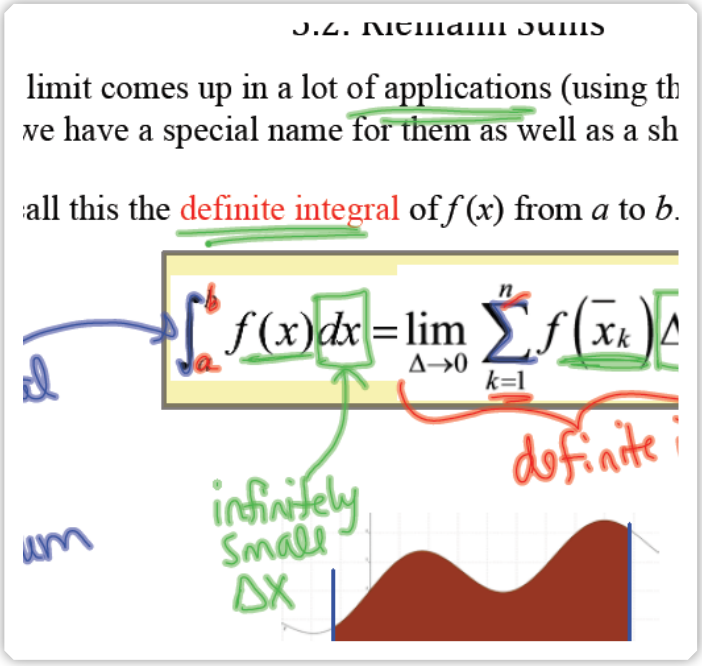
2013 IG FINAL REPORT

Department of Mathematics (2415)

A Little Flipped: Priming Learning with Prelectures in an Upper-Level Math Course



This project contributed to creating a technology-enhanced course path from 1151 through 2415 using instructional models (e.g., HyFlex, flipped) that afford student choice to experience "lecture" outside of class and use the inside of class time for active learning opportunities. This project introduced some elements of the flipped classroom into the 2415 curriculum, with the result that students engaged more actively with the material and reported greater appreciation than in traditional versions of the course.

The Ohio State University

Office of
Distance Education
and eLearning

Executive Summary

Goals

Math 2415 is a differential equations course for engineers designed to help engineers and scientists apply mathematics in their given major choice. This project introduced the use of online materials between class sessions (called "prelectures") as a way of preparing students to engage in active, collaborative learning during class time. The goal of prelectures was to enable students to remind themselves of crucial concepts they should already have known or to prepare for a new context that the upcoming class time will cover. The in-class time was also designed to be more interactive than in the past.

Outcomes

All of our goals were achieved. The students consistently completed the prelectures and found them helpful. Additionally, students participated more during class time than in previous semesters. Class time was also more interactive than in past semesters with student input altering how class time was spent.

Process Analysis

The project went well with all goals being met. The prelectures are being used and adapted in the current semester. Students continue to find them helpful. We are presenting on our findings at several conferences in 2014 and reviewers have reported interest and excitement about our findings.

What We Learned, in a Sentence

Students consistently participated in and enjoyed the prelectures and there was evidence during class that students were more prepared to participate in classroom discussions.

5 Talking Points

1. Articulate provided a good platform to introduce mathematical ideas to students before class time.
2. Students appreciate being reminded of previous mathematical ideas that will be used in class.
3. Students appreciate beginning mathematical contexts at home before class time so that they are prepared to participate in lecture.
4. Students participate more when they have a better understanding before class begins.
5. Interactive class time was made possible because of prelectures as well as because of the classroom settings. More classrooms with furniture designed for active learning and collaboration would be helpful for implementing this kind of reform.

Project Committee

Department of Mathematics

Lead

- **Darry Andrews** <dandrews@math.osu.edu>, Course Coordinator

Team

- **Greg Baker** <baker@math.osu.edu>, Faculty
- **Jenna Tague** <tague.6@math.osu.edu>, Online Material Developer and GTA
- **Amanda Roble** <roble@math.osu.edu>, Assessment Consultation

Task-Specific Team Members

- **Bryce Steel** <steel.28@math.osu.edu>, Tech Liaison

Office of Distance Education and eLearning (ODEE)

ODEE Project Lead

- **Henry Griffy** <griffy.2@osu.edu>, Grants Coordinator, ODEE Digital Scholarship

ODEE Constituents

- **Robert Griffiths** <griffiths.44@osu.edu>, Director, ODEE Digital Scholarship and Development
- **Tom Evans** <evans.1517@osu.edu>, ODEE Open Courses Coordinator

Project Goals and Objectives

Overview

Math 2415 is a differential equations course for engineering students. Generally the students are sophomore engineering students, although there are many students in science majors as well. Dr. Baker has written his own textbook to specifically meet the needs of engineering students at The Ohio State University, and is currently overseeing all sections of 2415.

We recognized that a large amount of mathematics learning occurs outside of the classroom and that active learning during class is necessary for learning. When students seek help outside of the classroom, they tended to utilize Internet resources. For the past three years, Dr. Baker and his math education graduate students have been introducing instructional technology and obtaining student feedback about the use of these technologies. We have revised the course components from term to term based on student feedback and access to new technologies. Thus, we have sought instructional media that would enable anytime/anyplace learning. These technologies include posting lecture videos through Adobe Connect, holding HyFlex office hours through Adobe Connect, and posting LiveScribe PenCast video solutions for difficult problems.

We proposed a flipped classroom format for our course because we have noticed over several iterations of this class, that students come in with missing or inappropriate background knowledge. Because of this, we chose to focus on these mathematical difficulties or obstacles in designing prelectures. We created Articulate prelectures that included content from past courses or introduction to mathematical contexts to be discussed in class the next day. Then the class time "lectures" were used for more student interaction, hands on learning, and problem solving.

The prelectures and class time were assessed using two sets of surveys: a large online pre- and post- as well as 4 in-class paper surveys.

Goals achieved

- **Re-design and build materials for flipped presentation:**
    - Provide online materials that students access before class, replacing traditional lecturing
    - Allow for flexibility and for the current instructor to add their own materials to the course
    - Create templates and style guides to ensure consistency and minimize instructor effort
        - *This goal was met. We prepared a 5-15 minute prelecture for all but five days of in-class time.*

- **Choose, integrate, and configure Learning Management System(s)**

    - *This goal was met. We chose Articulate Storyline and continue to use it during the current semester.*

Goals partially achieved

- **Re-design and build activities for the course structure:**

    - *We are still working on a good at-a-distance office hours solution, however all of the Math 2415 students are on-campus currently, so this is not essential.*
    - *The course could be put on a HyFlex synchronous form in the future however if need calls for it.*

- **Develop implementation plan and materials**

    - *We did develop the implementation plan and materials, but it was not clear our students that our section was a pilot section. We will make this clearer in future semesters.*

Goals not achieved

- **There were no goals not achieved.**

Goals not actively pursued

- **There were no goals not actively pursued.**

Project Implementation

Students affected by pilot

There were approximately 80 students enrolled in Math 2415. All of the students participated in the prelectures as a part of the course.

Approximate time spent by department faculty and staff on the project

TEAM MEMBER	HOURS
Greg Baker	200
Jennifer Czocher	50
Amanda Roble	50
Jenna Tague	150
Total	**450**

Approximate total cost (not including ODEE staff time)

RESOURCES	COST
Articulate license	[shared with 1151 team]
Total	**0**

Project Implementation Process/Timeline

MILESTONE/DELIVERABLE	TARGET	ACTUAL
Finalize Charter	Mon 3/18/2013	April
First Online Activity Prototypes (Mind-maps, storyboard, etc.)	Fri 4/12/2013	May

Decisions made about media types for online activities (based on online activity prototypes)	Mon 4/15/2013	May
Media templates and shared style guide completed	Mon 4/22/2013	July
1 online activity prototype of each course created	Fri 4/26/2013	July
Course Syllabi Drafts	Sat 5/11/2013	July
First in class prototypes	Sat 5/18/2013	July
IRB surveys and assessment plan completed	Sat 6/1/2013	July
Registration window open (incoming college students)	Tue 6/4/2013	On time
Carmen designed	Mon 6/3/2013	July
CITI training complete	Sat 6/8/2013	Pre-project
Decision about the amount of inclass support (TAs, tutor, something else) necessary	Mon 6/10/2013	June
2415 All materials (flipped material and in-class activities) for 1st third of course	Sat 6/15/2013	October
Finalize IRB submission	Mon 6/17/2013	August
IRB submission	Sat 6/22/2013	August
2415 All materials (flipped material and in-class activities) for 2nd third of course	Sat 7/13/2013	November
2415 All materials (flipped material and in-class activities) completed	Sat 8/10/2013	December

First day of class prep	Mon 8/12/2013	August
Final courses built & ready	Sat 8/17/2013	August*
First day of classes	Thu 8/22/2013	
Final day of classes	Wed 12/4/2013	

Relation of Charter Timeline to Project Timeline

There was a delay on when the first third of the course was completed for Math 2415. Since there is only one section of Math 2415, we designed the pre-lectures through a combination of our anticipated ideas of student needs and the actual students needs we observed in the class. Pre-lectures were thus created on a weekly basis throughout the course, rather than as a set of materials ahead of time.

Project Assessment

Outcome summary

The pre- and post-course surveys online were completed by 58 and 20 students, respectively. The low return rate on the post-course survey might be due to its administration being close to finals.

Overview of Assessment Plan and Methods

The study was carried out using survey methods using an existing instrument (Powers, Bright, & Bugaj, 2010). There were two types of surveys: a large online pre- and post-survey and four smaller in-class surveys. The questionnaires focused on many aspects of the adaptation of instructional technology in mathematics courses, but specifically the questionnaire asked three questions related to course cohesion:

1. I expect pre-class multi-media materials to prepare me to participate in class activities (group discussion, problem solving, etc.)
2. As a result of the out-of-class material, I expect to be confident in my understanding of the concepts that each module covered.
3. I expect the in-class activities to be clearly coordinated with the pre-class material.

These questions were given on a 5-point Likert scale and the verb tense was changed from the pre- to the post-questionnaire. Results of the survey were analyzed using Qualtrics descriptive statistics. Students were also given the opportunity to provide open-ended feedback on the surveys and qualitative responses were coded accordingly.

The in-class surveys asked the following questions related to the prelectures:

1. Did you complete the prelectures this week? (Circle one) All Some None
2. Were the lectures related to the prelectures this week?
3. If they were related, give an example of something from a prelecture that you felt was useful in a lecture.

Highlights from Assessments

- Of the 20 students who took the post survey, 65% met or exceeded their expectations for how the course was designed and taught.
- Our main purpose was to investigate the efficacy of a method of applying the flipped classroom model in a meaningful and coherent way that is based in theory of mathematics teaching and learning. Analysis suggests that a focus on cognitive

obstacles relative to the in-class material improves coherence of the course in the flipped classroom model.

- Although the change in mean on the second question above did not change significantly, the standard deviation nearly doubled. The reasons for this were explained by the open-response questions about aspects of the course. Students indicated that they either did not need the additional help and so found little use in the prelectures or they really appreciated the introduction to lecture material.

Details from Assessments

Table 1. Results from the online pre-survey.

QUESTION (5 PT LIKERT)	PRE-COURSE MEAN (SD)	POST-COURSE MEAN (SD)
I expect pre-class multi-media materials to prepare me to participate in class activities (group discussion, problem solving, etc.)	3.67 (0.95)	3.60 (0.67)
As a result of the out-of-class material, I expect to be confident in my understanding of the concepts that each module covered.	3.16 (1.03)	3.10 (1.94)
I expect the in-class activities to be clearly coordinated with the pre-class material.	3.88 (0.89)	3.90 (0.97)

Of the 20 students who took the post survey, 65% met or exceeded their expectations for how the course was designed and taught. Table 2 shows the results from the questions related to the online modules. There was no statistically significant in students' perceptions of the alignment between in- and out-of-class materials. This suggests that they found the materials helpful in maintaining instructional coherence. Although the change in mean on the second question above did not change significantly, the standard deviation nearly doubled. The reasons for this were explained by the open-response questions about aspects of the course. Students indicated that they either did not need the additional help and so found little use in the prelectures or they really appreciated the introduction to lecture material.

Table 2. Results from the in-class surveys.

	SURVEY 1 (N=59)	SURVEY 2 (N=62)	SURVEY 3 (N=53)	SURVEY 4 (N=55)
Completed all the prelectures	85%	82%	72%	81%
Prelecture was related to the lecture	85%	74%	85%	96%

Our main purpose was to investigate the efficacy of a method of applying the flipped classroom model in a meaningful and coherent way that is based in theory of mathematics teaching and learning. Analysis suggests that a focus on cognitive obstacles relative to the in-class material improves coherence of the course in the flipped classroom model. In this way, flipped classrooms models can provide a way of addressing cognitive obstacles in addition to being an alternative and cost-effective option.

Experience of Teaching with Learning Technology

Survey

Please indicate how strongly you agree or disagree with the following statements:

1. The use of technology improved student learning in my course.

   Strongly Agree

2. The use of instructional technology improved my teaching.

   Agree

3. My students had the technology skills needed to succeed in my courses.

   Strongly Agree

4. My students had adequate access to hardware and software.

   Strongly Agree

5. There was adequate network access for all on-campus activities.

   Agree

6. I spent too much class time teaching technology to my students.

   Disagree

7. Additional comments or feedback

Effect of Learning Technologies on Instruction

We continue using prelectures through Articulate Storyline because of the effect of participation we saw in students. We have altered some of them due to student requests, but overall it has changed the way that we begin class time and the kinds of interactions that take place during class time. Our class sessions are much more interactive now and we hear from a wider range of students rather than a select few.

Effect of Learning Technologies on Learning Outcomes

The Articulate Storyline prelectures had the biggest effect on learning outcomes. Although there was no change in student exam scores or homework scores, we saw a big change in participation during class time. Additionally we saw an increase in the depth (conceptually) of student ideas shared during class time.

Best examples of effect of technology on teaching

In the past, when we have introduced the mathematical modeling of pollution in a dam, students are slow to choose variables. There are usually long silences and the instructor must lead the students to the variables. Now with the prelecture, students have ideas about the variables and parameters that are a part of the problem, understand the difference between variables and parameters, and can move much more quickly to trying to mathematize the problem which is the stage that traditionally students have more trouble with.

Challenges

One of the biggest challenges currently with all technologies is the lack of ability to write mathematical symbols easily. Students cannot enter mathematics and instructors cannot enter mathematics for students to see (at least without struggle). There are also no technologies that allow students to draw diagrams or pictures, which is also problematic for solving mathematical problems.

Assessment of Assessment Plan

There was a large survey developed for use in both Math2415 and Math 1151. We found that we needed more specific details about the connections between the prelectures and the in-class time. Because of this, we developed our own survey given in-class four different times. In the end, the combination of the large online survey and the shorter in-class paper surveys provided us with the feedback and data we needed.

Experience of Tech-enhanced Teaching

Technology training and prep time increased significantly the first semester we used the prelectures. This semester (SP14), our prep time is back to normal though. The technology training was also somewhat difficult at first, especially getting Articulate to work Carmen, but one we figured that out, it was much easier.

From a pedagogical perspective, we really had to examine what past mathematical ideas and new mathematical ideas were needed for the next lecture. It allowed us examine and re-organize some of the course concepts in a different more conceptually coherent way.

Moving Forward

We are running the course this semester (SP14) the same as in the previous semester, so we have mainly left all of the elements the same. We kept a running log of the positives and negatives of each prelecture, and have revised them as necessary for this semester. We will continue to use them for as long as we are teaching the course and are presenting on this method at several conferences. We believe it will be well received in the mathematics education and engineering education communities!

Impact Grant Experience

Survey

Please indicate how strongly you agree or disagree with the following statements:

1. I am satisfied with the communication I received from the ODEE staff.

   Strongly Agree

2. I am satisfied with the grant project contributions I received from the ODEE staff.

   Agree

3. I have learned the skills necessary to continue related work on my own.

   Strongly Agree

4. I found the ODEE staff approachable.

   Strongly Agree

5. The lessons learned during this pilot will guide future course design.

   Strongly Agree

6. Additional comments or feedback

Reflections on the grant process—what went well

I have to say that the staff members were just fantastic in helping connect us with resources around campus. In particular, when we were having trouble between Carmen and Articulate at the beginning of the year, Henry's help was essential in troubleshooting the problems. It was extremely helpful and necessary support!

Reflections on the grant process—what did not go well

We wished that there had been a bit more thorough training on Articulate Storyline. Although we figured it out, it took stress and time that did not need to be taken.

Key lessons learned

Try to test everything before the semester starts. Create dummy Carmen courses and use them to test out all of the technology!

Suggestions for future recipients

Use the resources suggested by the staff members. There are wonderful people across campus that otherwise you would not know about!

Three words to describe working with the ODEE Team

1. Helpful
2. Supportive
3. Prioritizing

Ah-ha moment of the grant process

See the moment above where we had an excellent lecture because of the technology used during class.

Department Chair Statement of Impact

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Department of Mathematics

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Jan 31, 2014

To Whom it may concern:

First I would like to convey our department's gratitude for the OSU Office of Distance Education and eLearning Impact Grant that we received in early 2013 and to express my satisfaction with the outcome of its application to the development of a Flipped and Flexible section of our largest course, Math 1151: Calculus I. In the early 1990's, our department began an outreach program to Ohio high schools called Calculus Remote at OSU (CROSU) which allowed high school students to complete an OSU calculus course at a distance for OSU credit. CROSU was based on our Calculus with Mathematica course sequence, which we no longer offer. In 2012, I tasked a committee in the department to replace the CROSU program with a new program that would still allow high school students to complete the course remotely, but which would give high school students as close an experience as possible to the experience of current OSU calculus students. The result of this challenge was the conception of the Flipped and Flexible course setup, which not only let high school students remotely attend the same class as OSU students, but which provided a more flexible format for current OSU students and implemented many tenants of current educational research on active learning, all while staying within the current coordinated framework of Math 1151. The Impact Grant and OSU technical support came along at just the right time to help us implement this new course format.

This course format could be correctly described as distance, hybrid, flipped, or hyflex. In the pilot course, the lectures are presented online using Articulate Storyline lessons developed by our project team. These lessons build upon the high quality videos created for our MOOCulus course by reworking them to follow the current Math 1151 course and surrounding them with worked example videos, scaffolding slides, imbedded quiz questions, and choices for students in their path through the material, including how much help they need on specific topics. The recitations for this course are held in classrooms at OSU, but students can attend online through Carmen Connect if they choose. These recitations are groupwork-based, and students present their group solutions to the class. Homework and quizzes are online, but the exams are proctored, paper-and-pencil for security. High school students can take the exams at their high schools, and other OSU students only need to come on campus for the evening common exams. This makes this course format a very good choice for non-traditional students, students on regional campuses, student athletes, and students working full time.

Although there were small technical difficulties, the pilot went quite smoothly. Students performed essentially the same as students in other sections on common exams. We are quite satisfied with this result, considering the students met with an instructor at most 2 hours a week instead of the usual 5 hours a week. It is my impression that students were very satisfied with

the course as well. Students especially commented on how they really appreciated the flexibility of the online lectures. Many students in traditional sections also accessed the online lessons through our Mathematics and Statistics Learning Center website to help them learn the material. A positive consequence of this course format is the ability to offer a large course section without having to find a large lecture hall. Also, students who need to join Math 1151 after the beginning of the semester are still able access the lectures they otherwise would have missed.

I believe that there is definitely a group of students for whom this course set-up is highly beneficial, and the department is committed to continuing to offer a section of Math 1151 in the Flipped and Flexible format, as well as expanding to offer a section of Math 1152: Calculus 2 in this format in Autumn of 2014.

Sincerely yours,

Luis Casian

Professor and Chair

By ODEE Team

The 2014a Math Impact Grant was larger than most previous grant projects, in large part because it involved two distinct courses, developed by different teams for different students and curricula. Planning meetings and progress check-ins were held jointly, while most of the production work and certain aspects of implementation were done by or with each team individually. While this posed some logistical difficulties and complicated the planning process, ultimately the overlapping approach was worth it, as enough work could be accomplished in common to produce a net savings.

Goals and objectives pre and post relation/connection

The 2415 side of the Math project was a success. While less ambitious in scope than the 1151 side, in that it did not involve putting as much of the course online or fully flipping activities, the goals that the team set out to achieve were achieved. The introduction of sophisticated, online prelecture material was a significant step beyond the elearning work the team had previously engaged in. It involved the team learning a new technology (Articulate), developing and introducing a wider range of in-class active learning activities to engage students, and it required mapping this enhanced version of the course into a novel and experimental learning space (Enarson 311). All of this was undertaken with a course covering highly conceptual applications of advanced mathematics.

Given all these variables and complications, the team did a fine job of accomplishing what they set out to do. They further demonstrated smart judgment about what areas of the project deserved more, and which should receive less, effort.

Number and roles of ODEE individuals involved in the grant project

Four ODEE staff played significant roles in this project.

- Henry Griffy, Grants Coordinator, was project lead for ODEE. He convened regular standing meetings, facilitated the planning and implementation of the project, and coordinated the participation of relevant experts when needed.
- Robert Griffiths, Director, Digital Scholarship, consulted on the project at crucial moments.
- Andrew Kuhar, Learning Spaces, provided training and support for the experimental classrooms where the recitations were held.
- Sam Craighead, Learning Spaces (now Digital First), helped identify and schedule experimental classroom space for the recitation section.

Two additional ODEE staff worked with the project team on a distinct project that impacted this project's success:

- Valerie Rake and Vedu Hariths helped establish (and troubleshoot) SCORM-integration of the Articulate learning objects produced for this project.

Approximate number of ODEE people-hours spent on the grant project

TEAM MEMBER	HOURS
Total	**240 (including 1151 and 2415)**

About 1/3 of these hours were spent on the 2415 side of this project.

Reflection of what aspects of the grant process, procedures, and collaboration worked at or above expectations.

Most helpful for this grant was the team's previous experiences and experiments with technology-enhanced learning, coupled with their deep knowledge of the subject matter and how to teach it effectively. This experience enabled the team to add the prelectures into their teaching with minimal disruption and maximum effect. They likewise were familiar with the small disruptions that often accompany pilots of new elearning technology, so were able to accommodate such complications without major impact on the course. (In this case, there were difficulties getting a wireless microphone working in the classroom, as well as some difficulties getting grades from the prelectures to the Carmen gradebook.)

This grant project was to some extent a "two-fer" in that the single grant allowed us to support major revisions to two distinct courses. In addition to maximizing the use of ODEE resources, this dual model had other benefits. Meeting together helped the two teams share insights and solve shared problems together. Using similar tools allowed the teams to learn together.

Reflection of what aspects of the grant process, procedures, and collaboration were below expectations.

Some planned parts of this project were not followed through in large part because of personnel disruptions. Greg Baker, Jenna Tague, and Amanda Roble were the only team members consistently present throughout the project. Similarly, collaborations with some outside teams, such as UCAT, were interrupted before those collaborations could come to fruition. While the project succeeded, more could have been accomplished.

The two-for-one model had some drawbacks, however. Significant differences between the courses meant that some team members' time at some meetings was not well spent. Also, because the courses are (roughly) the beginning and end of a sequence, it was not always clear how to maximize alignments between them.

Three words to describe working with the recipients.

1. Driven
2. Enthusiastic
3. Smart

Describe an "ah-ha" moment during the grant project.

Seeing the teaching model in progress in the experimental space of Enarson 311 drove home the power of this teaching model. I saw a room full of students who could switch rapidly from listening to Greg Baker explain and demonstrate his model of problem-solving to using the model themselves in collaboration with fellow students. When I have seen similar teaching models in traditional classrooms, the students have to "fight the furniture" to work together. This room did not have that problem. Likewise, it was clear that the prelectures had prepared the students to get to work more quickly. Student conversations were not spent reviewing material or basic math, they started with the problem at hand.

Changes to our processes from this grant experience

Most changes to the grants process will involve seeking to replicate and expand on what went well with this project: seek teams with existing experience and momentum; seek departments willing to support projects and build on previous elearning projects; maximize the impact by coordinating as many people as possible.

This project also reinforces a lesson that most course-level design projects teach: a year is not long, so minimize delays and start as soon as possible. We have already taken steps to streamline the planning phase so that work can begin as soon as possible.