GOOD TEACHERS BORROW, GREAT TEACHERS STEAL: A CASE STUDY IN BORROWING FOR A TEACHING PROJECT

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ABSTRACT
Very few great ideas in teaching are without ancestors or descendants. This paper presents a case study in how one particular pedagogical project, the work at Saint Louis University as part of the National Science Foundation supported SUMMIT-P consortium, borrowed from other sources. The particular project was an interdisciplinary collaboration to make mathematics education more effective for business students. The various borrowings are treated in roughly chronological order from initial inspiration through planned adoption and adaptation of the work of others to the addition of features that only became available mid-project. The kinds of sources include a particular business calculus project, a pedagogical movement, other members of the SUMMIT-P consortium, and independent math technology projects including PreTeXt, WeBWorK, and GeoGebra.

KEYWORDS
borrowing, mathematics, business

Very few great ideas in teaching exist without ancestors or descendants. Instead, most good ideas come about because someone hears of an innovation from someone else and says either "I can do that" or "I can do better than that." Additionally, good projects generally incorporate features from other projects. This paper explores this practice within A National Consortium for Synergistic Undergraduate Mathematics via Multi-institutional Interdisciplinary Teaching Partnerships (SUMMIT-P), a National Science Foundation supported collaborative project with nine institutions working together. The Consortium is looking to expand the implementation of the recommendations of the Curriculum Foundation Project (CF) (Ganter & Barker, 2004; Ganter & Haver, 2011), developed by the Mathematical Association of America's Curriculum Renewal Across the First Two Years (CRAFTY) committee. Each institution picked at least one partner discipline and asked how to make mathematics instruction more effective for their partner discipline in their local context. The institutions were chosen to have a broad range of sizes and types. This paper will focus on the borrowing connected to the project at Saint Louis University (SLU), the first author's institution, but will involve borrowings connected to other consortium members. Our project looks at making mathematics instruction more effective for business students, but the practice of borrowing from the work of others easily translates to other contexts.

Phases of Borrowing

The borrowings will be broken down in phases based on SLU's SUMMIT-P project. As is typical for many grants there is a significant amount of work done before any proposal is written, a pre-project that starts the vision of the project. As with many projects, we started with a first idea from someone else that inspired us. During a talk at a conference, a speaker made a comment on using Excel in calculus for business students. As the project matured, we consciously looked for related pedagogical projects that could be borrowed from to make the implementation of our first idea stronger. This involved a literature search to see what others have tried. We wanted to see what others had done with calculus for business students and what they had done with Excel. As the project became more defined, we looked for other projects that have useful features which we could borrow. We joined SUMMIT-P, a collaborative project, and this involved a concentrated effort to look at the other sites in the consortium to see what could be harvested, either for our local SUMMIT-P project or for other classes on campus. This broadened the project from simply looking at a specific course, Business Calculus, to looking at making the mathematics education of business students more effective. Again, as is typical of any project, there was a shifting of definition and goals of the project, as various ideas were tried and depending on their success, pursued or modified. There were several points where we realized we started with the wrong answer to a question. There were also several points where we realized someone else had a better way to do something we wanted to do.

For all of the SUMMIT-P projects, the pre-project phase included some connection with CRAFTY and specifically with the CF guidelines. For SUMMIT-P there was then the forming of the consortium and bringing the projects together. This allowed borrowing from the other consortium members' pre-projects. As the implementation has proceeded, the SUMMIT-P members have been meeting with each other at the annual Joint Mathematics Meetings. There have also been a series of site visits among the members of the consortium. Both the meetings of the consortium and the site visits provide an opportunity for sharing ideas and materials.

Phase I: Historical Borrowing

Felkel and Richardson made a presentation at the International Conference on Technology in Collegiate Mathematics (ICTCM) in 2002 with the claim that business students should be taught mathematics mainly using spreadsheets instead of graphing calculators. The seed was planted. They pointed out that a spreadsheet, Excel in particular, was the computational engine of choice in the business world. At the time, incorporating spreadsheets seemed like a good idea that could be added to courses at SLU at some point when time was available. Implementing the idea then would have required using a computer classroom which was not easily accessible at that time. Five years later, the time was right to implement the idea in courses at SLU. The first attempt at implementation of Felkel and Richardson's (2006) ideas at SLU involved simply using their book, *Networked Business Math* (NBM). Our major change to their setup was to run the course with student laptops rather than a computer classroom. This first stage was simply a textbook adoption with an appropriate pedagogical shift. We simply wanted to adopt and adapt the course that Felkel and Richardson developed at Appalachian State University for SLU. We planned to offer feedback from the SLU experience to the textbook authors to be used in the next edition of the book. However, Felkel and Richardson had moved on to the next phase of their careers, which meant there would be no new edition of the book. To continue to use their concept meant creating a new version that used the approach. From the pre-project phase, we moved from borrowing to a phase of borrowing and improving.

Phase II: Turning an Idea into a Project

In the second phase we decided to write a book inspired by NBM. Our initial plan followed the structure of NBM and incorporated several features that differentiated the textbook from other one-semester calculus textbooks. For example, the examples emphasized business applications. Terminology and notational conventions in the book followed the practices used in business and economics. Numeric methods allowed for the development of concepts before the use of symbol manipulation formulas. At the same time, we made some changes that we felt also improved on the work of Felkel and Richardson. For example, instead of incorporating Maple examples and exercises, we incorporated a free online computer algebra system. We adjusted the use of Excel to eliminate macros and instead use it like a spreadsheet with small steps rather than like a graphing calculator with compact formulas. We consulted with the business faculty to supplement the topics covered and determine the order of the topics. For example, the business faculty believe partial derivatives and optimization are more important concepts for students than integration and should therefore be covered earlier in the course (May, 2013).

As the project grew, we desired to see if it could be grant supported. Looking for grant support requires a search of the literature to see what else had been done in the same direction. The search brought up CRAFTY CF and a textbook developed by Lamoureux and Thompson (2003) at the University of Arizona. The search provided reassurance that many of the ideas we had developed and incorporated in our book had also been thought about and implemented by other faculty at other institutions and were ideas that were supported by groups like the MAA. The literature search also led to thinking about why previous projects along the same lines had died out and asking ourselves, "How can we do it better?" The project was transformed from simply developing a new version of NBM to designing and writing a business calculus book, *Business Calculus with Excel* (May, 2019).

Phase III: Becoming Part of a Consortium

As drafts of *Business Calculus with Excel* were being solidified and class tested, an opportunity arose to join the SUMMIT-P consortium. Joining the consortium resulted in a broadening of our focus. Instead of just focusing on business calculus, we decided to make the study of mathematics in general more effective for students majoring in business disciplines. In particular, a central part of the effort would be a faculty seminar in the form of ongoing structured discussions between the faculty in the SLU Department of Mathematics and Statistics and the School of Business to understand which mathematics concepts and skills were important for business majors and what the business faculty wanted to help their students accomplish mathematically in their courses. A group of faculty from both disciplines have a monthly meeting or seminar to discuss how to make mathematics instruction more effective for business students. The business faculty involved in the meetings include representatives of each of their departments. This structure is directly borrowed from the CF recommendations. Our variation on the approach was that instead of having faculty from across many schools and departments at SLU discuss needs in mathematics over a weekend, we would have faculty from one school discuss the matter over several years. The extended discussion has allowed us to look at modifying the instruction in both disciplines. From the mathematics perspective, the discussions have allowed regular review of examples and presentations in mathematics classes to make sure terminology, notation, and applications based on business concepts and scenarios are correctly applied. Early discussions started with the standard issue of the mathematics that the business students did not know even if they had been covered in prerequisite courses. This led to conversations about techniques for identifying students who have gaps in their backgrounds and intervention strategies that could be employed without turning the business faculty into mathematics faculty. This has led to borrowings between the two disciplines related to the way they each operate that will be described later in the paper.

Phase IV: Discussions Do Not Go as Planned, Time for More Borrowing

The SLU project co-PIs started the faculty seminar with what they assumed to be a clear idea of where the business faculty would want to focus. We wanted to extend our work beyond the introductory business calculus course to higher level mathematics courses that are part of business majors and were confident that the business faculty would endorse the plan. We were wrong. Other than the co-PI from finance, the rest of the business faculty who participated in the seminar rarely used mathematics at a higher level than calculus in their undergraduate courses. For them, the bigger problem was student misunderstandings and misuse of lower level mathematics concepts and the hurdles these issues caused in business courses. While the business faculty were happy with the changes we made to Business Calculus, they felt that we should focus our efforts on College Algebra for Business instead of on advanced mathematics courses. This left us looking for examples of CRAFTY CF oriented, college algebra for business courses. We looked to other SUMMIT-P consortium members who had developed successful college algebra courses based on CF recommendations. Virginia Commonwealth University (VCU) had developed such a course before the start of SUMMIT-P (Ellington & Haver, 2011).

The first author arranged a visit to VCU to see how their course was organized and what materials they had developed. The VCU course was designed with different goals and with a

different audience in mind than what was envisioned for the SLU course. VCU aimed at a general education student audience with standard technology being used in the course instead of focusing on the particular needs of business majors. The course activities and assignments focused on the use of graphing calculators on a regular basis and only occasionally incorporated the use of Excel during lab activities. The lab classes added an extra contact hour to the course per week. With a larger student population than SLU, VCU offered many sections of College Algebra, so the course was highly coordinated. However, it also was solidly based on a modeling approach to developing concepts and skills and used a textbook that was compatible with the CF recommendations. VCU had developed worksheet materials that were ready to use. In particular, students routinely used functions based on real world data to explore algebra concepts.

We decided to pilot a single section of College Algebra for Business that fit into the standard course schedule time frame, met the learning objectives of the traditional college algebra course, and used Excel instead of the graphing calculator. The following semester offered the course using the textbook that VCU was using. We incorporated some of their organizational ideas and a series of worksheets that they had developed. In subsequent semesters, we have switched textbooks and modified the worksheets. Two particular worksheets were the foundation for developing a modeling-with-Excel thread that extends throughout the entire course. Questions on tests throughout the semester require students to find best fitting curves for a provided set of data. While the course has continued to be redesigned at SLU, borrowing VCU's basic model provided a foundation for developing a modeling based course, College Algebra for Business, at SLU. After observing students at VCU engaged in active learning in small groups, the first author had an idea for what was possible with SLU's course.

Phase V: Borrowing from Planned Site Visits

The design of the SUMMIT-P grant includes two rounds of site visits between members of consortium institutions. The visits serve several roles. They provide an outside perspective for feedback about the institution's project. They also provide an opportunity for the visiting institution to borrow materials, methods, and ideas from the institution being visited. Since each institution's project has a different scope and focus, the borrowing has taken the form of borrowing ideas or materials that were developed before the SUMMIT-P project instead of direct borrowing between ongoing SUMMIT-P projects.

LaGuardia Community College (LCC) visited SLU in the second year of the SUMMIT-P project. They are working with a model of pairing classes offered in the subjects of college algebra, trigonometry, and economics where the students in a particular section of one course also take a particular section of another course, and the two instructors coordinate how content is presented between their respective courses. During the site visit, LCC faculty were introduced to materials from the book *Business Calculus for Excel* (May, 2019), and they adapted these materials for some of their courses. For example, the algebraic review material in *Business Calculus for Excel* is presented through examples with contexts in economics. From this perspective, systems of linear equations are used to understand situations like finding market equilibrium, and solving quadratic equations is used for finding break-even points. LCC faculty met with SLU students taking College Algebra for Business during the site visit. Based on the discussion, they adjusted their approach to getting students to enroll in their courses by enlarging the role of advisors. This led to a more successful implementation of their paired classes idea.

A PI from Ferris State University (FSU) was part of a team visiting SLU in the second year of the SUMMIT-P project, and SLU visited FSU in the project's third year. As a result, FSU has adapted some of the materials and approaches they learned about during the site visits to revamp how they are introducing Excel into quantitative reasoning projects. During the FSU site visit, the SLU team was impressed with the materials FSU had developed for Quantitative Reasoning for Professionals, a two-semester course sequence at the intermediate algebra level. Based on institutional need, the FSU material could not be incorporated in SLU's intermediate algebra course. At FSU, quantitative reasoning fulfills the graduation requirement and is often the last mathematics course taken by many students. At SLU, intermediate algebra is taken by a small student population, most of whom need to take another mathematics course, typically College Algebra. However, we determined that the FSU quantitative reasoning material had great potential for a course offered in SLU's program for inmates at a regional prison. Students in the program are developing their skills in finite mathematics. They do not have internet access to complete online homework. Motivating concepts and skills with applications to real life situations is important for them. The FSU material is worksheet-based and incorporates mathematics concepts and skills into a semester long project. For example, running a shelter for victims of human trafficking or building a Death Star.

In each of these cases of sharing between institutions involved in the SUMMIT-P project, borrowing took the form of using a feature that had matured and been used for several years at one institution and incorporating the feature in a different way in a project at another institution that perhaps involved a different mathematics course or student population.

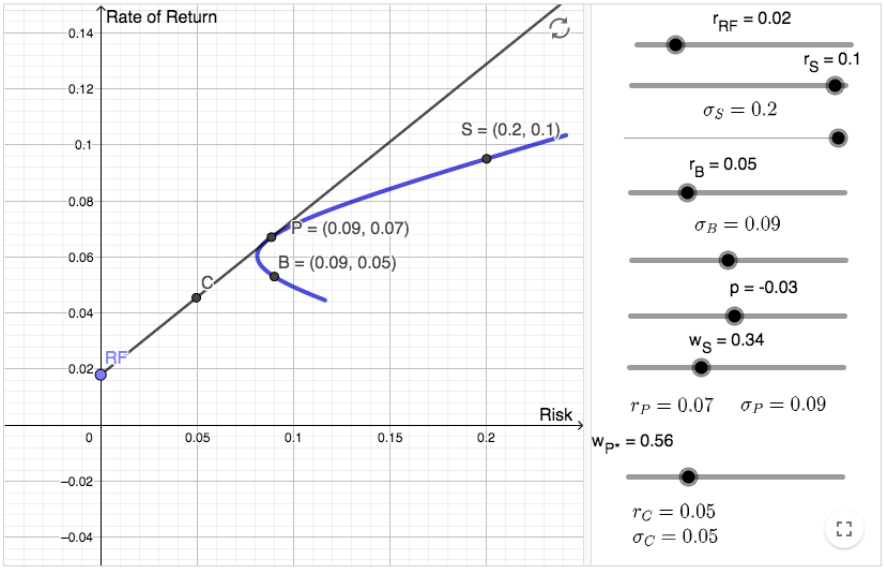
Phase VI: And the Borrowing Continues

One of the interesting kinds of borrowing for an interdisciplinary project is the borrowing that can be described as taking tools and methods that the mathematics community has been using for years and applying them to another discipline. In mathematics, we have always been concerned with placement level and prerequisite knowledge and have built structures for student success that include placement tests and remediation. SLU's partner discipline of business does not have a history of similar concerns. We used WeBWorK to create a series of online prerequisite skills tests for a number of courses in the SLU School of Business so that business faculty can identify the students who need remediation in material not directly taught in business courses and direct them to online resources designed to cover the specific mathematical skills needed (Bart, 2018).

Mathematics also has a long history of incorporating visualization tools, like GeoGebra, to create dynamic presentations for course content. Our partner discipline does not appear to have a similar history. We have started to develop an online GeoGebra book (i.e., a collection of GeoGebra applets) called *The Mathematics of Finance* (May, 2019) to be used in demonstrations that can be incorporated in business courses. The demonstrations allow the user to adjust the parameters for the function of a graph and then evaluate the function for a given value. This helps distinguish between parameter values for a given curve and the variable values where it is evaluated. For example, in Figure 1 the parameters are the rate of return and risk for two investments, S and B for stocks and bonds, as well as a correlation of the risks. The blue curve represents portfolio performance. The weighting of the investments gives a portfolio performance, which is a point on the curve. Changing the parameters (the right side of Figure 1) changes the shape of the curve, while changing the variable changes the position on the curve.

GeoGebra also allows for the graphing of the locus of points as the parametric values are changed. This may seem mundane from the mathematics perspective, but it is exciting and useful from the business perspective.

Figure 1
GeoGebra Demonstration of Investments



A final kind of borrowing is using new technologies from other projects to make technical details work better. The first version of *Business Calculus with Excel* (May, 2019) was produced as a set of Word files that were posted to the internet. Since then the technology for developing and presenting online textbooks has improved. PreTeXt is an open source technology, developed in part through a National Science Foundation grant, to develop and present mathematics textbooks online. We learned about PreTeXt at a Joint Mathematics Meeting workshop and have converted our textbooks to this presentation technology. We are in the process of converting all the homework problems to a WeBWorK format so that technology can be part of the grading process. With the WeBWorK version the students will get better feedback about their work and will get it instantaneously. The numerical values in the problems are randomized so that each student will solve versions of the problems. It also has a "Show me another problem" feature, which provides students with the opportunity to practice with different variants of a problem. The people behind the WeBWorK project are also working to improve the integration of GeoGebra with WeBWorK, which will allow randomized problems where the solution requires sophisticated numerical methods which are beyond the first author's ability to code. With the utilization of both GeoGebra and WeBWorK, borrowing involved changing to a different technology when we found a better way to handle some aspect of our project.

Conclusions

As the above narrative illustrates, our pedagogical project, much like pure research projects, builds on work accomplished by others and routinely incorporates techniques devised by others. The project started with an idea we learned about during a talk at a conference that we thought we would get to when we had time. We wanted to use their book. Trying to adapt their

idea to our situation meant the project would grow. As adopting a book turned into writing our own book, we consciously started looking at how other people had dealt with similar situations to ours. In our search, we found other innovators had produced technologies we could use, like PreTeXt, WeBWorK, and GeoGebra. We also found a community of people with similar interests in CRAFTY and an effective network to work with in the SUMMIT-P project. Joining the network pushed us to broaden our vision from producing a book to working with the needs of a discipline. It also gave us a structure for better interaction with the faculty of that discipline. The interaction with the business faculty helped us improve the consistency of problems students explore when studying the two disciplines. It also let us share teaching techniques and strategies between the disciplines. At several key points, we found the interaction with the business faculty was leading us in unanticipated directions. We were able to consult with the SUMMIT-P network and find ways that other schools had tried to deal with similar problems. That let us adapt a working product rather than starting from scratch.

Borrowing or stealing (with appropriate attribution, of course) helped us turn an idea from a talk at a conference into a great teaching project.

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