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Do Students Benefit From Supplemental Education? Evidence From a First-Year Statistics Subject in Economics and Business

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Evidence from a First Year Statistics Subject in Economics and Business[a]

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Abstract

Peer assisted study sessions (PASS) are a type of supplemental instruction (SI) that provide students with out-of-class study review sessions with a group of peers. A student, who has successfully completed the subject and acts as a mentor, facilitates the voluntary sessions.

Results of the PASS program at the University of Wollongong have been quite positive in that students, on average, who attend more PASS, achieve higher marks. However, a simple comparison does not control for self-selection bias.
We control for self-selection in two ways. Firstly, we use Heckman's two-stage correction technique to analyze the 2002 cohort. Secondly, students in the 2003 cohort were randomly allocated into three groups of equal size:

a. A control group that was allocated to normal tutorials with standard class sizes and ineligible to attend PASS
b. A group that was eligible to attend PASS and had normal tutorials of standard sizes
c. A group that was ineligible to attend PASS but allocated to normal tutorials with smaller class sizes.

The results of both methods are consistent and indicate the PASS program has a positive impact on the academic performance of students after correcting for selection bias.

JEL Codes: A2;C9
Key words: Economics Education; Teaching of Economics; Design of Experiments

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INTRODUCTION

Peer assisted study sessions (PASS) are a type of supplemental instruction (SI) that provide students with out-of-class study review sessions with a group of peers. A student, who has successfully completed the subject and acts as a mentor or Peer Leader, facilitates the voluntary sessions.

The PASS program has been implemented in six Faculties of the University of Wollongong since 2002. The results have been quite positive in that students who attend more PASS achieve higher marks and lower failure rates. Previous research, however, has been unable to adequately control for selection bias; that is, better or more able students may be more likely to attend PASS. Consequently, attendance may identify good students but not enhance performance. On the other hand, weaker students may attend more PASS in which case the benefits of the PASS program will be underestimated. In addition, even if the PASS program improves student performance, it may be the case that resources could be allocated even more productively, for example by reducing tutorial class sizes.

In this research, controlling for self-selection in first year statistics is done in two ways. Firstly, we use Heckman's two-stage correction technique (Heckman, 1979) to analyze the 2002 cohort. Secondly, students in the 2003 cohort were randomly allocated into three groups of equal size: (a) a control group, (b) a group eligible to attend PASS tutorials in additional to normal tutorials, and (c) a group ineligible to attend PASS but allocated to tutorials with smaller class sizes.

SUPPLEMENTAL INSTRUCTION AND THE PASS PROGRAM

The University of Wollongong (UOW) has utilized different forms of mentoring programs for many years with the objectives of assisting students in their transition to tertiary study and improving retention from first year to second year. In addition to retention issues, several faculties had expressed concern to Student Services about pass rates in some core first year subjects. Many students find that commencing university study can be like living in a foreign country for the first time. In order to survive you need to understand the language and culture of the discipline you are studying.

SI programs, from which PASS is derived, are frequently credited for improving pass rates as well as retention rates (see, for example, Bidgood, 1994; Blanc et. al., 1983; Loviscek and Cloutier, 1997 and McCarthy et.al., 1997).

UOW implemented a peer learning model in 2002 which was appropriate to the Australian higher education context. This was designed with the goals of:

- decreasing the failure rates of first and second year students in core subjects;
- improving retention rates of first and second year students;
- assisting with the transition of students to University life; and
- enhancing, recognizing and promoting the diversity of student learning styles.

The program was closely integrated with specific subjects of concern in a faculty rather than located in an external learning centre. It was considered important that students identified the program as an integral part of the faculty and subject they were studying.

What is PASS?

The PASS Programs augment subjects that have a historically high failure rate and/or are perceived by the student body as being difficult. Many of these subjects are core first year subjects which students encounter in the first and second semester of their transition to university life. Quite often, these core subjects bear little relation to the major the student has chosen, but are considered necessary for a solid grounding in that discipline. The program is non-remedial and open to all students enrolled in the nominated subject. Sessions are led by high achieving senior students called Peer Leaders, who are recruited on the basis of their academic record and their excellent interpersonal skills. Selected Peer Leaders also undertake a very intensive, subject specific two day training course.

In simple terms, PASS is an environment where students are presented with questions or examples related to course material and encouraged to collaborate with each other to form a solution. The leader actively participates in the group's pursuit of a solution by managing group dynamics, posing relevant questions to prompt further thought and guiding the group toward the correct answer. It is an open forum where advanced students are able to extend themselves and struggling students are able to gain a solid grounding in basic concepts and learn from their more advanced peers.

In PASS, the leaders are not there to re-teach, but to facilitate group learning and help the new students learn how to learn, a key graduate attribute as identified in UOW's mission statement. Leaders can assist their groups in looking at subject content and concepts, but they cannot look at any assessable tasks or give any assistance with them. As the students are told at the beginning of the program that the leaders are not involved with marking their

work, it creates an open climate whereby students feel free to ask any questions without concerns of prejudicing the marker.

In addition to decreasing failure rates for participants, surveys have revealed that regular attendance at PASS also promotes improved communication and public speaking skills, better problem-solving and analytical skills and improved ability to work as part of a group, all of which are designated by UOW as key graduate attributes. Participants in PASS also reported that they felt increased confidence in dealing with the subject, enjoyed the subject more and felt more comfortable in moving into tertiary study.

Students are encouraged to attend all 12 weekly PASS, each lasting 50 minutes. The apparent impact of voluntary attendance at PASS is quite dramatic as shown in Table 1. Increasing attendance at PASS is positively associated with higher average marks and lower failure rates. Amongst those who never attended PASS, the failure rate was 18.38 per cent; this is in sharp contrast to the 1.41 per cent failure rate amongst those who attended 10 or more PASS. However, the results in Table 1 do not control for self-selection. Students were free to attend as many PASS as they wanted. Those who never attended PASS had an average mark in the subject of 57 while those who attended 10 or more PASS had an average mark of 74. Although higher marks are associated with more frequent attendance, attendance, *per se*, may not cause better performance. Attendance patterns may simply identify high achieving students. However, if weaker students are more likely to attend PASS, the benefits of the PASS program will be underestimated unless corrected for self-selection.

[insert Table 1 here]

CONTROLLING FOR SELF-SELECTION

Heckman's Technique

Firstly, we use Heckman's two-stage correction technique to analyze the 2002 cohort. This technique is commonly used in economic analysis but its use in evaluating SI is uncommon. One exception is the study by Loviscek and Cloutier, 1997. They evaluated the impact of supplemental instruction in economics principles. "Three fifty-minute sessions were scheduled each week in which the primary task was to help students develop reasoning skills, rather than present a simple review of the lecture material" (Loviscek and Cloutier, 1997, p. 70). They found that attendance at SI improved performance. In addition, students who attended the optional SI sessions tended to be the weaker students, so the positive contribution of SI was increased significantly after correcting for self-selection using the Heckman technique. Their analysis was limited by a small sample, 81 students in total of whom only 14 participated in the SI program. In contrast, the sample size for the following econometric analysis of 2002 PASS participation and performance was 442 students of whom 324 attended one or more PASS.

The first stage of estimation using Heckman's technique is a Probit model used to explain PASS participation based upon certain student characteristics. The second stage is an OLS model that has marks received in ECON121 as the dependent variable. Included in this second equation is both the dichotomous PASS attendance variable (that is, the dependent variable in the first equation) as well as the inverse mills ratio variable (@MILLS), calculated as a by-product of the Probit model. This latter variable controls for self-selection. A negative coefficient for the @MILLS variable indicates that there is a self-selection bias that tends to underestimate the impact of the PASS program, meaning that on average,

weaker students tended to participate in PASS. A positive coefficient means that the impact of the PASS program is overstated, indicating that stronger students had a greater tendency to attend PASS. Variable definitions are reported in Table 2. Explanatory variables cover characteristics such as the student's gender, nationality, major area of study, as well as academic ability. Descriptive statistics relating to these variables are contained in Table 3.

[insert Table 2 and Table 3 here]

Probit model estimates are displayed in Table 4. Results for 4 different models are presented. First, the dependent variable, PASS attendance, is defined as a student attending at least 1 class in equations 1 and 2, and as attending at least 5 classes in equations 3 and 4. Second, all explanatory variables are included in equations 1 and 3, with a more parsimonious specification presented in equations 2 and 4. Estimation results from these equations appear to be quite robust, displaying consistent coefficient signs across specifications and offering a relatively high degree of explanatory power as evidenced by likelihood ratio tests and percentage of correct predictions. At this stage of the analysis there is some ambiguity in these equations as to whether there was a greater prevalence for academically stronger or weaker students to attend PASS. That is, results indicated that students with a higher GPA were more likely to attend, as were females and students from a low socioeconomic background.

[insert Table 4 here]

Results of the OLS model for ECON121 marks are presented in Tables 5 and 6. Equations are presented for PASS (1) and PASS (5) as well as for unadjusted and adjusted for self-selection. Again, results across the various specifications appear to be quite robust. There are two main features apparent in these equations. First, the coefficient for the variable controlling for self-selection @MILLS is negative. Second, the higher magnitude of the coefficient for PASS attendance in equations controlling for self-selection compared to the unadjusted equations. These results indicate that a self-selection bias is apparent, and consistent with Loviscek and Cloutier's findings, it is a bias that tends to understate the impact of the PASS program. The unadjusted equations suggest that PASS attendance increases marks by between two and a half to three marks. However, after adjusting for self-selection the effect of PASS attendance is to increase a student's results by approximately twenty marks. This indicates that without adjusting for self-selection, the prevalence of students of lower ability attending PASS make the program appear much less effective.

[insert Tables 5 and 6 here]

The coefficients of the other variables in Tables 5 and 6 are significant, robust and have the anticipated sign. Students who do well in other subjects tend to do better in ECON121 as do overseas students. On the other hand, the average result for female students is about two marks below that of males, other things being equal. This is consistent with other studies that have found that, although females do better in business and economic subjects generally, they are not as strong in statistics. Overseas students tend to perform better in quantitative subjects even though they are slightly below domestic students in other subjects.

Random Trial

Because the Heckman technique has been criticized on theoretical and practical grounds, we also conducted a randomized control trial to test the robustness of the results using the Heckman technique. Students in the 2003 cohort were randomly allocated into three groups of equal size: (a) a control group, (b) a group eligible to attend PASS tutorials in additional to normal tutorials, and (c) a group ineligible to attend PASS, but allocated to tutorials with smaller class sizes. Group (c) was created to test the hypothesis that resources spent on PASS may be more effectually allocated to reductions in tutorial class sizes.

Based on previous enrollments, it was estimated that 480 students would need to be allocated to tutorials for Spring 2003 session. Hence, given the need to create three equal-sized groups, this implied a maximum of 160 students in each group. Traditionally, tutorials in this course have contained approximately 20 students, so it was decided to create eight "traditional" and eight PASS-eligible tutorials, each limited to a maximum of 20 students.

The cost per student of running tutorials with approximately 20 students was estimated to be $32.06 as shown in Table 7. This estimate was based on all labour costs (preparation, face-to-face teaching, marking and on-costs). It does not include an estimate of any capital costs. The additional cost of running PASS sessions (training sessions, lecture attendance and face-to-face interaction) was estimated to be $17.60 per eligible student. This was based on attendance at PASS in 2002. Consequently, the total cost of tutorials and PASS sessions for PASS eligible students was estimated to be $49.66. A similar cost per student was achieved by reducing the average tutorial size for the third group in the study. It was estimated that by reducing the average size of tutorials from 20 to 12 the cost per student would be $50.63.

[insert Table 7 here]

As can be seen in Table 7, the actual cost per student was higher than planned for all three groups. This resulted from the fact that the number of students allocated to each group was less than planned. By the end of the session there were 418 students enrolled with the resulting average tutorial sizes ranging from 10.5 to 18.3 students. Because there were fewer students attending PASS than expected the number of tutorials was reduced from six to four. The actual number of students who attended PASS, on average, was only 5.6.

Students who made no attempt on any of the assessment tasks and who did not withdraw from the subject received a mark of zero and were removed from subsequent analysis. This left a total of 406 students that are included in subsequent analysis. Summary statistics presented in Table 8 reveal some surprising findings. The control group had the highest average (63.22), while the PASS eligible students had the lowest average (62.03). However, these differences are quite small.

[insert Table 8 here]

The coefficients of variation in Table 8 indicate there is a fair amount of relative dispersion of the marks within the 3 groups. The relative frequency distribution of grades awarded in Table 9 gives us a better sense of this dispersion, with the control group having relatively more Fails (0-44) while the Small tutorial group had relatively more Pass Conceededs (45-49). However, overall there were not substantial differences in the distribution of grades among the three groups.

[insert Table 9 here]

Average PASS attendance was very low in 2003 (1.91 per PASS eligible student) compared to 2002 (4.39 for all students), which may affect the findings. Table 10 shows that only 51 of the 129 students attended at least one session (less than 40%) and only 24 students attended 5 or more times. Attempts by the lecturer, tutors and PASS representatives to encourage attendance had little impact.

[insert Table 10 here]

Table 10 displays the average marks for those with nil attendance, positive attendance, as well as those within certain sub-sets of positive attendance. It is clear that average marks increase with attendance at PASS. For example, those attending 5-9 sessions had an average that was 6.38 marks above those who never attended a session. However, in a pattern similar to the 2002 cohort, this result may be clouded by the self-selection issue.

The initial PASS program attached to Econ 121 in Spring Session, 2002 had an excellent attendance record for a non-compulsory program, with some 70% of the enrolled cohort participating. Unfortunately, this attendance pattern was not achieved in the 2003 trial, primarily due to two reasons. Firstly, the enrolment process for PASS which is normally carried out simultaneously with all other enrolments in subject tutorials etc was delayed by some two weeks due to the structure of the trial. This meant that students were required to go "back to the system" so to speak after already settling their timetables. Also, in a flow-on effect due to the low take–up, only 4 PASS sessions were offered each week as opposed to

16 per week in 2002. This meant that students had less chance of finding a PASS session that suited their existing timetables.

Therefore, the low participation in PASS in 2003 was partly due to the design of trial. We carried out a hypothetical exercise by calculating the expected average mark for PASS eligible students assuming they had a pattern of attendance similar to the previous year. We used the means across attendance categories in 2003 and weighted these by the attendance pattern from 2002. The results are shown in Table 11.

[insert Table 11 here]

If students in each attendance cluster performed as they did in 2003 and had the PASS attendance patterns of 2002 prevailed, the 2003 PASS cohort would have achieved an average mark of 64.77. This is higher than their actual average mark of 62.03 and higher than either the control group (63.22) or the group attending small tutorials (63.01).

The results of the random trial suggest that there was little difference in the three groups. Neither smaller tutorial groups nor eligibility to attend PASS improved average marks. This conclusion is sensitive to likelihood that the trial design unintentionally discouraged students who were eligible from attending PASS. When compensation for this effect was introduced the PASS eligible students marginally outperformed the other two groups.

CONCLUSIONS

Results from the 2002 data indicated that there was a self-selection bias that tended to underestimate the effectiveness of the PASS program. That is, the prevalence of weaker students in the program tended to make the program appear less effective. After adjusting for the self-selection bias, PASS students could expect approximately twenty additional marks compared to non-attendees. The random trial conducted in 2003 showed there was a positive influence of PASS attendance but the magnitude was much smaller. After an adjustment of final marks for the PASS eligible group to account for the abnormally low PASS attendance, an average advantage of less than 2 marks was estimated. Reasons for the difference between 2002 and 2003 are not clear. It may have resulted from the fact that different adjustments for self-selection were made for the two groups; the Heckman correction technique was used for the first cohort and a random allocation of students was implemented for the second cohort. The Heckman technique may have overcompensated for self-selection although there is no theoretical reason for this to occur. In our view it is more likely that the process of randomly selecting students into the three groups changed the enrolment patterns into PASS and limited the impact of the additional tuition.

In 2002, and to a lesser extent in 2003, the findings indicate that PASS participation does benefit students in terms of marks achieved. This result is consistent with anecdotal evidence, overseas studies and some results obtained in other faculties at UOW. As noted earlier, the PASS program may also aid in promoting and enhancing other desirable graduate attributes and ease the transition of students to tertiary study. However, some revisions in the program, such as specifically targeting students at risk, may result in more cost effective outcomes.

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TABLE 1. Average Final Marks in ECON121 by PASS Sessions Attended (2002)

Number of PASS Tutorials	Number of Students	Average Total Mark (%)	Failure Rate (%)
0	136	56.97	18.38
1-4	116	62.58	10.34
5-9	144	67.81	5.56
10+	71	74.04	1.41
Total	467	64.30	9.85

TABLE 2. Variable Definitions

MARK	=	Mark/100 in ECON121 Spring 2002
PASS (1)	=	1 if student attended at least 1 PASS session, 0 otherwise
PASS (5)	=	1 if student attended at least 5 PASS sessions, 0 otherwise
GPA (S)	=	weighted average of marks in other subjects studied in Spring 2002
GPA (A)	=	weighted average of marks in subjects studied in Autumn 2002
COMM	=	1 if student is enrolled in Bachelor of Commerce degree, 0 otherwise
FEMALE	=	1 if student is female, 0 otherwise
OSEAS	=	1 if overseas student, 0 otherwise
NESB	=	1 if student from a non-English speaking background, 0 otherwise
SES	=	1 if student from lower socio-economic group, 0 otherwise
DISABLE	=	1 if student is disabled, 0 otherwise
@MILLS	=	inverse Mills ratio function of the probit residuals

TABLE 3. Descriptive Statistics

Variable	Mean	Standard Deviation
MARK	65.733	14.927
PASS (1)	0.733	0.443
PASS (5)	0.480	0.500
GPA (S)	62.589	11.244
GPA (A)	63.057	10.760
COMM	0.715	0.452
FEMALE	0.483	0.500
OSEAS	0.059	0.235
NESB	0.192	0.394
SES	0.307	0.462
DISABLE	0.083	0.276

TABLE 4. Probit Models of PASS Attendance

	PASS (1)		PASS (5)	
Equation	1	2	3	4
Constant	-0.780	-0.570	-1.661	-1.355
	(-1.708)[c]	(-1.363)	(-3.728)[a]	(-3.320)[a]
COMM	0.421	0.416	0.425	0.424
	(2.770)[a]	(2.754)[a]	(2.870)[a]	(2.882)[a]
GPA (A)	0.015	0.014	0.019	0.016
	(2.235)[b]	(2.105)[b]	(2.898)[a]	(2.498)[a]
SES	0.241	0.202	0.132	0.069
	(1.458)	(1.289)	(0.885)	(0.486)
Female	0.178	-	0.075	
	(1.253)	-	(0.565)	
NESB	-0.102	-	-0.054	
	(-0.539)	-	(-0.306)	
DISABLE	0.128	-	0.018	
	(0.482)	-	(0.077)	
OSEAS	0.372	-	0.689	
	(1.123)	-	(2.217)[b]	
Fraction of Correct Predictions	0.739	0.725	0.595	0.584
Likelihood ratio	18.148[b]	14.604[a]	21.851[a]	16.075[a]

Dependant variables are PASS(1) [Equations 1-2] and PASS(5) [Equations 3-4]
t-statistics in parenthesis
[a,b,c,] indicate significance at the 0.01, 0.05, and 0.10 levels, respectively.

TABLE 5. OLS Models for Marks using PASS (1)

BASIS	Unadjusted	Adjusted Probit Equation 1	Adjusted Probit Equation 2
Equation	1	2	3
Constant	9.336	1.059	-0.462
	(2.760)[a]	(0.225)	(-0.093)
PASS (1)	2.585	18.975	19.992
	(1.990)[b]	(3.097)[a]	(3.169)[a]
GPA (S)	0.878	0.827	0.830
	(17.052)[a]	(13.335)[a]	(13.472)[a]
OSEAS	9.772	8.789	10.709
	(3.992)[a]	(4.935)[a]	(5.932)[a]
FEMALE	-2.157	-3.103	-2.145
	(1.886)[b]	(2.696)[a]	(-1.874)[c]
@Mills	-	-10.071	-10.670
	-	(-2.700)[a]	(-2.767)[a]
$\bar{R}^2$	0.453	0.461	0.461
F	78.367[a]	65.058[a]	64.979[a]

Dependant variables is MARK
t-statistics in parenthesis
[a,b,c,] indicate significance at the 0.01, 0.05, and 0.10 levels, respectively.

TABLE 6. OLS Models for MARKS using PASS (5)

BASIS	Unadjusted	Adjusted Probit Equation 3	Adjusted Probit Equation 4
Equation	1	2	3
Constant	10.488	7.091	6.114
	(3.156)[a]	(1.880)[c]	(1.558)
PASS (5)	3.005	22.434	20.415
	(2.598)[a]	(3.904)[a]	(3.358)[a]
GPA (S)	0.867	0.779	0.802
	(16.759)[a]	(11.760)[a]	(12.275)[a]
OSEAS	9.311	5.558	10.222
	(3.801)[a]	(2.829)[a]	(5.645)[a]
FEMALE	-2.084	-2.557	-1.987
	(-1.832)[c]	(-2.318)[a]	(-1.755)[c]
@Mills	-	-12.457	-11.164
	-	(-3.437)[a]	(02.904)[a]
$\bar{R}^2$	0.457	0.473	0.467
F	79.642[a]	68.159[a]	66.661[a]

Dependant variables is MARK
t-statistics in parenthesis
[a,b,c,] indicate significance at the 0.01, 0.05, and 0.10 levels, respectively.

TABLE 7. Distribution of Students by Type of Tutorial Group, 2003

Type of Tutorial Group	Number of students	Mean Number Per tutorial	Cost Per Student ($) Planned	Actual
Control (traditional)	146	18.3	32.06	35.14
PASS Eligible	134	16.8	49.66	53.66
Small Tutorial	138	10.5	50.63	58.70

TABLE 8. Summary Statistics of Final Marks by Type of Tutorial Group, 2003

Type of Tutorial Group	Number completing	Mean Mark	Standard Deviation	Coefficient of Variation
Control (traditional)	139	63.22	13.87	21.95
PASS Eligible	129	62.03	17.20	27.73
Small Tutorial	138	63.01	17.19	27.28
Total	406	62.77	16.11	25.66

TABLE 9. Relative Frequency Distribution (%) of Grades by Type of Tutorial Group, 2003

Group	High Distinction (85+)	Distinction (75-84)	Credit (65-74)	Pass (50-64)	Pass Conceded (45-49)	Fail (0-44)
Control (traditional)	8.53	13.95	23.26	37.98	3.10	13.18
PASS Eligible	9.42	13.04	29.71	33.33	4.35	10.14
Small Tutorial	4.32	15.11	29.50	33.81	11.51	5.76
Total	7.39	14.04	27.59	34.98	6.40	9.61

TABLE 10. Summary Statistics by PASS Attendance in 2003

Pass Sessions Attended	Number of Students	Percent of Students	Mean Mark	Standard Deviation	Coefficient of Variation
0	78	60.47	60.06	18.93	31.52
1-4	27	20.93	61.85	15.45	24.98
5-9	18	13.95	66.44	11.60	17.46
10-11	6	4.65	75.17	4.62	6.15
All Students	129	100.00	62.03	17.20	27.73

TABLE 11. Reconstruction of Average Mark of PASS Eligible Students in 2003 Based on Pattern of Attendance in 2002

Pass Sessions Attended	Number of Students (2002 pattern)	Mean Mark in 2003
0	37.6	60.06
1-4	32.0	61.85
5-9	39.8	66.44
10-11	19.6	75.17
All Students	129	64.77 (weighted)