

Summer 2017

## Principles of Physics I Lab (Clayton)

Tatiana Krivosheev

*Clayton State University*, [tatianakrivosheev@clayton.edu](mailto:tatianakrivosheev@clayton.edu)

Caroline Sheppard

*Clayton State University*, [carolinesheppard@clayton.edu](mailto:carolinesheppard@clayton.edu)

Patricia Todebush

*Clayton State University*, [patriciatodebush@clayton.edu](mailto:patriciatodebush@clayton.edu)

Bram Boroson

*Clayton State University*, [bramboroson@clayton.edu](mailto:bramboroson@clayton.edu)

Justin Mays

*Clayton State University*, [justinmays@clayton.edu](mailto:justinmays@clayton.edu)

Follow this and additional works at: <http://oer.galileo.usg.edu/physics-collections>

 Part of the [Physics Commons](#)

---

### Recommended Citation

Krivosheev, Tatiana; Sheppard, Caroline; Todebush, Patricia; Boroson, Bram; and Mays, Justin, "Principles of Physics I Lab (Clayton)" (2017). *Physics and Astronomy Grants Collections*. 5.  
<http://oer.galileo.usg.edu/physics-collections/5>

This Grants Collection is brought to you for free and open access by the Physics and Astronomy at GALILEO Open Learning Materials. It has been accepted for inclusion in Physics and Astronomy Grants Collections by an authorized administrator of GALILEO Open Learning Materials. For more information, please contact [affordablelearninggeorgia@usg.edu](mailto:affordablelearninggeorgia@usg.edu).

# Grants Collection

Clayton State University



UNIVERSITY SYSTEM  
OF GEORGIA

Tatiana Krivosheev, Caroline Sheppard, Patricia Todebush,  
Bram Boroson, Justin Mays

---

# Principles of Physics I Lab

---





## Grants Collection

Affordable Learning Georgia Grants Collections are intended to provide faculty with the frameworks to quickly implement or revise the same materials as a Textbook Transformation Grants team, along with the aims and lessons learned from project teams during the implementation process.

Each collection contains the following materials:

- **Linked Syllabus**
  - The syllabus should provide the framework for both direct implementation of the grant team's selected and created materials and the adaptation/transformation of these materials.
- **Initial Proposal**
  - The initial proposal describes the grant project's aims in detail.
- **Final Report**
  - The final report describes the outcomes of the project and any lessons learned.



Unless otherwise indicated, all Grants Collection materials are licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/).

# Initial Proposal

---

## Application Details

---

### Manage Application: Textbook Transformation Grant

---

**Award Cycle:** Round 3

**Internal Submission  
Deadline:** Sunday, May 31, 2015

---

**Application Title:** 140

**Submitter First Name:** Tatiana

**Submitter Last Name:** Krivosheev

**Submitter Title:** Professor of Physics

**Submitter Email Address:** tatianakrivosheev@clayton.edu

**Submitter Phone Number:** 678-466-4783

**Submitter Campus Role:** Proposal Investigator (Primary or additional)

**Applicant First Name:** Tatiana

**Applicant Last Name:** Krivosheev

**Co-Applicant Name(s):** Bram Boroson, Caroline Sheppard, Patricia  
Todebush, Justin Mays

**Applicant Email Address:** tatianakrivosheev@clayton.edu

**Applicant Phone Number:** 678-466-4783

**Primary Appointment Title:** Professor of Physics

**Institution Name(s):** Clayton State University

---

### Team Members (Name, Title, Department, Institutions if different, and email address for each):

Bram Boroson, Assistant Professor of Physics, Department of Natural Sciences,  
bramboroson@clayton.edu

Tatiana Krivosheev, Professor of Physics, Department of Natural Sciences,  
tatianakrivosheev@clayton.edu

Caroline Sheppard, Professor of Chemistry, Department of Natural Sciences,  
carolineclower@clayton.edu

Patricia Todebush, Professor of Chemistry, Department of Natural Sciences,  
patriciatodebush@clayton.edu

Justin Mays, Director, Distance Learning, Center for Instructional Development,  
JustinMays@clayton.edu

**Sponsor (Name, Title, Department, Institution):**

Division of Chemistry and Physics, Department of Natural Sciences, Clayton State University

**Proposal Title:** 140

**Course Names, Course Numbers and Semesters Offered:**

Principles of Physics Laboratory I, PHYS 2211L, Fall 2015, Spring 2016, Fall 2016.

Principles of Physics Laboratory II, PHYS 2212L, Fall 2015, Spring 2016, Fall 2016.

Introductory Physics Laboratory I, PHYS 1111L, Summer 2015, Fall 2015, Spring 2016, Summer 2016, Fall 2016.

Introductory Physics Laboratory II, PHYS 1112L, Summer 2015, Fall 2015, Spring 2016, Summer 2016, Fall 2016.

Principles of Chemistry Laboratory I, CHEM 1211L, Summer 2015, Fall 2015, Spring 2016, Summer 2016, Fall 2016.

Principles of Chemistry Laboratory II, CHEM 1212L, Summer 2015, Fall 2015, Spring 2016, Summer 2016, Fall 2016.

Organic Chemistry Laboratory I, CHEM 2411L, Summer 2015, Fall 2015, Spring 2016, Summer 2016, Fall 2016.

Organic Chemistry Laboratory II, CHEM 2412L, Summer 2015, Fall 2015, Spring 2016, Summer 2016, Fall 2016.

**Final Semester of Instruction:** Fall 2016

**Average Number of Students per Course Section:** 24

**Number of Course Sections Affected by Implementation in Academic Year:** 25

**Total Number of Students Affected by Implementation in Academic Year:** 600

**List the original course materials for students (including title, whether optional or required, & cost for each item):** PHYS 1111L, 1112L, PHYS 2211L, PHYS 2212L Lab Manuals printouts (\$12-\$15), Required.  
Chemistry 1211L, 1212L Lab Manuals (\$20), Required.  
Hayden McNeil Student Lab Notebook, (\$28) Required.

**Proposal Categories:** Specific Top 50 Lower Division Courses

**Requested Amount of Funding:** \$30,000.00

**Original per Student Cost:** \$12 - \$28; \$17.7 (average for three disciplines)

**Post-Proposal Projected Student Cost:** \$0

**Projected Per Student Savings:** \$12 - \$28; \$17.7 (average for three disciplines)

**Plan for Hosting Materials:** Other

#### **Project Goals:**

Convert the existing laboratory manuals for eight (8) Physics and Chemistry courses: Principles of Physics Laboratory I and II, Introductory Physics Laboratory I and II, Principles of Chemistry Laboratory I and II, and Organic Chemistry Laboratory I and II into the integrated IPython notebooks - a web-based interactive computational environment that combines code execution, text, mathematics, plots and rich media into a single document. Because of the steadily increasing cost of course materials, many of Clayton State students elect to forgo purchasing/printing laboratory manuals in order to conserve funds. This is of great concern for our full-time, first-year students who are required to live on campus and incur additional housing expenses with a finite amount of financial resources. For instance, 92% of our first-year students received federal and/or state financial aid during Fall Semester 2014. Since IPython is an open access software that can be downloaded free of charge, it will translate into a projected cost savings of \$10,620 per year for students in twenty five (25) sections of chemistry and physics.

#### **Statement of Transformation:**

Students using the existing laboratory manuals for eight (8) courses: Principles of Physics Laboratory I and II, Introductory Physics Laboratory I and II, Principles of Chemistry Laboratory I and II, and Organic Chemistry Laboratory I and II must spend \$10,620 per year for the required laboratory manuals and notebooks. Although our students come from a variety of cultural and economic backgrounds, the cost of the materials can be prohibitive for who have limited financial resources.

Undergraduate students majoring in science (chemistry or biology), computer science, mathematics, pre-pharmacy, and pre-engineering are the main stakeholders enrolled in these courses. Using the IPython notebooks throughout all introductory Physics and Chemistry courses will re-enforce the interdisciplinary nature of science, stress the similarities in scientific methods and techniques, and make the transition from one course to the other more responsive to student needs. Overall access to these no cost learning materials will greatly enhance the science-laboratory experience for the students. In particular:

1. Students will be able to complete the laboratory reports inside an electronic file and submit it to their instructors electronically;
2. Students will be exposed to a new technology (seen in many industries and graduate schools);
3. Students will be able to access and implement computational laboratories and simulations more efficiently using the built-in Python language;
4. Students will gain a better understanding of the relationship between laboratory experiments that they are required to implement throughout the semester;
5. Students will be able to maintain all course materials in a central, single-source location for ease of reference and access;
6. Students will gain valuable undergraduate laboratory experience closer to what they will experience in employment and professional schools via the transformation to IPython.

Additionally, the transformation from textbooks to open access learning materials will allow faculty stakeholders, full-time professors in the Department of Natural Sciences who teach the courses, to share materials without difficulty, since notebooks can be copied and shared; and, retain copies of student notebooks for assessment purposes.

By the end of AY2016, all introductory Physics, Chemistry, and Organic Chemistry laboratories within the department will use the integrated IPython notebooks. Starting in AY2017, the upper-level Chemistry and Physics laboratories will transition to the integrated IPython notebook method of teaching and learning.

### **Transformation Action Plan:**

Several electronic laboratory notebooks were considered to replace the paper laboratory manuals before the IPython platform was chosen. The benefits of IPython notebooks include major cost savings, ease of use and the built-in Python language feature that allows the implementation of numerical simulations in the calculus-based Physics laboratories.

Existing laboratory manuals (including procedures, pre-lab and post-lab assignments, and sample Excel files) will be converted to the IPython notebook format. In Physics, students are currently required to organize and process the experimental data in Microsoft Excel, and complete the laboratory report in Microsoft Word. With the IPython electronic notebook single-source data management will be achieved, students will complete the required data processing and laboratory reports in IPython.

Several of the Physics laboratories will include a new content: numerical simulations of the phenomena investigated in the laboratory exercise.

Currently Chemistry students record data in a physical laboratory notebook, and complete the laboratory report in Microsoft Word. After the changeover, students will input all laboratory observations and raw data and pictures of laboratory equipment, and analyze the data, calculate results and graph in the IPython system. Questions will be answered in the notebook to ensure qualitative understanding of the laboratory materials. Students will still be required to complete a formal written report and a laboratory practical final exam, at the end of the semester.

The following faculty members will be responsible for the transformation:

- Dr. Boroson: subject matter expert facilitating the transformation and instructor of record for PHYS 2211L, PHYS 1111L;
- Dr. Krivosheev: subject matter expert facilitating the transformation and instructor of record for PHYS 2212L, PHYS 1112L;
- Dr. Todebush: subject matter expert facilitating the transformation and instructor of record for CHEM 1211L, CHEM 1212L;
- Dr. Sheppard: subject matter expert facilitating the transformation and instructor of record for CHEM 2411L, CHEM 2412L;
- Mr. Mays: instructional designer in charge of development and administration of the assessment, distribution of the course materials.

All developed IPython notebooks will be easily accessible from the instructor's website, the Natural Sciences Department website, and GitHub public repository.

**Quantitative & Qualitative Measures:** The following tools will be used to assess the effectiveness of the project on student success and experience:  
Student feedback surveys will be used to qualitatively assess student attitudes and experience;  
Lawson's Classroom Test of Scientific Reasoning (LCTSR) will be administered in all courses before and after the implementation of the project to quantitatively assess the effectiveness of transformation;  
Student grades (overall and for selected laboratory exercises) will serve as a quantitative measure of achieving course outcomes. The student overall grades in each of the affected courses will be compared to the overall grades from the previous 3 semesters to measure the success of the transformation. The average student grades for selected laboratory exercises before and after the transformation will serve as a quantitative measure of achieving course outcomes. The analysis of the DWF rates for these laboratory courses are not particularly meaningful since these rates are principally due to the co-requisite physics and chemistry courses.

#### **Timeline:**

- Summer 2015: Student feedback surveys are developed. Sampler notebooks (one laboratory activity per course affected by the transformation) are developed.
- Fall 2015: All laboratory activities are transformed into IPython format, new computational content in Physics is introduced and integrated.

Notebooks are posted on the instructors' webpages and uploaded to the GitHub repository. LCTSR and student feedback surveys are administered to students in all Physics and Chemistry classes affected by the project implementation.

- Spring 2016: Notebooks are used in CHEM 1211L, CHEM 2411L, PHYS 2211L, and PHYS 2212L for the first time. Quantitative measures are collected and analyzed. Surveys are administered and analyzed. Notebooks are fine-tuned, if needed.
- Summer 2016: Notebooks are developed for the Introductory Physics I and II laboratories.
- Fall 2016: Notebooks are implemented in all sections of Introductory Physics I and II Laboratories, Principles of Physics I and II Laboratories, Principles of Chemistry I and II Laboratories, and Organic Chemistry Laboratory I and II.

**Budget:**

Justin Mays, Instructional Designer @ \$5000

Salary differential for release time to support development

\$5,000.00

Tatiana Krivosheev, Physics subject matter expert @ \$5000

Bram Boroson, Physics subject matter expert @ \$5000

Caroline Sheppard, Chemistry subject matter expert @ \$5000

Patricia Todebush, Chemistry subject matter expert @ \$5000

Salary differential for release time to support development

\$20,000.00

3 Undergraduate student assistants @ \$1,400 x 3

Assist subject matter experts Summer 2015, Fall 2015, Spring 2016

\$4,200.00

Project Expenses: Travel

Kickoff event attendance

\$800.00

Total

\$30,000.00

**Sustainability Plan:**

Once implemented, all laboratory courses (CHEM 1211L, CHEM 1212L, CHEM 2411L, CHEM 2412L, PHYS 1111L, PHYS 1112L, PHYS 2211L, and PHYS 2212L) affected by the transformation, the new learning materials will be offered for the indefinite future. Once the materials are posted on the faculty web pages, Department of Natural Sciences webpage and online public repository, minimal to no maintenance is required. The team members responsible for the development and initial teaching with the iPython notebooks will present the notebooks, tutorials on their development and usage, and lessons learned in the process of their development to the other faculty of Natural Sciences Department and larger teaching community (through the conference presentations and workshops). Course materials may be updated as necessary by the members of Chemistry and Physics division to incorporate additional experiments or technologies, and shared with all faculty teaching the courses through the online public repository.



May 20, 2015

Dr. Tatiana Krivosheev  
Professor of Physics,  
Department of Natural Sciences  
2000 Clayton State Blvd.  
Morrow, GA 20360

***Reference: – Support for the Affordable Learning Georgia Textbook Transformation Grant Proposal***

Dear Dr. Krivosheev:

I am pleased to support you and your team's efforts to submit a proposal to offer Clayton State students no cost learning materials as part of the University System of Georgia's initiative, Affordable Learning Georgia Textbook Transformation, to eliminate a substantial and growing part of what's driving up the cost of higher education: the often prohibitive expense of class materials. Lowering the price of textbooks has long been something reformers see as a way to help students burdened by rising tuition. The cost of new printed textbooks continue to rise—up more than 7 percent last year alone, according to the Bureau of Labor Statistics, and 82 percent between 2002 and 2012, as calculated by the Government Accountability Office, the non-partisan research arm of Congress (<http://www.gao.gov/assets/660/655066.pdf>). This project will replace approximately 25 Physics and Chemistry Laboratory I and II courses in the spring 2016 to fall 2016 with the preliminary work to be completed in the Summer/Fall 2015, resulting in savings of more than \$10, 620 per year for 600 students.

The Physics and Chemistry Department-wide plan is to continue using these materials into the indefinitely Faculty may contribute to the continued development of the materials (by suggesting revisions or contributing to the pool of homework problems, for example) to enhance their long-term utility and sustainability. Continuous evaluation of effectiveness will inform revisions for future semesters.

The department-wide scope of work outlined in the proposal supports our core institutional value of community engagement, as well as our strategic plan to “create an outstanding educational experience that stimulates intellectual curiosity, critical thinking, and innovation”. Additionally, the proposed partnership represents a depth of efficient and beneficial resource sharing and collaboration that is vital to serving our students in the best possible way. Your team has a long standing relationship for working together to develop 21<sup>st</sup> century instructional models that use a combination of proven and innovative teaching and learning models to prepare both educators and students to meet the challenges of living and working in a global society. Therefore, I am confident that this partnership is fully capable of implementing and managing the project successfully.

Sincerely,

  
Nasser Momayezi  
Dean of the College of Arts and Sciences

# Syllabus

---



## PHYS 2211L - Principles of Physics Laboratory I Course Syllabus - Fall 2016

---

Individuals with disabilities who need to request accommodations should contact the Disability Services Coordinator, Edgewater Hall 255, 678-466-5445, [disabilityservices@clayton.edu](mailto:disabilityservices@clayton.edu).

---

**Course Description:**

**Number and Title:**

PHYS 2211L (CRN 80494)

Principles of Physics Laboratory I

**Credit Hours:**

1.0 semester credit hour

**Catalog Description:**

Laboratory accompanying PHYS 2211, Principles of Physics I

**Course Prerequisites and Co-requisites:**

Prerequisites or co-requisite: MATH 2502, Calculus II

Co-requisite: PHYS 2211, Principles of Physics I

Note: Due to the co-requisite nature of PHYS 2211 and PHYS 2211L, if PHYS 2211L is dropped, then PHYS 2211 must also be dropped and vice versa.

**Notebook Computer Requirement:**

Each CSU student is required to have ready access throughout the semester to a notebook computer that meets faculty-approved hardware and software requirements for the student's academic program. Students will sign a statement attesting to such access. For further information on CSU's Official Notebook Computer Policy, please go to <http://www.clayton.edu/hub/itpchoice/notebookcomputerpolicy>.

**Computer Skill Prerequisites:**

Able to use the Windows™ operating system.

Able to use a the Microsoft Word™ word processing program.

Able to send and receive e-mail using the Outlook™ or Outlook Express™ program **Only use your CSU e-mail account or the e-mail system included in D2L to communicate academic information to your instructor.**

Able to attach and retrieve attached files via email.

Able to use a Web browser.

**In-class Use of Student Notebook Computers:**

Student notebook computers are required in the classroom at **every** laboratory meeting. Bring your notebook computer to every laboratory meeting.

---

**Program Learning Outcomes:**

General education outcomes.

The following links provide tabular descriptions of the communications outcome and the critical thinking outcome components (see PHYS 2211L in the tables):

[Communications outcomes components](#)

[Critical thinking outcomes components](#)

Chemistry outcomes:

PHYS 2211L is a required course in the B.S. degree program in Chemistry. PHYS 2211L supports outcomes 2, 4, 5, 6, and 7 of the Chemistry major:

- 1.
2. demonstrate a broad range of basic laboratory skills applicable to chemistry, and improved chemical research skills.
- 3.
4. apply knowledge of physics and mathematics to solve chemical problems.
5. communicate scientific information in a clear and concise manner both orally and in writing.
6. collect, evaluate and interpret scientific data, and employ critical thinking to solve problems in chemistry and supporting fields.
7. collaborate effectively on team-oriented projects.

---

**Course Learning Outcomes:**

§ Course Outcome 1: Be able to identify, describe, and apply the basic laws of classical mechanics and wave motion.

§ Course Outcome 2: Be able to use the scientific process and gain facility with experimental techniques.

---

**Term:**

Spring Semester 2016

---

**Instructor Information:**

**Instructor:**

Instructor	Office	Office Hours
Dr. Tatiana Krivosheev phone: (678) 466-4783 fax: (678) 466-4899 e-mail: <a href="mailto:TatianaKrivosheev@clayton.edu">TatianaKrivosheev@clayton.edu</a> internet: <a href="http://faculty.clayton.edu/tkrivosh/home">http://faculty.clayton.edu/tkrivosh/home</a>	Lakeview Discovery and Science Center Room 235K	Monday, Tuesday, and Wednesday 10:00 a.m. –12:00 noon

---

**Lab Meetings:**

**Lab room:**

NBS, Room 184

**Lab Times:**

12:35 p.m. - 3:25 p.m., Monday

---

**Textbook information:**

**Text:**

None required. However, the PHYS 2211 course text, Hugh D. Young and Roger A Freedman, University Physics, 14th edition, Pearson; 2015, is an important reference.

---

**Evaluation:**

Laboratory reports 12 @ 50 points	600
<b>TOTAL</b>	<b>600</b>

The final examination for the course is scheduled during the final regularly scheduled laboratory period November 21, 2016.

---

**Grading:**

<b>A</b>	90 - 100%
<b>B</b>	80 - 89%
<b>C</b>	70 - 79%
<b>D</b>	60 - 69%
<b>F</b>	below 60%

---

**Mid-term Progress Report**

Due to the relatively small number of laboratory reports that will have been returned by mid-term, no mid-term grade will be reported for this course. Students making unsatisfactory progress will be contacted individually by the instructor before mid-term. Based on this information, students may choose to withdraw from the course and receive a grade of "W." Students pursuing this option must fill out an official withdrawal form, available in the Office of the Registrar, by mid-term, which occurs on October 7, 2016. [Instructions for withdrawing are provided at this link.](#)  
**The last day to withdraw without academic accountability is Friday, October 7, 2016.**

**Course Schedule:**

Laboratory	Date	Topic
------------	------	-------

	Aug 15	Intro Lab – Attendance Required
1	Aug 22	<a href="#">Measurement and Error Propagation</a>
2	Aug 29	<a href="#">Acceleration due to Gravity</a>
	Sep 5	No Lab - Labor Day
3	Sep 12	<a href="#">Opposing Forces</a>
4	Sep 19	<a href="#">Projectile Motion</a>
5	Sep 26	Pressure in Fluids
6	Oct 3	<a href="#">Conservation of Energy</a>
	Oct 7	Midterm - last day to withdraw without accountability
	Oct 8 - 11	No Lab - Fall Break
7	Oct 17	<a href="#">Ballistic Pendulum</a>
8	Oct 24	Archimedes Principle
9	Oct 31	Center of Mass

10	Nov 7	<a href="#">Oscillatory Motion</a>
11	Nov 14	<a href="#">Standing Waves Lab</a>
12	Nov21	<a href="#">Final Examination</a>
	Nov 28	No Lab
	Dec 5	No Lab

---

**Course Policies:**

Students must abide by policies in the [Clayton State University Student Handbook](#), and the [Basic Undergraduate Student Responsibilities](#).

**University Attendance Policy**

Students are expected to attend and participate in every class meeting. Instructors establish specific policies relating to absences in their courses and communicate these policies to the students through the course syllabi. Individual instructors, based upon the nature of the course, determine what effect excused and unexcused absences have in determining grades and upon students' ability to remain enrolled in their courses. The university reserves the right to determine that excessive absences, whether justified or not, are sufficient cause for institutional withdrawals or failing grades.

**Course Attendance Policy**

Attendance is required for lab and examination periods. Any absence must be accompanied by a written excuse from a competent authority (doctor, judge, etc).

**Missed Work**

Without excuse, a grade of zero points will be assigned for the missed work.

**Academic Dishonesty**

Any type of activity that is considered dishonest by reasonable standards may constitute academic misconduct. The most common forms of academic misconduct are cheating and plagiarism. All instances of academic dishonesty will result in a grade of zero for the work involved. All instances of academic dishonesty will be reported to the Office of Student Life/Judicial Affairs. Judicial procedures are described beginning on page 14 of the [Student Handbook](#) (Procedures for Adjudicating Alleged Academic Conduct Infractions).

**Disruption of the Learning Environment**

Behavior which disrupts the teaching-learning process during class activities will not be tolerated. While a variety of behaviors can be disruptive in a classroom setting, more serious examples include belligerent, abusive, profane, and/or threatening behavior. A student who fails to respond to reasonable faculty direction regarding classroom behavior and/or behavior while participating in classroom activities may be dismissed from class. A student who is dismissed is entitled to due process and will be afforded such rights as soon as possible following dismissal. If found in violation, a student may be administratively withdrawn and may receive a grade of WF.

A more detailed description of examples of disruptive behavior and appeal procedures is provided at <http://www.clayton.edu/portals/5/disruptiveclassroombehavior.pdf>

**Other Policies**

Laboratory reports are due at the beginning of the next meeting after the lab was conducted. Late submission of the laboratory reports will result in a grade penalty of 10% of the available points per working day (Monday through Friday) that the assignment is late. Late reports will not be accepted after the final course meeting (November 21, 2016).

Visitors (friends, children, etc.) may not attend lab without the permission of the instructor.  
No smoking, eating or drinking is permitted at any time in the lab room.

---

**Important dates:**

In-class final examination: November 21, 2016.

Last day to drop without academic accountability: Friday, October 7, 2016.

# Final Report

---

# Affordable Learning Georgia Textbook Transformation Grants

## Final Report

**Date:** December 22, 2016

**Grant Number:** 140

**Institution Name(s):** Clayton State University

**Team Members (Name, Title, Department, Institutions if different, and email address for each):** Dr. Caroline Sheppard, Professor of Chemistry, Department of Chemistry and Physics, [CarolineSheppard@clayton.edu](mailto:CarolineSheppard@clayton.edu); Dr. Patricia Todebush, Professor of Chemistry, Department of Chemistry and Physics, [PatriciaTodebush@clayton.edu](mailto:PatriciaTodebush@clayton.edu); Dr. Bram Boroson, Professor of Physics, Department of Chemistry and Physics, [BramBoroson@clayton.edu](mailto:BramBoroson@clayton.edu); Dr. Tatiana Krivosheev, Professor of Physics, Department of Chemistry and Physics, [TatianaKrivosheev@clayton.edu](mailto:TatianaKrivosheev@clayton.edu); Dr. Justin Mays, Director, Center for Instructional Development, [JustinMays@clayton.edu](mailto:JustinMays@clayton.edu)

**Project Lead:** Dr. Tatiana Krivosheev

**Course Name(s) and Course Numbers:**

Principles of Physics Laboratory I, PHYS 2211L

Principles of Physics Laboratory II, PHYS 2212L

Introductory Physics Laboratory I, PHYS 1111L

Introductory Physics Laboratory II, PHYS 1112L

Principles of Chemistry Laboratory I, CHEM 1211L

Principles of Chemistry Laboratory II, CHEM 1212L

Organic Chemistry Laboratory I, CHEM 2411L

Organic Chemistry Laboratory II, CHEM 2412L

**Semester Project Began:** Summer 2015

**Semester(s) of Implementation:** Spring 2016, Summer 2016, Fall 2016

**Average Number of Students Per Course Section:** 24

**Number of Course Sections Affected by Implementation:** 25 sections a year, on average

**Total Number of Students Affected by Implementation:** about 600

## 1. Narrative

A. Describe the key outcomes, whether positive, negative, or interesting, of your project. Include:

The goal of the project was to convert the existing laboratory manuals for eight (8) Physics and Chemistry courses: Principles of Physics Laboratory I and II, Introductory Physics Laboratory I and II, Principles of Chemistry Laboratory I and II, and Organic Chemistry Laboratory I and II into the integrated IPython (Jupyter) notebooks - a web-based interactive computational environment that combines code execution, text, mathematics, plots and rich media into a single document. After a preliminary work was concluded by the end of the Fall 2015 semester, the developed laboratory materials were implemented in four of these courses (PHYS 2211L, PHYS 2212L, CHEN 1211L, and CHEM 1212L) in the Spring 2016 Semester. The remaining materials were implemented in the CHEM 2411L course in the Summer 2016 Semester, and CHEM 2412L in the FALL 2016 Semester. Overall access to these no cost learning materials greatly enhance the science-laboratory experience for the students. In particular:

- a. Students are able to complete the laboratory reports inside an electronic file and submit it to their instructors electronically;
- b. Students are exposed to a new technology (seen in many industries and graduate schools);
- c. Students are able to access and implement computational laboratories and simulations more efficiently using the built-in Python language;
- d. Students gain a better understanding of the relationship between laboratory experiments that they are required to implement throughout the semester;
- e. Students are able to maintain all course materials in a central, single-source location for ease of reference and access;
- f. Students gain valuable undergraduate laboratory experience closer to what they will experience in employment and professional schools via the transformation to IPython.

Additionally, the transformation from textbooks to open access learning materials allows faculty stakeholders, full-time professors in the Department of Natural Sciences who teach the courses, to share materials without difficulty, since notebooks can be copied and shared; and, retain copies of student notebooks for assessment purposes.

In PHYS 2211L/PHYS 2212L course the implementation was a fairly smooth process with the expected outcomes. In the Spring 2016 the notebooks were used in two (2) sections of PHYS 2211L and one (1) section of PHYS 2212L. That was followed by one (1) section of PHYS 2211L and one (1) section of PHYS 2212L in the Fall 2016. The results of student surveys show that all the outcomes have been met and the students appreciated not only the no cost nature of the laboratory materials, but the value of having an easy to organize, easy to share electronic document which allows to complete all parts of the laboratory "under one roof". Students commented on the ease of computing that notebooks provided and the value of this experience for their future professions. In fact one of the most rewarding parts of the experience was the fact that a number of students decided to use these skills in their following research projects. Interestingly enough the initial phase of the implementation was met with some resistance from the students since they had to master additional software skills. Two student assistants were

employed to help students to master these skills and by the end of the semester students not only became comfortable with Jupyter, but recognized the value of it as shown by the results of the surveys. During the second semester of implementation the resistance was noticeably less. One of the noticeable side effects of converting laboratory reports to an electronic format was an increase in time needed to grade the reports electronically, which is partially due to the necessity of downloading and uploading the reports and the greater “transparency” of the student actions performed in the course of the laboratory. For example, it is easy to see the mistakes done in the calculations or graphing.

We have decided to postpone the full implementation of the notebooks in the algebra based laboratories (PHYS 1111L, PHYS 1112L) until all instructors are comfortable with teaching with the Jupyter even though all the materials are developed and we have enough student “experts” to serve as student assistants in these courses.

The implementation was less smooth in Chemistry laboratories. In fact after the first semester of teaching it became evident that Jupyter notebooks may not be optimal for Chemistry due to an image-heavy rather than calculation – heavy nature of the laboratory reports.

In Summer 2016, one section of CHEM 2411L (13 students) used the Jupyter laboratory notebook. Of the 11 laboratory experiments in the course, 8 (73%) were completed using the electronic notebooks. The remaining reports were completed using Word. All reports were submitted in the D2L course management system.

Results of the student survey indicated that students did not like this particular electronic notebook, although they do like having the different parts of the experiment in one document and they recognized electronic notebooks are a valuable skill. For 2412L in the Fall 2016 semester, a different (still free) notebook (OneNote) was implemented. This accomplished the same result of students not having to purchase a laboratory notebook, and gave them the electronic lab notebook experience, but avoided some of the coding/accessibility issues of Jupyter. OneNote is also shared with the instructor, so it acts more like a traditional laboratory notebook, rather than simply a method for compiling reports.

In Fall 2016, two sections of CHEM 2412L (26 students) used the Microsoft OneNote program as an electronic laboratory notebook. All 8 laboratory experiments in the course utilized the electronic notebooks. All reports were submitted in the D2L course management system. Results of a student survey indicate that students did like this particular electronic notebook, although they did have problems with inserting images on some versions. Students appreciated the easy accessible, free, sharable notebook alternative.

#### B. Describe lessons learned, including any things you would do differently next time.

Although the students appreciate no cost, easy to use materials in the end, the initial response may be resistive. Persistence and additional support coming from the peers are essential to the overall success of the implementation. Solutions that are appropriate for some courses may not be optimal

to others. The Jupyter notebooks fit the computational nature of the physics laboratories better than chemistry laboratories. That forced the team to seek and adopt other software products which were better suited for the image heavy nature of the organic chemistry reports. The distribution of the graded laboratory reports can be a complicated and time-consuming task and the team still fine-tunes the process.

## 2. Quotes

- Provide three quotes from students evaluating their experience with the no-cost learning materials.

"It made all the information available in one place: theory and the report. Everything is done for you as long as you put in the right code. Less papers to print, meaning less money to spend on papers and ink. One get to learn about coding."

"Electronic notebook's are what future generations will use and being exposed to such an idea was outstanding."

"As a computer science/mathematics major, I found processing data using a programming language like python quite relevant to the overall focus of my education. "

## 3. Quantitative and Qualitative Measures

### 3a. Overall Measurements

#### Student Opinion of Materials

**Was the overall student opinion about the materials used in the course positive, neutral, or negative?**

#### PHYSICS courses:

Total number of students affected in this project: 120

- Positive: 87.2 % of 85 number of respondents
- Neutral: 0 % of 85 number of respondents
- Negative: 12.8 % of 85 number of respondents

#### Chemistry courses, Jupyter notebooks

Total number of students affected in this project: 13

- Positive: 42 % of 12 number of respondents
- Neutral: 0 % of 12 number of respondents
- Negative: 58 % of 12 number of respondents

**Chemistry courses, One Note notebooks**

Total number of students affected in this project: 24

- Positive: 94 % of 18 number of respondents
- Neutral: 0 % of 18 number of respondents
- Negative: 6 % of 18 number of respondents

### Student Learning Outcomes and Grades

**Was the overall comparative impact on student performance in terms of learning outcomes and grades in the semester(s) of implementation over previous semesters positive, neutral, or negative?**

Choose One:

- Positive: Higher performance outcomes measured over previous semester(s)
- Neutral: Same performance outcomes over previous semester(s)
- Negative: Lower performance outcomes over previous semester(s)

### Student Drop/Fail/Withdraw (DFW) Rates

**Was the overall comparative impact on Drop/Fail/Withdraw (DFW) rates in the semester(s) of implementation over previous semesters positive, neutral, or negative?**

**Drop/Fail/Withdraw Rate:**

PHYS 2211L/PHYS 2212L:

13 % of students, out of a total 46 students affected, dropped/failed/withdrew from the course in the final semester of implementation.

Choose One:

- Positive: This is a lower percentage of students with D/F/W than previous semester(s)
- Neutral: This is the same percentage of students with D/F/W than previous semester(s)
- Negative: This is a higher percentage of students with D/F/W than previous semester(s)

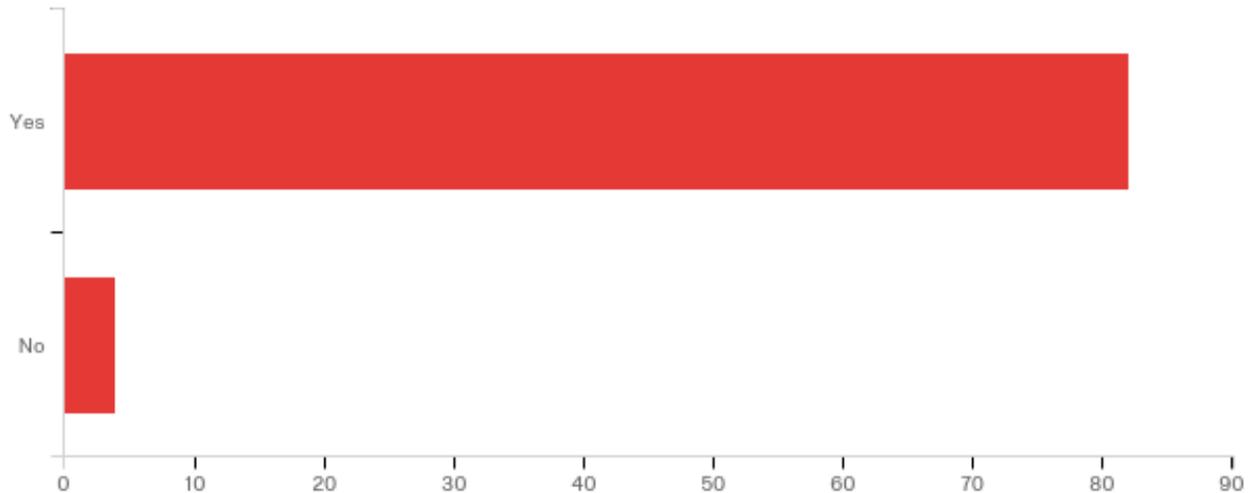
**Note:** All the courses affected by the transformation are laboratory courses. Traditionally, the Drop/Fail/Withdraw rates in these courses are driven by the co-requisite lecture courses rather than the laboratories themselves.

### 3b. Narrative

Below is the summary of the projected outcomes and the supporting evidence. Through the access to developed no cost materials

- a. Students are able to complete the laboratory reports inside an electronic file and submit it to their instructors electronically;

#### Q4 - Was it convenient to have all parts of the laboratory in an easily accessible format?



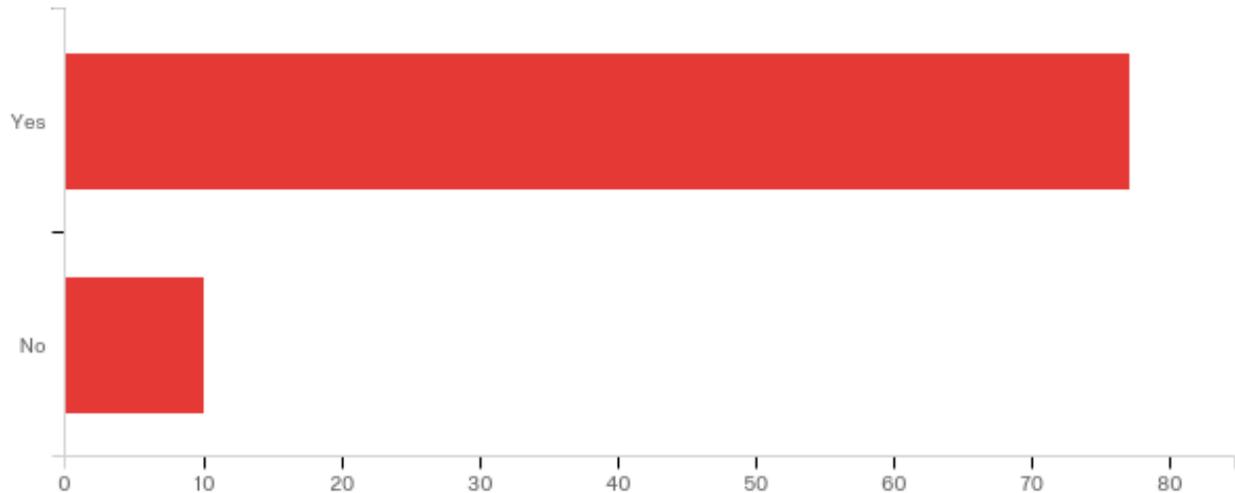
#	Answer	%	Count
1	Yes	95.35%	82
2	No	4.65%	4
	Total	100%	86

Student comments:

- Although the calculations are hard to grasp if you are just coding them in, electronic notebooks make it easy to share and keep up with data. Plus this gives engineering majors the ability to use computer science concepts outside of comp sci courses.

- b. Students are exposed to a new technology (seen in many industries and graduate schools);

#### Q3 - Do you feel that electronic notebooks are a valuable skill?



#	Answer	%	Count
1	Yes	88.51%	77
2	No	11.49%	10
	Total	100%	87

Do you feel that learning to keep an electronic laboratory notebook is a valuable skill?

- A. Yes 94%
- B. No 6%

Student comments:

- Even though I don't dominate the system, I still see its value and usefulness. Because of this, I think that it will be beneficial to incorporate more practice exercises that will serve as a tutorial for using the notebook. Future students will be able to take fully advantage of this system both in school and in the workforce, therefore I support the idea of replacing printed reports with these electronic notebooks.
- The coding is good!! Since I will be an engineering major in the future
- As a computer science/mathematics major, I found processing data using a programming language like python quite relevant to the overall focus of my education.

- c. Students are able to access and implement computational laboratories and simulations more efficiently using the built-in Python language;

Student comments:

- Being able to use code to analyze data is an invaluable skill that any future scientist should have in his/her tool belt.
- 
- Its easy and it could be done fast because the computation is easy
  - I'm a computer guy, so I like anything that prevents me from having to write things by hand. I'm also happy to use a programming language with a robust math library rather than trying to get Excel to bend to my will.
  - Once you get used to how the programming works, the electronic notebooks are a lot easier to complete and a lot less stressful.
  -
- d. Students gain a better understanding of the relationship between laboratory experiments that they are required to implement throughout the semester;

Student comments:

- I get to reuse codes.
- 
- You can reuse codes you have done before.
- e. Students are able to maintain all course materials in a central, single-source location for ease of reference and access;

Student comments:

- I can easily access the old data when I need. It's easier to organize. It's easy to share the data with others.
- The easy access from any device and the sharing capabilities
- I liked the collaboration bit and having access to my notebook from my phone
- Easy to access and easy to add information and pictures
- Having the ability to create my own pages (as many or as few as I needed)
- Type anywhere
- It was easy to input information without it becoming lost
- The easy accessibility
- I liked how it was saving paper and also easy to access pre-lab procedures
- Easier to access than Jupyter
- Available whenever I need it, don't need a physical notebook to carry around, saves paper, no printing, easy attachment of pictures I like the fact that I don't have to print multiple documents.
- I like the fact that it is all conveniently in one place.

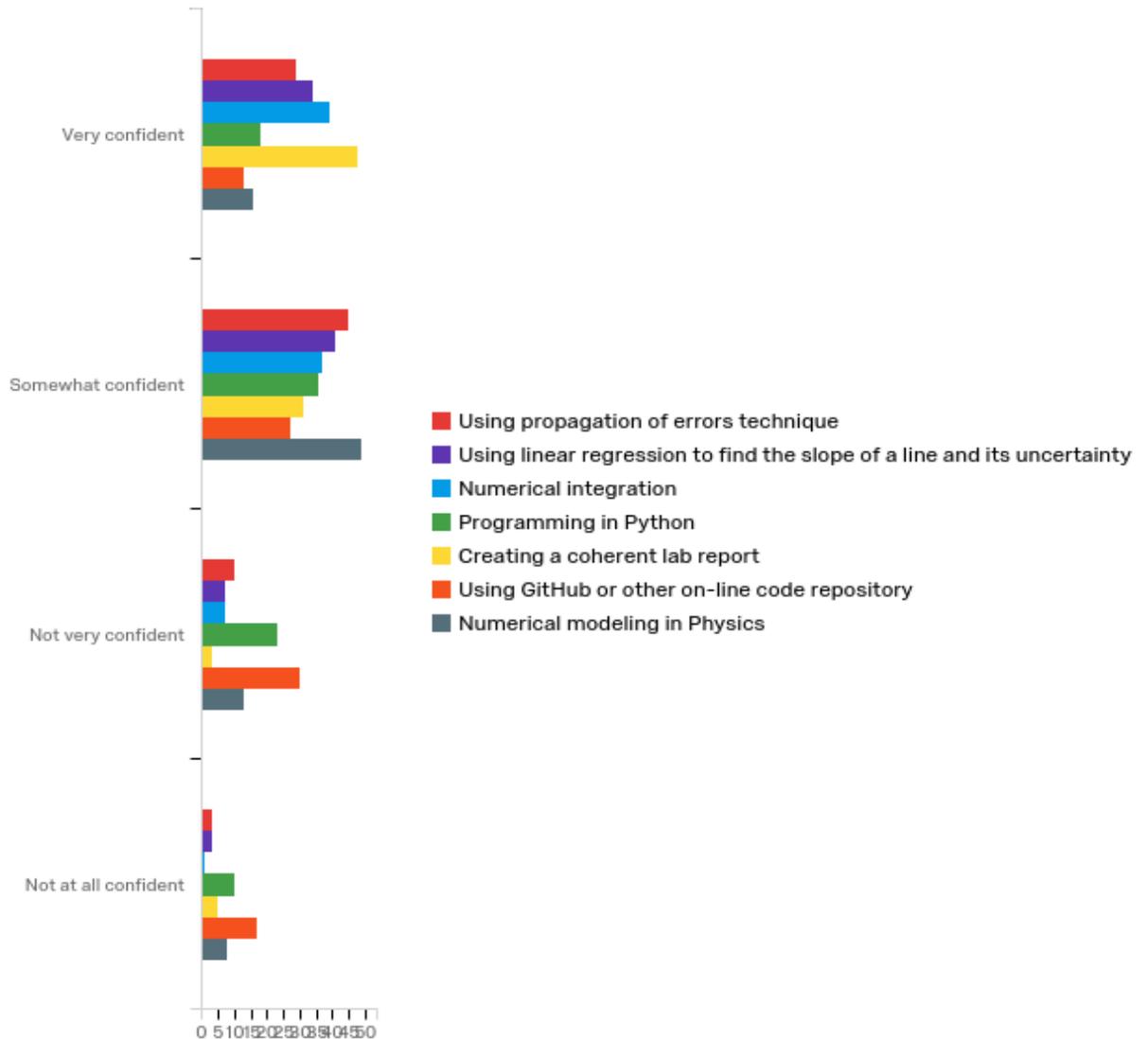
- f. Students gain valuable undergraduate laboratory experience closer to what they will experience in employment and professional schools via the transformation to IPython.

Student comments:

- Electronic notebook's are what future generations will use and being exposed to such an idea was outstanding.
- As a computer science/mathematics major, I found processing data using a programming language like python quite relevant to the overall focus of my education.
- The coding is good!! Since I will be an engineering major in the future

In physics laboratories the overall course objectives were met as evidenced by the following survey question as well as the specific laboratory reports grades and grades overall presented below.

**Q1 - How confident are you at the following?**



The following are the samples of the overall grades for the sections affected by the transformation and the average grades achieved in specific laboratory reports.

The average grades Fall 2016, PHYS 2211L: 84.5%.

Specific laboratories:

Acceleration due to gravity 87.9%

Opposing forces 75.3%

Oscillatory Motion 95.5%

Spring 2016, PHYS 2212L, Specific laboratories:

Capacitors 95.5%

Resistors 98.0%

#### **4. Sustainability Plan**

All laboratory courses (CHEM 1211L, CHEM 1212L, CHEM 2411L, CHEM 2412L, PHYS 1111L, PHYS 1112L, PHYS 2211L, and PHYS 2212L) affected by the transformation are offered several times during an academic year. The materials posted on the faculty web pages, Department of Chemistry and Physics webpage and online public repository require minimal to no maintenance. The team members responsible for the development and initial teaching with the Jupyter notebooks presented the notebooks, tutorials on their development and usage, and lessons learned in the process of their development to the other faculty of Department of Chemistry and Physics and larger teaching community (through the conference presentations and workshops). Course materials may be updated as necessary by the members of Chemistry and Physics department to incorporate additional experiments or technologies, and shared with all faculty teaching the courses through the online public repository.

#### **5. Future Plans**

Throughout the course of the project the team had to research a number of open source learning materials, such as various electronic notebooks (once it became apparent that the Jupyter notebooks were not optimal for the use in chemistry laboratories). Instructors involved in the project report that they became more aware of the no cost materials and plan to actively seek them for the future use in their courses. The attendance of the kick-off meeting made the team aware of the licensing options and the importance of the creative commons license.

The team presented the project at a number of conferences, in particular at the Winter 2016 American Association of Physics Teachers Meeting (New Orleans, LA), Spring 2016 SACS –AAPT Meeting (Morrow, GA), and Student Academic Conference at Clayton State University (Morrow, GA). The team plans to present the project at a future national and regional chemistry meetings and produce a publication as well.

#### **6. Description of Photograph**

(left-right) Dr. Caroine Sheppard, Chemistry instructor of record; Dr. Patricia Todebush, Chemistry instructor of record; Dr. Krivosheev, Physics instructor of record; Dr. Justin Mays, instructional designer.