An Evaluation of Student Performance in an Introductory Programming Course with and without the Quantitative Analysis Prerequisite: A Piece of the Assessment Process

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Introduction

Prerequisites are standard in any curriculum and serve as a measure of course preparedness. The sequencing of course prerequisites provides structure to a curriculum. ABET accreditation evaluation criteria require sequences of courses using a prerequisite structure be included in the curriculum. Thus, assessing the validity of course prerequisites can be an integral part of overall curriculum assessment. Measuring the effect of course prerequisites on student performance in subsequent courses is one way to test the effectiveness of course prerequisites and the validity of the curriculum's structure.

Numerous studies have examined the effect of prerequisites on subsequent course performance, with mostly negative results. Marchal and Roberts found that grades for students who fulfilled the computer literacy prerequisite for a business communications course did not differ from students without the prerequisite[1]. Bashford studied student performance as they progressed through reading, English and mathematics course sequences[2]. Her results suggest that simply passing prerequisite courses does not guarantee that students will be successful in subsequent courses, although students who earned higher grades in the English and mathematics prerequisites earned higher grades in subsequent course than students who passed with a "C". Wilson studied whether taking a math prerequisite course affected final grades in an introductory chemistry course and concluded that the math prerequisite was not a significant predictor of higher chemistry course grades[3].

This paper investigates whether completion of a quantitative analysis (or its equivalent) course prerequisite affected students' final course grades in an introductory programming course. It tests the assumption that students who took the prerequisite earned higher grades in the programming course than students who did not have the prerequisite. Final course grades are examined for students who completed the prerequisite, students who did not complete the prerequisite and students who took the prerequisite course concurrently with the programming course.

Method

In Fall 1997 the Computer Technology (CPT) department at Indiana University Purdue University Indianapolis (IUPUI), a large, public, midwestern urban university, revised the computer math requirements for CPT majors. The Computer Applications in Finite Math course was replaced with a new Quantitative Analysis I course (QA1). QA1 was designed as a first semester course intended to teach students "qualitative and quantitative problem solving featuring a systems approach that relies on graphic models to describe such concepts as relations, sequences, and logic patterns".[4] QA1 covers such topics as set theory, logic, descriptions of data, modeling techniques, general systems theory and descriptive statistics. Its goal is to provide students with the quantitative skills that are used in second and third semester CPT courses.

In Spring 1998 the QA1 course, or an equivalent course in problem solving (see Table 1), was made a prerequisite to the introductory programming course. The introductory programming course was changed from a first semester course to a second semester course. These changes were codified in the 1998 Plan of Study which took effect in Fall 1998. Both the QA1 course and the introductory programming course are required of all CPT majors.

Table 1. QA1 Equivalent Courses

Department	Course
MATH	Finite Mathematics
PHIL	Elementary Symbolic Logic
EET	Digital Fundamentals 1

The study population consists of 183 students who were enrolled in 6 sections of an introductory programming course (teaching Visual Basic) during spring semester 2000. Data were collected on the students' final grade, whether or not the student had previously taken the quantitative analysis prerequisite course (or an approved substitution), if the student was concurrently enrolled in the QA1 prerequisite course, the grade they received in the prerequisite course, and how many credit hours they completed prior to taking the programming course. Students who withdrew from the programming class before a final grade was assigned were removed from the sample, leaving 159 usable subjects. Students who were concurrently enrolled in the QA1 prerequisite and withdrew from the prerequisite course were placed into the no prerequisite group. Frequencies and grade distributions for each group based on when the prerequisite course was taken are given in Table 2.

Final course grades were assigned on an A-B-C-D-F scale with pluses and minuses. Final grades were converted to numeric equivalents using the scale shown in Table 3.

An analysis of final course grades across sections was conducted to test for any section bias in grading. Final grades for students who had the prerequisite course, students who took the perquisite concurrently and students who did not have the prerequisite were compared.

Because QA1 is intended to equip beginning students with the problem solving skills needed in the programming course, and it is possible for students to acquire equivalent skills through experience, the sample was then limited to students with less than the mean number of credit hours. Graduate non-degree students were also removed from the sample since it was assumed they had earned a minimum of 120 credit hours in order to graduate, irregardless of the credit hours recognized by IUPUI.

Table 2. Prerequisite Group Frequencies

			Grade Distribution				
Group	**N**	**Percent**	**A**	**B**	**C**	**D**	**F**
Prerequisite	83	52.2	27	27	21	5	3
Concurrent	18	11.3	1	6	5	3	3
None	58	26.5	18	15	9	6	10
Total	159	100.0					

Table 3. Numeric Equivalents to Letter Grades

Letter Grade	Numeric Value	Letter Grade	Numeric Value
A	4.0	C	2.0
A-	3.7	C-	1.7
B+	3.3	D+	1.3
B	3.0	D	1.0
B-	2.7	D-	0.7
C+	2.3	F	0.0

Results

To test for the existence of section bias in grading, final course grades across sections were examined. Table 4 shows summary statistics across sections along with the results of the analysis of variance. The final course grades did not significantly differ across sections.

An analysis of variance was conducted to determine if there were any significant differences among the final grades of the three prerequisite groups. The results in Table 5 shows indicate a significant difference at the .10 level among the means of the three groups. To isolate the source of the differences, pairwise comparisons of the group means were conducted (see Table 6). A significant difference in group means was found between the prerequisite and concurrent groups.

Table 4 Analysis of Variance - Final Course Grade by Section

Mean Grades by Section

Section	N	Mean	Std. Deviation
517	29	2.44	1.08
518	24	2.92	1.08
519	25	2.55	.922
520	27	2.32	1.40
521	23	2.46	1.43
522	31	2.72	1.32
Total	159	2.57	1.22

ANOVA - Course Grade by Sections

	Sum of Squares	df	Mean Square	F	Sig.
Between Sections	6.09	5	1.22	.816	.540
Within Sections	228.24	153	1.49		
Total	234.32	158			

Table 5 Analysis of Variance - Final Course Grade by Prerequisite Group

Mean Grades by Prerequisite Group

Group	N	Mean	Std. Deviation
Prerequisite	83	2.82	1.00
Concurrent	18	1.94	1.22
None	58	2.39	1.40
Total	159	2.57	1.22

ANOVA - Course Grade by Prerequisite Group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	14.18	2	7.09	5.03	.008
Within Groups	220.14	156	1.41		
Total	234.32	158			

Table 6 Multiple Comparisons of Final Grade for the Three Prerequisite Groups

	Group (I)	Group (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower	Upper
Tukey HSD	Prerequisite	None	.43	.20	.088	-.05	.91
		Concurrent	**.88**	**.31**	**.014**	.15	1.6
	Concurrent	None	-.45	.32	.349	-1.20	.313
		Prerequisite	**-.88**	**.31**	**.014**	-1.6	-.15
	None	Concurrent	.45	.32	.349	-.31	1.2
		Prerequisite	-.43	.20	.088	-.91	.05

Since it is possible that the problem solving skills taught in the QA1 prerequisite can be acquired through experience, the sample was limited to students with less than the mean number of credit hours (~65). Graduate non-degree students were also removed from the sample since they were assumed to have more than 120 credit hours, irregardless of the number of hours recognized by the university. An independent sample t-test was conducted to test for significant differences in course grades for this sample. Results are given in Table 7. A significant difference in the programming course grade was found between students having the prerequisite and students who did not have the prerequisite for this sample.

Table 7 Independent Samples Test for Students with < 65 Credit Hours

Mean Grades by Prerequisite Group

Group	N	Mean	Std. Deviation
Prerequisite	35	2.59	.921
None	37	1.96	1.46
Total	72	2.26	1.26

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval	
								Lower	Upper
Equal variances assumed	14.66	.000	2.18	70	.032	.632	.289	.055	1.21
Equal variances not assumed			**2.21**	**61.23**	**.031**	**.632**	**.286**	**.060**	**1.20**

Discussion

The lack of significant differences in programming course grades between sections supports the assumption that grading scales were consistent across sections increasing the reliability of the sample used.

For the overall sample, no significant difference in the programming course performance was found between students who had the quantitative prerequisite and those who did not. This can suggest that the programming course does not make enough use of the knowledge taught in the QA1 prerequisite. Or perhaps that students without the QA1 prerequisite delay taking the prerequisite course because they feel they already have the necessary knowledge.

However when the sample was limited to students with less than 65 credit hours, the equivalent of two years of college study, students with the prerequisite earned significantly higher grades on average in the programming course than students without the prerequisite. The average increase (.632) represents an improvement of more than half a letter grade. This suggests that the QA1 prerequisite is more beneficial for associate level students than it is for students who have more than two years of college credit. Perhaps the CPT department should accept a wider range of substitute courses for QA1 or waive the requirement for those students.

Surprisingly, students who took the QA1 prerequisite concurrently with the programming course earned significantly worse grades, almost an entire letter grade (.88) than those students with and without the prerequisite. This could be due to the small number in the concurrent prerequisite group (18). Or perhaps this represents a group of students who did not have the requisite skills needed to perform well in the programming course, but did not want to wait a semester to complete the prerequisite course. This result suggests that the CPT department should do all it can to dissuade or prevent students from taking the two courses concurrently.

Conclusion

This study used comparative means analyses to determine whether a quantitative analysis prerequisite improved student performance in a subsequent introductory programming course. The results suggest that the prerequisite course is of most use to students who have less than two years of college course experience, and that students should not take both courses concurrently. Additionally, for students with more than two years of college course experience, the CPT department should consider waiving the quantitative analysis course prerequisite or accepting more courses as substitutes.

Since the placement of the quantitative analysis course in the curriculum is focused on second semester (or entering) students, these results support the current curriculum structure in the CPT department. For beginning students, the current sequencing of the courses is appropriate. This information can be included as part of the department's overall assessment plan. It is hoped that this analysis would encourage other departments to conduct similar investigations as part of their assessment program.

References

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