AC 2010-785: CONTEMPORARY COLLEGE ALGEBRA COURSE

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Contemporary College Algebra Course

Abstract

Research indicates that the issue of how to teach College Algebra has been a focal point of discussion in literature, conferences, and debates. At our institution of higher learning, traditional teaching methods in which the instructor delivers information from the textbook and solves problems on the board for College Algebra courses have been primarily used as a mode of instruction for the past few decades. The university has experienced high FWD (Fail-Withdrawal-D) grade rates due to high school preparation, lack of reflection of students' needs and change of student attitude. In order to remedy the problem of high FWD rates, many colleges and universities have endeavored to suggest, develop, adopt, and apply new College Algebra programs considering their own environments. Some colleges and universities take advantage of modern computer technology software such as MATLAB, MATHEMETICA, and MAPLE. Yet, some colleges and universities find solutions from previous successful methodologies. In order to remedy high FWD grade rates in College Algebra, the university has been trying to partially reconstruct the college algebra course by joining the national HBCU College Algebra Reform Project since the spring semester of 2007. Unlike the traditional instructional method of focusing on the development of algebra skills, the new program adopts the method of student learning by inner group discussion as its primary learning methodology and emphasizes integration of real-world problems and mutual activity for better understanding of the principles of mathematics. The aim of this article is to introduce the contemporary College Algebra course and to present the interim assessment by analyzing effects of the program in the aspect of how well those who completed the new program perform in successive mathematics courses. In particular, the present study addresses the non-STEM and STEM majors' challenges and their competitiveness in Pre-calculus. By analyzing the results of this study, it provides strong evidence that the student passing rate of College Algebra increased between 5%-10%. Also, the data proves that, on average, post-program grades are greater than pre-program grades. Furthermore, the study indicates that the contemporary college algebra course is not as sufficient as a prerequisite course for Pre-Calculus for both STEM and Non-STEM majors.

Introduction

The issue of how to teach College Algebra has been a major focal point of discussion in much of literature, conferences, and debates. At our institution of higher education, the traditional teaching method for the college algebra course in which the instructor delivers information from the textbook and solves problems on the board has been primarily used as the mode of instruction for the past few decades. However, various problems including students' insufficient high school preparation, outdated curriculums, lack of reflection of students' needs, change of students' attitude, and etc. have led school to confront these problems seriously because the majority of the students' performance has become worse in the course causing the FWD (Fail-Withdrawal-D grade) rates to be inordinately high. Small[1,2] states that the high FWD rates have shown up nation-wide in the 40 – 60 % range. Figure 1 presents our university's situation for the last 3 years. In fact, the numeric data shown in Figure 1 looks somewhat overestimated and it should stand around the 40 -50 % range when considering students' abilities.

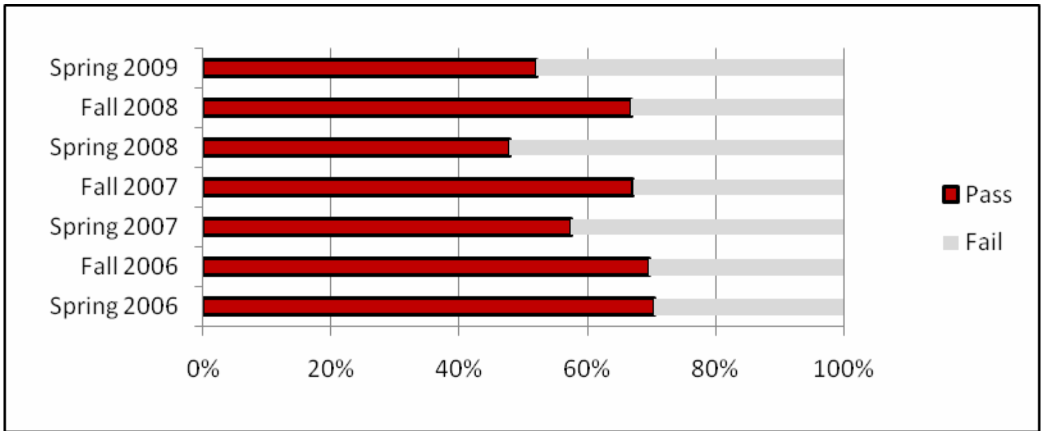

Figure 1. SSU College Algebra Pass Rates

Such deficiency could cause many problems of academic placement, curriculum design, development of student career plans, and etc. In order to solve this issue, many colleges and universities have taken the initiative to suggest, develop, adopt, and apply new College Algebra programs that best fit their learning environments. Some colleges and universities take advantage of modern technology, such as technology based teaching[3,4,5], web-based homework program[6,7,8,9,10], online teaching software[11], and supplemental tools such as MAPLE, MATLAB[12,13,14], and etc. Meanwhile, some schools base their method of teaching on previous teaching methods that were successful[15].

Since the spring semester of 2007, our school has also been partially reconstructing the college Algebra course by running a pilot program in several sections. The program is supported through the HBCU College Algebra Reform Project which was designed by Small[1,16,17] and innovated and positively accepted by many colleges and universities[18,19,20].

While the traditional teaching method focuses on the development of algebra skills, the pilot program adopts a new learning methodology under the name "contemporary College Algebra (CCA)." In the CCA class, the students are urged to learn more from their classmates through inner group discussions. The CCA emphasizes the integration of real-world problems and promotes mutual activity to inspire students and help them to better understand the principles of algebra. By doing this, students are finally forced to do self-thinking and produce a sufficient pedagogical output as much as or more than they would in the traditional setting. More systematic information about the CCA is described again in section 2.

Again, due to the lack of experimental proofs for success of the program, our school started the program by offering only a limited number of sections, primarily, for the non-STEM (non-Science-Technology-Engineering-Mathematics) major students. It was also assumed that some students take College Algebra as their terminal mathematics course for their graduation degrees, thus more, eliminating the need for formulaic algebraic techniques for the advanced mathematics class. Nevertheless, each CCA class actually contains STEM majors in a certain ratio; much like in the traditional one because there is no specific administrative restriction on STEM majors' enrollment into CCA sections. Consequently, students in the program were drawn from the same pool and with the same conditions as those who were in the traditional class. Such data is shown below in the Table 1.

The present study first aims to introduce the contemporary College Algebra course at our institution. In section 2, one addresses the general overview of the HBCU College Algebra Reform Project and how our school accepts it as its pilot program. The second purpose of this study presents the interim assessment of the pilot program by analyzing students' final grades. In section 3, the study focuses on how well the non-STEM and STEM majors in the CCA classes are being trained up to an expected level. The students' performance is numerically analyzed on how successful they are in the Pre-calculus course and then compared to students from the traditional class. Additional analysis is presented in section 4 in more detail. In section 5, overall assessments for the pilot program are discussed, and future visional issues are directed.

New program overview

Compared to the traditional College Algebra, contemporary College Algebra (CCA) is designed to educate students for the future workplace or real life needs rather than to train them for the past. The largest cohort (approximately one-third) of students passing college algebra goes into schools of business. However their need for elementary data analysis, modeling real-world problems, using technology, gaining small-group experience, and developing communication skills are not addressed in traditional college algebra (TCA) courses. In spite of providing numerous exercises involving exponential functions, the traditional courses do not prepare social or life science majors to model growth situations, nor does it prepare economic majors to model the multiplier effects of increased spending. Thus, the primary difference lies on the content and the pedagogical focus. More detailed views of this information are found in Small's articles [16, 17].

Contents

Rather than fixate on pre-calculus, College Algebra re-focuses on the practical, quantitative needs of today's students to use mathematics in their personal and professional lives. Thus, the course's content mainly consists of real-world problem-based questions and emphasizes problem solving in the modeling sense while including elementary data analysis. In our institution, the CCA course is also based on the text "Contemporary College Algebra: Data, Functions,

Modeling"[16], and techniques which are introduced and motivated by real-world situations. However, our institution uses partially changed ways rather than following all topics in the text.
Data and Variables: Students study how to read and display data in the formats of table, bar charts, pie charts, scatter plots and line plots. They learn the summary measures, such as average, median, mode, etc. of a set of numbers. Using variable expressions, the students establish equations for solving real-model problems. These problems contain applications of linear equations, systems of linear equations, ratio or percentage calculation, and etc.

Basic Algebra skills and Functions: Basic algebra and the concept of the function are treated with the most emphasis in CCA. In order to train the algebra skills and introducing to the function and its basic theories, our institution temporarily adopt the traditional teaching methods. This symbolical teacher-centered instruction is run for one third of a semester. Although all types of functions which are treated in TCA cannot be covered in detail, instructors try to push the students to get knowledge of the basic concepts of functions, at least around the polynomials. The main reason for doing this is to place STEM and non-STEM majors of CCA into the same placement as ones in TCA. Topics contain definitions, operations, sketching graphs, zeros and algebraic skills. Some of simple examples from real-models are taken to explain graphical and numerical approximation. Examples include problems such as measuring the real distance between the school and the student parents' house or finding the expectation of supply and demand in market.

Modeling: The last contents of the course are involved with real life modeling. For this concept we focus on monetary matters that take place in markets, banks, or businesses. Students study topics such as the mortgage plan, decision problems from different financial products, and pay amount in the market.

Pedagogical methods and techniques

The CCA class's main pedagogical method involves having small-group in-class-discussions. Completing work-sheet problems in groups (known as in-class activities) has become a principal learning methodology for the CCA classes.

- Student-centered rather than instructor-centered pedagogy: Place the focus on student learning rather than on covering content. For example, maximum of hands-on activities and minimum of lecturing are mainly emphasized.

To do this, questionnaires are provided on the worksheet on a daily basis, and the students are asked to turn in the answers at the end class. In order for students to stay involved, instructors frequently question the students individually or in group. Through interdisciplinary collaboration and exploratory learning, students are expected to develop communication skill and their own ways of recognizing diverse principles. Additionally, students are expected to learn to recognize the mistakes that they can make, seek a depth of understanding, and then have the confidence of solving the solution in the similar environment.

Another important learning method to enhance students' understanding of the knowledge is to assign a group project in the middle of semester. This activity is counted as a regular test. This project requires the student to explore the issued topic, collect related data on the topic, and numerically analyzing the data before organizing their conclusion on a poster board. They are also required to make a presentation about the poster and it is scored in the professional manner. Through the project, they not only get a better understanding of the situations by revealing their own opinions logically, but the students also learn the appropriate use of computational techniques or technology in response to their needs for the visualization of posters. In recent semesters, our students conducted their projects on the topic "How can we improve the SSU teaching and learning environment?" The scopes taken by students contained the problem of higher prices for school supplies and textbooks on campus, the relative lowness of tuition fees at HBCUs, living expenses as an on-campus freshman, school athletes' physical abilities, meal plans, and etc. A group even suggested the increase of contact hours of the College Algebra course by showing the results of other schools.

Intermediate assessment

It is very remarkable that the CCA class creates a very positive change in the students' attitude towards mathematics. First of all, the CCA class agreed that they were surprised that the mathematics they were learning could be useful in everyday life. Most of them showed the interests in problems relating to life games, regardless of the depth of their mathematical knowledge. Moreover, as long as the class created and maintained an exploratory environment, the majority of students seemed to embrace the refreshed approach of the contemporary program through the first month of semester. The students are often excited to interact with each other as they solve problems and discuss techniques and reasons. Absolutely a few students still feel uncomfortable with the new learning methodology and show less interest in class participation. But as time passes, students are engaged more actively in the group action and revealed more interests than in usual classes. The past surveys on CCA classes prove that the increment of the students' interest in mathematics matches the positive comments.

Experimental group and data

Now we explore the effect of the pilot program by comparing the CCA class to the TCA class. This study is achieved by watching the passing rate of the course. For this objective, we selected students who took the College Algebra course between the spring semester of 2007 and the summer semester of 2008. Table 1 shows the distribution of the student population during those periods. The more recent results cannot be included because students are taking Pre calculus now or have less opportunity to do it. The total number of students is 1306, and among this number of students, 1035 students (79.25 %) take non-STEM disciplines (Business or liberal arts or undeclared) as their majors. 153 students took CCA, and 125 of the students in it preferred to study the non-STEM subjects. This corresponds to 81.7 %. Table 1 also implicitly reflects the usual pattern of what kinds of areas US young people want to work in the future.

Table 1. Experimental group

Semester	Mode	# of Sec	Total	STEM	Non-STEM					Non-STEM (%)
					Und	Acc	CIS	Bus	Lib	
Spring 07	TCA	13	**291**	56	43	12	6	50	124	**80.75**
	CCA	2	**33**	4	5	3	0	8	13	**81.18**
Summer 07	TCA	3	**73**	9	13	5	3	6	37	**87.67**
Fall 07	TCA	17	**484**	120	52	43	10	90	169	**75.21**
	CCA	3	**85**	16	13	10	1	16	29	**81.18**
Spring 08	TCA	11	**247**	47	29	24	4	43	100	**80.97**
	CCA	2	**35**	8	4	5	0	3	15	**77.14**
Summer 08	TCA	3	**58**	11	8	2	4	5	28	**81.03**
Total			**1306**	**271**	**167**	**104**	**28**	**221**	**514**	**79.25**

TCA: Traditional College Algebra, CCA: Contemporary College Algebra, Und: undeclared major, Acc: Accounting major, CIS: Computer Information system major, Bus: business management or marketing, Lib: Liberal Arts major

First of all, Table 2 shows the grade distribution of experimental students in College Algebra. The table shows that 61.92 % of students in TCA and 67.32 % of the ones in CCA received passing grades of A, B or C. Overall 62.55 % of the student population completed their first goals in the given period.

Table 2. College Algebra pass rate

	A	B	C	D	F/W/WF	Total	P.R.(%)
TCA	149	198	367	122	317	1153	61.92
CCA	19	22	62	17	33	153	67.32

P.R.: Passing rates

Figure 2 illustrates the success rates in each type of classes. Compared to TCA, CCA shows a little higher passing rate at around 5 % higher. The reason for this slightly higher percentage is thought to be because of relatively easier content in CCA. For more detail, Table 3 and Table 4 distinguish the success rates of students in College Algebra according their majors, genders, and

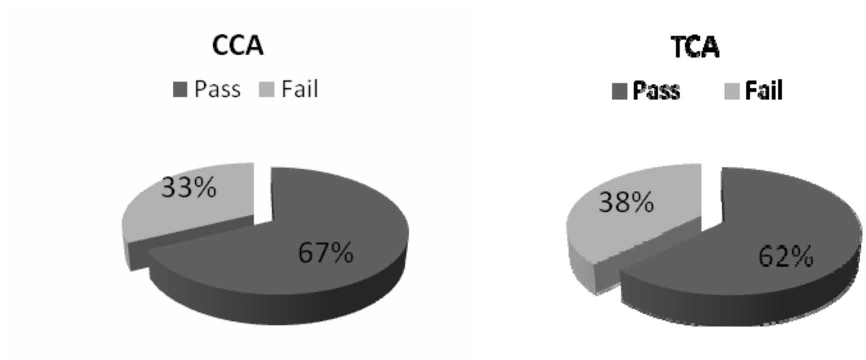

Figure 2. Overall Passing Rates in College Algebra

the class time. First, the ratio of male students to female students is given at 598 to 708 which is almost 46 %: 54 %. As shown in the table, the serious problems of failure occur for non-STEM major male students in the traditional classes. The success rate for them remains just below 60 %. Meanwhile, the highest success rate appears in the group of STEM major female students in CCA, reaching almost 73 %. Data shows that female students perform relatively better in the College Algebra class, but an exceptional case also occurs for non-STEM students in CCA.

Table 3. College Algebra pass rate according to the gender

	Major	Gender	A	B	C	D	F/W/WF	Total	P.R.
TCA	STEM	Male	20	22	27	12	29	110	62.72
		Female	26	29	36	16	26	133	68.42
	Non-STEM	Male	38	67	136	49	131	421	57.24
		Female	65	80	168	45	131	489	64.00
CCA	STEM	Male	3	5	4	1	4	17	70.59
		Female	1	0	7	2	1	11	72.73
	Non-STEM	Male	3	9	24	5	9	50	72.00
		Female	12	8	27	9	19	75	62.67

Figure 3 represents the overall success rates of non-STEM majors in both CCA and TCA classes. Even though the success rate for non-STEM majors is a little bit reduced by 1 % compared to overall rates, it still shows that CCA classes stand at a 5 % higher rate. Meanwhile, Figure 4 shows the overall success rates of STEM majors in both CCA and TCA classes. Relatively, the mathematics course seems easier to STEM majors. Their success rates stand above the average. It is remarkable that the CCA class has a 9 % higher success rate. This may be understood that STEM majors can adapt to the new mathematical environment much faster, due to a better caliber of mathematics.

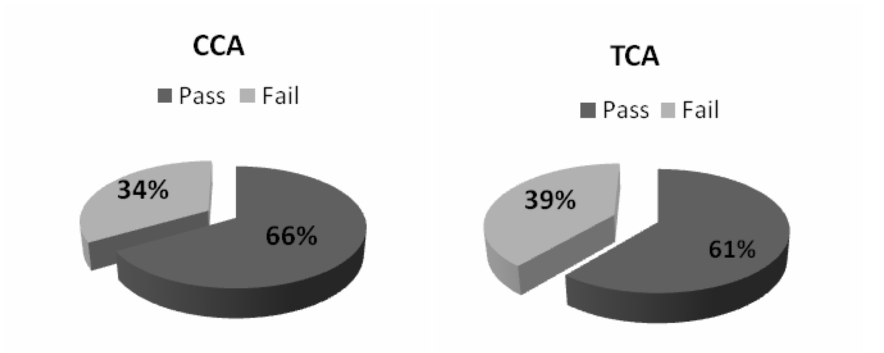

Figure 3. Non-STEM majors' Passing Rates in College Algebra

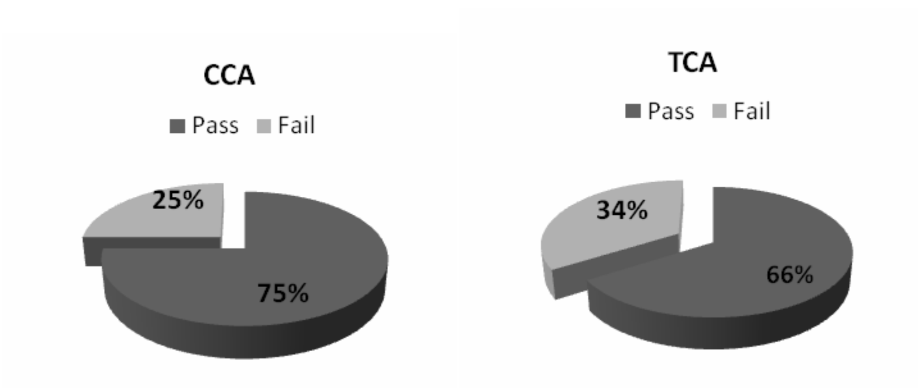

Figure 4. STEM majors' Passing Rates in College Algebra

Table 4 compares students' final grades based on the time that class was given. As we see in the table, more students obtained passing grades in night classes rather than in the morning class. This may be the reason that many students can get lazy in attending morning class. The overall success rate for the classes is almost 58.55 % for the morning classes, 63.12 % for afternoon classes, and 72.90 % for the night classes. Another reason is that teachers are more generous to working students who take mostly night classes.

Figure 5 compares the success rates between STEM and non-STEM majors in each type of classes. In each class, the stair-up pattern of success rates along the order of morning, afternoon and night are reflected in the cleaner manner. It is against our expectation, like in the study[21], that morning classes have higher success rates than evening classes.

Table 4. College Algebra pass rate according to the class time

	Major	Class Hr	A	B	C	D	F/W/WF	Total	P.R.
TCA	STEM	Morning	22	24	28	11	30	115	64.34
		Afternoon	21	23	30	15	21	110	67.27
		Night	3	4	5	2	4	18	66.67
	Non-STEM	Morning	46	59	142	60	125	432	57.18
		Afternoon	41	61	109	30	105	346	60.98
		Night	16	27	53	4	32	132	72.72
CCA	STEM	Morning	2	2	3	2	2	10	70.00
		Afternoon	2	1	3	1	2	9	66.67
		Night	0	2	5	0	2	9	77.78
	Non-STEM	Morning	0	3	18	6	12	39	53.85
		Afternoon	6	7	16	8	5	42	69.04
		Night	9	7	17	0	11	44	75.00

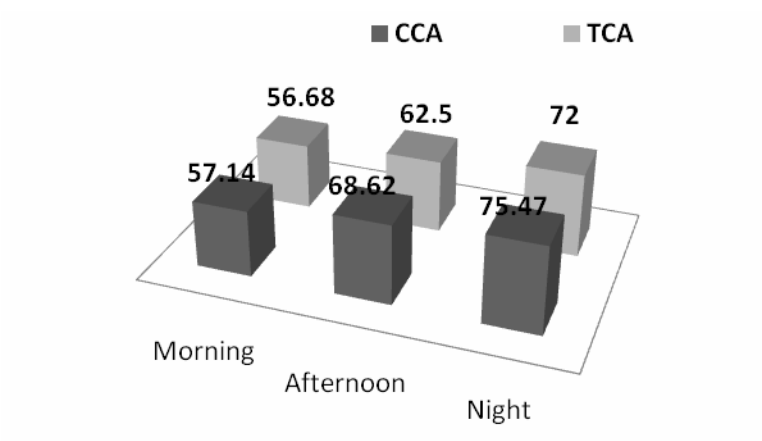

Figure 5. Passing Rate in College Algebra according to class time

Now we turn our concern to the students' performance in Precalculus. Although the CCA is designed as a terminal math class for a degree, like other TCA classes, each CCA class has a similar number of STEM majors who are required to take up to the Calculus courses. Moreover, in our institution, business major students are also required to take higher-level mathematics courses, such as Precalculs. As presented in Table 5, the total number of students who have taken precalculus after the TCA or CCA courses druing a given period is 419. 370 of these students come from TCA and 49 from CCA. This implies that 419/1153 (36.34 %) of TCA and 49/153 (32.03 %) of CCA students took Precalculus. In fact, because of the curriculum, the actually exempted students from Precalculus must belong to departments of liberal arts school or undeclared majors, which occupy almost 50 % of overall student population. Thus, the numbers

419 and 49 yield almost all possible students who can take Precalculus when we count the students with passing grades.

Table 5 shows the grade distribution in Pre-calculus from both TCA and CCA. Data says that students from TCA become better accustomed to the class than students from CCA. Overall, the Pre-calculus course also had a 35 – 40 % failing rate as like in College Algebra course, and resultantly many students do not meet the academic requirement. Figure 6 also illustrates this fact in a more obvious way.

Table 5. Grade distribution in Pre-calculus

	A	B	C	D	F/W/WF	Total	P.R.
TCA	43	83	113	67	64	370	64.59
CCA	3	10	16	9	11	49	59.18

For more details, Table 6 shows how students perform in Precalculus courses in accordance with their genders. Based on the data, we could extract the grade distribution of non-STEM and STEM majors. Figure 6 and Figure 7 respectively illustrate non-STEM and STEM majors' passing rates in Precalculus. As shown in data and figures, 5% more students for non-STEM majors and 7% more students for STEM majors from TCA succeeded in Pre-Calculus. Although the size of the experimental group of STEM majors in CCA is small, such differences in percentages prove that the CCA class is less effective than students who are supposed to take the advanced mathematics courses.

Table 6. Pre-calculus passing rate according to the gender

	Major	Gender	A	B	C	D	F/W/WF	Total	P.R.
TCA	STEM	Male	16	14	17	13	17	77	61.04
		Female	13	19	21	14	13	80	66.25
	Non-STEM	male	8	25	44	22	21	120	64.17
		Female	6	25	31	18	13	93	66.67
CCA	STEM	Female	1	2	2	2	1	8	62.50
		Male	1	1	1	1	2	6	50.00
	Non-STEM	Male	0	4	6	5	3	18	55.56
		Female	1	3	7	1	5	17	64.71

Table 6 also explains the success rates according to their genders. The success ratio of males to females at 64:66 in non-STEM majors and at 61:66 in STEM majors, from TCA, means that both male and female students from TCA perform relatively similar work. Meanwhile, the success ratio of 55:64 in non-STEM majors and 62:50 in STEM majors, from CCA, says that male non-

STEM major students from CCA are less competitive in Precalculus classes, but male STEM majors from CCA are much more competitive than female students. In particular, it is interesting that non-STEM majors' passing ratios (57:64 in TCA and 72:62 in CCA) as shown in Table 3 are completely reversed in Precalculus class. This may mean that non-STEM major male students are well-accustomed to the CCA class but they find it difficult to adapt to the traditional Precalculus class.

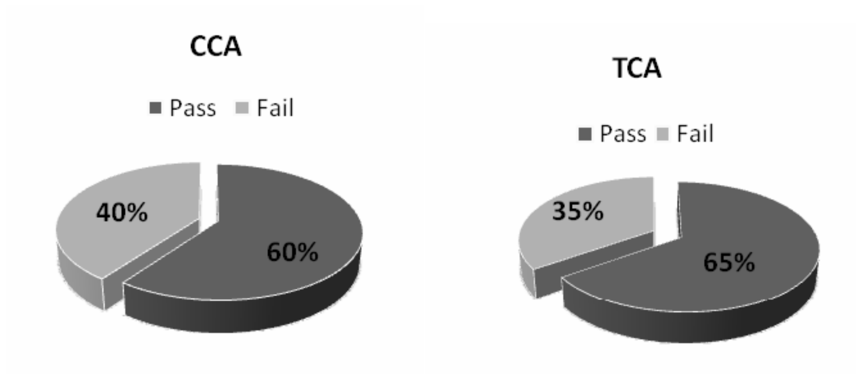

Figure 6. Non-STEM majors' passing rates in Pre-calculus

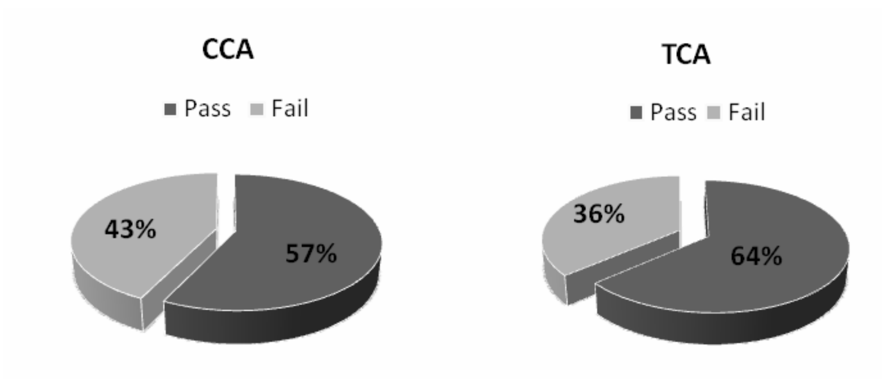

Figure 7. STEM majors' passing rates in Pre-calculus

Effectiveness of CCA class for Pre-calculus

As described above, the success rates of students in Pre-calculus from CCA and TCA are compared overall at 59 % to 64 %. This wide gap does not get close, even considering students' major principles. Such a phenomenon can be analyzed together with various factors which can make any effect on students' achievements. The primary factor is considered to be repeated content. In fact, the contents covered in Pre-calculus are mostly covered in TCA with an exception to the trigonometric functions. Thus, students from TCA benefit from repetitive learning in Pre-calculus. Meanwhile, students in CCA have fewer opportunities, not only to come into contact with the exact concepts of mathematical theories, but also to be exposed to all of the contents given in TCA. It is, in fact, impossible to cover all TCA topics in CCA class because of the self-learning characteristic of CCA class. Secondly, even though a topic in CCA is treated as a topic as in TCA, patterns of problems common to students are quite different from ones in TCA or Pre-calculus. This means that students from TCA may have rich experience, or they could be better trained for the regular patterns of problems which could appear on Pre-calculus tests. Becoming familiar with the patterns of problems is very critical for students to succeed in traditional mathematics courses of certain regularized questions. They include most of the low leveled mathematics courses, such as College Algebra, Pre-calculus, Calculus, and etc which deliver the basic algebraic skills or techniques. The knowledge or experience in CCA could be more applicable in their future workplace or real lives when they measure their real property, select financial products, purchase a product in a market, and so on. Students' learning patterns are also a crucial factor for success, although it is not that big. In TCA and Pre-calculus classes, students must be forced to understand individually, but in CCA they are asked to search for solutions by themselves through discussions with their classmates. Students in CCA talk about various ways of approaching a solution, but they don't imply the shortcuts. Instead, in TCA and Pre-calculus, they are taught the short-cut or simple method to get the exact solution. Finally, students need to find the right class that is offered at the right time.

Thus CCA is not recommendable to those who have to enter the math-intensive program, such as STEM majors or even business majors. Nevertheless, the ratio 67% to 62 % of the success rate in College Algebra yields that the CCA class itself plays an adequate role as a new instructional method. Also the assessment outlined above reveals that the CCA class does have a positive impact on student attitudes toward mathematics.

The article assessed non-STEM and STEM major students' caliber of work shown in Pre-calculus. Overall results showed that classes using the CCA experienced, on average, an increased pass rate of 5 %, and an increased mastery rate (those students making A's and B's) of 19 %. As for accompanying the CCA course, 84 % of students said they would recommend to their instructors the use of this methodology in all of their math courses. Although taking CCA may cause a serious problem for students who take further advanced math courses, such as Pre-calculus, CCA class still looks helpful to non-STEM majors in the aspect that they can go forward to their academic degrees.

Conclusion and future direction

Students empowered with the necessary mathematical knowledge, confidence, and skills, are being enabled to continue in more advanced mathematics or quantitatively based courses, and to get degrees in related areas. In these aspects, the CCA course

- contributes to student confidence and self-satisfaction through doing group work or group projects

- lets students use technology and enables students to model and analyze the real situation, which they had been previously unable to do because of the algebraic manipulations involved
- has an impact on student attitudes toward mathematics
- reduces the FWD rate so that more students pursue their degrees by being released from the math fetter
- educates them with more hands-on knowledge in their professional or working areas
- and helps the diversity of learning methodologies of mathematics,

it is very valuable enough to be adopted as a part of the school education system. However, in order to expect better results and to be set as a regular program for College Algebra at our school, there are a few things to be improved, such as

- smaller size of class
- curriculum change for target students
- reorganized contents fitting the students' needs in the school
- securing enthusiastic teachers with high expectations

Under a better teaching and learning environment, the maximized effect of education could be expected.

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