Table of Contents

Application Summary

Competition Details

Competition Title:	Textbook Transformation Grants, Round Sixteen (Spring 2020 - Spring 2021)
Category:	University System of Georgia
Award Cycle:	Round 16
Submission Deadline:	01/13/2020 at 11:59 PM

Application Information

Submitted By:	Cathy Hakes
Appplication ID:	3982
Application Title:	507
Date Submitted:	01/14/2020 at 8:13 AM

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Submitter Title:	Executive Director

Application Details

Proposal Title
507

Requested Amount of Funding
$10,800

Priority Category (if applicable)
Specific Core Curriculum Courses

Final Semester:
Spring 2021

Course Title(s)
Physical Science with Laboratory

Course Number(s)
PSCI 1101K

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Additional Team Members (Name and email address for each)
n/a

Sponsor Name
Joseph Sloop

Sponsor Title
Interim Dean

Sponsor Department
School of Science and Technology

Total Number of Student Section Enrollments Affected by Project in One Academic Year
220

Average Number of Student Section Enrollments Affected per Summer Semester
20

Average Number of Student Section Enrollments Affected per Fall Semester
80

Average Number of Student Section Enrollments Affected per Spring Semester
120

Original Required Commercial Materials (title, author, price, and bookstore or retailer URL showing price)

Recommended Textbooks:

Title: Soft Condensed Matter

Author: Richard Jones

Price: $58.61

URL:

https://www.amazon.com/Condensed-Matter-Oxford-

Master-Physics/dp/0198505892/ref=sr_1_1?crid=

QS49H23TBL2Y&keywords=soft+condensed+

matter+physics&qid=1576694322&sprefix=

soft+condensed%2Caps%2C133&sr=8-1

Title: Conceptual Integrated Science

Author: Paul Hewitt

Price: $210.80

URL: https://ggc.bncollege.com/shop/ggc/textbook/conceptual-integrated-science

Original Total Cost per Student
$269.41

Post-Project Cost per Student
$0

Post-Project Savings per Student
$269.41

Projected Total Annual Student Savings per Academic Year
$59,270.20

Using OpenStax Textbook?
No

Project Goals

The goals of the project are:

A) Improve non-science major student success by introducing physical science concepts in the everyday context.

Creating and teaching science courses for non-science majors is a challenge [1]. Students may have extensive science training or none at all, due to the minimal prerequisites for such courses. While science majors take multiple courses across scientific disciplines and obtain a solid scientific worldview through these exposures, non- science majors take only a couple of science courses [2] during their entire undergraduate study. For instructors of science to non-science majors, it can be a challenge to sustain these students' interest and ensure their success. On the one hand, cramming a course full of multiple scientific concepts can be intimidating to students and hard to grasp in just one semester. On the other, focusing on a narrow set of concepts has the risk that students come out of the course with a narrow scientific worldview. In order to understand how best to teach non-science majors science, we need to ask this question first: What do non-science majors stand to gain from a science classroom?

David Hawthorne, director of education and outreach at the national socio-economic center at University of Maryland says one of the most important learning outcomes of his course on teaching non-science students about pollination is "detail distillation" [3] - Students learn that every complex problem has a simple solution (which could be right or wrong depending on the application). Developing such an aptitude to analyze and breakdown complex daily problems into their most basic parts and solve, is also very useful for decision-making. Most leadership roles across governments and companies are held by non-science majors who graduated with degrees in business, finance, education, etc. We believe that imparting a scientific worldview to non-science majors would lead to better decision making.

This course transformation proposes to teach non-science majors how science helps simplify and understand complex everyday phenomena through examples of everyday complex materials like food, soap, shampoo, and even traffic. Take ketchup for example. How is ketchup able to be a liquid while squeezed through the bottle and a solid that holds its shape on the plate both at the same time? The advantage of teaching in such a fashion is students can learn multiple science concepts directly useful in their everyday life, as well as ensuring their constant engagement and enthusiasm in learning science through the course.

Here are some quotes from non-science major students taking the physical science course with theme "Conceptual Physics" showing their interest in learning science in the everyday context:

"For Physical Science, there were some concepts that I never really thought about in the real world. It was very interesting how science in real-life works."

"Learning measurements about basic world functions and being able to calculate them exactly."

This project proposes to develop new course material on the "Science of Everyday Materials" for the Physical Science Course PSCI 1101K at GGC. This theme represents one of several Physical Science Course themes being offered at GGC, and was recently approved to be taught for the first time across three sections in Spring 2020. Currently, the course has two recommended textbooks: "Soft Condensed Matter" by Richard Jones as well as "Conceptual Integrated Science" by Paul Hewitt. However, there are several problems with these above textbooks:

- "Soft Condensed Matter" by Richard Jones is the standard textbook for teaching senior undergraduate majors the science behind everyday materials, however is considerably advanced for non-science majors.
- "Conceptual Integrated Science" is the standard textbook taught across other Physical Science themes such as conceptual physics. However, this book does not contain all the topics required to cover the science of everyday materials.

The project team will simplify content from these two recommended textbooks in order to create accessible zero-cost material for PSCI 1101K science of everyday materials theme. Moreover, the team will introduce novel pedagogical methods where students learn and discover concepts in the context of everyday materials through common activities like making coffee, and playing with sand. By understanding the science behind everyday materials, the team is able to make science and its technical concepts more interesting to learn, less intimidating, and more engaging to non-science major students. Ultimately, the project team aspires to remove barriers to the students' success in this and their future science courses.

B) Increase student savings by creating zero-cost content

Currently, the science of everyday materials theme has two recommended textbooks that cost a total of

$269.41 per student. Because of the varied levels of non-science major student prior scientific knowledge, a large number of students would want to purchase the recommended materials so that they do not fall behind in class. Further, because these students are not exposed to many science courses, they might want to buy and keep books for the content.

Through the proposed project, students will have access to comprehensive content on the science of everyday material in one repository for zero-cost. This will create significant savings. Currently, it is estimated that 11 courses in physical science over the pilot project (four in fall 2020, one in summer 2020 and six in spring 2021) will be taught with this theme, with an average of 20 students each section, and savings of $59,270.20 in total. However, physical science courses themes are chosen by the instructor, and in total 26 physical science 1101K sections were taught in 2019. Thus, the potential student savings with average 20 students per section is $140,093.20 if these materials are widely adopted among all PSCI 1101K instructors.

C) Create novel, accessible content on the science of everyday materials. In particular, create online chapters, visual lecture smart notes, and homework suitable for the PSCI 1101K transformation.

The Nobel Prize physicist Richard Feynman once said, “If you can't explain something to a first year student, then you haven't really understood it.” Intuitively, you might think that simple everyday materials like ketchup, shaving foam, and shampoo are easy to explain. However, these everyday materials are actually complex to understand, which is why the current standard text on everyday soft materials, “Soft Condensed Matter” by Richard Jones, is a senior science major undergraduate text and far from being a simple, easy-to-comprehend book especially for the non-science major. The challenge then becomes how to create accessible content on everyday materials, while at the same time not diluting the scientific concepts by simplifying the explanation.

One of the important goals for this project is to create accessible content for non-science majors so that they come out of the course having a solid understanding behind the science of everyday complex phenomena. We will accomplish this aim by assembling a combination of chapters accessible to both students and instructors, as well as in-class materials that engage students and promote students to probe and discover the science behind everyday materials.

Statement of Transformation

Overview of the Transformation

PSCI 1101K (Physical Science with Laboratory) is a general education course for non-science majors. It is a theme-based course with a menu of themes offered each semester. According to the GGC course site, this course is designed so that at the end of the course students will:

1. Communicate scientific issues effectively in oral and written form;
2. Distinguish scientific studies from popular opinions by employing critical thinking skills and the scientific method;
3. Effectively collect, analyze and present data and correctly construct and interpret charts, graphs and tables to draw scientific conclusions; and
4. Apply the fundamental concepts and methodologies of physics and/or chemistry to investigate a scientific theme.

Recently, there is a waning of student interest and participation in science across high school, colleges, and universities. Research has found that learning science in the everyday context is more relevant to their out-of-school lives and results to students demonstrating increased motivation and interest in learning [4].

This project aims at creating novel accessible content on the science of everyday materials for the PSCI 1101K theme with the same title. The intrinsic benefit of this theme is its context in the students' daily lives, which has been shown to increase student engagement. Moreover, it covers a wide range of scales from atoms to grains of sand to cars in traffic. Thus, this theme provides students with a wholesome view of the physical world. In Spring 2020, Dr. Vivek, PI will be teaching PSCI 1101 with the theme of "Science of Everyday Materials." The theme was added to the GGC catalog since it is a topic that can be used effectively to draw appreciation of physical science concepts.

Placing this theme in the broader context, "Soft Matter" is the broad study of everyday squishy materials and their applications. Soft Matter is a new and upcoming topic in the field of physics, which became an independent division of the American Physical Society (APS), just this year in 2019 [5] (called DSOFT) when its membership crossed roughly 3% of the total APS membership. Overall, DSOFT stands out as a long-awaited home for physicists studying the mysteries of the everyday. APS DSOFT member-at-large Elisabetta Matsumoto from Georgia Institute of Technology states, "The beauty of this field lies in its ability to reinvigorate the intrinsic curiosity about the world known to every child" [5].

While Drs. Vivek and Tangirala have found through experience that topics on everyday materials are of considerable interest to diverse non-science audiences, there is a large gap on accessible content for diverse non-technical audiences. The current standard text, "Soft condensed matter" by Richard Jones is intended for senior science majors. The current course theme has two recommended texts. In addition to this book, the other text is "Conceptual Integrated Science" by Paul Hewitt. The same "Conceptual Integrated Science" textbook is required for another PSCI 1101K theme, namely conceptual physics, which is priced at $210.80. When Dr. Tangirala taught the PSCI 1101 last semester with the theme of conceptual physics, he required the textbook by Hewitt. Added together, these two textbooks are significantly expensive for the average student, and, hence, a barrier to student interest and success. This proposal aims on transforming material from the two textbooks into accessible online content, with materials taken and simplified from recent research articles and URL links. Instructor and student resources, such as in-class smart notes, PowerPoint presentations for each chapter, and engaging homework material, will be created.

Current State of the Course

Drs. Vivek and Tangirala have decided not to require textbooks for the course for several reasons: First, the standard textbook on the physics of everyday materials (Soft Condensed Matter by Richard Jones) is **a senior undergraduate text**. Drs. Vivek and Tangirala will have to adapt the course for a lower-level Physical Science course by keeping non-science majors in context. Second, the physics team's required text by Hewitt does not sufficiently cover the fundamental topics the two faculty members require. In fact, there are only five chapters and one subsection that will be of use to the course. Third, online materials will be of greater value as a teaching tool since the faculty can regularly update them and can tailor them to be engaging and relevant for a student population that may already be intimidated by a physics course. Finally and more importantly, the students will be able to use the online resources on the very first day of class and alleviate additional financial burden to them.

When Dr. Vivek taught introductory physics for algebra majors (Physics 1111K) using the OpenStax College physics textbook, a student came up to him and said that having an online textbook was a lifesaver. He went on to say, “I am a non-traditional student without any financial support from my parents or guardians. I do have a set budget that is channeled towards other expenses for my household. Having access to this textbook was awesome.” The student also said, “Having access to this textbook definitely improved my grade. It improved my understanding of certain concepts taught in class.” That experience made an impact on Dr. Vivek, which resolved him to pursue developing online resources for this introductory course for non-science majors. Georgia Gwinnett College has small class sizes, and this physics lab course enrolls only 20 students per section. Despite this number, 26 sections or 520 students take PSCI 1101 each year. This number represents a total of about $140,093 in possible savings if no-cost materials were adopted.

Ultimately, providing no-cost curriculum material will help improve students' success in the classroom. The physical sciences, which consists of the broad areas of astronomy, physics, chemistry, and Earth Sciences, are often regarded as intimidating or “difficult” subjects. For instance, the project team noted that physical sciences courses taught have an average DWF rate of 30% (measured from Spring 2019) and 31% (Fall 2019). By replacing the high-priced books with no-cost and interesting, team-based class activities, the PIs hope to decrease the DWF rates and increase the possibility of students progressing to other perceived “difficult” courses with confidence.

Project’s transformative impact on course and department

At GGC, there are 26 PSCI 1101 courses for non-science majors that are taught every year on average. These courses are theme based, and multiple themes exist. The proposed project aims on providing free, accessible content for one such theme: the Science of Everyday Materials. This project would save expenditures of PSCI 1101 students taking this theme and offer all physics instructors the opportunity to attract more students since the course materials are free. Thus, this would be a zero-cost option that instructors could choose. The instructors do not have to worry about the textbook since the team will review and update them each semester, if needed; and their students will have their materials in place for students to use on the first day of classes.

Project’s transformative impact on institution

Currently, there is no one textbook source for the science of everyday materials physical science theme. Although this is of broad interest to the public and various audiences, existing resources focus on senior undergraduate level material for science majors. This project team will simplify existing resources and realize this resource.

The proposed transformation could also be a great resource for outreach to public schools across the region. Recently, the National Research Council developed a framework for K-12 science standards to promote student learning in the practical context, called the next generation science standards (NGSS) [6]. This framework emphasizes students taking practical examples from the natural world and understanding cross-disciplinary concepts by delving into the examples, rather than learning concepts a priori. The intended transformation would be a way for students to learn scientific concepts cutting across physics, chemistry, and biology through examples of common everyday materials. As this course is for undergraduate non-science majors, it would also be accessible for high school students. Drs. Vivek and Tangirala will discuss with public school teachers in the area how best to make the content accessible to high school students.

More importantly, the project has the potential to provide savings of $140,093, should it be adopted/adapted by the 26 PSCI 1101 sections, which enroll 20 students in each section. The project team will work to publicize this project to all faculty teaching the PSCI 1101 and 1102 courses. In addition, the project team will request all faculty teaching PSCI 1101 and 1102 to disseminate surveys (mentioned in the qualitative and quantitative measures section), and share the results of the survey. Thus, faculty can quantitatively evaluate whether to adopt the “Science of Everyday Materials” theme with associated materials and course content and/or apply for ALG Textbook Transformation grant funding based on their survey results.

Transformation Action Plan

Overview of Plan

Through the ‘Science of Everyday Materials’ theme, students will use the framework of materials science to discover and explore the broad question: How do small-scale microscopic interactions between individual constituents lead to macroscopic bulk properties? Getting students to think this way will expose them to ask questions about these common household items and to ask how science pertains to different aspects in their daily lives. Moreover, this will guide them to think scientifically and pose questions that make sense of science and scientific concepts. These questions may include natural and situational phenomena such as:

- How do interactions between trapped air particles lead to solid/liquid properties of squishy materials like ketchup and shaving foam?
- How do interactions between drivers lead to traffic patterns?

This theme does not limit students to a certain discipline and can be a way to ensure non-science majors learn concepts across multiple disciplines. Moreover, the theme may trigger their curiosity and inclination to learn more about science, and enable them to appreciate and communicate various scientific concepts present in day-to-day experiences.

In order to accomplish the aim of creating an engaging science course, the project team will utilize the existing course textbooks and transform them into a one unified, focused textbook that is accessible online and on the first day of classes. Most of the content will be simplified from the first resource; however, key concepts on basic science such as “phases of matter” and “units of life” will be taken from the second text.

The team has reviewed the previous textbooks and created a proposed framework for the transformed textbook materials. The team has already started also the preliminary review and evaluation of OER materials culled from OpenStax, Merlot, Galileo, and others. The preliminary work provided the project team with examples of possible links, which are provided in the table below in select chapters of the proposed transformation. All materials will meet the learning outcomes developed for the course.

Current Textbooks versus Proposed Transformation

<u>A. Current textbooks (relevant chapters) and other sources</u>

Textbook 1: Soft Condensed Matter by Richard Jones

Chapter 1. Soft matter an overview

Chapter 2. Forces, energies, and timescales in soft matter

2.2 Gases, liquids and solids

2.3 Viscoelastic behavior

Chapter 3. Phase transitions

Chapter 4. Colloidal dispersions

Chapter 6. Supramolecular self-assembly in soft matter

Textbook 2: Conceptual Integrated Science by Paul Hewitt

Chapter 1. About Science

Chapter 4. Momentum and Energy

4.9 The Work-Energy Theorem

Chapter 6. Heat

Chapter 11. Investigating Matter

Chapter 15. The Basic Unit of Life- The Cell

Chapter 18. Diversity of Life on Earth

<u>B. Proposed Transformed chapters</u>

Chapter 1. Squishy materials: an overview

Chapter 2. Phases of matter (link)

2.1 Gases

2.2 Liquids

2.3 Solids

Chapter 3. Viscoelastic everyday materials

3.1 Combinations of solid and liquid properties

3.2 Ketchup (link)

3.3 Cornstarch (link)

3.4 Skin care creams and lotions (link)

Chapter 4. Everyday colloids

4.1 Coffee (link)

4.2 Milk

4.3 Ink

4.4 Blood

Chapter 5. Self-assembly in squishy materials

5.1 Why do water and oil not mix?

5.2. Surface tension and soap bubbles (link)

5.3 Applications of liquid crystals

Chapter 6. Soft Biological materials

6.1 Squishy DNA

6.2 Traffic jams (link)

Chapter 7. Scientific visualization

7.1 Mutual Attraction between objects (link)

7.2 Math tools for Physics, unit conversions, scientific measurement (link)

7.3 States of Matter (link)

7.4 Acceleration due to Gravity (link)

Sample descriptions of course weekly contents based on the proposed textbook include:

Science behind common kitchen materials - cornstarch, ketchup and nuts (Week 1 and 2): Students will learn the counterintuitive viscoelastic properties all around us. As an activity, students will qualitatively assess the physics behind non-Newtonian fluids like ketchup and cornstarch in water. Through this, they will understand the differences between shear thinning (like ketchup, which liquefies on application of large force) versus shear thickening (cornstarch in water, which solidifies on application of large force). Another activity will help students understand the phenomenon of granular convection, which causes larger nuts or grains of cereal to rise to the top, also known as the Brazil nut effect.

Physics of soap bubbles (Week 3): What makes soap bubbles stable, and how do you make huge soap bubbles? Students will learn the concept of surface tension and make large soap bubbles using soap, special surfactant, and water.

Coffee and colloids (Week 4): As an experimental problem, pour-over coffee is a highly interesting platform: bean grind, water temperature, flow rate, etc. Coffee itself is a complex chemical system consisting of micron-sized particles called colloids that give its characteristic smell and taste. Students will learn the science behind doing good experiments, what are colloids, and the science of percolation. Students will develop methods to quantify properties of coffee beans as a porous media. At the end, the ‘perfect’ coffee will be judged based on the method of preparation that gets the most votes.

Aside from the online textbook, visual PowerPoint (with embedded smart notes) and homework will be created.

1) Create online chapters on science of everyday materials

We will create accessible content for non-science majors by presenting scientific content in a simple and engaging manner. An example is the study of the key scientific concept of 'viscoelasticity'- the science behind how the same material can have both liquid (viscous) and solid (elastic) properties. In order to make the content engaging, students will learn key concepts in the context of everyday materials like shaving foam, ketchup, soap, etc. Subsequent chapters will be about how concepts from the science of everyday materials can apply in other real world contexts, such as in the emergence of solid-like traffic jams at high density and crowding of humans at a concert or subway station.

2) Visual PowerPoint and embedded smart notes for instructors to teach the course

By default, the course content of everyday materials is visual. PowerPoints will be useful for students to visualize scientific concepts behind everyday materials. For the class, each chapter will be one PowerPoint presentation.

In addition, Dr. Vivek has had success in previous courses using smart notebooks to create in-class lecture notes. The usefulness of this is that it creates near-perfect PDFs similar to those created in one-note or on an IPad, with a fraction of the cost. The Rocketbook smart reusable notebook along with erasable pen is $29.95, at least 10 times cheaper than an IPad. In addition, students are able to see notebook contents as they are being written, similar to a blackboard or whiteboard, by displaying through an overhead projector. This notebook will be used to create in-class lecture notes that can be embedded in PowerPoint so that students have a central access to in-class content for each chapter.

3) Engaging homework to solidify scientific concepts in everyday materials

Assignments will be based on applying content learned in class to solidify conceptual understanding of everyday materials. These will cover concepts such as viscoelasticity, where students are provided with some viscoelastic properties and would need to explain the underlying phenomenon of shear thinning or shear thickening, etc.

Back-of-the-envelope calculations such as dimensional analysis are very powerful tools that physicists use to make inferences about the real world. Common examples include colloidal particles such as those in milk, coffee, or sand that either uniformly mix or sediment at the bottom, depending on size and density of the particle. A rough back-of-the-envelope estimate can be made based on the ratio of thermal to gravitational forces to figure out which size mixes versus sinks. Homework questions will be made to apply these concepts learned in class and solve homework problems.

A number of useful online simulations such as PhET States of Matter exist, where students can test concepts such as pressure, volume, and temperature and how they influence solid or liquid or gas phases and phase transitions. Homework problems will be given where the student probes the effect of various 'knobs' on the system so that the student can visualize the impact of these knobs on phases and phase transitions.

Team members' roles

Both Dr. Vivek and Dr. Tangirala are experts in the science of materials. Dr. Vivek did his PhD on experimental squishy materials. He has done numerous demonstrations at the Atlanta Science Festival as well as for K-12 students on squishy materials like cornstarch in water, and making huge soap bubbles. In addition, Dr. Vivek's research on physics of traffic in the internet-connected era has been featured across numerous popular outlets including Forbes, arsTechnica, Nature, etc. Dr. Tangirala is a subject matter expert on condensed matter physics, and particularly simulation aspects. Apart from this, Dr. Tangirala has been involved in scientific outreach and teaching non-technical audiences for more than a decade.

Drs. Vivek and Tangirala will draw from their technical experience in condensed matter, and teaching diverse non-technical students at GGC to create novel content on the science of everyday materials, which is readable and accessible to non-science majors. The roles for designing the materials reflect on Dr. Vivek and Dr. Tangirala's expertise as well as their passion and experience in teaching and giving demonstrations to non-technical audiences. Specific roles are as follows:

Dr. Vivek is the subject matter expert and instructional designer for the PSCI 1101 theme course. He will design materials for chapters on viscoelastic materials, colloids, soap bubbles, and traffic (Chapters 1, 3, 4, and parts of chapter 5 and 6).

Dr. Tangirala is the subject matter expert and instructional designer for the PSCI 1101 theme course. He will design materials for topics related to phases of matter, liquid crystals, DNA, and scientific visualization (Chapter 2, parts of chapter 5 and chapter 6, and chapter 7).

Both Drs. Vivek and Tangirala will work on writing materials. Dr. Tangirala will take the lead in accomplishing the project's evaluation plan, including the creation of survey questions on SurveyMonkey.

Plan for providing access

Students can access the course materials through D2L. Meanwhile, free open access chapters on Galileo will be available for download, with the proposed chapters indicated. Along with the text content in chapters, links will be provided where students can also read other useful content, as indicated in the example links. The ALG repository in Galileo will enable our GGC and USG colleagues to access the free online materials.

Quantitative & Qualitative Measures

The project team will submit a request for IRB approval once the project starts. The survey will be conducted at the end of the semester, and the data collected will help the PIs to modify and improve the learning materials to be used in the following semesters.

The PIs will collect the data below for each goal. Quantitative data will be collected from faculty who are conducting courses using the newly proposed materials. For example, they will be asked to evaluate statements on a 1-5 Likert-scale from strongly disagree to strongly agree. See below for specific data items for each goal.

Qualitative data will be collected by surveying faculty, students, and project clients. There will be open-ended questions to obtain feedback. The data will be collected at both the beginning and end of the semester and compared with similar data from PSCI 1101K courses of differing theme. Comparison with other PSCI 1101K themes will be done by requesting the respective faculty to disseminate these survey forms to their classes. The comparison results will be used to evaluate the efficacy of the course materials in improving student success. In addition, these results will be shared with the faculty members teaching PSCI 1101K with different theme, so that they can evaluate the relative benefit of the "Science of Everyday Materials" theme, which could lead to broader adoption of this theme and the proposed materials across other PSCI 1101K instructors at GGC.

GOAL A: Improve non-science major student success by introducing physical science concepts in the everyday context.

Qualitative Measure, Methods, and Tools

Questionnaires with open-ended questions will be distributed to the students. Questions regarding student perception and interest in science will be asked at both the beginning and end of the semester to ascertain if learning concepts in the everyday context improved student success. The answers will also be compared with other PSCI 1101K sections through the help of faculty members teaching the courses.

- What is your overall perception of learning science? What aspect is most challenging?
- How do you think learning science impacts your daily life?
- Did the course positively impact your perception and grasp of science?
- Do you feel comfortable explaining content from the class to a peer?
- What was the impact of the no-cost textbook on your grade?

Quantitative Measure, Methods, and Tools

We will collect data on course success as required by ALG instructions and compare it to previous data from the course as well as from other concurrent PSCI 1101K themes to check for improvements in the following:

- Retention rate in the course
- Passing and failing rate
- Drop and withdrawal rate
- Percentage of students getting As, Bs, Cs, Ds, Fs, and
- Percentage of students achieving student learning outcomes.

GOAL B: Increase student savings by creating zero-cost content.

Qualitative Measure, Methods, and Tools

Anecdotal evidence from the class will be recorded, pertaining to whether the cost savings had an impact on student enrollment and success. Questions may include:

- What was most helpful from the course materials?
- What would you like to change from the course materials?
- Did having free online materials on the first day of class help improve your success in the course? If so, how did it help you with the course?

Quantitative Measure, Methods, and Tools

The questionnaire may include the following questions to ascertain students' perception of no-cost textbook,

- The course is to help you learn how science works in everyday materials. Did the textbook and homework help you gain a better understanding of science? From 1 (not at all) to 5 (exceptionally so), to what extent did the materials help you?
- From 1 (not at all) to 5 (exceptionally so), to what extent did having a free textbook and other class materials help prepare you before coming to class?
- From 1 (not at all) to 5 (exceptionally so), to what extent did having a free textbook and other class materials help you complete the class?
- From 1 (not at all) to 5 (exceptionally so), to what extent did having a free textbook and other class materials help your class performance?

GOAL C: Create novel, accessible content on the science of everyday materials. In particular, create online chapters, visual lecture smart notes, and homework suitable for the PSCI 1101K transformation.

Qualitative Measure, Methods, and Tools

During flipped class sessions, in addition to covering in-class content, students will be asked a qualitative question on what they felt about the delivery of the particular chapter, and what can be improved.

Open-ended questions will be asked as below.

- What was most helpful from the course materials?
- What would you like to change from the course materials?

Quantitative Measure, Methods, and Tools

Surveys will be collected where students rate their experience with course content as follows.

- How accessible was the course content from a rating of 1 (not at all) to 5 (exceptionally so)?
- How clear was th course content delivered by the instructor from a rating of 1 (not at all) to 5 (exceptionally so)?
- How engaging was the course content from a rating of 1 (not at all) to 5 (exceptionally so)?

Timeline

The project is from Spring 2020 to Spring 2021.

Spring 2020. The project work will begin this semester. The team will finalize the division of labor. We will identify, review, and select the materials. We will consult also with our Library staff (Ms. Bethany Nash) to help us with identifying OER links that can enhance our work. If needed, the team will create new materials. Submit semester report.

Summer 2020. Pilot in one section in summer 2020. Administer the questionnaire and revise chapters as needed. Submit semester report.

Fall 2020. Teach the course using the developed course materials in ~four sections. Conduct survey at the end of the semester. (Number of sections is based on faculty assignment.) Review the student comments and make further revisions if needed. Submit semester report.

Spring 2021. Teach the course in ~six sections. Conduct survey. Analyze data collected. Finish quantitative and qualitative data analysis. Prepare the final report.

Budget

Type of grant: Standard scale

Total amount requested: $10,800

Budget justification

A. Personnel

Funds are requested to cover the pay and fringes of the team members. The amounts requested and their roles are provided below as justification for the requested amount.

Dr. Skanda Vivek, PI, requests $5,000 to cover pay and fringes. He will manage the project and will be responsible for preparing chapters 1, 3, 4, 5, and 6, as well as instructor's notes and assignments for these chapters.

Dr. Sairam Tangirala, co-PI, requests $5,000 to cover pay and fringes. He will be responsible for preparing chapters 2, 5, 6, and 7, overseeing the evaluation plan, and take the lead in creating and analyzing student surveys.

B. Travel

$740 is requested for two members to attend the kickoff meeting and to disseminate materials at conferences.

C. Supplies

$60 is requested to get two Rocketbook reusable smart notebooks for both instructors to create in-class notes.

Sustainability Plan

The goal of the project is to create novel accessible content on the science of everyday materials for non-science majors. In order to ensure the content is relevant, chapter updates will be made as necessary for the OER materials on GALILEO. These updates could include novel applications of the physics of everyday materials such as the science of complex networks including road transportation networks and smart city infrastructure. In addition, new URL links on existing content could also be part of the updates.

The course is also associated with a significant lab component where students do hands-on experiments such as making huge soap bubbles, developing collective robots, and realizing the perfect cup of coffee. This lab material will be the focus of an ancillary ALG grant. Since PSCI 1101K course themes are chosen by instructor, we will discuss and evaluate if other faculty are interested in adopting the theme and associated OER materials. By incorporating their inputs, it could be possible to have a large-scale adoption across all PSCI 1101K sections being taught at GGC. This would lead to significant yearly student saving of $140,093.20, which could be the subject of a large-scale transformation ALG grant.

Once this project is completed, we plan to present our OER materials at conferences like Georgia Undergraduate Research Conference and SACS-AAPT (Southern Atlantic Coast Section of the American Association of Physics Teachers). Such presentations will enable us to disseminate the materials repository to other Physical Sciences instructors across the USG and to pursue collaborative efforts for broader adoption. Ultimately, this effort will impact student learning by promoting scientific thought process through commonly found household materials, while bolstering student savings at a larger scale.

Acknowledgment

Grant Acceptance

[Acknowledged] I understand and acknowledge that acceptance of Affordable Learning Georgia grant funding constitutes a commitment to comply with the required activities listed in the RFP and that my submitted proposal will serve as the statement of work that must be completed by my project team. I further understand and acknowledge that failure to complete the deliverables in the statement of work may result in termination of the agreement and funding.

Georgia Gwinnett
COLLEGE

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December 10th, 2019

Re: Affordable Learning Georgia, University System of Georgia

Dear Grant Writing Committee Members,

I am pleased to fully support the "Affordable Learning Georgia Textbook Transformation Grant" grant proposal submitted by two faculty, Drs. Skanda Vivek and Sairam Tangirala, of the School of Science and Technology at Georgia Gwinnet College (GGC). The proposed textbook transformation project aims at authoring no-cost-to-students curriculum materials to replace the currently recommended copyrighted textbook for a new Physical Science course with theme "Science of Everyday Materials". The newly developed curriculum-relevant materials intend to significantly lower the textbook related cost for students registering into this course. This course is a general education science course that falls under the program plan for non-science majors, designed to prepare non-science major students to understand and communicate appropriate scientific concepts.

Through this course theme, students will learn how unusual combinations of solid, liquid, and gaseous properties emerge from the microscopic scale in everyday materials such as ketchup and shaving foam. Understanding the physics of everyday materials has interdisciplinary applications in a wide range of subjects including topics in physics, chemistry and biology such as food, shampoo, and blood. Finally, students will use tools learned to explore a wide variety of systems including custom built collective robots, bacterial colonies, slime molds, even traffic.

Dr. Vivek is scheduled to teach three sections of the aforementioned course in Spring 2020, and is preparing teaching materials along with Dr. Tangirala. They have the knowledge, skills and experience needed to perform and succeed in the action plan of the grant. If awarded the grant, I will work with them to facilitate and provide necessary resources to ensure the success of this project. Please let me know if you have more questions or need more information regarding this proposal.

Sincerely,

Joseph C. Sloop

Joseph Sloop, Ph.D.
Interim Dean, School of Science and Technology
Georgia Gwinnett College

Affordable Learning Georgia

Textbook Transformation Grants, Round Sixteen
(Spring 2020 – Spring 2021)
Proposal Form and Narrative

Applicant, Team, and Sponsor Information

Institution(s)	Georgia Gwinnett College
Applicant Name	Skanda Vivek
Applicant Email	svivek@ggc.edu
Applicant Phone #	678-722-1623
Applicant Position/Title	Assistant Professor of Physics
Submitter Name	
Submitter Email	
Submitter Phone #	
Submitter Position	

Please provide the first/last names and email addresses of all team members within the proposed project. Include the applicant (Project Lead) in this list. Do not include prefixes or suffixes such as Ms., Dr., Ph.D., etc.

	Name	Email Address
Team Member 1	Skanda Vivek	svivek@ggc.edu
Team Member 2	Sairam Tangirala	stangira@ggc.edu
Team Member 3		
Team Member 4		
Team Member 5		
Team Member 6		
Team Member 7		
Team Member 8		

If you have any more team members to add, please enter their names and email addresses in the text box below.

Please provide the sponsor's name, title, department, and institution. The sponsor is the provider of your Letter of Support.

Joseph Sloop, Interim Dean, School of Science and Technology, Georgia Gwinnett College

Title of the Project:

"Science of Everyday Materials"- Developing Zero Cost Physical Science Curriculum for Non-Science Majors

Project Information and Impact Data

Priority Category / Categories	Specific Core Curriculum Courses
Requested Amount of Funding	$10,800
Course Names and Course Numbers	PSCI 1101K (Physical Science with Laboratory)
Final Semester of Funding	Spring 2021
Total Number of Student Section Enrollments Affected by Project in One Academic Year	220
Average Number of Student Section Enrollments Affected per Summer Semester	20
Average Number of Student Section Enrollments Affected per Fall Semester	80
Average Number of Student Section Enrollments Affected per Spring Semester	120
Original Required Materials	Recommended Textbooks: Title: Soft Condensed Matter Author: Richard Jones Price: $58.61 URL: https://www.amazon.com/Condensed-Matter-Oxford-Master-Physics/dp/0198505892/ref=sr_1_1?crid=QS49H23TBL2Y&keywords=soft+condensed+matter+physics&qid=1576694322&sprefix=soft+condensed%2Caps%2C133&sr=8-1 Title: Conceptual Integrated Science Author: Paul Hewitt Price: $210.80 URL: https://ggc.bncollege.com/shop/ggc/textbook/conceptual-integrated-science

Average Post-Project Cost Per Student Section Enrollment	$0
Average Post-Project Savings Per Student Section Enrollment	$269.41
Average Post-Project Savings Per Student Section Enrollment	$269.41
Projected Total Annual Student Savings Per Academic Year	$59,270.20 (for 220 students from 11 sections in an academic year)
Using OpenStax Textbook?	No

NARRATIVE SECTION

1. PROJECT GOALS

The goals of the project are:

A) Improve non-science major student success by introducing physical science concepts in the everyday context.

Creating and teaching science courses for non-science majors is a challenge [1]. Students may have extensive science training or none at all, due to the minimal prerequisites for such courses. While science majors take multiple courses across scientific disciplines and obtain a solid scientific worldview through these exposures, non- science majors take only a couple of science courses [2] during their entire undergraduate study. For instructors of science to non-science majors, it can be a challenge to sustain these students' interest and ensure their success. On the one hand, cramming a course full of multiple scientific concepts can be intimidating to students and hard to grasp in just one semester. On the other, focusing on a narrow set of concepts has the risk that students come out of the course with a narrow scientific worldview. In order to understand how best to teach non-science majors science, we need to ask this question first: What do non-science majors stand to gain from a science classroom?

David Hawthorne, director of education and outreach at the national socio-economic center at University of Maryland says one of the most important learning outcomes of his course on teaching non-science students about pollination is "detail distillation" [3] - Students learn that every complex problem has a simple solution (which could be right or wrong depending on the application). Developing such an aptitude to analyze and breakdown complex daily problems into their most basic parts and solve, is also very useful for decision-making. Most leadership roles across governments and companies are held by non-science majors who graduated with degrees in business, finance, education, etc. We believe that imparting a scientific worldview to non-science majors would lead to better decision making.

This course transformation proposes to teach non-science majors how science helps simplify and understand complex everyday phenomena through examples of everyday complex materials like food, soap, shampoo, and even traffic. Take ketchup for example. How is ketchup able to be a liquid while squeezed through the bottle and a solid that holds its shape on the plate both at the same time? The advantage of teaching in such a fashion is students can learn multiple science concepts directly useful in their everyday life, as well as ensuring their constant engagement and enthusiasm in learning science through the course.

Here are some quotes from non-science major students taking the physical science course with theme "Conceptual Physics" showing their interest in learning science in the everyday context:

> "For Physical Science, there were some concepts that I never really thought about in the real world. It was very interesting how science in real-life works."

"Learning measurements about basic world functions and being able to calculate them exactly."

This project proposes to develop new course material on the "Science of Everyday Materials" for the Physical Science Course PSCI 1101K at GGC. This theme represents one of several Physical Science Course themes being offered at GGC, and was recently approved to be taught for the first time across three sections in Spring 2020. Currently, the course has two recommended textbooks: "Soft Condensed Matter" by Richard Jones as well as "Conceptual Integrated Science" by Paul Hewitt. However, there are several problems with these above textbooks:

- "Soft Condensed Matter" by Richard Jones is the standard textbook for teaching senior undergraduate majors the science behind everyday materials, however is considerably advanced for non-science majors.

- "Conceptual Integrated Science" is the standard textbook taught across other Physical Science themes such as conceptual physics. However, this book does not contain all the topics required to cover the science of everyday materials.

The project team will simplify content from these two recommended textbooks in order to create accessible zero-cost material for PSCI 1101K science of everyday materials theme. Moreover, the team will introduce novel pedagogical methods where students learn and discover concepts in the context of everyday materials through common activities like making coffee, and playing with sand. By understanding the science behind everyday materials, the team is able to make science and its technical concepts more interesting to learn, less intimidating, and more engaging to non-science major students. Ultimately, the project team aspires to remove barriers to the students' success in this and their future science courses.

B) Increase student savings by creating zero-cost content.

Currently, the science of everyday materials theme has two recommended textbooks that cost a total of $269.41 per student. Because of the varied levels of non-science major student prior scientific knowledge, a large number of students would want to purchase the recommended materials so that they do not fall behind in class. Further, because these students are not exposed to many science courses, they might want to buy and keep books for the content.

Through the proposed project, students will have access to comprehensive content on the science of everyday material in one repository for zero-cost. This will create significant savings. Currently, it is estimated that 11 courses in physical science over the pilot project (four in fall 2020, one in summer 2020 and six in spring 2021) will be taught with this theme, with an average of 20 students each section, and savings of $59,270.20 in total. However, physical science courses themes are chosen by the instructor, and in total 26 physical science 1101K sections were taught in 2019. Thus, the potential student savings with average 20 students per section is $140,093.20 if these materials are widely adopted among all PSCI 1101K instructors.

C) Create novel, accessible content on the science of everyday materials. In particular, create online chapters, visual lecture smart notes, and homework suitable for the PSCI 1101K transformation.

The Nobel Prize physicist Richard Feynman once said, “If you can't explain something to a first year student, then you haven't really understood it.” Intuitively, you might think that simple everyday materials like ketchup, shaving foam, and shampoo are easy to explain. However, these everyday materials are actually complex to understand, which is why the current standard text on everyday soft materials, “Soft Condensed Matter” by Richard Jones, is a senior science major undergraduate text and far from being a simple, easy-to-comprehend book especially for the non-science major. The challenge then becomes how to create accessible content on everyday materials, while at the same time not diluting the scientific concepts by simplifying the explanation.

One of the important goals for this project is to create accessible content for non-science majors so that they come out of the course having a solid understanding behind the science of everyday complex phenomena. We will accomplish this aim by assembling a combination of chapters accessible to both students and instructors, as well as in-class materials that engage students and promote students to probe and discover the science behind everyday materials.

2. STATEMENT OF TRANSFORMATION

Overview of the Transformation

PSCI 1101K (Physical Science with Laboratory) is a general education course for non-science majors. It is a theme-based course with a menu of themes offered each semester. According to the GGC course site, this course is designed so that at the end of the course students will:

1) Communicate scientific issues effectively in oral and written form;
2) Distinguish scientific studies from popular opinions by employing critical thinking skills and the scientific method;
3) Effectively collect, analyze and present data and correctly construct and interpret charts, graphs and tables to draw scientific conclusions; and
4) Apply the fundamental concepts and methodologies of physics and/or chemistry to investigate a scientific theme.

Recently, there is a waning of student interest and participation in science across high school, colleges, and universities. Research has found that learning science in the everyday context is more relevant to their out-of-school lives and results to students demonstrating increased motivation and interest in learning [4].

This project aims at creating novel accessible content on the science of everyday materials for the PSCI 1101K theme with the same title. The intrinsic benefit of this theme is its context in the students’ daily lives, which has been shown to increase student engagement. Moreover, it covers a wide range of scales from atoms to grains of sand to cars in traffic. Thus, this theme provides students with a wholesome view of the physical world. In Spring 2020, Dr. Vivek, PI will be teaching PSCI 1101 with the theme of "Science of Everyday Materials." The theme was added to the GGC catalog since it is a topic that can be used effectively to draw appreciation of physical science concepts.

Placing this theme in the broader context, "Soft Matter" is the broad study of everyday squishy materials and their applications. Soft Matter is a new and upcoming topic in the field of physics, which became an independent division of the American Physical Society (APS), just this year in 2019 [5] (called DSOFT) when its membership crossed roughly 3% of the total APS membership. Overall, DSOFT stands out as a long-awaited home for physicists studying the mysteries of the everyday. APS DSOFT member-at-large Elisabetta Matsumoto from Georgia Institute of Technology states, "The beauty of this field lies in its ability to reinvigorate the intrinsic curiosity about the world known to every child" [5].

While Drs. Vivek and Tangirala have found through experience that topics on everyday materials are of considerable interest to diverse non-science audiences, there is a large gap on accessible content for diverse non-technical audiences. The current standard text, "Soft condensed matter" by Richard Jones is intended for senior science majors. The current course theme has two recommended texts. In addition to this book, the other text is "Conceptual Integrated Science" by Paul Hewitt. The same "Conceptual Integrated Science" textbook is required for another PSCI 1101K theme, namely conceptual physics, which is priced at $210.80. When Dr. Tangirala taught the PSCI 1101 last semester with the theme of conceptual physics, he required the textbook by Hewitt. Added together, these two textbooks are significantly expensive for the average student, and, hence, a barrier to student interest and success. This proposal aims on transforming material from the two textbooks into accessible online content, with materials taken and simplified from recent research articles and URL links. Instructor and student resources, such as in-class smart notes, PowerPoint presentations for each chapter, and engaging homework material, will be created.

Current State of the Course

Drs. Vivek and Tangirala have decided not to require textbooks for the course for several reasons: First, the standard textbook on the physics of everyday materials (Soft Condensed Matter by Richard Jones) is **a senior undergraduate text**. Drs. Vivek and Tangirala will have to adapt the course for a lower-level Physical Science course by keeping non-science majors in context. Second, the physics team's required text by Hewitt does not sufficiently cover the fundamental topics the two faculty members require. In fact, there are only five chapters and one subsection that will be of use to the course. Third, online materials will be of greater value as a teaching tool since the faculty can regularly update them and can tailor them to be engaging and relevant for a student population that may already be intimidated by a physics course. Finally and more importantly, the students will be able to use the online resources on the very first day of class and alleviate additional financial burden to them.

When Dr. Vivek taught introductory physics for algebra majors (Physics 1111K) using the OpenStax College physics textbook, a student came up to him and said that having an online textbook was a lifesaver. He went on to say, "I am a non-traditional student without any financial support from my parents or guardians. I do have a set budget that is channeled towards other expenses for my household. Having access to this textbook was awesome." The student also said, "Having access to this textbook definitely improved my grade. It improved my understanding of certain concepts taught in class." That experience made an impact on Dr. Vivek, which resolved him to pursue developing online resources for this introductory course for non-science majors. Georgia Gwinnett College has small class sizes, and this physics lab course enrolls only 20 students per section. Despite this number, 26 sections or 520 students take PSCI 1101 each year. This number represents a total of about $140,093 in possible savings if no-cost materials were adopted.

Ultimately, providing no-cost curriculum material will help improve students' success in the classroom. The physical sciences, which consists of the broad areas of astronomy, physics, chemistry, and Earth Sciences, are often regarded as intimidating or "difficult" subjects. For instance, the project team noted that physical sciences courses taught have an average DWF rate of 30% (measured from Spring 2019) and 31% (Fall 2019). By replacing the high-priced books with no-cost and interesting, team-based class activities, the PIs hope to decrease the DWF rates and increase the possibility of students progressing to other perceived "difficult" courses with confidence.

Project's transformative impact on course and department

At GGC, there are 26 PSCI 1101 courses for non-science majors that are taught every year on average. These courses are theme based, and multiple themes exist. The proposed project aims on providing free, accessible content for one such theme: the Science of Everyday Materials. This project would save expenditures of PSCI 1101 students taking this theme and offer all physics instructors the opportunity to attract more students since the course materials are free. Thus, this would be a zero-cost option that instructors could choose. The instructors do not have to worry about the textbook since the team will review and update them each semester, if needed; and their students will have their materials in place for students to use on the first day of classes.

Project's transformative impact on institution

Currently, there is no one textbook source for the science of everyday materials physical science theme. Although this is of broad interest to the public and various audiences, existing resources focus on senior undergraduate level material for science majors. This project team will simplify existing resources and realize this resource.

The proposed transformation could also be a great resource for outreach to public schools across the region. Recently, the National Research Council developed a framework for K-12 science standards to promote student learning in the practical context, called the next generation science standards (NGSS) [6]. This framework emphasizes students taking practical examples from the natural world and understanding cross-disciplinary concepts by delving into the examples, rather than learning concepts a priori. The intended transformation would be a way for students to learn scientific concepts cutting across physics, chemistry, and biology through examples of common everyday materials. As this course is for undergraduate non-science majors, it would also be accessible for high school students. Drs. Vivek and Tangirala will discuss with public school teachers in the area how best to make the content accessible to high school students.

More importantly, the project has the potential to provide savings of $140,093, should it be adopted/adapted by the 26 PSCI 1101 sections, which enroll 20 students in each section. The project team will work to publicize this project to all faculty teaching the PSCI 1101 and 1102 courses. In addition, the project team will request all faculty teaching PSCI 1101 and 1102 to disseminate surveys (mentioned in the qualitative and quantitative measures section), and share the results of the survey. Thus, faculty can quantitatively evaluate whether to adopt the "Science of Everyday Materials" theme with associated materials and course content and/or apply for ALG Textbook Transformation grant funding based on their survey results.

3. TRANSFORMATION ACTION PLAN

Overview of Plan

Through the 'Science of Everyday Materials' theme, students will use the framework of materials science to discover and explore the broad question: How do small-scale microscopic interactions between individual constituents lead to macroscopic bulk properties? Getting students to think this way will expose them to ask questions about these common household items and to ask how science pertains to different aspects in their daily lives. Moreover, this will guide them to think scientifically and pose questions that make sense of science and scientific concepts. These questions may include natural and situational phenomena such as:

> How do interactions between trapped air particles lead to solid/liquid properties of squishy materials like ketchup and shaving foam?
>
> How do interactions between drivers lead to traffic patterns?

This theme does not limit students to a certain discipline and can be a way to ensure non-science majors learn concepts across multiple disciplines. Moreover, the theme may trigger their curiosity and inclination to learn more about science, and enable them to appreciate and communicate various scientific concepts present in day-to-day experiences.

In order to accomplish the aim of creating an engaging science course, the project team will utilize the existing course textbooks and transform them into a one unified, focused textbook that is accessible online and on the first day of classes. Most of the content will be simplified from the first resource; however, key concepts on basic science such as "phases of matter" and "units of life" will be taken from the second text.

The team has reviewed the previous textbooks and created a proposed framework for the transformed textbook materials. The team has already started also the preliminary review and evaluation of OER materials culled from OpenStax, Merlot, Galileo, and others. The preliminary work provided the project team with examples of possible links, which are provided in the table below in select chapters of the proposed transformation. All materials will meet the learning outcomes developed for the course.

Current Textbooks versus Proposed Transformation	
Current textbooks (relevant chapters) and other sources	**Proposed Transformed chapters**
Soft Condensed Matter by Richard Jones: 1. Soft matter an overview 2. Forces, energies, and timescales in soft matter 2.2. Gases, liquids and solids 2.3. Viscoelastic behavior 3. Phase transitions 4. Colloidal dispersions 6. Supramolecular self-assembly in soft matter **Conceptual Integrated Science by Paul Hewitt:** 1. About Science 4. Momentum and Energy 4.9. The Work-Energy Theorem 6. Heat 11. Investigating Matter 15. The Basic Unit of Life- The Cell 18. Diversity of Life on Earth	**Proposed Equivalent Curriculum:** 1. Squishy materials: an overview 2. Phases of matter (link) 2.1. Gases 2.2. Liquids 2.3. Solids 3. Viscoelastic everyday materials 3.1. Combinations of solid and liquid properties 3.2. Ketchup (link) 3.3 Cornstarch (link) 3.4 Skin care creams and lotions (link) 4. Everyday colloids 4.1. Coffee (link) 4.2. Milk 4.3. Ink 4.4. Blood 5. Self-assembly in squishy materials 5.1. Why do water and oil not mix? 5.2. Surface tension and soap bubbles (link) 5.3. Applications of liquid crystals 6. Soft Biological materials 6.1. Squishy DNA 6.2. Traffic jams (link) 7. Scientific visualization 7.1. Mutual Attraction between objects (link) 7.2 Math tools for Physics, unit conversions, scientific measurement (link) 7.3 States of Matter (link) 7.4 Acceleration due to Gravity (link)

Sample descriptions of course weekly contents based on the proposed textbook include:

> Science behind common kitchen materials - cornstarch, ketchup and nuts (Week 1and 2): Students will learn the counterintuitive viscoelastic properties all around us. As an activity, students will qualitatively assess the physics behind non-Newtonian fluids like ketchup and cornstarch in water. Through this, they will understand the differences between shear thinning (like ketchup, which liquefies on application of large force) versus shear thickening (cornstarch in water, which solidifies on application of large force). Another activity will help students understand the phenomenon of granular convection, which causes larger nuts or grains of cereal to rise to the top, also known as the Brazil nut effect.
>
> Physics of soap bubbles (Week 3): What makes soap bubbles stable, and how do you make huge soap bubbles? Students will learn the concept of surface tension and make large soap bubbles using soap, special surfactant, and water.
>
> Coffee and colloids (Week 4): As an experimental problem, pour-over coffee is a highly interesting platform: bean grind, water temperature, flow rate, etc. Coffee itself is a complex chemical system consisting of micron-sized particles called colloids that give its characteristic smell and taste. Students will learn the science behind doing good experiments, what are colloids, and the science of percolation. Students will develop methods to quantify properties of coffee beans as a porous media. At the end, the 'perfect' coffee will be judged based on the method of preparation that gets the most votes.

Aside from the online textbook, visual PowerPoint (with embedded smart notes) and homework will be created.

1) Create online chapters on science of everyday materials

We will create accessible content for non-science majors by presenting scientific content in a simple and engaging manner. An example is the study of the key scientific concept of 'viscoelasticity'- the science behind how the same material can have both liquid (viscous) and solid (elastic) properties. In order to make the content engaging, students will learn key concepts in the context of everyday materials like shaving foam, ketchup, soap, etc. Subsequent chapters will be about how concepts from the science of everyday materials can apply in other real world contexts, such as in the emergence of solid-like traffic jams at high density and crowding of humans at a concert or subway station.

2) Visual PowerPoint and embedded smart notes for instructors to teach the course

By default, the course content of everyday materials is visual. PowerPoints will be useful for students to visualize scientific concepts behind everyday materials. For the class, each chapter will be one PowerPoint presentation.

In addition, Dr. Vivek has had success in previous courses using smart notebooks to create in-class lecture notes. The usefulness of this is that it creates near-perfect PDFs similar to those created in one-note or on an IPad, with a fraction of the cost. The Rocketbook smart reusable notebook along with erasable pen is $29.95, at least 10 times cheaper than an IPad. In addition, students are able to see notebook contents as they are being written, similar to a blackboard or whiteboard, by displaying through an overhead projector. This notebook will be used to create in-class lecture notes that can be embedded in PowerPoint so that students have a central access to in-class content for each chapter.

3) Engaging homework to solidify scientific concepts in everyday materials

Assignments will be based on applying content learned in class to solidify conceptual understanding of everyday materials. These will cover concepts such as viscoelasticity, where students are provided with some viscoelastic properties and would need to explain the underlying phenomenon of shear thinning or shear thickening, etc.

Back-of-the-envelope calculations such as dimensional analysis are very powerful tools that physicists use to make inferences about the real world. Common examples include colloidal particles such as those in milk, coffee, or sand that either uniformly mix or sediment at the bottom, depending on size and density of the particle. A rough back-of-the-envelope estimate can be made based on the ratio of thermal to gravitational forces to figure out which size mixes versus sinks. Homework questions will be made to apply these concepts learned in class and solve homework problems.

A number of useful online simulations such as PhET States of Matter exist, where students can test concepts such as pressure, volume, and temperature and how they influence solid or liquid or gas phases and phase transitions. Homework problems will be given where the student probes the effect of various ‘knobs’ on the system so that the student can visualize the impact of these knobs on phases and phase transitions.

Team members’ roles

Both Dr. Vivek and Dr. Tangirala are experts in the science of materials. Dr. Vivek did his PhD on experimental squishy materials. He has done numerous demonstrations at the Atlanta Science Festival as well as for K-12 students on squishy materials like cornstarch in water, and making huge soap bubbles. In addition, Dr. Vivek’s research on physics of traffic in the internet-connected era has been featured across numerous popular outlets including Forbes, arsTechnica, Nature, etc. Dr. Tangirala is a subject matter expert on condensed matter physics, and particularly simulation aspects. Apart from this, Dr. Tangirala has been involved in scientific outreach and teaching non-technical audiences for more than a decade.

Drs. Vivek and Tangirala will draw from their technical experience in condensed matter, and teaching diverse non-technical students at GGC to create novel content on the science of everyday materials, which is readable and accessible to non-science majors. The roles for designing the materials reflect on Dr. Vivek and Dr. Tangirala’s expertise as well as their passion and experience in teaching and giving demonstrations to non-technical audiences. Specific roles are as follows:

Dr. Vivek is the subject matter expert and instructional designer for the PSCI 1101 theme course. He will design materials for chapters on viscoelastic materials, colloids, soap bubbles, and traffic (Chapters 1, 3, 4, and parts of chapter 5 and 6).

Dr. Tangirala is the subject matter expert and instructional designer for the PSCI 1101 theme course. He will design materials for topics related to phases of matter, liquid crystals, DNA, and scientific visualization (Chapter 2, parts of chapter 5 and chapter 6, and chapter 7).

Both Drs. Vivek and Tangirala will work on writing materials. Dr. Tangirala will take the lead in accomplishing the project's evaluation plan, including the creation of survey questions on SurveyMonkey.

Plan for providing access

Students can access the course materials through D2L. Meanwhile, free open access chapters on Galileo will be available for download, with the proposed chapters. Along with the text content in chapters, links will be provided where students can also read other useful content, as indicated in the example links. The ALG repository in Galileo will enable our GGC and USG colleagues to access the free online materials.

4. QUANTITATIVE AND QUALITATIVE MEASURES

The project team will submit a request for IRB approval once the project starts. The survey will be conducted at the end of the semester, and the data collected will help the PIs to modify and improve the learning materials to be used in the following semesters.

The PIs will collect the data below for each goal. Quantitative data will be collected from faculty who are conducting courses using the newly proposed materials. For example, they will be asked to evaluate statements on a 1-5 Likert-scale from strongly disagree to strongly agree. See below for specific data items for each goal.

Qualitative data will be collected by surveying faculty, students, and project clients. There will be open-ended questions to obtain feedback. The data will be collected at both the beginning and end of the semester and compared with similar data from PSCI 1101K courses of differing theme. Comparison with other PSCI 1101K themes will be done by requesting the respective faculty to disseminate these survey forms to their classes. The comparison results will be used to evaluate the efficacy of the course materials in improving student success. In addition, these results will be shared with the faculty members teaching PSCI 1101K with different theme, so that they can evaluate the relative benefit of the "Science of Everyday Materials" theme, which could lead to broader adoption of this theme and the proposed materials across other PSCI 1101K instructors at GGC.

GOAL A: Improve non-science major student success by introducing physical science concepts in the everyday context.

Qualitative Measure, Methods, and Tools

Questionnaires with open-ended questions will be distributed to the students. Questions regarding student perception and interest in science will be asked at both the beginning and end of the semester to ascertain if learning concepts in the everyday context improved student success. The answers will also be compared with other PSCI 1101K sections through the help of faculty members teaching the courses.

- What is your overall perception of learning science? What aspect is most challenging?
- How do you think learning science impacts your daily life?
- Did the course positively impact your perception and grasp of science?
- Do you feel comfortable explaining content from the class to a peer?
- What was the impact of the no-cost textbook on your grade?

Quantitative Measure, Methods, and Tools

We will collect data on course success as required by ALG instructions and compare it to previous data from the course as well as from other concurrent PSCI 1101K themes to check for improvements in the following:

- Retention rate in the course
- Passing and failing rate
- Drop and withdrawal rate
- Percentage of students getting As, Bs, Cs, Ds, Fs, and
- Percentage of students achieving student learning outcomes.

GOAL B: Increase student savings by creating zero-cost content.

Qualitative Measure, Methods, and Tools

Anecdotal evidence from the class will be recorded, pertaining to whether the cost savings had an impact on student enrollment and success. Questions may include:

- What was most helpful from the course materials?
- What would you like to change from the course materials?
- Did having free online materials on the first day of class help improve your success in the course? If so, how did it help you with the course?

Quantitative Measure, Methods, and Tools

The questionnaire may include the following questions to ascertain students' perception of no-cost textbook,

- The course is to help you learn how science works in everyday materials. Did the textbook and homework help you gain a better understanding of science? From 1 (not at all) to 5 (exceptionally so), to what extent did the materials help you?
- From 1 (not at all) to 5 (exceptionally so), to what extent did having a free textbook and other class materials help prepare you before coming to class?
- From 1 (not at all) to 5 (exceptionally so), to what extent did having a free textbook and other class materials help you complete the class?
- From 1 (not at all) to 5 (exceptionally so), to what extent did having a free textbook and other class materials help your class performance?

GOAL C: Create novel, accessible content on the science of everyday materials. In particular, create online chapters, visual lecture smart notes, and homework suitable for the PSCI 1101K transformation.

<u>Qualitative Measure, Methods, and Tools</u>

During flipped class sessions, in addition to covering in-class content, students will be asked a qualitative question on what they felt about the delivery of the particular chapter, and what can be improved.

Open-ended questions will be asked as below.

- What was most helpful from the course materials?
- What would you like to change from the course materials?

<u>Quantitative Measure, Methods, and Tools</u>

Surveys will be collected where students rate their experience with course content as follows.

- How accessible was the course content from a rating of 1 (not at all) to 5 (exceptionally so)?
- How clear was the course content delivered by the instructor from a rating of 1 (not at all) to 5 (exceptionally so)?
- How engaging was the course content from a rating of 1 (not at all) to 5 (exceptionally so)?

5. TIMELINE

The project is from Spring 2020 to Spring 2021.

Spring 2020. The project work will begin this semester. The team will finalize the division of labor. We will identify, review, and select the materials. We will consult also with our Library staff (Ms. Bethany Nash) to help us with identifying OER links that can enhance our work. If needed, the team will create new materials. Submit semester report.

Summer 2020. Pilot in one section in summer 2020. Administer the questionnaire and revise chapters as needed. Submit semester report.

Fall 2020. Teach the course using the developed course materials in ~four sections. Conduct survey at the end of the semester. (Number of sections is based on faculty assignment.) Review the student comments and make further revisions if needed. Submit semester report.

Spring 2021. Teach the course in ~six sections. Conduct survey. Analyze data collected. Finish quantitative and qualitative data analysis. Prepare the final report.

6. BUDGET

Type of grant: Standard scale

Total amount requested: $10,800

Budget justification

A. Personnel

Funds are requested to cover the pay and fringes of the team members. The amounts requested and their roles are provided below as justification for the requested amount.

Dr. Skanda Vivek, PI, requests $5,000 to cover pay and fringes. He will manage the project and will be responsible for preparing chapters 1, 3, 4, 5, and 6, as well as instructor's notes and assignments for these chapters.

Dr. Sairam Tangirala, co-PI, requests $5,000 to cover pay and fringes. He will be responsible for preparing chapters 2, 5, 6, and 7, overseeing the evaluation plan, and take the lead in creating and analyzing student surveys.

B. Travel

$740 is requested for two members to attend the kickoff meeting and to disseminate materials at conferences.

C. Supplies

$60 is requested to get two Rocketbook reusable smart notebooks for both instructors to create in-class notes.

7. SUSTAINABILITY PLAN

The goal of the project is to create novel accessible content on the science of everyday materials for non-science majors. In order to ensure the content is relevant, chapter updates will be made as necessary for the OER materials on GALILEO. These updates could include novel applications of the physics of everyday materials such as the science of complex networks including road transportation networks and smart city infrastructure. In addition, new URL links on existing content could also be part of the updates.

The course is also associated with a significant lab component where students do hands-on experiments such as making huge soap bubbles, developing collective robots, and realizing the perfect cup of coffee. This lab material will be the focus of an ancillary ALG grant. Since PSCI 1101K course themes are chosen by instructor, we will discuss and evaluate if other faculty are interested in adopting the theme and associated OER materials. By incorporating their inputs, it could be possible to have a large-scale adoption across all PSCI 1101K sections being taught at GGC. This would lead to significant yearly student saving of $140,093.20, which could be the subject of a large-scale transformation ALG grant.

Once this project is completed, we plan to present our OER materials at conferences like Georgia Undergraduate Research Conference and SACS-AAPT (Southern Atlantic Coast Section of the American Association of Physics Teachers). Such presentations will enable us to disseminate the materials repository to other Physical Sciences instructors across the USG and to pursue collaborative efforts for broader adoption. Ultimately, this effort will impact student learning by promoting scientific thought process through commonly found household materials, while bolstering student savings at a larger scale.

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