMTs (9.6%) and final exam MCQs (10.8%) results for the regular (5+ PASS) participants.

Multiple comparisons (using Tukey corrections at the 95% level) between mean grades for students attending 0, 1-4, or 5+ PASS sessions showed significant differences between the 5+ and 0 groups (+0.61 to +0.95 grade points) and the 5+ and 1-4 groups (+0.51 to +0.92 grade points), but no significant difference between the mean grades of students attending 0 sessions and 1-4 sessions.

Recruitment of students into second and third year Chemistry courses between 2000 and 2003 is shown in Table 3. There is a sustained increase in enrolment numbers of second year students since 2002, and of third year students since 2003, respectively. While there may be numerous factors that have contributed to this increase, there does not appear to be any change in the numbers of first level students during this period. Factors influencing students' decisions to continue with Chemistry in second and subsequent years of their degree program are therefore more likely to be ones that they were confronted with during their first year at University.

Table 3. Recruitment of Science students in 2<sup>nd</sup> and 3<sup>rd</sup> level Chemistry courses, 1999 - 2004

Chemistry level	No. students in 1 <sup>st</sup> , 2 <sup>nd</sup> and 3 <sup>rd</sup> level Chemistry courses											
	1999		2000		2001		2002		2003		2004	
1 <sup>st</sup> /Semester	1279	1029	1165	874	1126	973	1125	1073	1228	1106	1160	1074
1 <sup>st</sup> /Year	2308		2039		2099		2353		2334		2234	
2 <sup>nd</sup> /Semester			110	95	87	106	148*	177*	173*	178*	200*	148?*
2 <sup>nd</sup> /Year			205		193		325*		351*		358?*	
3 <sup>rd</sup> /Semester					109	108	138	86	122*	145*	161*	158?*
3 <sup>rd</sup> /Year					217		214		267*		319?*	

\*2<sup>nd</sup> and 3<sup>rd</sup> level students who were offered PASS in 1<sup>st</sup> level Chemistry

### Qualitative: Chemistry course

Students were categorised from two principal groupings based on their intention or non-intention to proceed with chemistry prior to commencing first year chemistry. More students in the non-intending group attended PASS sessions (93% vs. 72%) than the intending group. This 'non-intending' cohort felt that PASS was a more worthwhile part of their first year course (88% vs. 65%) than the 'intending' cohort. In terms of impact on future intentions, significantly more students in the non-intending group who now intended to complete a whole degree focussed on chemistry (C), rather than study chemistry only to second year (NC) (40% vs. 14%), had attended PASS.

The (C) student cohort also reported that PASS had a greater positive impact on their intention to continue studying chemistry in second year than the (NC) cohort (60% vs. 40%), intention to become a professional working in the field of chemistry (40% vs. 7%), ability to imagine themselves as chemists in the future (44% vs. 8%) and ability to imagine themselves as advanced undergraduate students in chemistry (60% vs. 40%). Specifically, students felt that PASS had a great positive impact on their belief that working as a chemist could be intellectually stimulating, on their ability to succeed in chemistry, on their sense of belonging as a chemistry student, and on the quality of their learning and understanding of chemistry.

### Quantitative: Statistics Course

Results for the statistics course (STAT1201) were similar to the outcomes in Chemistry. Figure 1 shows an effects plot that gives the mean grade of students in Semester 2, 2003 against how many PASS sessions they attended and what their university entrance (OP) score had been. An OP score of 1 is the highest and it would be expected that these students might perform better than those with a larger OP score. For each level of PASS attendance, the mean grade increases steadily with OP score. Multiple linear regression was used to assess the joint relationship between grades and both the OP and the number of PASS sessions attended. While the modelled relationship was not very strong (R-squared + 0.21), there was significant evidence that mean grade is related to both OP ( $p < .003$ ) and PASS attendance ( $p < .016$ ). For example, students in the lowest OP group (8+) who



attended PASS 10 or more times had a mean grade of 4.75, higher than that of OP 1-3 students who didn't attend any PASS, who had a mean of 4.36.

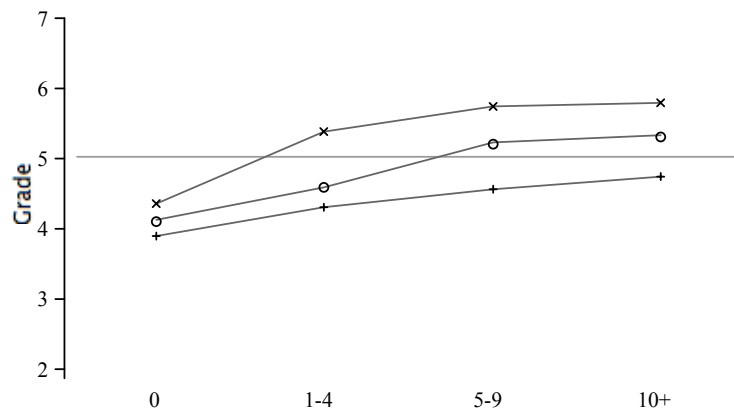


Figure 1. Mean grades for students by PASS attendance for OP 1-3 (+), OP 4-7 (\*), and OP 8+ (o)

The lines in Figure 1 are roughly parallel, and a multiple regression for grade using OP score and PASS attendance shows no evidence of interaction between OP and PASS attendance on mean grade ( $p = .819$ ), as suggested by Figure 1. It appears therefore that increase in mean grade is related to PASS attendance in a similar way regardless of student OP score which concurs with related findings by Biggs (1999b, p4). As STAT1201 is a service course for first year Biology and Chemistry based degree programs, retention of students in second year statistics courses did not apply in this instance.

## Insights: creating a productive learning environment

### Leaders

PASS leaders play a pivotal role in the success of PASS. They are responsible for creating a productive learning environment for their students that is both learning centred and student directed, and is thus structured to meet the diverse learning needs and styles of students. By sharing similar career interests with students, they can communicate their appreciation for the extent to which the discipline is of use to them. Explicit instruction to leaders concerning the scope of their facilitative role is therefore of paramount importance.

Selection of leaders is based on their previous academic performance in the course as well as for their enthusiasm and communication skills. They attend a workshop during which they practise their role as facilitators of learning in the context of social constructivism. They are also made aware of principles of active learning, modes of facilitation, and strategies to foster communication. Leaders re-attend at least one first level lecture every week, and are encouraged to use this time to both consolidate existing knowledge and plan an activity for their next session, based on aligning key concepts from the lecture material with learning objectives. While leaders are academically competent in the coursework, their own cultural and disciplinary backgrounds allow them to create study activities flavoured with their own cultural and interdisciplinary overtones, enriching the learning context with personal examples of authenticity.

### Study Activities

While the principles of action learning are applied to PASS, the cornerstone of every session is the leader-generated study activity. These instructional activities are designed to formatively test students' understanding and to keep it aligned with progressive summative assessment. Current leaders have access to activities generated by previous leaders that facilitate not only knowledge recall and recognition but also association and deduction. These activities are made available to academic staff so that they can monitor their students' learning progress and rectify problem areas.



## Alignment of teaching, learning and assessment

One of the strengths of the chemistry and statistics curricula is their learning-centred approach to teaching which encourages students to explore both the application of their course work in authentic and personally meaningful situations. In this respect, PASS provides a venue where students can practice problem solving activities from their CMTs and laboratory books, as well as critique journal articles and plan projects in collaboration with their peers. For example, students are encouraged to research personally relevant statistically based topics and thus become aware of the benefits of statistical analysis in scientific investigation. PASS can enhance student learning regardless of the instructional mode or the learning context: sessions can operate in the library, the computer-based interactive learning centre or the seminar room. Through active and authentic learning, students develop a sense of ownership with the course while they engage more deeply with the discipline.

## Conclusion

Incorporating active learning into first level chemistry and statistics courses has helped to improve student performance by promoting an inquiring, analytical and creative approach to student learning. The development of students' cognitive and affective skills is thus enhanced in a peer assisted learning environment where students feel free to exercise independent judgement and practise the skills of the discipline within a collaborative learning framework. PASS participants report heightened quality of learning and understanding of the coursework, ability to succeed and proceed within the discipline, and a greater sense of belonging within a community of learners.

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