

Affordable Learning Georgia Textbook Transformation Grants

Final Report

Date: May 25, 2015

Grant Number: #7 (R1)

Institution Name(s): Southern Polytechnic State University (now Kennesaw State University)

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Project Lead: Lake Ritter

Course Name(s) and Course Numbers: Calculus II (MATH 2254)

Semester Project Began: Fall 2014

Semester of Implementation: Spring 2015

Average Number of Students Per Course Section: 35

Number of Course Sections Affected by Implementation: 2

Total Number of Students Affected by Implementation: 70

1. List of Resources Used in the Textbook Transformation

A. Open Access Texts Used:

- a) *Calculus: Late Transcendentals* by Guichard and Friends (CC BY-NC-SA 3.0)
http://www.whitman.edu/mathematics/calculus_late_online/
- b) *APEX Calculus I & APEX Calculus II* by Hartman, Heinold, Siemers, and Chalisehajar (CC BY-NC 3.0) <http://www.vmi.edu/content.aspx?tid=36957&id=10737419979>

B. No Cost Online Homework System: WebWork, a product of the Mathematical Association of America (University supported webserver) <https://webwork.spsu.edu/webwork2>

C. Materials Adapted or Created:

- a) Integrated text portal for adapted/combined course text:
http://educate.spsu.edu/lritter/RitterDengALG_CalculusII_Portal.htm
- b) Supplemental Materials webpage including lecture slides (CC BY-NC-SA 4.0) to accompany adapted text and links to external open access Java Applets
http://educate.spsu.edu/lritter/RitterDengALG_CalculusII_InstructorMaterials.htm

2. Narrative

For this project, we analyzed the open access offerings of calculus textbooks looking for a suitable substitute for the departmentally approved text used in our calculus sequence. Our focus was on the course Calculus II (MATH 2254) in which Stewart Calculus 7e (late transcendentals) has been the traditional text. We chose this particular course because of its significance as a gateway course for engineering and applied sciences (we have been a polytechnic institution) and because of its historically poor success rates (DFW rates are often higher than 50%). The goals of the program discussed herein included

- 1) Adopting or adapting a no-cost alternative text that would satisfy the needs of our course based on program and learning outcomes, and to facilitate student access to said text;
- 2) Assess student experience and course success using a no-cost alternative text; and to
- 3) Assess faculty experience using a no-cost alternative with attention to feasibility of expanding the use of low-to-no-cost course materials.

Adoption/Adaptation of no-cost text

The market is flush with options for calculus textbooks catering to curricular variations. While the availability of open access offerings is expanding, we had a rather small pool of texts that were potentially appropriate for our needs. Ultimately, we determined that two of these texts should be combined so as to adequately cover the material in our course—each text alone having deficits. The texts chosen (linked to in the resources section of this report) were Whitman Calculus and APEX Calculus.

The preliminary challenge was to coordinate between the two texts, with different chapter numbering and formats, and offer the students and instructors a *single text* experience with easy access and minimal frustration. Our solution was to create a single web-portal page in which we divided the course into chapters (using a letter system chapter A, B, and so forth with sections A.1, A.2, etc.) with corresponding links to appropriate materials in each text. (This page is available to the public on the University server—and every effort will be made to transfer the page to the new University server due to SPSU/KSU consolidation.) The students were given the option of downloading all or parts of the texts to personal machines.

To assess the usability of the adapted text, we surveyed students in our no-cost sections on their use and experience with the text portal. Of the 42 respondents to questions relating to how the text was accessed, 38% reported using the portal exclusively, 43% reported using the portal occasionally (in conjunction with download), and 19% used only downloaded versions. When asked about ease of navigating the portal, its layout, and coordination of the text, only 1/40 respondents found using the page *somewhat difficult or confusing* (see survey results in appendix B). The remaining respondents were either neutral or found our format easy to use. Despite concerns that the unusual format of the text would hinder student access or cause frustration, student responses indicate that the portal is a viable means of combining open access texts for student use.

As an instructor using the combined text, I (Ritter) coordinated all lectures and lecture slides to the online text. All references to material whether in lecture, in online homework, and for exams was made using the *numbering* (lettering) system (e.g. Chapter A, section A.1) designed for the text. The

adaptation required restructuring 21 homework files for use in WebWork to accompany the course. Once the material was adapted, I found its use seamless and fluid—not significantly different from a traditional text. I was quite pleased with the student response to the text. Most notably that they did not indicate feeling *cheated* or frustrated by the change. (It should be noted that they were informed via the class schedule of the difference prior to enrollment.) My own experience mirrors that of the students.

Student Experience and Success

In addition to student's responses to the text format, we were particularly interested in whether the no-cost alternatives would have any impact on student learning. To assess student learning, each of the investigators ran two sections of Calculus II, one using the traditional *Stewart* text and one using exclusively the no-cost materials. We considered responses to common embedded exam questions across all four sections to evaluate student mastery of learning outcomes. In addition, we compared DFW rates and aggregated data on end of term Faculty Course Assessment Reports (FCARs). (FCARs are institution wide instruments used to report on learning outcomes in compliance with the University's plan for continuous improvement of academic programs.)

Each of the four sections in the study (2 traditional, 2 no-cost) filled to capacity with 35 students each. Rather coincidentally, 16 students withdrew with a grade of W, 4 students from each section. The DFW rates for the no-cost sections were slightly higher than for the traditional text class for both instructors. Deng had DFW rates of 34.3% (12/35) and 25.7% (9/35) in the no-cost and traditional sections, respectively. Ritter had DFW rates of 45.7% (16/35) and 42.9% (15/35) in the no-cost and traditional sections, respectively. The department wide DFW for MATH 2254 for this term is 48.9%.

Despite the slight discrepancy in DFW rates, the student's sense of their own learning experience with the no-cost materials was predominantly neutral to positive. For example, when surveyed about the effect of no-cost on their perception of learning and grade impact, 39.5% of respondents said the no-cost text had no perceived effect on their learning of the material. Another 39.5% perceived a positive impact on learning, and only 2.3% perceived the no-cost text as detrimental. When asked about the impact of WebWork, the open homework system, 13.9% perceived no impact on their learning, 44.2% perceived a positive impact, and 7.0% perceived WebWork as being detrimental to their learning. (See section 4. on the Quantitative and Qualitative Analysis and Appendix B.)

The substitution of no-cost materials for this significant (*TOP 50*) course appears to have no appreciable impact on student learning and success. We would argue that this is a success for the program and the potential for no-cost materials since the substitution does have an appreciable, positive impact on student expense.

Faculty Experience and Feasibility of No-Cost Alternatives

The primary challenge with implementing no-cost materials was the preparation of a uniform *text* (creating of the webportal) and coordination of the WebWork assignments with the text needed to simulate polished commercial products. Easy access, readability, and ADA accessibility were of major concern in designing the text portal. As mentioned, coordination of two books had the potential to lead to a lot of frustration---e.g. chapter 10 material in one text corresponds to chapter 6 in another. I (Ritter) was particularly intent on coordinating lecture to text section because I teach using dynamic slides with

a write-on tablet computer and archive all of the content created in class for later student access. But, as also mentioned earlier, once the text portal was created (as well as the WebWork assignments and the base slides), I found the implementation smooth. Use of the text created, or an updated version, should pose no problem for other faculty in the department. I created a set of corresponding lecture slides that is also available to the other instructors and the public.

One of the issues that we were aware of during the planning phase of this program was the potential for a change in the Calculus format due to consolidation of SPSU and KSU. After beginning this ALG program, it was decided that the New University would adopt an *early transcendentals* curriculum for the Calculus I & II sequence. Our program involved teaching in the traditional, late transcendental, curriculum. Our main text, the Guichard (Whitman), is available in both formats—an important factor in our choice of this text. (The APEX is strictly early transcendental.) To use the open access approach will require a redesign of the online text portal. Two of the four chapters can be used in their current form, some of the material will be rendered obsolete, and some of the material will be used to create a similar online text for Calculus I. Having determined that our general approach is functional for students and faculty, we can implement the required curriculum changes according to the template we put in place during the current pilot.

A secondary concern going forward is with departmental approval for text substitution in a course with a standardized text. While we had no difficulty securing approval for this ALG pilot, the post consolidation department is significantly larger (formerly 19, currently 57 full time math faculty) with different policies and procedures in place. We have discussed with the new department chair, Professor Joe DeMaio, the requirements for running future sections of Calculus I and II with the open access materials. No permission is necessary for use of WebWork as a no-cost homework system. Approval for text substitution is required from the Curriculum Committee. Fortunately, Dr. DeMaio has indicated that the results of the current ALG project will likely satisfy the committee's requirements. Expanded adoption of no-cost materials within the department for this sequence is still uncertain.

As a peripheral benefit of the current project, we have become familiar with high quality open access texts for courses other than Calculus. Most notable are the Linear Algebra text *A First Course in Linear Algebra*, by Robert Beezer and the Differential Equations text *Elementary Differential Equations* by William Trench. The text for Linear Algebra and Differential Equations courses in the new department are chosen by the instructor of record. Ritter in particular will implement use of these open texts as early as spring 2016.

3. Quotes

- 1) *Not having to pay for a textbook was great. Webwork portal was a fair representative of the material that was covered in class.*
- 2) *I wish every class used free edu. Materials*
- 3) *Online textbook is the way to go*
- 4) *I love the no-cost textbook idea, but I did not find the Whitman textbook to be helpful in clarifying ideas I did not understand. That being said, I also found that I did not need the*

textbook, as my notes and other online resources proved to be enough for me to master the material on my own.

- 5) *Lots of the practice HW problems in the online textbook do not have answers or work from how you got the answers. Please include this in the future! Very important!*

4. Quantitative and Qualitative Measures

Our quantitative assessment of the program is based on comparison of grade related data across four sections of Calculus II run in spring 2015. Each of the two investigators conducted one class using the traditional¹ departmental text Stewart 7th Ed. and one class using exclusively no-cost-to-student text and online homework system. Grade related data includes DFW information, overall class GPA information, as well as grade averages on specific examination questions tied to the departmental learning outcomes for the course.

Retention and Course Success

Each of the four sections filled to capacity with 35 students each. This means that the study originally included 70 students in the combined no-cost classes and 70 in the traditional classes. (Department wide, 14 sections of non-honors Calculus II were offered serving 370 combined students.) Prior to the University's set date for students to drop a course, 16 students withdrew with a grade of W; the withdrawals were evenly distributed amongst the sections with 4 W's in each class. Each instructor used four midterm examinations and a comprehensive final exam to assess student mastery of the material. However the treatment of homework differed between instructors with Deng using an optional homework grade worth up to 6.6% of the semester average and Ritter using a required homework grade worth 15% of the final semester average. (Measures of Learning Outcomes as discussed later did not include homework grade data.) The DFW rates for the study sections along with recent historical DFW and departmental rates are given in Table 1.

Instructor	Spring '15 No-Cost	Spring '15 Traditional	Fall '14	Spring '14
Deng	34.30%	25.70%	28.60%	25.50%
Ritter	45.70%	42.90%	36.10%	49.00%
Department Wide		48.90%	44.20%	45.80%

Table 1: DFW rates for no-cost and traditional sections by instructor with departmental and recent historical data.

Each of the two investigators taught one or more sections of Calculus II in spring and fall of 2014 (data is averaged across multiple sections where applicable). This information is included for comparison. We see that the DFW rates for the no-cost sections are slightly higher than for the traditional ones. It is not clear whether this difference results from the choice of course materials. Overall, the DFW rates for all

¹ Throughout, the term *Traditional* is used to denote those classes in which students were required to purchase or otherwise obtain the text *Stewart Calculus 7th Ed.*

study sections are well within the normal range for the department and are consistent with rates for the specific instructors involved. Deng observed a higher rate of attendance in his no-cost class, but a higher level of aptitude in his traditional class. Ritter's classes were very similar in terms of aptitude, though attendance was better in the traditional class. In Ritter's no-cost class 12 out of 31 students, a full 38.7%, received homework averages below 70%. By comparison, only 8 in 31 students (25.8%) had homework averages below 70% in the traditional class.

The overall GPA data for the classes along with historical data for the investigating instructors and the department are given in Table 2.

Instructor	Spring '15 No-Cost	Spring '15 Traditional	Fall '14	Spring '14
Deng	2.39	2.68	2.56	2.77
Ritter	2.10	2.19	2.27	1.93
Department Wide		1.96	1.99	1.98

Table 2: Class GPAs for no-cost and traditional sections by instructor with departmental and recent historical data.

The class GPAs show a similar difference between the two class types with the no-cost students having a slightly lower overall GPA. But again, the class GPAs across all study sections are above the departmental average for the same course. And the differences between instructors are consistent with historical data for each. Interestingly, the class with the highest number of final semester letter grades of A was Ritter's no-cost class. The distribution of grades A, B, and C are shown in figure 1.

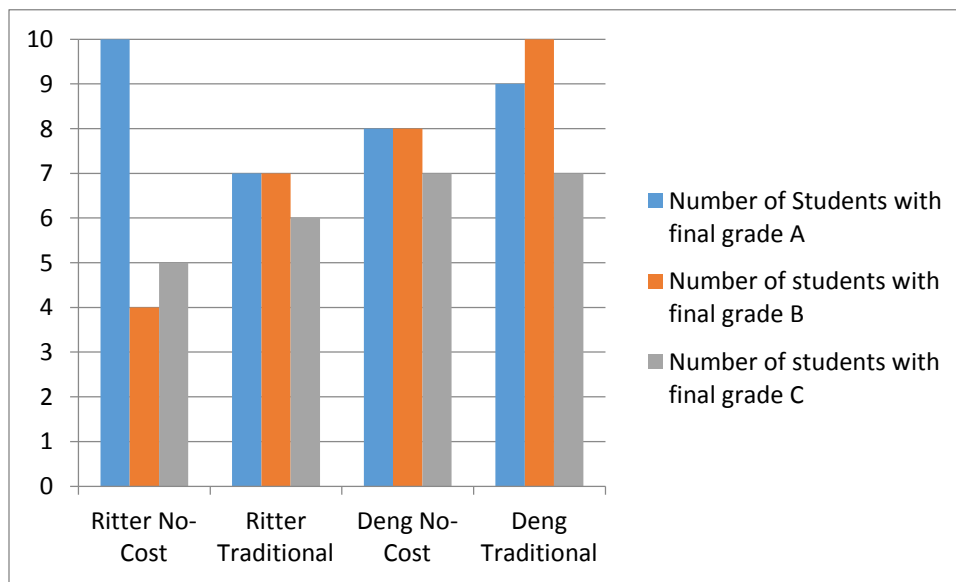


Figure 1: Distribution of letter grades A, B, and C by instructor and class type.

Assessment of Learning Outcomes

The department has a set of five specified learning outcomes for MATH 2254. Each of these outcomes is analyzed by every faculty member teaching the course, and the results are presented in a Faculty Course Assessment Report (FCAR). As indicated in the proposal for this study, professors Deng and Ritter

collaborated on the inclusion of embedded exam questions for the students in this study. Although the exams were written independently, the common questions were based on the course learning outcomes. Each professor in the study recorded measures for each learning outcome based on semester exam questions, final exam questions, and the average of these two measurements. The results are presented as a class average of percentage of maximum possible points available on target question(s). The learning outcomes (which will be identified by the numbers 1—5) for MATH 2254 are:

Upon completing this course students should be able to:

- 1) Find derivatives and integrals of transcendental functions.
- 2) Apply techniques to evaluate integrals.
- 3) Use tests to determine series convergence.
- 4) Determine Taylor series for common functions.
- 5) Describe curves in parametric form and polar coordinates

The departmental sets a suggested *success criterion* as being 70% or above on the overall average for each outcome. Individual instructors are at liberty to raise or lower this criterion. The following figures show the FCAR data for the four sections in the study. The FCARs are included as appendix A.

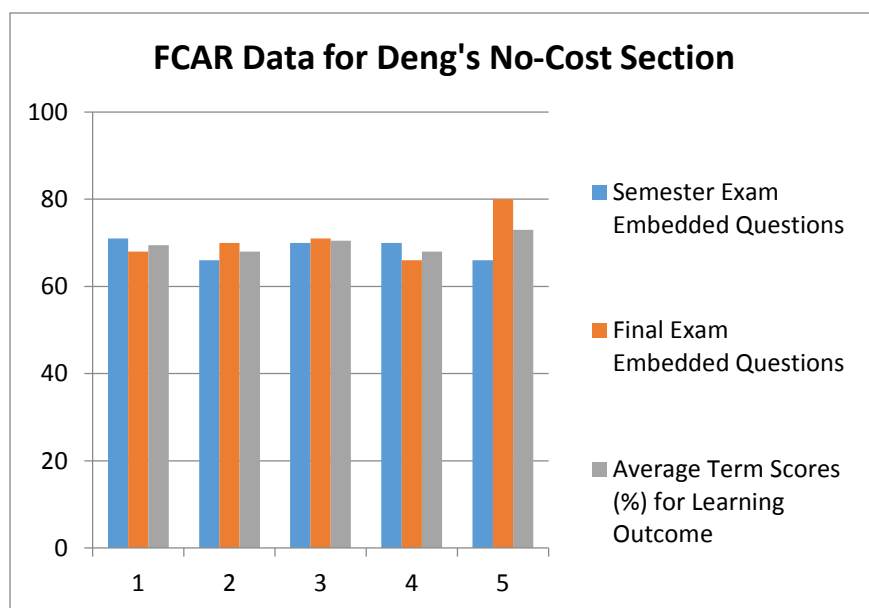


Figure 2: Measures of Learning Outcomes for Deng's No-cost class. The horizontal axis corresponds to learning outcome by number. The vertical axis is %.

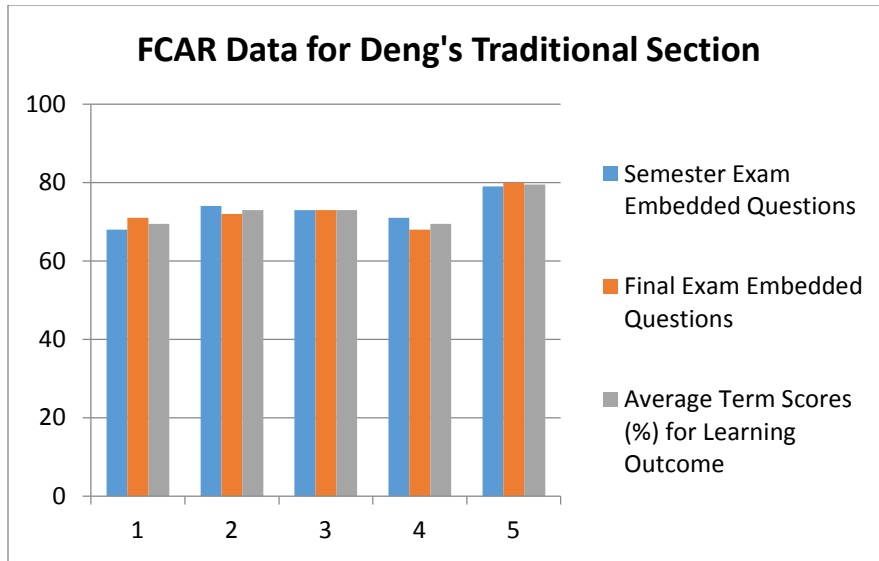


Figure 3: Measures of Learning Outcomes for Deng's traditional class. The horizontal axis corresponds to learning outcome by number. The vertical axis is %.

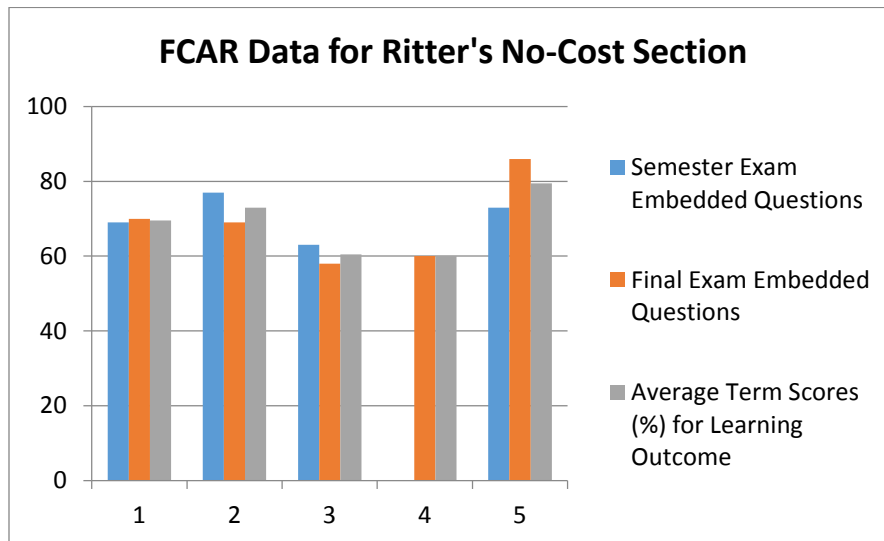


Figure 4: Measures of Learning Outcomes for Ritter's No-cost class. The horizontal axis corresponds to learning outcome by number. The vertical axis is %. Material for outcome 4 was covered after the last semester exam, so no semester exam data is available.

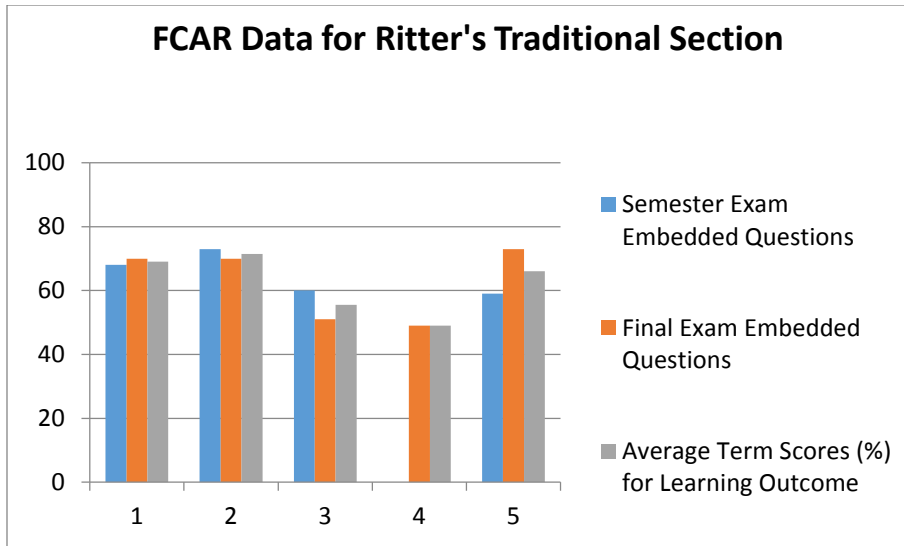


Figure 5: Measures of Learning Outcomes for Ritter's traditional class. The horizontal axis corresponds to learning outcome by number. The vertical axis is %. Material for outcome 4 was covered after the last semester exam data is available.

There is no appreciable difference in the measured success by learning outcome for the no-cost versus traditional text students. Figure 6 shows the average of the measure of success of learning outcome across both no-cost and both traditional sections. (The values are computed as the average of the "Average term scores" for each instructor according to text type, no-cost or traditional.)

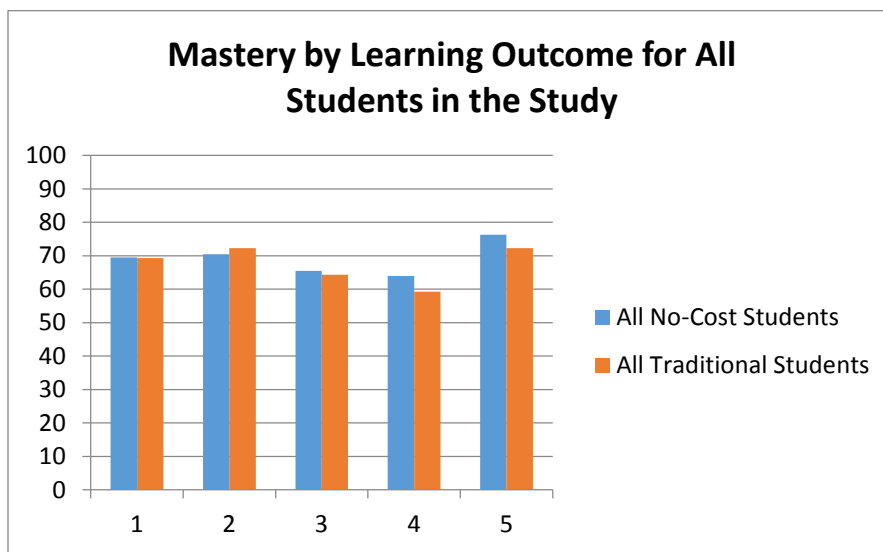


Figure 6: Measure of each learning outcome (1--5) for all students according to text type.

Qualitative Analysis

We sought to determine student perspective on the texts chosen for the no-cost sections as well as their experience with WebWork and with the adapted format we created—i.e. the online text portal. To this end, we conducted a survey of the students in the no-cost classes a few weeks prior to the end of the

term. In keeping with the requirements for our IRB approval, the survey was purely voluntary and anonymous. Several students agreed to participate. (It should be noted that not all participants responded to every question.) The survey instrument with the tallied results is included as appendix B.

We asked the students to rate each of the Guichard (Whitman) and APEX calculus texts on several factors. These are

- 1) ease of navigating the electronic textbook;
- 2) ease of finding important results (formulas, definitions);
- 3) comprehensibility;
- 4) instructions given for exercises in the text;
- 5) difficulty of exercises in the text;
- 6) and overall text quality

The responses were overwhelmingly neutral to positive for both texts. For example, only 3 out of 43 respondents found navigating Guichard “somewhat difficult”, and similarly 3 out of 43 found navigating APEX “somewhat difficult.” Students were asked to rate each text using a scale of 1—5 with 5 being the best. For example, the options for rating navigability were

1= Extremely difficult, 2= Somewhat difficulty, 3= Neutral, 4= Fairly easy, and 5= Very easy.

The student responses are illustrated in figure 7. The values shown are calculated by multiplying the number of respondents giving a particular numerical score by that numerical score, adding these products, and dividing by the total number of responses to that question. For example, when asked about navigating Guichard, 3 students rated it “2”, 17 rated it “3”, 17 rated it “4”, and 4 students rated it “5”. This gives a numerical score shown in figure 7 of $\frac{3(2)+17(3)+17(4)+4(5)}{3+17+17+4} = 3.54$.

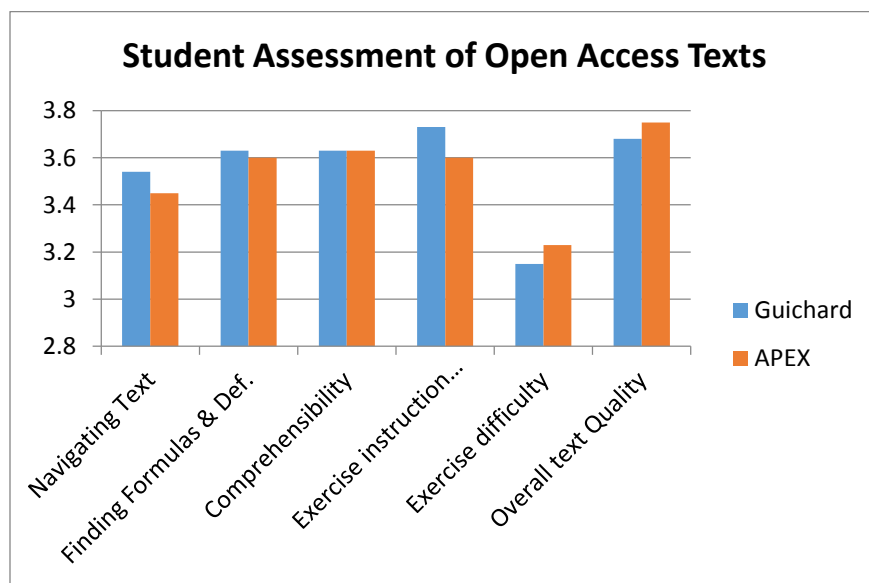


Figure 7: Averages of student assessment of the chosen course texts. Properties are rated on a scale of 1 to 5 with 5 being the best.

We see that the texts were generally well received by the students. Given that the Guichard is available in an early transcendentals format, these results will serve as strong evidence of acceptability when we request future permission to attempt Calculus I and/or II using these open access text books.

We had some serious concerns about the ease of access given the use of two textbooks. The online portal page that we designed to serve as a single text was used by the majority of students. Of the students who participated in our survey on the texts, 42 responded to questions about how they accessed the text. Only 8 students, 19%, reported downloading the texts and using downloads exclusively. The remaining 81% used the portal page at least occasionally in conjunction with having downloads; 16 of 42 (38%) used the portal exclusively. We were pleased to find that students had an overall positive experience with the portal. We asked them to rate their experience, again using the 5 point scale with 5 being the best, on

- 1) navigation using the portal page,
- 2) the quality of the page layout, and
- 3) the quality of the coordination between the texts using the page.

The results of the survey are given in figure 8. The values were calculated using the same averaging schematic as the results in figure 7.

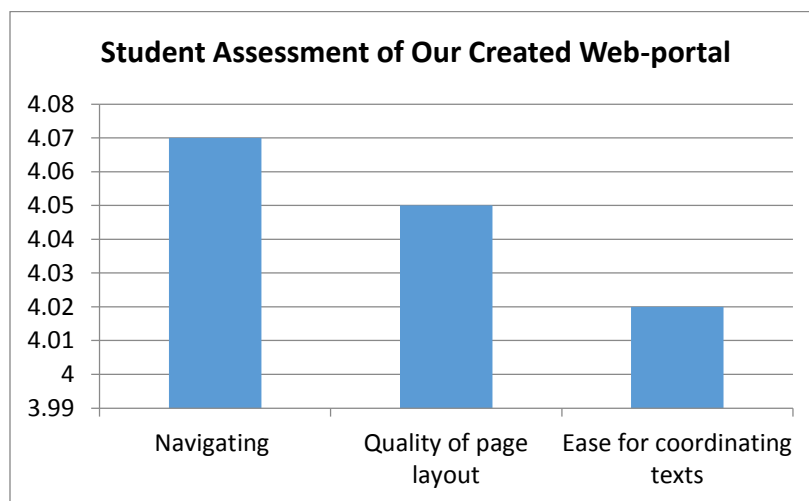


Figure 8: Results of student survey questions regarding the text web portal. Averages are given for a 1-5 point scale with 5 being best.

These responses indicate to us that our approach to the two-text problem was effective in meeting the needs of the students in the course. In addition, the students on the whole reported no marked, perceived detriment to their learning in the course. We posed the following question about their general experience with no-cost materials:

1. Use of the no-cost materials (*select all that apply*)
 - a. Probably has not affected my understanding of course content (for good or bad). **17**
 - b. Has made it easier to understand the course concepts and/or keep up with the class. **17**
 - c. Had made it more difficult to understand the course concepts and/or keep up with the class. **1**
 - d. I believe it has positively impacted my grades in this class. **13**

- e. I believe it has negatively impacted my grades in this class.

Each number in bold is the numbers of respondents who gave that response. We happily note that no student who participated in the survey perceived a negative impact on his or her grade.

We posed a similar question about the use of WebWork, the no-cost online homework system.

- 2. The WebWork online homework system (select all that apply)
 - a. Probably has not affected my understanding of course content (for good or bad). **6**
 - b. Has made it easier to understand the course concepts and/or keep up with the class. **19**
 - c. Had made it more difficult to understand the course concepts and/or keep up with the class. **2**
 - d. I believe it has positively impacted my grades in this class. **20**
 - e. I believe it has negatively impacted my grades in this class. **1**

Unfortunately, two students did report difficulty with WebWork, and one felt it negatively impacted his or her grade. Interestingly, the two students who chose option c. were both in Deng's section in which homework was not a required part of the semester grade. The one student who chose option e. was from Ritter's section in which homework was required. Despite this sad fact, 20 students believed that the homework system had a positive impact on their semester grade.

Additional Information

We surveyed students in all of the study sections, no-cost and traditional, to get a sense of student use and experience with textbooks. This survey also contained some demographic (class, major) information, and is included in appendix C. Some of the results were similar to data available elsewhere. For example, the Lumina Foundation (sited on the ALG By-the-Numbers page) reported 30% of students not purchasing a required text in 2013. We found that 25 of our 85 students surveyed (29%) reported not purchasing required materials in a math class. Most of those reported mastering the concepts without the required material and perceiving no negative grade impact as a result. About 45% of the students also report a preference for hard copy as opposed to e-texts. We see a bit of inertia amongst both students and faculty when it comes to making a transition between the classic textbook and modern electronic alternatives.

Conclusions

As stated, the future of open access materials for Calculus at the new KSU is still unclear. We do not have complete freedom to make changes to course material for courses deemed *general education*—this includes Calculus I and II but not Calculus III. However, the results of the current program indicate that there is no negative impact on student performance and learning outcomes when no-cost materials are substituted for traditional ones. The impact on DFW rates and assessment of learning outcomes is neutral to negligible. Moreover, student response to the alternative texts and the methods we used to combine them were neutral to positive. These results arm us with strong evidence to support introduction of open access materials into the Calculus I and II sequence.

5. Sustainability Plan

As we have noted, circumstances within the department have changed significantly due to the SPSU/KSU consolidation. While we attempted to prepare for how such changes could affect the future implementation of our pilot, we were unable to anticipate all consequences of the new structure we find ourselves working within.

The department decided during the fall 2014 term that post consolidation, the Calculus I, II sequence would be taught in the *early transcendentals* format. We chose the Guichard text in part because it is available in both early and late forms, and the APEX text is already in our new format. This will not require us to choose different texts, however it will require a complete remodel of the text portal. In particular, chapters A and C will need to be replaced with material appropriate to the early transcendentals structure. Fortunately, Ritter can undertake this task during the process of creating a similar online portal for Calculus I. The creation of Calculus I and redesign of Calculus II will begin in fall 2015. However, the texts for these courses may not be ready for implementation prior to summer 2016.

Future offerings with the no-cost materials for the Calculus I & II sequence will also require permission from the math department's Curriculum Committee. (These courses fall under the heading of *general education courses* and hence have a standardized text and topics list.) We have discussed this requirement with the department chair Professor DeMaio. He informed us that report from this study will likely meet the requirements of the Curriculum Committee for future implementation.

The SPSU/KSU consolidation has also impacted the IT services and the web presence of the new University. Ritter contacted IT services to determine what steps would be required to maintain the pages and associated files used in this program (in addition to his other faculty related pages and files). Amanda Leith, project manager for the OU Education Consolidation project, informed us on May 8, 2015 that all pages and files will be migrated to the new system in the near future. We will receive URLs and credentials once the migrated pages are available. We do not anticipate any problems, but have been assured that IT will assist us if we find any discrepancies.

6. Future Plans

One of the unexpected benefits of our program was that it brought to our awareness the expanding selection of high quality open access texts available for mathematics courses. While the future use of open access for the Calculus I & II sequence at the new KSU is unclear at this point, several high demand courses for engineering students do not require departmental approval for the text. The notable cases in point are Differential Equations and Linear Algebra. SPSU has been running about 20 sections a year (Fall-Spring-Summer) of Differential Equations serving roughly 650 students. Linear Algebra serves 250–300 students annually. I (Ritter) have identified top notch texts that have received the American Institute of Mathematics approval. And depending on my teaching assignments, I will be using these no-cost texts in my future courses beginning as early as Spring 2016. (These courses are high on my request list as they are consistent with my field of expertise.)

As part of my participation in this program, I attended the South Eastern Sectional conference of the Mathematical Association of America (MAA) in March 2015. I submitted an abstract to present our program which was accepted for inclusion in a session on Calculus. This section of the MAA serves

Alabama, Georgia, North and South Carolina and Tennessee. I was able to share with local colleagues a wealth of resources on open access materials as well as present information on the ALG Georgia Initiative. That presentation, which includes links to external resources as well as our adapted text, is available on my Faculty *Research* website. (The presentation in pdf is available here: http://educate.spsu.edu/lritter/MAA2015_Talk.pdf Hyperlinks appear on slides in the form of burgundy *buttons*.) Having already received an inquiry into our adapted text by another Georgia faculty member, the presentation at the MAA conference was an opportunity to share these resources with a broader audience including faculty from neighboring states. Interestingly, I was unable to find any programs analogous to the ALG initiative in the four other SE states (the only accessible programs I found were Georgia's and California's.) Fortunately, the resources highlighted in the presentation are available without respect to location.

I will share an updated version of this presentation, one that will include our pilot results, at the 2016 SE Sectional meeting at the University of Alabama at Birmingham. The current program results will also be used to support a trial of the no-cost text in Calculus I at KSU once the text is adapted for the course in the *early transcendentals* format. The trial requires approval from the Curriculum Committee. The department chair has initially indicated that the current program can be used as such support, and there is precedent within the department for using alternative teaching materials within standardized courses.

7. Description of Photograph

The photo is that of the investigators, Professor Shangrong Deng on the left and Professor Lake Ritter on the right. We are posing in one of the KSU Marietta Campus classroom with one of the slides from Ritter's no-text classes in the background. The heading on the slide shows reference to our no-cost text in which we used a lettering system for the chapters to coordinate between two text books.