Effects of course coordination and part-time precalculus instructor support on student academic performance

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Abstract

This study aims to measure the impact of course coordination and part-time Precalculus instructor support on students academic performance. Our results show the Precalculus passing rate (71.53%) was slightly higher in the post-coordination cohorts. However, this difference was not statistically significant from the passing rate (70.70%) of the cohorts in pre-coordination. Also, there was no significant difference between the passing rates (66.90% vs 65.25%) of calculus in the pre- and post-coordination cohorts. However, when accounting for the two versions of calculus, we observed one passing rate was statistically significantly lower in post-coordination cohorts, while the other passing rate was statistically significantly higher after Precalculus coordination. This paper discusses how our results confirm that a careful curriculum design in addition to a dedicated course coordination can have a significant positive impact on students' learning and their academic performance. We observed that the reflective teaching philosophy and opportunity to engage in critical conversations about teaching and learning promoted through course coordination influenced classroom practice and resulted in improved student outcomes. We recommend that departments should recognize the importance of course coordination and encourage faculty to work closely towards the common aim of delivering the best teaching practices.

Keywords: Precalculus; Calculus; STEM; Course Coordination; Part-time Faculty; Retention.

1. Motivation

Educational research studies have indicated that the level of interest towards Science, Technology, Engineering, and Mathematics (STEM) has declined both in terms of enrolment (Sjøberg and Schreiner, 2007) and student motivation to learn science (Osborne et al, 2003). This problem has been especially concerning in western countries and more prosperous Asian nations (Thomas and Watters, 2015). Despite the strong labor-market demand for STEM, these fields still attract a smaller share of students (OECD, 2019). In the United States of America, the number of students in STEM fields has remained constant while the demand for STEM majors has been increasing (Carnevale et al, 2011). In the coming years, approximately a million STEM graduates are expected to be needed to meet the economic demands of the USA workforce (President's Council, 2012). This trend points towards the need for research on attracting and retaining STEM students in higher education. Existing research shows that students' classroom and learning experiences can influence their decisions to pursue STEM degrees, especially initial experiences in introductory mathematics courses (Pampaka et al, 2012). Students often blame poor instruction as a cause for leaving science majors (Seymour and Hewitt, 1997). Therefore, improving instruction may influence their decision to stay in STEM (Ellis et al, 2014).

2. Methods

2.1. Background

This proposal presents work from a larger project focused on developing a model for promoting part-time (or adjunct) instructors' learning through various resources and support. Our project, *Adjunct Mathematics Instructor Resources and Support: Improving Undergraduate Precalculus Teaching and Learning Experience* (Project AMIRS), aims to measure the impact of course coordination and support on part-time Precalculus instructors' knowledge, instructional practices, and job satisfaction as well as students' academic success and retention in STEM majors. We use coordination of Precalculus to further the goals of implementing best practices for learning and instruction, improving content and pedagogical content knowledge of instructors, creating a professional learning community, and improving student academic achievement. In this paper, we present our findings regarding *how course coordination and adjunct instructor support impact student academic performance*.

2.2. Context

In Fall 2016, our department adopted a research-based curriculum, *Precalculus: Pathways to Calculus* (Carlson et al, 2010), and began to provide a variety of supports such as course coordination (common syllabus, pacing, and assessments in addition to access to a designated course coordinator (second author)), as well as workshops and professional learning

opportunities to help our instructors implement the curriculum.

In our department, there are two different 4-credit first-courses in Calculus. All science majors are required to take "Calculus I," with the exception of Biology and Information Technology (IT). Biology and IT students take "Calculus A," which is an equivalent course that is specifically designed for life science majors. The primary learning goal of Calculus A is to acquire the ability to understand the importance of the mathematical concepts in calculus and apply them to solve problems in life sciences. This course is particularly important and challenging since students are not required to take any additional mathematics courses. Unlike Calculus I but similar to Precalculus, Calculus A is mainly taught by part-time instructors. Moreover, Calculus A is a coordinated course with a common syllabus, pacing, project, and final exam, in addition to access to a designated course coordinator (first author).

2.3. Participants

The participants in our study were students who took Precalculus in our department during either Fall or Spring semester between Fall 2015 and Spring 2018 (6 cohorts). A student enters a cohort when they take the Precalculus course for the first time. A sub-cohort is comprised of students who pass the couse the same semester they enter the cohort and take the subsequent Calculus course over the immediate following semester (Fall or Spring).

2.4. Data Collection

In this study, we report on I) academic achievement and II) retention, described below. All data were provided by our university's Office of Institutional Research which is housed within the Office of Information Technology.

I) Academic achievement was measured by students' Precalculus and corresponding subsequent Calculus grades over 6 semesters from Fall 2015 to Spring 2018. The grades were classified in one of the following three categories: 1) Pass, P ($> 70\%$); 2) Fail, F ($< 70\%$); or 3) Withdrawn, W. We refer to these as the P/F/W categories. **II) Retention** refers to retaining students in STEM education during their academic careers, for instance from the freshman to sophomore year.

2.5. Data Analysis

For the purposes of this study, pre-coordination refers to the two cohorts (Fall 2015 and Spring 2016) before the adoption of *Pathways Precalculus*, where instructors did not receive any formal training or support for course coordination. Correspondingly, post-coordination refers to the four cohorts (Fall 2016 to Spring 2018) after the adoption of *Pathways*, where instructors received formal training and support for course coordination through the department. We compared the Precalculus and Calculus passing rates as well as retention rates between the pre- and post-coordination cohorts using the chi-square test. All the

statistical analyses were conducted in statistical software R (Team, R. C., 2017).

3. Results

3.1. Precalculus achievement

The analysis result of students' achievement in Precalculus using the P/F/W categories by comparing student pass rates along with the corresponding standard errors (SE) before and after the start of Project AMIRS is given in Table 1. Two cohorts (N = 587) were included in the pre-coordination and four cohorts (N = 1131) were included in the post-coordination. The passing rate (71.53%) was slightly higher in the post-coordination cohorts. However, this difference was not statistically significant from the passing rate (70.70%) of the cohorts in pre-coordination with p-value 0.7605.

Table 1. Precalculus and Calculus passing rate along with the corresponding standard error (SE) comparison between pre- and post-coordination.

Final Grade	Precalculus		Calculus	
	Pre-coordination Count (%, SE)	Post-coordination Count (%, SE)	Pre-coordination Count (%, SE)	Post-coordination Count (%, SE)
P	415 (70.70%, 1.88%)	809 (71.53%, 1.34%)	192 (66.90%, 2.78%)	346 (65.25%, 2.07%)
F	124 (21.12%, 1.68%)	230 (20.34%, 1.20%)	72 (25.09%, 2.56%)	148 (28.08%, 1.96%)
W	48 (8.18%, 1.13%)	92 (8.13%, 0.81%)	23 (8.01%, 1.60%)	33 (6.26%, 1.06%)
Total	587 (100%)	1131 (100%)	287 (100%)	527 (100%)

3.2. Precalculus to Calculus achievement

Next, we compared the passing rate of all calculus sections (Calculus I + Calculus A) between the pre- and post-coordination cohorts: 287 out of 415 students who passed Precalculus took calculus during the immediate following semester in the pre-coordination cohorts; 527 out of 809 students who passed Precalculus took calculus during the immediate following semester. These students were included in the comparison of calculus passing rate. Table 1 shows there was no significant difference between the passing rates (66.90% vs 65.25%, p-value 0.7789) of calculus sections combined (I & A) in the pre- and post-coordination cohorts.

3.3. Calculus I vs. Calculus A

Since students who take Calculus I and Calculus A come from different populations and the two courses are run differently, we analyzed students' performance separately in Calculus I and Calculus A by looking at their pass rates (> 70%) both pre- and post-coordination. By analyzing the aggregate data from 2 cohorts who took Calculus I during the immediate following semester passing Precalculus before coordination (N = 148) and 4 cohorts after coordination (N = 253), we observed the Calculus I passing rate was statistically significantly lower (p-value = 0.0137) in post-coordination cohorts, and the failing rate was significantly higher in post-coordination cohorts. On the other hand, Calculus A passing rate was statistically significantly higher (p-value = 0.045) after Precalculus coordination (Table 2).

Table 2. Calculus I and A passing rate along with the corresponding standard error (SE) comparison between pre- and post-coordination cohorts.

Final Grade	Calculus I			Calculus A		
	Pre-coordination Count (%, SE)	Post-coordination Count (%, SE)	Chi-square test (p-value)	Pre-coordination Count (%, SE)	Post-coordination Count (%, SE)	Chi-square test (p-value)
P	91 (61.49%, 4.00%)	122 (48.22%, 3.14%)	**0.0137**	101 (72.66%, 3.78%)	224 (81.75%, 2.33%)	**0.045**
F	42 (28.38%, 3.71%)	103 (40.71%, 3.08%)	**0.0177**	30 (21.58%, 3.49%)	45 (16.42%, 2.24%)	0.2501
W	15 (10.14%, 2.48%)	28 (11.07%, 1.97%)	0.9014	8 (5.76%, 1.98%)	5 (1.82%, 0.81%)	0.0624
Total	148 (100%)	253 (100%)		139 (100%)	274 (100%)	

We also compared the passing rate between Calculus I and Calculus A in the pre- and post-coordination cohorts. In the pre-coordination cohorts, Calculus I passing rate (61.49%) and Calculus A passing rate (72.66%) were near statistical significance at 5% (p-value 0.059). Calculus I and Calculus A had significantly different passing rates (48.22% vs 81.75%) in post-coordination cohorts with p-value of 0.

3.4. Student Retention

Retention rate was defined as the ratio of number of students whose initial major was STEM and remained in STEM through the end of the Spring 2018 semester or when they graduated

to the number of students whose initial major was STEM. Using a chi-square test to compare the two retention rates, 359 out of 466 (77.04%) in the pre-coordination cohorts and 410 out of 505 (81.19%) in the post-coordination cohorts, we found they were not significantly different at the level of 5%.

4. Discussion

4.1. Course Coordination

These results are quite interesting given the fact that similar to our Precalculus curriculum, Calculus A is also a coordinated course with a focus on active learning and conceptual understanding. Students in Calculus A are consistently provided opportunities to connect the subject matter to their interests in real world applications. By doing so, the underlying relationship between apparently disparate areas of science can be illuminated, which offers students a glimpse of a bigger picture. On the other hand, Calculus I sections are typically taught in a lecture format and the level of course coordination is significantly lower.

We conjecture that the course coordination played an important role in Calculus A, especially since the coordinator was also involved with the AMIRS project and the Precalculus course coordination effort. Similar to Precalculus, the coordination of Calculus A included common syllabus and pacing, and common assessments amounting to 50% of the final grade. The part-time faculty who taught Calculus A also had access to a designated coordinator who met with them regularly to discuss course objectives, pacing, suggested in-class engaging activities, and other effective pedagogical approaches.

4.2. Course Design

Beyond course coordination, we hypothesize that a focus on course design impacted student achievement. The two coordinators of Precalculus and Calculus A courses participated in a Research Academy for University Learning program through which they defined goals, objectives, assessments, and curriculum mapping for the course sequence Algebra-Precalculus-Calculus, described as follows:

Goals: The overarching goals for the sequence of courses were defined as follows: (1) be able to use modeling and problem solving techniques to solve mathematical problems; and (2) understand connections between multiple representations of functions (e.g., tables, graphs, equations).

Objectives: To define our Specific Learning Objectives (SLOs), we used each course specific objective and put an emphasis on the student, used observable action verbs, and created concrete learning statements. For example, the goal to understand connections between multiple representations of functions became the SLO: Students can interpret the

rate of change for a function from a graph, table, or equation. The SLOs also helped us plan for common assessments.

Assessment: While goal setting enhances the course, assessing whether those goals are reached is crucial. Thus, assessment should be integrated seamlessly into the entire course. In particular, formative assessments can assure that substantive learning happens at every step of the process. Formative assessments were incorporated as they foster understanding and keep both the instructor and the students in the loop with what is happening in class.

Curriculum mapping: Next, we created the curriculum mapping (outlined in Table 3) by aligning the SLOs with each course and indicating where each would be introduced (I), reinforced/practiced (R), mastered (M), and summatively assessed (A). This map helped us improve communication with course instructors. We also anticipated that the curriculum mapping could encourage reflective practice as instructors planned for their lessons.

Table 3. Curriculum Mapping for Algebra-Precalculus-Calculus Course Sequence.

Course	SLO1: Algebraic Processes	SLO2: Relations & Functions	SLO3: Rate of Change	SLO4: Antiderivatives & Areas Under a Curve
Algebra	I R A	I R A		
Precalculus	R M A	R M A	I R A	
Calculus	M	M A	R M A	I R A

5. Conclusion

Our results suggests that a careful curriculum design in addition to a dedicated course coordination can have a significant positive impact on students' learning and their academic performance. In particular, we observed that the reflective teaching philosophy and opportunity to engage in critical conversations about teaching and learning influenced classroom practice and resulted in improved student outcomes.

Due to a number of issues including the ever-growing pressure on full-time faculty to intensify their research, it is becoming more challenging for them to be engaged in sustained and deep conversations around teaching and learning or to actively participate in course design and coordination. Our recommendation is that departments, with cooperation from the administration, should recognize the importance of course coordination and encourage both full-time and part-time faculty to work closely with each other towards the common aim of delivering the best student-centered teaching practices. Our recommendation is aligned with what other research has suggested for best teaching practices (e.g. Wieman and Gilbert, 2014;

Wright 2011).

We plan to continue analyzing our student data, including other assessment reports, in order to verify our presented findings. Subsequently, we would like to encourage departments to utilize the curriculum mapping (Table 3) in Calculus I classes across the sections and promote active learning among the full-time faculty.

Aknowledgement

References

Buch, K., McCullough, H., & Tamberelli, L. (2017). Understanding and responding to the unique needs and challenges facing adjunct faculty: a longitudinal study. *Int J Educ Res*, *16*(10), 27-40.

Burnstad, H. (2007). *Best practices for supporting adjunct faculty*. R. E. Lyons (Ed.). Anker Pub.

Carlson, M., Oehrtman, M., & Moore, K. (2010). Precalculus: Pathways to calculus: A problem solving approach. *Rational Reasoning*.

Carnevale, A. P., Smith, N., & Melton, M. (2011). STEM: Science Technology Engineering Mathematics. *Georgetown University Center on Education and the Workforce*.

Ellis, J., Kelton, M. L., & Rasmussen, C. (2014). Student perceptions of pedagogy and associated persistence in calculus. *ZDM*, *46*(4), 661-673.

EXCEL, E. T., & MILLION, P. O. (2012). REPORT TO THE PRESIDENT.

Kimmel, K. M., & Fairchild, J. L. (2017). A Full-Time Dilemma: Examining the Experiences of Part-Time Faculty. *Journal of Effective Teaching*, *17*(1), 52-65.

OECD., D. S. E. (2019). SOCIETY AT A GLANCE 2019. ORGANIZATION FOR ECONOMIC.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International journal of science education*, *25*(9), 1049-1079.

Pampaka, M., Williams, J., Hutcheson, G., Wake, G., Black, L., Davis, P., & Hernandez-Martinez, P. (2012). The association between mathematics pedagogy and learners' dispositions for university study. *British Educational Research Journal*, *38*(3), 473-496.

Sjøberg, S., & Schreiner, C. (2007). Perceptions and images of science and science education. In *Communicating European Research 2005* (pp. 151-158). Springer, Dordrecht.

Seymour, E., & Hewitt, N. M. Talking about leaving: Why undergraduates leave the sciences, 1997. *Boulder, CO: Westview*.

Team, R. C. (2017). R: A language and environment for statistical com- puting. *R Foundation for Statistical Computing, Vienna, Austria. URL https://www. R-project. org*.

Thomas, B., & Watters, J. J. (2015). Perspectives on Australian, Indian and Malaysian approaches to STEM education. *International Journal of Educational Development*, *45*, 42-53.

Wieman, C., & Gilbert, S. (2014). The teaching practices inventory: A new tool for characterizing college and university teaching in mathematics and science. CBE—Life Sciences Education, 13(3), 552-569.

Wright, G. B. (2011). Student-centered learning in higher education. International Journal of Teaching and Learning in Higher Education, 23(1), 92-97.