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Engaging Students Early by Internationalizing the Undergraduate Calculus Course

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Abstract: Today's world is global. However, despite increasing numbers and diversity of participants in Study Abroad programs, only 10% of U. S. college students get that experience. There is an ever-growing need for students to become aware of and experience other cultures, to understand why others think and act differently. Internationalization is the conscious effort, begun nearly 40 years ago, to integrate an international, intercultural, and global dimension into the purpose, functions, and delivery of post-secondary education.

Albany State University began a Global Program Initiative in the 1990s. In 2016, we extended into mathematics the curriculum innovations of this program. The result has engaged students in a serious way, both in mathematical modeling and in cultural research. We have introduced students to new skills of research and presentation. For the past few years we have offered one section of Calculus II in traditional mode and one in internationalized mode, and we have compared results. In this article, we give details of the process and highlight the success of the program. We end with more recent examples from Spring 2020.

1 Introduction

Engaging students is my passion. Albany State University in Albany, Georgia, has been focusing for some years on new teaching strategies aiming, among other things, to engage students in an international context and to keep them from switching out of STEM majors (science, technology, engineering, and mathematics). At Albany State, many students are the first in their families to attend college and to have had the educational opportunities and the resources that are taken for granted amongst students elsewhere. I myself came from Nigeria at age 8; I was very fortunate to have mentors who got me to where I am today. I want to pass on this preparatory knowledge so that more students will be able to pursue higher education on an equal footing with their peers. In 2016, I was invited by the Office for Global Programs to join one of their workshops for Internationalizing the Curriculum: Faculty Development Training ([https://](https://www.codee.org/)

[//www.asurams.edu/academic-affairs/oie/oie-publications.php](http://www.asurams.edu/academic-affairs/oie/oie-publications.php)). I had already successfully added research and presentation components to various early mathematics courses so that students would not be waiting until senior theses to learn these skills. Adding an internationalization focus made for a much richer experience. In 2020, I brought some of my students to the Joint Mathematics Meetings in Denver to give them more experience and further raise their horizons.



Figure 1: Chinenye Ofodile (far right) with students brought to Denver for JMM 2020. From left to right: Robert Lavender, Erria Gates, Amiralca Johnson, Darlena Mills, Tavis Jackson. (Photo by B. West.)

At those meetings I gave a talk on my successful effort to “Internationalize the Undergraduate Calculus II Course,” which led to an invitation to contribute to the CODEE Journal. Here I will explain how this program came into being and report on the results of the first two years, Spring 2018 and Spring 2019. Finally, I will conclude by sharing the work of the most recent students enrolled in Spring 2020.

2 Global Program Structure

The term “internationalization,” originally used in political science and governmental circles, emerged for education some 40 years ago as the conscious effort to integrate an international, intercultural, and global dimension into the purpose, functions, and delivery of post-secondary education [5, p. 4]. Jane Knight (University of Toronto) has been at the forefront of defining this movement from the beginning and has worked with universities, governments, and UN agencies in over 70 countries.

Albany State University came on board early, in the 1990s, with the establishment of a Global Program Initiative, and has expanded it ever since. We had very few students interested in the study abroad program, not even enough of them to apply for available funds. So we decided instead to bring the global experience into the classroom.

Internationalizing the curriculum became a major focus. Early departments to join included History, English, Finance, Music, and Education (teacher preparation). Later, Mathematics was added to the list. Interested faculty were required to attend intensive professional development workshops for new teaching strategies.

That 2016 workshop was key for me. The outstanding speakers, Dr. James Hill, Dr. Michael Smithee, and Dr. Nneka Nora Osakwe, all shared insights from their many years of experience, and we learned about internationalization efforts in other courses. Dr. Osakwe asserted “Albany State is at the forefront of publishing what faculty members are doing in curriculum internationalization. There are many publications with information on internationalizing the curriculum on campuses, but not many about what faculty actually do in the classroom. You see lots of publications that talk about what should be done or about principles.”

The workshop included the following topics:

- Infusing Internal Perspectives in Courses
- The Internationalization of Curriculum at Albany State: Reflections on a Disparate Evolution
- Internationalization: Learning Outcomes and Assessment

We also discussed revisions to syllabi, assignments, activities, course assessments, and the inclusion of presentation and manuscript components.

3 Introducing Global Components into Calculus II

Subsequently, we compared and analyzed two sections of Calculus II offered at Albany State, a traditional section and an internationalized one whereby real world problems were added to the first differential equation they encountered, $y' = ky$.

The students in the internationalized section, working either as individuals or in pairs, were asked at the beginning of the course to pick a real world topic where a population seemed to be increasing (or decreasing) at an ever greater (or slower) rate. They were assigned to

- research the culture and background for that topic.

When they reached $y' = ky$ at the end of the course, they were then asked to

- solve the DE and find parameters to fit the data found in their research and predict future behavior;
- suggest interventions that might diminish the rate of change.

Students really dug into their topics, did the math, and thought hard specifically about the last requirement. In addition to writing up their work as a proper research report, they had to present it in class and later at regional meetings. In 2018 and 2019 we were able in some cases to have the teams report their ideas to appropriate local agencies (yet another skill!) and have agencies respond that they would try some of the interventions.

4 The Internationalized Sections of 2018, 2019

Below are important details about the internationalized sections in 2018 and 2019:

- Class size: 17 in 2018; 12 in 2019
- Instructional practices: Group Work, Quizzes, Exams
- Assessment practices: Exams (4), Quizzes (4), Problem Solving (daily applications)
- Writing Assignments, Homework, Research Component
- Internationalizing content areas:
 - Students were assigned to a group by the professor.
 - Each group was assigned a topic by the professor. (Later, students were given the option to choose their own topic.)
 - Each group researched the culture and way of life of the country or region for its chosen topic, prior to application and content).
 - Real world applications/examples were distributed to each group, containing various content areas.
 - Each group was able to master the content area by relating the culture to its application.
 - Each group then used their data to fit parameters to the solution of $y' = ky$.
 - Each group then could predict and analyze future behavior and suggest interventions.
 - All students were assessed by their doing a presentation in front of their peers; they were assessed both as groups and individually. See Figures 2, 3, 4. (Students later also presented their work at regional conferences.)
- International research topics for 2018 and 2019:
 - Refugee Crisis in Greece;
 - The Unemployment Epidemic in Nigeria;
 - Health Problems in Lower Socioeconomic Areas of the US;
 - Increasing Rates of Human Immunodeficiency Virus in Dougherty County;

- Economic Growth & Development in The City of Albany and Dougherty County;
- The Effect of the One Child Policy in China.

Comparing the internationalized class with the traditional class, we found promising benchmarks:

- There was an increase of class performance incorporating internationalization.
- The passing rate was higher in the course in which internationalization was incorporated.

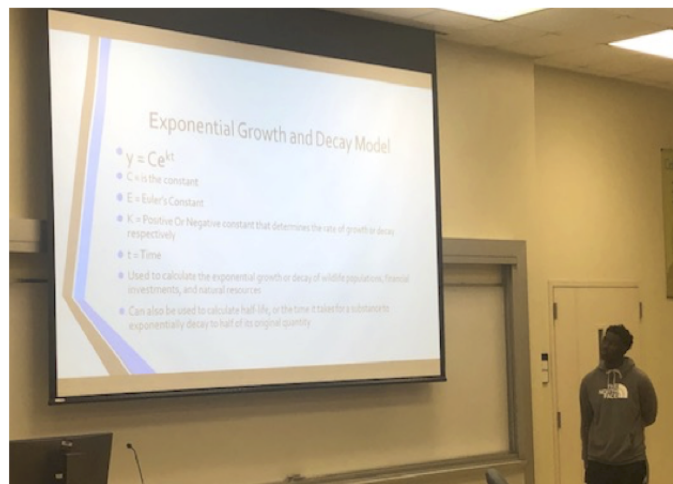


Figure 2: Explaining the mathematics (Class photo).

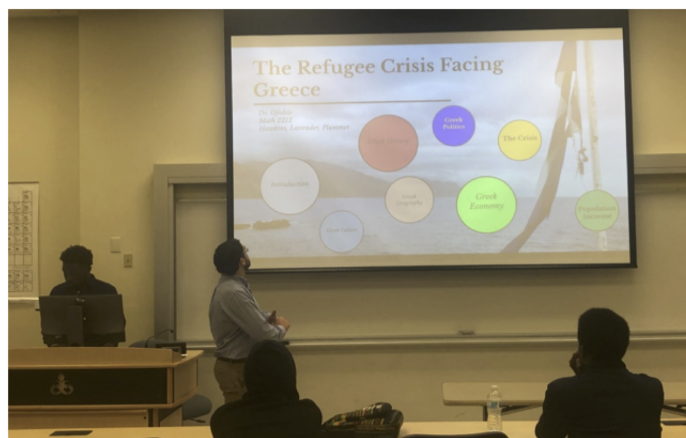


Figure 3: A slide from the Greek Refugee Crisis presentation (Class photo).

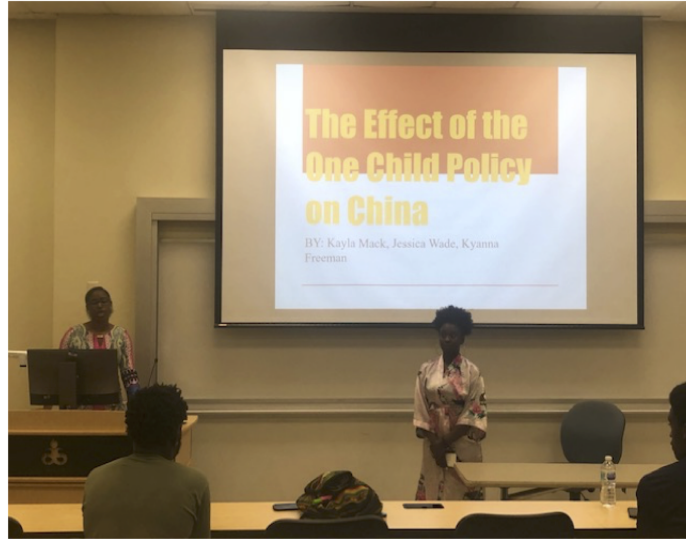


Figure 4: A slide from the One Child Policy in China presentation. Note how this student went all-out and wore Chinese clothing to emphasize the Chinese culture. (Class photo).

5 Changes in Spring 2020

After the Denver Joint Mathematics Meetings in January 2020, and after the Spring semester began, COVID-19 disrupted almost all of our plans. The switch to online instruction was especially difficult for students without resources at home; we lost the chance to help them get their papers into LaTeX, to present them to varied audiences, and to work together over the summer on polishing the drafts for publication. We did succeed, however, before the semester ended, in getting preliminary drafts of the papers in progress. These drafts were subsequently finished as much as possible given the many hurdles of reorganizing the students' lives.

The international research topics for 2020 included some previous topics and some new ones:

- i. The Refugee Crisis in Greece;
- ii. The Unemployment Epidemic In Nigeria;
- iii. Cardiovascular Disease in the United States;
- iv. The Impact of HIV in Georgia, USA;
- v. The Effects of Abortions in Georgia, USA;
- vi. Prevention and Control of Coronavirus Outbreaks in the Last Twenty Years;
- vii. The Increased Rate of Homeruns by Year in Major League Baseball;
- viii. Employing Youths Aging out of Foster Care.

Exactly as the previous students had done, the 2020 students enthusiastically dug into their topics, applied the math, and thought hard about that last requirement to suggest ways to modify the exponential trends. Their diverse choice of topics is fascinating. Section 7 presents a summary of several 2020 projects with links to the students' papers, somewhat edited. Due to the COVID-19 disruption, we did not have a chance to truly refine them.

6 Preparing Student Papers

Please keep in mind that these are written by beginning college students, with little of the prior research and mathematical writing experience of many of their peers. What should come across is the total engagement, and diligence at research, that is precipitated by asking a key question about exploring the simplest differential equation.

When I introduce $y' = ky$ in class, I give the usual presentation of the general and particular solutions. I use the half-life example to discuss exponential growth versus decay, depending on whether k is positive or negative. Then we spend considerable time, over several class periods, analyzing student bank accounts. Students each receive a monthly check and are instructed to deposit it in a bank. Some students withdraw money to buy textbooks, etc., and others just leave the money to grow. They then bring in three months of bank statements and compare with their individual growth rates.¹ They had to do research and analyze their accounts, and then project the growth from the 3 months (one quarter) to 12 months (1 year). The individualization of this task really engaged them, while teaching them skills they would need for their international research projects. Because the solving of this DE was worked out so thoroughly in class, you will note that many of the papers tend to work directly from its solution, $y(t) = Ce^{-kt}$.

You may think some of the students' research conclusions and suggestions are ingenuous; the point we are making, however, is how thoroughly the students become engaged. They have learned many new skills, including research, writing, and presenting to others, even in their very first contact with differential equations. If there had been more time in the semester (and the summer) for discussion and feedback, students would have modified their models. Nevertheless, they have greatly broadened their horizons and been introduced to possible studies and careers they never had imagined. They are better prepared to pursue future modeling and research.

7 Student Papers, Spring 2020

All of these student papers can be found at <https://scholarship.claremont.edu/codee/vol14/iss1/1/>.

¹When I asked the students "How did you determine which bank to use?" I gave three choices: "parents' bank, the most convenient, or the bank with the highest interest?" The most frequent answer was "parents". But this question made them think about other options.

7.1 Refugee Crisis in Greece

Refugees have been streaming into Greece in ever-increasing numbers, creating huge pressure on the Greek economy, healthcare, and tourism. The steadily rising queue of applications for asylum has created an ever-increasing backlog. Robert Lavender and James Hawkins delved into Greek history and culture, tabulated data, and using the exponential solution to $y' = ky$, projected into the future. They suggest that the strong character of the Greek people would prevail. A key would be to process the asylum claims more quickly – then new immigrants could be employed to stimulate the economy.

7.2 The Unemployment Epidemic in Nigeria

Unemployment numbers in many African nations are among the highest in the world. Nigeria has one of the top rates, and is often seen as having no opportunities. Tavis Jackson maintains a global perspective as he digs into the background of the problem from many angles. With extensive research (23 references!), he studies the history, traditions, and economy of Nigeria. He lists several avenues to lower the unemployment rate – concentration on infrastructure (water, electricity, roads) will improve living standards; access to education (schools and universities) must include emphasis on training with new technologies. These corrections will lead to more and better jobs.

7.3 Cardiovascular Disease in the United States

Cardiovascular diseases (CVD), which include heart diseases, strokes, and other problems involving narrowing or closed blood vessels, are the leading cause of death in the United States. They affect men and women of all ethnic and racial populations. Risk factors include age, inheritance, and many lifestyle choices. AunJrae Barnes details all of this, and concludes that targeting these risk factors can make a great difference. It was much harder than expected to gather data, because every website seemed to give data for only a year or two at a time, and used a different measure (with different combinations of diseases under the CVD label). Eventually a site was found that gave CVD deaths (all in the same measure) from 1950-2017; this data was used to predict future levels.

7.4 The Impact of HIV in Georgia, USA

Of the southern states, Georgia has had the highest rate of HIV/AIDS cases, and good data is available. Consuela Blue researched the disease and its effects on people, then using data from 2013-2017 predicted forward. She points out that personal decisions are extremely important in fighting this disease, and proposes ways to help people make better decisions.

7.5 The Effects of Abortions in Georgia, USA

For more than a decade, Georgia, USA has had one of the highest abortion rates in the United States. Jazlyn Meeks discusses all the aspects of this controversial topic – physical,

psychological, social — and the difficulties encountered by many women. Giving women support and education had been successfully lowering the annual numbers of abortions from 2010 to 2015. But then the data for 2016-2018 showed disturbing increases. By fitting parameters to the data from 2012 and 2013, the graph shows a gradual decline, with a projected continuation to 2022. More attention to the mechanisms that had been successful until 2015 should further lower the curve.

7.6 Prevention and Control of Coronavirus Outbreaks in the Last Twenty Years

Coronaviruses that affect humans include those responsible for the SARS and MERS epidemics, for which we can find much data, and the unprecedented pandemic of COVID-19, for which data is still evolving. Increased contact with wild animals and the ever-expanding travel issues in this age of globalization seem to be prime causes. Mohammed Najeeb wrote his paper in Spring 2020, when COVID-19 was just beginning in the United States; his data ends during April. After examining the data and information on how SARS and MERS were contained, he concentrates on outbreaks in Georgia, U.S.A. and how “shelter in place” and social distancing seem to be key to bringing the numbers down.

7.7 The Increased Rate of Homeruns by Year in Major League Baseball

Baseball was the subject that engaged Pierce Thomas, who looked at the increasing number of home runs every year, most recently after the era of steroid scandals. He investigates what might be the causes of recent spikes, and suggests modifications to the pitchers’ mound to restore more excitement to the game.

8 Conclusions

Internationalizing our Calculus II course has been a very positive move, but it is only the beginning. When I was approached with an interest in internationalizing a course, I first envisioned internationalizing a particular course, Calculus II. However, while teaching that course, my vision for internationalizing expanded into other courses and included collaboration with different disciplines on research that incorporates both content based and pedagogical skills.

As a result, workshops and seminars across the university have been created with an intent to internationalize more courses. In addition, relationships across disciplines have also been created. We plan internationalization projects in Calculus III, Differential Equations, and other higher level courses, so that students will be thoroughly prepared when they begin their senior theses. Our big picture is to get all professors involved.

We are building partnerships with colleagues at Georgia State University, The Georgia Institute of Technology, Kennesaw State University, Florida State University, and other universities. We are also entering partnerships with other universities for the National Science Foundation REU (Research Experiences for Undergraduates) programs to expand

the students' experience. (Two of our mathematics students had applied to the 2020 REU at University of California, Berkeley, but COVID-19 cancelled that.)

The students in our internationalized Calculus II courses have greatly broadened their horizons, at the beginning of their college experience; they have been introduced to possible studies and careers they never had imagined. That trip to Denver in January 2020 was the first time some of them had left the city of Albany, GA. They are now eager to move forward. At the JMM meetings we met with various exhibitors, such as NSA, and forged new relationships, such as with University of Pittsburgh (computational biology), and with IBM in North Carolina (corporate sector).

Before COVID-19 interrupted everyone's lives, we were planning spring break trips abroad to increase students' exposure to the cultures they were researching. Online teaching has been far less successful than our former methodologies, but when the pandemic is behind us, we expect to be able to again move forward with our original ideas.

Other obstacles were faced prior, unrelated to the pandemic. The unfortunate problem with the last paper (Employment for Youths Aging out of Foster Care) brings a word of caution in general. Collecting appropriate data was unexpectedly difficult for many of the students. What they needed sounded so simple – just a list of annual figures over a span of at least five years. All too often that was not readily available – many sites tended to give data for only one or two years, and worse yet, these isolated bits of data were often to different measures, as already mentioned for cardiovascular diseases, so the figures given were not comparable from year to year.

We have found two ideas that can help with the data problem:

- Writing to “Ask a Librarian” at the Library of Congress. Be warned, however, that this may not be a very quick fix. It can result in multiple exchanges, and more hours than students (or professors) have available.
- Asking the college or university library to assign a class librarian to the course. This can greatly increase the efficiency of the searches, because this person would understand the course goals, and the students would have a single contact for search assistance. We have a colleague in humanities who has taught online courses for many years with research components; when Harper College (near Chicago) started the class librarian concept a few semesters ago, the quality of student papers there immediately showed vast improvement.

Our internationalized students are definitely becoming better prepared to pursue future modeling and research. Already some of them from the first years of the program have continued with higher level math courses, and some have fulfilled my vision by heading to graduate school. One student has completed a master's degree in Data Studies at Columbia University and returned to Georgia for a good job. Others are pursuing Engineering at University of Illinois and Computer Science at University of Alabama. Most recently, three students from Spring 2020 have already moved from Albany State to Georgia Tech to pursue Engineering.

It has been a good beginning.

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