

**Grade Analyses: 02-03 Tutorial Program
Calculus Final Exams: A & B-term
AY 2002-2003 Davis Project
Report prepared by Martha J. Henry
3/4/03**

Statistically significant differences related to academic performance for students who were involved in the innovative “Project-based Learning Community (PLC)” for 2002-03 and their respective controls were found for MA 1022, the B-term Calculus II course, with respect to the basic skills components of the final exam. Significant statistical differences were not detected for MA 1021, the A-term Calculus I course, for either the final exam score or the basic skills component. When comparisons were conducted between the two experimental PLC sections, significant differences were found for the final exam scores in calculus II for B-term (MA 1022) but not for the basic skills components.

ABSTRACT

Academic performance for the first year Calculus courses in A-term (MA 1021) and B-term (MA 1022) were analyzed for the 02-03 Project-Based Learning Community (PLC) students and the PLC control students in the 02-03 academic year. The Project-Based Learning Community (formally known as the Tutorial program) is an innovative first year program, funded by a Davis Foundation grant, with a multidisciplinary approach to learning math, physics, and humanities. In AY 02-03 there were two separate sections of students who experienced the PLC innovation. Grade data included overall final exam scores as well as components of the exams that tested students' basic skills knowledge regarding calculus.

t-test analyses yielded significant differences between the experimental and the control students for basic skills component scores in MA 1022 only with the differences significantly favoring the PLC group. Analyses were also conducted to determine if there were any significant differences between the two PLC experimental sections. *t*-test analyses yielded significant differences between the two PLC sections such that PLC section 1, consisting of students who volunteered for the innovation, out performed the PLC section 2, consisting of students who were solicited to enroll in the innovation, with respect to MA 1022 final exam grades.

INTRODUCTION

Comparisons were made of academic performance for the 02-03 Project-Based Learning Community (PLC) experimental students and control students in Calculus I and II final exam grades. In addition to overall exam scores, sections of the exam identified to test students' basic skills in calculus were analyzed to determine whether the PLC students, due to the outcome-goals based program, would be disadvantaged with respect to these skills. Statistical comparisons were conducted to determine whether there were any significant differences related to Calculus (I & II) performance between the two PLC sections.

02-03 Project-Based Learning Community Program Description¹

General features of PLC

The Project-Based Learning Community is a program offered to first-year WPI students that blends Physics, Math, and Humanities together in a unified learning experience constructed around group projects, outcomes measures, and internet resources and technologies (principally Maple and PowerPoint). This option is offered to students as a way to master fundamental knowledge and simultaneously begin the group project approach to learning that is distinctive to degree requirements at WPI.

For consideration for membership in the PLC, students are required to enroll in the following PLC-instructor-led courses for both A- and B-terms: introductory Math, introductory Physics, and Humanities.

For the Humanities portion of the course, students work in groups on 6 different projects that are designed, whenever possible, to incorporate ideas and concepts from Math and Physics. For each project, students produce a written report and an oral presentation utilizing PowerPoint.

PLC class meetings are characterized by discussions between faculty and students as a free exchange of ideas. Students are encouraged to consult with one another on assignments. Calculus quizzes are designed around outcomes goals, and students are permitted to re-take failed Calculus quizzes and Physics exams. Physics and Calculus homework is not collected.

Aside from Physics lecture, PLC students from each section attend all conferences and class meetings in a private room to which students have access 24 hours per day, 7 days per week.

Special characteristics and issues of the 2002 - 2003 PLC offering

For the offering in the 2002-2003 academic year, students enrolling in PLC were assigned to one of two possible sections of the course. Section 1 was led by the same three professors for both A- and B-terms, each of whom had previously participated in variations of the program. Section 2 A-term was led by three professors, one of whom had previously participated in variations of the program. Due to difficulties the Physics department had with obtaining coverage for another non-PLC class for B-term, the Section 2 A-term Physics professor was replaced with another Physics professor for B-term.

¹ Portions of this description were obtained from various printed sources and through personal communications with those who contributed to the design, development, and operation of the PLC, and was prepared by Paula Quinn.

Each PLC section had its own private room within which they met and worked. The sections communicated very infrequently with each other. Although students were granted access to the rooms 24 hours per day, 7 days per week, technical difficulties interfered with students' ability to use their identification cards to gain electronic access to the rooms at will. Because rooms were not ready for students until the middle of the second week of A-term, PLC sections met in various locations for the first week and a half of classes. The rooms were furnished with the following: tables, chairs, wireless classroom networking, several computers, and white boards (although installation of computers and white boards was not completed until week 5 of A-term). In B-term, PLC students were also given laptops for their personal use (for the remainder of the PLC).

02-03 Project-Based Learning Community Sample Selection²

PLC group

The criteria a student was required to meet for participation in the PLC included enrollment (or anticipated enrollment) in introductory Math (MA 1021) for A-term and its continuation (MA 1022) in B-term plus introductory Physics (PH 1110) for A-term and its continuation (PH 1120) in B-term. Recruitment was limited to students enrolling in introductory Math and introductory Physics courses for two reasons:

- one goal of the Davis Project is to improve retention of first-year students, and the majority of WPI's non-returning first-year students begin their studies by enrolling in introductory Math (MA 1021), and
- the PLC was designed around topics that would relate well to topics covered in introductory Math and introductory Physics courses.

Student recruitment for the 2002 - 2003 Davis PLC began via ground mail in late May/early June 2002, before classes began, through a program planning guide called "Blueprint for Success" that was sent to all incoming first-year WPI students. The program planning guide is a booklet designed to aid incoming students in selecting courses. The booklet included a section called "The Project-Based Learning Community Option" that described the PLC and informed students of the procedure for enrolling in the PLC.

Because there were not enough students to fully populate two PLC sections of those who initially expressed interest in the program, one of the PLC faculty members sent a solicitation letter to those students who had not already declared interest but who had registered for MA 1021, PH 1110, and a Humanities and Arts course for A-term. Additional recruitment efforts continued during on-campus orientation for first-year students and included the following: testimonials given by former PLC students (students from an earlier version of the program known as the "Tutorial") during a Physics talk to first-year students, an "open forum" given by members of the Office of Academic resources, personal suggestions to potentially appropriate students from members of the Office of Academic Resources and the Office of Academic Advising.

When enrollment information for the PLC was obtained a few weeks into B-term, 44 first-year students (35 males and 9 females) were identified as having been members of

² Prepared by Paula Quinn

the PLC for both A- and B-terms. Of these 44 students, 23 (20 males and 3 females) were members of Section 1 and 21 (15 males and 6 females) were members of Section 2.

In addition to these students, one other male was also identified as having joined the PLC in B-term, but he was excluded from all grade analyses because he had not been a PLC member for both A- and B-terms. (However, the additional male who joined in B-term was taken into consideration when selecting the Control group because it was believed that his data would be relevant to grade analyses that were to be conducted for B-term data.) Another two males were identified as having been enrolled in PLC but, because they were also identified as transfer students, were excluded from all analyses. Several students who had joined PLC at the beginning of the year and who subsequently left for various reasons were excluded from all analyses. All participants in the 2002 - 2003 experimental group of Davis PLC knowingly participated.

Control group

When selecting the Control group for the 2002 - 2003 Davis PLC, efforts were made to select a group with a course enrollment and gender profile that was as similar as possible to the 2002 - 2003 Davis PLC students. The PLC students were enrolled in the following courses: introductory Math (MA 1021) for A-term and its continuation (MA 1022) in B-term, introductory Physics (PH 1110) for A-term and its continuation (PH 1120) in B-term, and a Humanities course in both A- and B-terms. Therefore, members of the Control group were selected from a pool of students who met the following criteria:

- enrollment in the introductory Math course (MA 1021) for A-term
- enrollment in the introductory Physics course (PH 1110) for A-term (excluding students enrolled in a section believed by some to have had an exceptionally strong, and non-traditional, emphasis on group work)
- enrollment in the continuation course for introductory Math (MA 1022) for B-term
- enrollment in the continuation course for introductory Physics (PH 1120) for B-term.

Additionally, students who met the above criteria and also were enrolled in any Humanities and Arts course³ for both A- and B-terms or for only A-term were given preference for selection because their course loads mirrored those of the PLC students more closely than did those of students not taking Humanities and Arts courses.

The Control group was selected based on enrollment information that was obtained from the WPI Registrar a few weeks into B-term. At the time the Control group was selected, records indicated that there were 17 students who had enrolled in all of the following courses: non-PLC sections of MA 1021 and qualifying sections of PH 1110 for A-term, non-PLC sections of MA 1022 and non-PLC sections of PH 1120 for B-term, and qualifying Humanities courses for both A- and B-terms. All of these students were included in the Control group (15 males and 2 females). At the time the Control group was selected, records indicated that there were 7 students enrolled in all of the following courses: non-PLC sections of MA 1021 and qualifying sections of PH 1110 for A-term, non-PLC sections of MA 1022 and non-PLC sections of PH 1120 for B-term, and a qualifying Humanities course for A-term. All of these students were also included in the Control group (5 males and 2 females). At the time the Control group was selected,

³ A qualifying Humanities and Arts course was a course from one of the following areas: History, English, Theatre, Rhetoric, Philosophy, Religion, Writing, Art History, or Humanities.

records indicated that there were 49 students enrolled in the following courses: non-PLC sections of MA 1021 and qualifying sections of PH 1110 for A-term and non-PLC sections of MA 1022 and non-PLC sections of PH 1120 for B-term. Of these students (40 males and 9 females) only 16 males and 5 females were needed to obtain a Control group that was matched for gender with the PLC group. Out of this group 16 males and 5 females were randomly chosen to complete the Control group. The Control group consisted of a group of 45 students who were gender-matched with the PLC students (36 males and 9 females).

Assessing baseline academic equality of the PLC and Control groups

The baseline academic equality of the groups was established through a comparison of SAT verbal and SAT math scores for the two groups through the use of *t*-tests. For SAT verbal scores, there was no significant difference between the PLC group ($M = 585.91$, $SD = 71.80$) and the Control group ($M = 578.64$, $SD = 84.48$), $t(86) = .44$, $p = .665$. For SAT math scores, there was no significant difference between the PLC group ($M = 651.59$, $SD = 65.63$) and the Control group ($M = 637.27$, $SD = 59.12$), $t(86) = 1.08$, $p = .285$.

METHOD

Procedure

Comparisons of MA 1021 and MA 1022 Calculus final exam scores and basic skills component scores⁴ were made for the 02-03 PLC experimental and the corresponding control groups. A second level of analysis was conducted to determine if there were any significant differences between the two experimental sections with respect to both final exam grades and the basic skills components in MA 1021 and MA 1022.

Analyses

t-tests were conducted to determine if there were any significant differences between the PLC experimental students and their corresponding control students. *t*-tests were also utilized in the finer-grained analysis between the two experimental sections.

RESULTS

Results for the academic performance analyses for MA 1021 and MA1022 between PLC experimental and control students are shown in Table 1. *t*-test analyses yielded no significant differences between the PLC experimental students and PLC control students for either the final exam score or the basic skills component score for the MA 1021 Calculus course offered in A-term. In the MA 1022 Calculus course offered in B-term, *t*-test analyses revealed significant differences for the basic skills component score between the PLC experimental students ($M = 21.3$, $SD = 10$) and PLC control students ($M = 16.2$, $SD = 11.9$).

⁴ This was a portion of the final exam for the course that required a passing grade in order to proceed to the next course, regardless of the numerical score received on the rest of the exam or in the course as a whole.

Table 1. *PLC Experimental and Control Academic Performance for MA 1021 and MA 1022*

Grade Data	PLC Mean (SD)	N (E)	Control Mean (SD)	N (C)	df	t-value	p-value (a)
MA 1021 Final Exam	92.3 (19.3)	44	92.7 (20.6)	45	87	-.114	.90
MA 1021 Basic Skills Component	22.8 (6.9)	44	22.8 (7.8)	45	87	.041	.97
MA 1022 Final Exam	80.1 (33.8)	42	79.9 (34.9)	42	82	.022	.982
MA 1022 Basic Skills Component	21.3 (10)	42	16.2 (11.9)	42	82	2.125	.037*

* $p < .05$

Results for the finer-grained analyses comparing the PLC Section 1 with PLC Section 2 are shown in Table 2. t-test analyses revealed no significant differences between the two experimental sections for either the final exam scores or the basic skills component for MA 1021. For the B-term calculus course (MA 1022), t-test analyses revealed significant differences for the final exam scores between PLC Section 1 experimental students ($M = 93.7, SD = 27.2$) and PLC Section 2 experimental students ($M = 68.9, SD = 35.1$). No other significant differences were found between the two experimental sections.

Table 2. *PLC 1 and PLC 2 Academic Performance for MA 1021 and MA 1022*

Grade Data	PLC 1 Mean (SD)	N (E)	PLC 2 Mean (SD)	N (C)	df	t-value	p-value (a)
MA 1021 Final Exam	92.3 (20.3)	23	92.2 (18.7)	21	42	.004	.997
MA 1021 Basic Skills Component	22.6 (8)	23	23.1 (5.6)	21	42	-.233	.817
MA 1022 Final Exam	93.7 (27.2)	19	68.8 (35.1)	23	40	2.533	.015*
MA 1022 Basic Skills Component	21.3 (9.4)	19	21.3 (10.7)	23	40	.004	.997

* $p < .05$

DISCUSSION

Statistically significant differences related to academic performance for students who were involved in the innovative PLC for AY 02-03 and their respective controls were found for MA 1022, B-term Calculus II course, with respect to the basic skills components of the final exam. Significant statistical differences were not detected for MA 1021, the A-term Calculus I course, for either the final exam score or the basic skills component. When comparisons were conducted between the two experimental PLC sections, significant differences were found for the final exam scores in calculus II for B-term (MA 1022) but not for the basic skills components.

The academic performance comparisons revealed that in B-term, the PLC experimental students significantly outperformed their control counterparts and PLC Section 1 significantly out performed PLC Section 2 with respect to final exam scores. Although these findings are significant, they only reflect one aspect of the PLC innovative programming and should be compared with overall grade point averages (GPA)⁵ for a complete picture of academic performance related to the innovative programming. Also, further assessments unrelated to academic performance as measured by grade data are also being conducted to help illustrate the similarities and differences between the two experimental PLC sections and their control counterparts.

⁵ Academic performance reports for 02-03 PLC students related to GPA will be provided in the future.