Affordable Materials Grants, Round 21:

Transformation Grants

(Spring 2022-Spring 2023)

Proposal Form and Narrative

# Notes

* The proposal form and narrative .docx file is for offline drafting and for our review processes. Submitters must use the online Google Form for proposal submission, including uploading this document.
* The only way to submit the official proposal is through the Google Form. The link to the online application is on the [Round 21 RFP Page](https://www.affordablelearninggeorgia.org/about/rfp_r21).
* The italic text provided below is meant for clarifications and can be deleted.

The Round 21 Kickoff will include an asynchronous training module, required for all team members to complete, followed by the synchronous Kickoff Meeting on March 25, 2022 from 1pm-4pm. At least two team members from each awarded team (unless the award is for one individual) are required to attend the synchronous Kickoff Meeting.

# Applicant and Team Information

*The* ***applicant*** *is the proposed Project Lead for the grant project. The* ***submitter*** *is the person submitting the application (which may be a Grants Officer or Administrator). The submitter will often be the applicant—if so, just list leave the submitter blank.*

| Requested information | Answer |
| --- | --- |
| Institution(s) | University of Georgia |
| Applicant name | Nandana Weliweriya Liyanage |
| Applicant email  | nandanaw@uga.edu |
| Applicant position/title | **Assistant Professor** |
| Submitter name  | Nandana Weliweriya |
| Submitter email  | nandanaw@uga.edu |
| Submitter position/title | **Assistant Professor** |

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.

| Team member | Name | Email address |
| --- | --- | --- |
| Team member 1 | Shameer Abdeen | mabdeen@georgiasouthern.edu |
| Team member 2 |  |  |
| Team member 3 |  |  |
| Team member 4 |  |  |
| Team member 5 |  |  |
| Team member 6 |  |  |

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

|  |
| --- |
|  |

# Project Information

| Requested information | Answer |
| --- | --- |
| Priority Category / Categories*Projects in these categories will receive three extra points in the final score for fitting a priority of these particular rounds of Transformation Grants. The type of funding for the project is determined by the funding categories criteria above. As of Round 18, projects can be a part of more than one category. Note that the below categories only indicate priority, not which applications qualify for a grant. Select all that apply.* | *Priority categories:* * *Collaborative Projects with Professional Support*
* *Student Participation in Materials Evaluation and/or Development*

 |
| Requested Total Amount of Funding*$30,000 maximum total award per grant* | ***$5000.00*** |
| Final Semester of Project | *All Transformation Grants for Round 22 end in Spring 2023.*  |
| Using OpenStax Textbook?*This is to indicate to OpenStax that they can provide additional support and resources to your team during the adoption process.* | *Yes* |

# Impact Data

Please fill in the data below with impact data in below with one course (all sections) in each table, and only include courses and instructors that are specifically part of the scope of this grant proposal. Add or remove tables as needed. **Please only put a single averaged or totaled (as appropriate) number in each box. Do not put ranges or mathematical equations in any of these boxes.** If the materials used by different instructors in a course vary drastically, it is possible to enter one course per instructor.

For a multi-course project, if a significant amount of students are assumed to take courses in a sequence and only one textbook is used for these courses, please take this into account in your total *(i.e. only include that book in the first course they would purchase it for OR adjust the number of students affected. Please explain in the notes section if making such adjustments).*

Clarification:

* In the fall 2022 semester, UGA offers three calculus-based first-semester physics courses (PHYS 1251).
	+ PHYS 1251 (CRN: 38-057)
	+ PHYS 1251 (CRN: 38-058)
	+ PHYS 1251 (CRN: 50-072)
* These are three sections of the same course scheduled to be taught by the same instructor, the PI of this proposal, Nandana Weliweriya.
* Each section has an enrollment of 72 students, making 216 just for fall 2022. We plan to use the same pre-lecture videos again in the spring 2023 semester courses, leading to 432 students.

## Course 1

| Row # | Requested information | Answer |
| --- | --- | --- |
| N/A | Course title and number | PHYS 1251 (CRN:38-057) - Introductory Studio Physics for Engineers I |
| N/A | Course instructors | Nandana Weliweriya Liyanage |
| 1 | Average number of students enrolled per section | 72 |
| 2 | Average number of affected course sections scheduled in a summer semester | 0 |
| 3 | Average number of affected course sections scheduled in a fall semester | 1 |
| 4 | Average number of affected course sections scheduled in a spring semester | 1 |
| 5 | Total number of course sections scheduled in an academic year *Add up rows 2-4.* | 2 |
| 6 | Total number of student section enrollments per academic year*Multiply row 1 and row 5.* | 144 |
| 7 | Original required commercial materials*Include each title, author, price for a new copy purchased from either your campus bookstore, the publisher, or Amazon, and a URL to the book showing the price.* | Publisher (McMillan learning) generated pre-lecture videos $55 per student, per semester |
| 8 | Original cost per student section enrollment*Add up the cost of all materials in row 7.* | $55 |
| 9 | Average post-project cost per student section enrollment | $0 |
| 10 | Average post-project savings per student section enrollment*Subtract row 9 from row 8.* | $55 |
| 11 | Projected total annual student savings per academic year*Multiply row 10 and row 6.* | $7920 |

## Course 2

| Row # | Requested information | Answer |
| --- | --- | --- |
| N/A | Course title and number | PHYS 1251 (CRN:38-058) - Introductory Studio Physics for Engineers I |
| N/A | Course instructors | Nandana Weliweriya Liyanage |
| 1 | Average number of students enrolled per section | 72 |
| 2 | Average number of affected course sections scheduled in a summer semester | 0 |
| 3 | Average number of affected course sections scheduled in a fall semester | 1 |
| 4 | Average number of affected course sections scheduled in a spring semester | 1 |
| 5 | Total number of course sections scheduled in an academic year *Add up rows 2-4.* | 2 |
| 6 | Total number of student section enrollments per academic year*Multiply row 1 and row 5.* | 144 |
| 7 | Original required commercial materials*Include each title, author, price for a new copy purchased from either your campus bookstore, the publisher, or Amazon, and a URL to the book showing the price.* | Publisher (McMillan learning) generated pre-lecture videos $55 per student, per semester |
| 8 | Original cost per student section enrollment*Add up the cost of all materials in row 7.* | $55 |
| 9 | Average post-project cost per student section enrollment | $0 |
| 10 | Average post-project savings per student section enrollment*Subtract row 9 from row 8.* | $55 |
| 11 | Projected total annual student savings per academic year*Multiply row 10 and row 6.* | $7920 |

## Course 3

| Row # | Requested information | Answer |
| --- | --- | --- |
| N/A | Course title and number | PHYS 1251 (CRN:50-072) - Introductory Studio Physics for Engineers I |
| N/A | Course instructors | Nandana Weliweriya Liyanage |
| 1 | Average number of students enrolled per section | 72 |
| 2 | Average number of affected course sections scheduled in a summer semester | 0 |
| 3 | Average number of affected course sections scheduled in a fall semester | 1 |
| 4 | Average number of affected course sections scheduled in a spring semester | 1 |
| 5 | Total number of course sections scheduled in an academic year *Add up rows 2-4.* | 2 |
| 6 | Total number of student section enrollments per academic year*Multiply row 1 and row 5.* | 144 |
| 7 | Original required commercial materials*Include each title, author, price for a new copy purchased from either your campus bookstore, the publisher, or Amazon, and a URL to the book showing the price.* | Publisher (McMillan learning) generated pre-lecture videos $55 per student, per semester |
| 8 | Original cost per student section enrollment*Add up the cost of all materials in row 7.* | $55 |
| 9 | Average post-project cost per student section enrollment | $0 |
| 10 | Average post-project savings per student section enrollment*Subtract row 9 from row 8.* | $55 |
| 11 | Projected total annual student savings per academic year*Multiply row 10 and row 6.* | $7920 |

If you have more courses to add, copy the table as many times as needed to complete all courses on the grant.

# Narrative Section

# Title: Integrating Well Aligned Pre-Lecture Videos in Student-Centered Large Enrollment Undergraduate Physics Courses.

## Project Goals:

* This project aims to improve the quality of introductory-level physics courses and support physics education research at UGA.
* Generate pre-lecture videos for calculus-based first-semester physics courses at UGA (PHYS 1251) and have students consume them at no charge.
* Assess the effectiveness of these pre-lecture videos using virtual reality headsets and eye-tracking data.

# Introduction:

The Programme for International Student Assessment (PISA) recently reported that the US, once the leader in science and technology, has not reported any improvement in Standardized Test scores since the year 2000. The US is now behind many countries and placed 30th of 64 countries in mathematics and 11th in science. Meanwhile, many global studies reported that employers hire increasing numbers of new college graduates each year than they did the previous year. On the other hand, most future jobs will require a solid knowledge base of math and science. STEM education becomes essential; it creates critical thinkers, increases science literacy, and enables the next generation of innovators because problem-solving is a crucial part of the STEM educational process. The University of Georgia has many programs that train current students to become well qualified for their future procession to tackle real-world issues by joining the workforce to fulfill this demanding request. In addition to the recent efforts by UGA as a whole, the reports, as mentioned earlier, lead us to re-evaluate our undergraduate curriculum and find ways to incorporate opportunities that allow undergraduate STEM students to solve problems much closer to real-world issues.

In 2020, the National Girls Collaborative Project reported an encouraging finding that 74% of middle school girls express an interest in STEM as a major when they get to college. Students choose to pursue STEM disciplines in college because they want to learn about the world around them, finding innovative solutions to real-world challenges: like developing a much-needed vaccine for the COVID-19 pandemic. Further, playing a role in some of the country's significant discoveries and developments: like working with NASA's Perseverance rover, Ingenuity helicopter projects, or SpaceX's mission to colonize Mars. These ambitions also motivate STEM disciplines to lead to the most substantial employment rates and salaries.

While educators, policymakers, and the general public agree that education in STEM is essential, Physics is widely considered the building block for STEM disciplines, including science and engineering. Studying physics strengthens coceptual, quantitative reasoning, critical thinking, and problem-solving skills to better understand other science disciplines. Most importantly, Physics is the most fundamental of sciences that extends well into our daily actions such as walking, driving a car, understanding how a camera lens works, or explaining why a pencil bends in water?

Driven by many reasons mentioned above, when these highly motivated college students enter their introductory-level courses, the material and traditional instruction methods we currently use in our programs play a significantly destructive role in students' interest in remaining in physics courses. As a solution, education researchers find Student-Centered Active Learning Environments (integrated learning environments) where the space is designed to facilitate interactions between small groups working on hands-on activities, questions, simulations, or experiments. Over time, integrated learning environments were reported to improve learning and retention for students of all levels, genders, and races. And even found encouraging instructors to revise their teaching approaches.

Besides, undergraduate-level physics courses often heavily feature solving textbook problems by applying conceptual knowledge and problem-solving techniques. These textbook problems, often modeled after real-world scenarios, are usually situated through narrative and illustrations that provide known values, constraints, and the requirement to find unknown values to achieve the desired outcome. Two fundamental assumptions upon which this approach is based are (a) that students can relate the textbook problems represented on 2-D paper to the real-world 3-D problems that they intend to mimic, and (b) that students, given the ability to obtain the known values themselves, would know how to do so correctly. The gap between textbook problem representations and real-world problems, growing frustration comes with 2-D illustrations that textbooks try to represent scenarios in the real world in 3-D, and limited opportunities to solve real-world problems individually or collaboratively dampen students' motivation to persist in physics.

Educators and researchers looked for solutions to incorporate technology to overcome the above barrier. Over the years, technology has also begun to change the roles of teachers and learners in all settings. Technology plays a crucial role in facilitating collaborative learning while it helps students research subjects, share ideas and learn specific skills. Resolving this issue, physics education researchers introduced the idea of incorporating pre-lecture videos in integrated learning environments. Pre-lecture videos are short video clips containing narration and animations to introduce core physics topics. These short videos lay the groundwork for students' conceptual understanding before students ever set foot in class that students will discuss in detail later inside the classroom.

# Statement of Transformation:

Benefiting from both the USG's STEM Initiative and the UGA's DeLTA project (undergraduate STEM education transformation project), UGA offers all introductory-level calculus-based engineering physics courses in integrated learning environments, AKA SCALE-UP classrooms in the physics building and science learning center. In these settings, before the pandemic, I required my students to use a textbook to purchase from a publisher. Align with the textbook; I assign my students to watch pre-lecture videos to make sure they come prepared for the class. In response to students' financial hardships highlighted during the pandemic, I moved from expensive textbooks to OpenStax textbooks. Even though this move saved money for students, I could not find a reasonable alternative for pre-lecture videos. I had to stick with the book publisher's videos that cost each student about $55 per semester. While my lecture slides are now more aligned with the OpenStax textbook, students keep coming to the class after watching pre-lecture videos created for a different textbook.

In addition to that, there are some topics covered in physics 1 and 2 (PHYS 1251 and PHYS 1252) courses that the publisher does not have any pre-lecture videos. While discussing these topics, the instructors have to proceed without assigning any pre-lecture videos. This happens even after students pay to get the service for the whole semester. Besides a waste of students' money, this badly affects students' interest in the course material.

After a couple of semesters of being back to in-person instructions, many students and I find book publishers' pre-lecture videos ineffective and should be replaced by instructor-generated ones. Also, 3-D models and animations have proven to facilitate students' conceptual learning and positively contribute to remedying misconceptions in the classroom. This brings the need to create pre-lecture videos by myself for each class day to match the topics discussed in the class, which I need to spend some time in addition to prep for teaching. This link: <https://drive.google.com/drive/folders/1LCzlFNQjEGMQvIIFNK7EJEchDGJi0cm0?usp=sharing> shows a few sample pre-lecture videos we generated for physics courses.

# Timeline:

In the fall 2022 and spring 2023 semesters, I, Nandana Weliweriya, am scheduled to teach three sections each of PHYS 1251 Studio Physics I (72 students per section), impacting 432 students for the upcoming academic year, saving them a total of $23,700. The same approach could be easily extended to PHYS 1252 Studio Physics II in the following year with comparable impact.

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| --- | --- |
| **Semester** | **Description** |
| Summer 2022*(Initial stage of pre-lecture video production and meetings with co-Pi and the other instructors in the UGA physics)* | * Initial meeting(s) to discuss the content of the OpenStax textbook and create the final set of topics aligned with student learning outcomes
* Generate an initial set of pre-lecture videos for a selected list of topics
* Bi-Weekly meeting to evaluate the produced pre-lecture videos to make sure we have them aligned with the OpenStax textbook, student learning outcomes
* Make more and more pre-lecture videos as preparation to use in the PHYS 1251 sections of fall 2022
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| Fall 2022*(The phase of using pre-lecture videos and collect data to measure the effectiveness)* | * Keep making more pre-lecture videos to use in the PHYS 1251 sections of fall 2022, if we need to make changes as we move on
* Use the research timeline mentioned below to access the effectiveness of these pre-lecture videos
* Monthly meetings to discuss the progress, housekeeping
 |
| December 2022 - January 2023*(The phase of planning for spring 23 semester)* | * Gather the outcomes of the research on fall 22 videos
* Meetings to make plans, modify videos to be used in spring 2022 semester courses
 |
| Spring 2023*(The phase of using existing/modified pre-lecture videos and collect data to measure the effectiveness)* | * Use existing, modified pre-lecture videos in spring 2022 semester
* Use the research timeline mentioned below to access the effectiveness of these pre-lecture videos
* Monthly meetings to discuss the progress, housekeeping
 |
| Summer 2023 | * Plan for extending self-generated pre-lecture videos for other physics courses like PHYS 1252 (second semester calculus based physics course)
 |

# Future work, Sustainability, Measures:

In addition, this project provides a great setting to generate data for UGA's physics education research group to support our pedagogical research and support the existing engineering and physics collaboration. Supporting this collaboration, Nandana Weliweriya is the PI of a current Learning Technologies Grants provided by UGA's Center for Teaching and Learning (*Utilizing Virtual Reality as a Pedagogical Tool to Augment, Transform Textbook Material and Enable Remote, Collaborative Problem-Solving, while Supporting Education Research in STEM Problem-Solving.*) Also, the Co-PI of the EETI Augmented, Remote, and Virtual Experimentation Grants, UGA's Engineering Education Transformations Institute (*Exploring XR Technologies to Augment and Transform Textbook Problems and Enable Remote, Collaborative Problem-Solving in Engineering Courses.*)

We will make this project a part of ongoing collaborative studies to assess the effectiveness of newly generated pre-lecture videos using the Eye-tracking enabled virtual reality headsets during student problem-solving exercises. We will have a mix of pre-lecture videos and pop-up multiple-choice questions in these problem-solving exercises. We will investigate students' performance using near and far transfer multiple-choice questions while monitoring students' attention and cognitive states. We plan not just to do this study at UGA; we have Dr. Shameer Abdeen, a Visiting Assistant Professor from Georgia Southern University, onboard planning to implement these in his studio physics courses in fall 2022. We will use the findings of these investigations to constantly improve the quality of pre-lecture videos towards improving instructions to better serve students in Georgia and contribute to the development of educational theories to help educators nationwide.

# Timeline:

**Individual learning outcomes, effectiveness of pre-lecture videos will be evaluated by: Time line** Fall 22, Spring 23

|  |  |  |  |
| --- | --- | --- | --- |
| **Course and** **time** | **Evaluation method** | **Original Purpose of Evaluation method** | **Use of Evaluation method in this project** |
| PHYS 1251 | Pre/post, Multiple-choice test: Force Concept Inventory (FCI)  | To assess students' understanding of the most basic concepts in Newtonian physics using everyday language and common-sense distractors. | **Pre/post-tests within courses:** Conducting these FCI Pre/post-tests in fall 2022 and spring 2023 will measure students’ mastery of concepts taught in the PHYS 1251 course. We have previously collected FCI Pre/post-test scores in PHYS1251 courses in the last five years.  |
| PHYS 1251 | Weekly quizzes, mid-terms and final exam scores.  | Demonstrate individual students’ understanding of basic concepts/ principles | Weekly quizzes and monthly exams give us a continuous way of measuring individual students' understanding of basic concepts/ principles. We compare scores between semesters and DFW rates.  |
| PHYS 1251 | Interviews  | We will have a mix of pre-lecture videos and pop-up multiple-choice questions in these problem-solving exercises that will be conducted using Virtual reality headsets with eye-tracking.  | To assess the effectiveness of newly generated pre-lecture videos using the Eye-tracking enabled virtual reality headsets during student problem-solving exercises. We will have a mix of pre-lecture videos and pop-up multiple-choice questions in these problem-solving exercises. We will investigate students' performance using near and far transfer multiple-choice questions while monitoring students' attention and cognitive states. |

The project will present ample scholarship opportunities, and we aim to publish and present in a diversity of venues for virtual Reality, engineering education, and physics education. More undergraduate researchers will be involved in both collecting and analyzing on this project will include but not be limited to AJ Turtle (AJ), Chaudhry Nicolas Gibran Rasool (NR), Cora Romick (CR), Aditya Vurukala (AV). There will be many more faculty, graduate and undergraduate researchers involved within and beyond UGA.

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| --- | --- | --- |
| Date | Objective | Person(s) Responsible |
| May/22 – August/22 | Create pre-lecture videos, evaluate, modify | Nandana Weliweriya (NW),Shameer Abdeen (SA) |
| August/22-December/22 | Collect data using Fall courses | NW, SA, NR |
| September/22 -December/22 | Analyze pilot data | NW, SA, NR |
| October/22 -December/22 | Analyze fall 21 data | NW, SA, NR, CR, AV |
| January/23-May/23 | Collect data using spring 22 courses | NW, SA, NR, CR |
| March/23- July/23 | Analyze spring 22 data | NW, SA, NR, CR, AV |
| February/23- July/23 | Work on publications in engineering education, and physics education (PERC) | NW, SA, NR, CR, AV |
| April/2023 | Present initial findings in UGA CURO | NR, CR, AV |
| June/23- July/23 | Present and publish articles at AAPT (American Association of Physics Teachers) and PERC (Physics Education Research Conference) | NW, SA, NR, CR, AV and any new undergraduates to join the team |
| January/23- July/23 | Apply for internal and external grants: UGA SEED grants, NSF Grant- IUSE: HER  | NW, SA, Kyle Johnsen (School of Electrical and Computer Engineering, UGA), Siddharth Savadatti (College of Engineering, UGA), Craig Wiegert (UGA physics), Paula Lemons (UGA Biochemistry and Molecular Biology), Eleanor Sayre (Kansas State University, Physics), Sanjay Rebello (Purdue University, Science Education Curriculum and Instruction) |

# Budget

* Dr. Nandana Weliweriya will oversee the project and handles the creation, implementation of the newly created pre-lecture videos in fall 22 and spring 23 in his PHYS 1251 courses. A $4,000 is requested for 2022 summer, 2022 Fall salary support and fringe.
* A $1000 is requested to buy equipment (like camera), subscriptions for software, travel/present at conferences.

# Letter of Support

*The Department Chair from the corresponding project, or the Department Chair’s direct report such as the Dean or Provost, must provide a signed Letter of Support for the project. This letter should acknowledge the following:*

* *The department will provide support for fund disbursement in correspondence with the Grants/Business Office.*
* *The department approves of the work on the proposal by the applicant(s).*
* *The department acknowledges the sustainability of the use of these affordable resources after the grant work is complete.*

*In the case of multi-institutional affiliations, all participants’ institutions must provide a letter of support.*

*Please provide the name and title of the department chair (or other administrator) who provided you with the Letter of Support.*

|  |
| --- |
| **Phillip Stancil, Professor of Physics and Department Head**pstancil@uga.edu |

# Grants or Business Office Acknowledgment Form

*Institutional Grants/Business Offices will be responsible for fund disbursement, often in correspondence with the Department Chair, including expense and travel reimbursement. All applicants will need to provide a signed Acknowledgement Form, the template for which is linked on the RFP page, stating that the Grants/Business Office knows about the applicant’s intent to apply for an Affordable Materials Grant. Either the Department Chair or the Project Lead can work with the Grants/Business Office to get this signed form.*

*In the case of multi-institutional affiliations, all participants’ institutions must provide this form.*

*Please provide the name and title of the grants or business office representative who provided you with the acknowledgement form.*

|  |
| --- |
| *# Attached and emailed* |