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Application Summary

Competition Details

Competition Title:	Textbook Transformation Grants, Round Fourteen (2019-2020)
Category:	University System of Georgia
Award Cycle:	Round 14
Submission Deadline:	04/09/2019 at 11:59 PM

Application Information

Submitted By:	Cathy Hakes
Appplication ID:	3362
Application Title:	471
Date Submitted:	04/09/2019 at 9:06 AM

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Submitter Phone Number:	678-407-5875
Submitter Title:	Executive Director, Office of Research and Sponsored Programs

Application Details

Proposal Title
471

Final Semester of Project
Summer 2020

Requested Amount of Funding
$25,800

Type of Grant

No-or-Low-Cost-to-Students Learning Materials

Course Title(s)
Discrete Math

Course Number(s)
MATH 2300

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Sponsor Name
Dr. Thomas Mundie

Sponsor Title
Dean

Sponsor Department
School of Science and Technology, Georgia Gwinnett College

Original Required Commercial Materials (title, author, price)
Discrete Math and Its Applications, Kenneth H. Rosen, $205.55

Average Number of Students per Course Section Affected by Project in One Academic Year
28

Average Number of Sections Affected by Project in One Academic Year

13

Total Number of Students Affected by Project in One Academic Year
336

Average Number of Students Affected per Summer Semester
56

Average Number of Students Affected per Fall Semester
140

Average Number of Students Affected per Spring Semester
140

Original Total Cost per Student
$205.55

Post-Project Cost per Student
0

Post-Project Savings per Student
$205.55

Projected Total Annual Student Savings per Academic Year
$69,064.80

Using OpenStax Textbook?
No

Project Goals

A) Improve student success in MATH 2300 (Discrete Mathematics) by creating no-cost Online textbook and materials.

The transformed course will have materials that not only align with all the course objectives but also address specifically three-course objectives which students are known to find particularly challenging. They are: **i)** Reasoning mathematically — being able to understand and construct mathematical arguments; **ii)** Demonstrate algorithmic thinking — verifying that algorithms work and analyzing the time required to perform specific algorithms; and **iii**) Use appropriate technology in the evaluation, analysis, and synthesis of information in problem-solving situations. The team will develop quality content materials and audio-visual ancillary materials to replace the current textbook. These materials will be designed to be more appropriate for the type of students in information technology (ITEC) programs such as those at GGC. The design of the materials will be accomplished by integrating algorithms and their analysis and implementing their code throughout the course. Through the development of substantive audio-visual materials and a significant depth of accessible and applied examples than are currently found in the standard commercial discrete math texts, the proposed textbook will address topics students are recognized to have particular challenges with. These challenges include algorithms and their analysis, and the more abstract proof techniques involved in mathematical induction. One drastic consideration that has been a reality at several institutions is that information technology (IT)/computer science (CS) programs are increasingly displeased with the discrete mathematics courses that math departments are servicing their majors with and have, in some cases, taken back these courses into their own departments in order to service their IT and CS majors better.

B) Encourage the wider use of free online textbooks within the GGC math program. Currently, the GGC math program subscribes to several very expensive commercial vendor textbooks and platforms, in their multiple section courses. A major project goal, then would be to use the success in transforming the textbook in a multiple section course like MATH 2300, discrete math, as a pilot to stimulate conversations about low/no cost options in multiple section math courses, such as MATH 2450 linear algebra, MATH 2220 multivariable calculus, and potentially even high student enrollment courses like MATH 1113 precalculus. Particularly in MATH 2300, students often do not buy the textbook or wait until very late in the semester to purchase. At times, they download pirated versions of the textbook. This is true in other courses as well. Through the ALG Textbook Transformation grant, the project team will be able to create a model or template for the conversion of multi-section courses to free online materials.

C) Provide curated audio-visual materials, especially on the targeted topics that students generally struggle with. Students in MATH 2300 complain that materials to support learning in discrete math are scarce, especially at the IT sophomore level. This is particularly the case with the topics of mathematical induction, and algorithms and their computation analysis and implementation. All audio-visual materials developed as part of this project are intended to be made available as open courseware type content, available to the entire USG community and ideally the public also.

Statement of Transformation

Overview of the Transformation

Expensive textbook costs are often associated with students not buying the textbook at all, buying the textbook late, and even piracy. Textbook costs are always a big concern to the students at GGC and GGC MATH 2300 is no exception. The current textbook used in the course costs a student $206. While this cost in itself is an issue, all the instructors of MATH 2300 agree that the textbook has some major weaknesses that also align with the Mathematical Association of America's (MAA) review of the text (Stenger 2015). Stenger mentions that the textbook is comprehensive, has extensive end-of-chapter exercises, and may serve usefully as references; however, its major weaknesses lie in the paucity of motivated examples with complete explanations. Students complain that many of the examples are not inspiring, poorly explained with key steps missing, and focused mainly on computer science rather than information technology and related real-world applied areas. The treatment of algorithm analysis and their performance is also limited. The complexity of a few algorithms is presented in outline, whereas students would rather see them in a real-world programming language such as open source Python, R, or Matlab/Octave.

Discrete Math or GGC MATH 2300 is a required course for all GGC Information Technology (ITEC) majors. Serving also as a co-requisite for GGC ITEC 2150 Intermediate Programming, GGC MATH 2300 is a high impact course. It plays an important role in student success in the IT program and is a cross-disciplinary course serviced by the math program. By eliminating the textbook and using open educational resources, we propose to lower costs for students, deliver a more focused curriculum, and provide students with real-world applications and experience on a more powerful database management system. As reported by the team, the percentage of students receiving a grade of D, F, I or Withdrawing (DFWI rate) from this course since 2016 through the end of 2018 is 42%. The project is designed to provide quality content and supporting materials for the entire course coverage with a focus on targeted high impact areas of the course—algorithms and their analysis, and proof techniques especially mathematical induction. The goals are to provide materials at no cost to the general student population of the course, which also addresses student progression in the ITEC program and the DFWI rate.

Transformation description

To bring about the transformation of the MATH 2300 course, we will develop materials that align specifically with the objectives of the course, especially the three high impact course objectives we know the students in the course struggle with as described in the project goals above. Again, these are **i)** Reasoning mathematically - being able to understand and construct mathematical arguments; **ii)** Demonstrating algorithmic thinking - verifying that algorithms work, and analyzing the time required to perform specific algorithms; and **iii)** Using appropriate technology in the evaluation, analysis, and synthesis of information in problem-solving situations.

The team will develop quality content materials, and audio-visual ancillary materials to replace the current textbook. These materials will be designed to be more appropriate for ITEC programs such as those at GGC. We will accomplish this task by integrating algorithms and their analysis and by implementing their code throughout the course. We plan to utilize a number of Open Educational Resources (OER) in the discrete mathematics/discrete structures domain and create content that will address topics that students find especially challenging. By developing substantive new materials and resources, students will be better prepared to tackle more demanding subjects of the course and progress to the next level of their studies.

Stakeholders affected by the transformation

The main stakeholders affected by the transformation will be approximately 336 undergraduate students enrolled annually in the discrete math course at GGC. Discrete math is a required General Education course, falling in Area F of all four information technology program concentrations at GGC. Not only that, but it is also a pre/co-requisite for students wanting to move into programming and software development classes beginning with ITEC 2150 Intermediate programming. At GGC, students majoring in the B.S Mathematics (Pure Math Concentration) are required to take an ITEC programming class, such as ITEC 2120 in their program of study and encouraged to take the discrete math course MATH 2300 as their Area F additional course. Thus, the course is cross-disciplinary.

The other stakeholders are faculty members. We envisage that faculty in the University System of Georgia (USG) and across the nation who teach an introductory course in discrete math or its variant discrete structures can benefit from the materials developed and curated for this course.

Project's transformative impact on the course and department

Impact of this transformation on stakeholders and course success. The transformation is aimed at eliminating the need for students to purchase the textbook for the course. Its aims are also to develop materials that align with the course objectives and to enhance specific targeted areas of the course curriculum that students are known to struggle with. Taking an integrative perspective of programming and algorithms as they fit into the course will help improve student success and engagement in the course and better position them for their ITEC programming curricula in courses like ITEC 2150 (Intermediate programming) and ITEC 3150 (Advanced Programming). Finally, we will connect the topics covered to real-world discrete mathematics applications beyond hard computer science,

which is the emphasis in the current Rosen text (Rosen 2012).

Project's transformative impact on the institution

Transformative impact on the program, department, institutions, access institution and/or multiple courses. MATH 2300 is a general education requirement, in Area F, and is a course required for all ITEC majors at GGC. This is generally the case for all information technology and computer science programs in the nation. Quoting from Information Technology Curricula 2017 "The IT 2017 task group recommends that a robust information technology program should have at least discrete structures (mathematics) and a variety of other mathematical experiences to prepare a competent IT professional for the mid-2020s." (Association of Computing Machinery 2017, page 52)

We will adopt a no textbook model and this approach where applicable can be replicated in other math courses at GGC. Given the rising cost of textbooks for students, we believe this model can serve as an example for other access institutions across the nation. In particular, we will develop content, by way of examples, solved exercises, and end-of-chapter exercises for each of the major sections of the course. We plan to develop programming code for each of the important solved examples along the lines of the Textbook Companion Project for the Rosen text (Sai 2017) but to better align with our developed materials. We plan to develop high-quality audio-visual materials to accompany each of the important sections and/or examples along the lines that one of our current investigators, Dr. Josh Roberts, has been involved with and also as available at Open Courseware Sites, but edited and adapted for the GGC Discrete MATH 2300 course. Finally, we will identify open educational resources and will plan to adapt and to link these materials with our discrete math course objectives. In addition, we will develop materials that consist of outline course notes, PowerPoint, programming labs, homework, and active learning activities that can be used by other USG faculty teaching courses in discrete math/discrete structures. In addition, we believe that an active learning method, coupled with a cooperative learning approach and real-world application integration will result in improvements in student engagement and success.

Transformation Action Plan

There is currently a Schaum's Outline Series Discrete Math Text (Schaum 2009). While this is a low-cost option, we plan to adopt a **no-cost transformation** in our project. Moreover, we have found the current Schaum's Discrete Math text is not suitable for the GGC ITEC students for several reasons, but mostly pertaining to the fact its treatment of algorithms is not aligned in an integrated way to programming/coding. There is, for example, no description of the standard sorting or searching algorithms, like bubble sort, or merge sort. As a result, we plan to develop these no-cost materials:

- Brief accessible, section summaries/outlines for each of the major course topics that use Schaum's outline series;
- Solved examples, both conceptual and applied, to accompany each summary section and each major topic section
- End-of-section exercises, comparable to the solved examples and solved exercises, with some problems for topic extensions for each major topic section
- Complete program (Octave/Python) code and or pseudo code for each major topic section examples
- Comparable programming (Octave/Python) assignments and/or projects for each end-of-topic exercise section

The course materials will be collected from a number of online sources. The following is a list of the resources that we plan to use in the course. We will be creating weekly modules in D2L and will be including the links to the specific area within these sources that students can click on to gain access to the resource.

- GGC library resources (http://www.ggc.edu/academics/library/
- Open Textbook Library (https://open.umn.edu/opentextbooks)
- BC Open Textbooks (https://opentextbc.ca/)
- Merlot (https://www.merlot.org/merlot/viewMaterial.htm?id=293413)
- W3 Schools (https://www.w3schools.com/sql/
- Khan Academy (https://www.khanacademy.org)
- Oracle Docs (https://docs.oracle.com)

Specific resources we plan to link to and/or augment or adapt include:

(a) Open discrete math textbooks:

- Oscar Levin text: https://www.merlot.org/merlot/viewMaterial.htm?id=1209141 Excellent, well-curated, mathematical text.No discussion of Algorithms and Algorithm analysis
- Cusack text: https://cusack.hope.edu/Notes/Notes/Books/Active%20Introduction%20to%20Discrete%20Mathematics%20and%20Algorithms/ActiveIntroToDiscreteMathAndAlgorithms.2.6.3.pdf Good discussion of algorithms, and their analysis and integration with Java Programming languageGood interactive approach to discrete mathGood discussion of graph theoryNot well curated/ peer reviewed
- Hammack text: https://www.merlot.org/merlot/viewMaterial.htm?id=1374816 Good discussion of algorithms, and their analysisGood exercisesVery limited treatment of graph theory
- Doer Levasseur text: https://www.merlot.org/merlot/viewMaterial.htm?id=740675> Good integration with SAGE open source system and MathematicaVery limited treatment of modular arithmetic and number representation systems, a major component of the GGC discrete math course.

(b) Videos:

Dr. Josh Roberts: https://www.youtube.com/playlist?list=PL8rEwockjR-rITNMrZYj0pDM1YlV3JUr5

Used by GGC professor Dr. Josh Roberts currently teaching MATH 2300 Spring 2019

Links to videos collected by Dr. Josh Roberts students in Discrete Math fall 2018:

https://docs.google.com/spreadsheets/d/1L27xkOZqAhhHzajcbwtROwweN_cayJ8sX8EoZzsDh2U

Used by GGC professor Dr. Josh Roberts students currently in MATH 2300 Spring 2019

Professor Shai Simonson: http://www.oercommons.org/courses/discrete-mathematics/view

Videos and lecture notes that can be used and/or adapted for our course.

MIT OCW: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-042j-mathematics-for-computer-science-fall-2010/video-lectures/

https://www.merlot.org/merlot/viewMaterial.htm?id=1126630

(c) Open courseware:

- MIT OCW Principles of Discrete Applied Mathematics:
  https://www.merlot.org/merlot/viewMaterial.htm?id=555485>

Course and syllabus instructional design/redesign necessary for the transformation

The instructional design of the course will center on organizing the contents into modules in the learning management system D2L. The syllabus and all materials used in the course will be made available in D2L for the learners. There will be links that are set to open in a new browser window for all the OER resources used in the course. The course syllabus will be modified to reflect the no textbook format and will include a list of the major open educational resources that will be used in the course. The added Python/Octave programming assignments will be graded components. The contents covered in the course will be mapped to the course objectives.

Team members' roles

Team member and PI Mohamed Jamaloodeen: Associate Professor of Mathematics will serve as a subject matter expert, instructional designer, and project manager. He regularly teaches this course at GGC. He is also the Chair of Faculty in the Mathematics discipline. He will assist with identifying, gathering and developing custom course materials especially designing solved examples, solved exercises and end-of-section exercises and programming assignments and/or projects. He will work on the programming-related materials with Dr. Sebastien Siva who has domain expertise in the programming component of the ITEC major. He will also coordinate with content with all members of the team including Dr. Josh Roberts who will be mainly tasked with developing the supporting audio-visual materials, especially videos on the major topics of the course and the targeted impact areas of mathematical proofs and mathematical induction, and programming and algorithm analysis.

Dr. Jamaloodeen has extensive experience adopting open course materials and developing supporting materials such as videos to help students understand the materials. For example, in AY-2010-11, he taught the inaugural Math 2220 multivariable calculus course at GGC. He made use of a free (public domain) online text by Michael Corral (http://www.mecmath.net/calc3book.pdf). Group projects were an integral component of the course and students were encouraged to use computer Algebra systems like Maple or Scientific Workplace on these projects. Students worked in teams of two and were given separate oral defense examinations on their projects. He developed videos to supplement class material using Echo 360 and SmartBoard Video capturing tools. Students gained much from these videos, were very appreciative, and wrote to the Dean's office commenting on them. He also has experience in developing assignments. As a consultant to a statistical certification body in summer 2011, he developed assignment items for a graduate online statistics course. He wrote 88 mixed problem assignment items, with solutions, for non-parametric tests, logistic regression modeling, and one and two-way ANOVA. He wrote 83 discussion assignment problems, with solutions, and SPSS output for non-parametric tests, logistic regression modeling, one and two-way ANOVA and bootstrapping methods for inference. He also developed a final project with 2 scenarios with different data sets for 10 students involving bootstrapping inference. Finally, he has done much research on integrating computer programming into the GGC math discrete courses and has presented his findings at several conferences including ICTCM 2018 and the Joint Math Meetings in Baltimore 2019 (Jamaloodeen 2018).

Team member and Co-PI: Kathy Pinzon: Associate Professor of Mathematics will serve as a subject matter expert and instructional designer in the course. She has taught the course on several occasions at GGC. She has used a class discussion board called piazza, which supports discussions using mathematical symbols when teaching the course. She plans to incorporate this type of feature into the no-text course. She will also assist in developing practice problems and course materials like section outlines and PowerPoint and assignments for several of the major course topics.

Dr. Pinzon has extensive experience with surveys and assessment data analysis from Course-Embedded Research Experiences (CUREs) grants she has run and with her being a major developer and overseer of the Mathematics Peer Supplemental Instruction (PSI) program at GGC. She is considering the possibility of extending the GGC math PSI program to the discrete math class and so can help with designing, administering, and analyzing this project. She will also assist the effort to identify, gather, and map OER resources to the course objectives. She will assist Dr. Jamaloodeen and lead the evaluation effort for the project. This will include obtaining IRB approval, creating assessment tools (surveys, common assessment questions for each goal), obtaining consents, administering surveys, collecting data (from students, faculty, and Banner), and conducting data analysis. She will work with Dr. Jamaloodeen to compile the necessary grant reports. She will also help in organizing the materials so that they can be easily shared with stakeholders at GGC and outside of GGC.

Team member Dan Pragel: Assistant Professor of Mathematics will serve as a subject matter expert and instructional designer in the course. He is one of the primary instructors of this course and has served as one of its coordinators. As a graph theorist, discrete math is his primary domain of research and he has published academically in discrete math journals. He will assist with developing practice problems, course materials like section outlines, PowerPoint, and assignments for several of the major course topics particularly in the areas of graph theory, combinatorics, logic, proof theory, and modular arithmetic and number representations systems. He will also oversee all pedagogical aspects of this project through piloting modules as they are completed in the fall of 2019. Dr. Pragel is scheduled to teach two sections of MATH 2300 discrete math in the fall of 2019 and will be assigned to teach the course in Spring 2020, should our grant application be successful.

Team member Josh Roberts: Assistant Professor of Mathematics will serve as a subject matter expert and instructional designer in the course. He has taught discrete math at GGC over several semesters beginning in the fall of 2018. He brings new and valuable insights on how to transform the course. Dr. Roberts has been a Mathematical Association of America Project NExT Fellow and, as a Fellow, learned about and developed videos and video notes for his students in many of his classes including discrete math, college algebra, quantitative reasoning, statistics topology, and complex analysis. His main role will be to develop quality videos for all major topics of the course. He will assist, as needed, with developing practice problems, course materials like section outlines, PowerPoint, and assignments for several of the major course topics. Dr. Roberts has experience with this type of activity. In graduate school, he assisted a professor in writing a low-cost textbook for college algebra. He helped write some of the sections as well as most of the exercises. Dr. Roberts will also assist Dr. Pragel in overseeing all pedagogical aspects of this project through piloting modules as they are completed in the fall of 2019. Dr. Roberts is scheduled to teach two sections of MATH 2300 discrete math in the fall of 2019 and will be assigned to teach the course in spring 2020 should our grant application be successful.

Team member Sebastien Siva: Associate Professor of Information Technology will serve as a cross-disciplinary subject matter expert and instructional designer in the course. He will incorporate programming assignments into the course. He is the author of the ITEC 2120 open source textbook in which he has incorporated the Python Code visualizer enabling students (in a web browser) to write and visualize the execution of Python code. He has experience also in teaching ITEC 2140 (programming fundamentals) and can judge the appropriate coding level of programming assignments for this course. In the last decade, he has developed over 200 different coding assignments and projects for a variety of coding classes with many automated approaches to grading both inside and outside of D2L.

He will also assist Kathy Pinzon with project assessment. As far as data analysis goes, he has considerable experience in longitudinal (multi-semester) analysis of student performance at GGC. This will allow us to examine how our course modifications impact students in down-the-line courses such as ITEC 2150 and ITEC 3150.

Below is a breakdown of the major topics covered in the course and role of the PIs:

- Propositional Logic, Applications of Propositional Logic, Propositional Equivalences, Predicates and Quantifiers, S Nested Quantifiers [Dr. Pragel, Dr. Jamaloodeen]
- Sets, Set Operations, Functions [Dr. Pragel, Dr. Jamaloodeen]
- Pseudocode, Algorithms, The Growth of Functions, Complexity of Algorithms [Dr. Jamaloodeen, Dr. Pinzon, Dr. Siva]
- Divisibility and Modular Arithmetic, Integer Representations and Algorithms [Dr. Pragel, Dr. Roberts]
- Mathematical Induction , Recursive Definitions and Structural Induction, Recursive Algorithms [Dr. Pragel, Dr. Roberts, Dr. Pinzon, Dr. Siva]
- The Basics of Counting, The Pigeonhole Principle, Permutations and Combinations [Dr. Pragel, Dr. Siva]
- An Introduction to Discrete Probability [Dr. Jamaloodeen]
- Divide-and-Conquer Algorithms and Recurrence Relations [Dr. Jamaloodeen, Dr. Siva]
- Relations and Their Properties, n-ary Relations and Their Applications, Representing Relations [Dr. Pinzon]
- Graphs and Graph Models, Graph Terminology and Special Types of Graphs, Representing Graphs and Graph Isomorphism [Dr. Pragel, Dr. Roberts]
- Applications of Trees, Tree Transversal [Dr. Pragel, Dr. Siva, Dr. Pinzon, Dr. Roberts]

Plan for providing access

The course materials developed will be hosted in GGC's Brightspace (D2L) (https://ggc.view.usg.edu/d2l/home). Students who enroll in the course will have free access to the materials in the course. The PIs will also make the course materials available at the GGC Wiki page http://wiki.ggc.usg.edu/wiki/Main_Page. This will result in broader access to course materials for educators and students across the nation.

Quantitative & Qualitative Measures

The project team will request IRB (Institutional Review Board) approval for the project's evaluation plan.

GOAL 1: Improve student success in MATH 2300 (Discrete math) by creating no-cost online textbook and materials.

Qualitative Measure, Methods, and Tools

The PIs will survey the students at the end of each semester to evaluate the effectiveness of the proposed open source resources, the active learning activities, and the cooperative learning activities. The questionnaire will ask students to rate questions on a Likert scale of Strongly Disagree to Strongly Agree, and will consist of questions focusing on the following main ideas:

- The materials will be easily and reliably accessed at all times.
- The materials are well-organized so that the necessary information can be found quickly.
- The materials clearly explain concepts and are useful to learn the content.
- The materials have enough exercises and examples to support students' learning needs.
- The active learning activities were useful and engaging.
- The collaborative learning experience improved my ability to work in teams.

The questionnaire will also include open-ended questions, such as:

- What did you like about the new course materials?
- How can the new course materials be improved?
- Did the availability of free online textbook help improve your success in the course? If so, how did it impact your learning and success in the course?
- Any other comments?

Quantitative Measure, Methods, and Tools

The PIs will collect the following data regarding students' performance in the course:

1. Student performance on common assessment questions in the final exam corresponding to each learning outcome of the course. This data will be gathered from faculty teaching the class.
2. Student grades on a final common assessment in all sections of the course. This data will be gathered from faculty teaching the class.
3. Grade distribution in all sections of the course. This data will be gathered from Banner and will be compared with existing historical grade distribution data for this class.

In addition, the PIs will compare the cost of the current textbook with the cost of the new learning materials (expected to be free).

GOAL 2: Increase adoption of no/low-cost materials in other multiple sections GGC math courses.

Qualitative Measure, Methods, and Tools

We will send a short questionnaire (1-2 questions) to faculty who have expressed interest or decided to use our materials. Our plan is to ask them about their experiences in utilizing the textbook and/or resource materials. The questionnaire mentioned in the evaluation of Goal 1 above will be adapted for statements of GGC Math 2450, Math 2600 and Math 2220 instructors to rate, such as:

- **I am likely to participate in a project transforming the required text in my Math 2450/Math 2600/Math 2220 to a low or no-cost option based on my teaching the transformed MATH 2300 course.**

Quantitative Measure, Methods, and Tools

Course coordinators in Linear Algebra (MATH 2450), Math Modeling (MATH 2600) and Multivariable calculus (MATH 2220) will be encouraged to teach a section of the transformed MATH 2300. Through carefully designed Qualtrics surveys, we will ask these instructors at the end of the project about their impressions and the likelihood of their implementing similar low/no-cost transformations in other sections or math courses. We will track this information in order to provide us with quantitative data on the effectiveness of this project as springboard to leverage affordable learning across more multiple section Math courses.

GOAL 3: Encourage the wider use of the free online textbook within the USG by disseminating the course materials and informing colleagues in the field of best practices and lessons learned.

Goal 3 will result in presentations at conferences and sharing of materials online.

Qualitative Measure, Methods, and Tools

We will send a short questionnaire (1-2 questions) to faculty who have expressed interest or decided to use our materials. Our plan is to ask them about their experiences in utilizing the textbook and/or the resource materials.

Quantitative Measure, Methods, and Tools

We will track the number of presentations we conducted to disseminate information on the project, as well as the number of faculty members who have expressed interest in utilizing our materials.

Timeline

The project will be piloted in 2019 and full implementation will be in spring 2020 semester.

Summer 2019: The team members will use summer 2019 semester to identify, gather, and map OER resources to the course objectives. This will include developing content material, audio-visual ancillaries, applied examples, solved exercises, end-of-section exercises, programming assignments, and projects.

Fall 2019: The team members expect to create more supporting materials for the course in Fall 2019, including completing the creation of materials from summer and also work on common assessment questions, quizzes, and other materials.

The organization of all of these materials in D2L will start in summer 2019 and is expected to be complete in fall 2019. Some of the materials developed in summer 2019 will be piloted in fall 2019 in multiple sections with ~28 students per section, impacting 140 students. Initial feedback from students will be obtained. Evaluation plan and instruments will also be developed during this semester.

Spring 2020: All of the learning materials are expected to be ready and organized by the end of fall 2019 and will be used in all sections of the class in spring 2020, which will affect 140 students in five sections. More data will be collected at the end of spring 2020.

Summer 2020: The team members expect to continue using the new materials in summer 2020 in two additional sections that will affect 56 students, and collect more data. There might be minor tweaks to the material during this time, based on student feedback from fall 2019 and spring 2020. Data analysis for fall and summer semesters will also happen during this time. A report will be created and submitted by the end of the grant period. Lastly, PIs expect to work on dissemination efforts this semester by presenting at conferences to reach off-campus faculty and by reaching out to on-campus faculty at course coordination meetings and discipline meetings.

Budget

6. BUDGET

(a) Type of Grant: Large Scale Transformation--all-section, math discipline-wide transformation

(b) Total request: $25,800

(c) Budget and Justification

Funds are requested for:

Personnel: $25,000.00

Funds are requested to cover the compensation and fringe (FICA/SS, FICA Med, Retirement) of Drs. Jamaloodeen, Pinzon, Pragel, Roberts, and Siva at $5,000 each.

Dr. Jamaloodeen will serve as project manager. He will lead in the further identification, gathering, and mapping of OER resources to the course objectives. He will participate in developing course content and assignment materials as described in the breakdown of topics covered. Having developed computer programming activities, he will support Dr. Siva in the programming content and design of programming assignments and exercises. Having developed videos previously, he will coordinate with Dr. Roberts on developing videos and other audio-visual materials and also work on developing the supporting materials for the three targeted high impact areas. He will also coordinate the development of all assignment and end-of-section exercises.

Dr. Pinzon will be primarily involved with developing content as described in the breakdown of topics covered and assist with identifying, gathering and developing custom course materials. She will lead the evaluation effort for this project, including obtaining IRB approval, creating assessment tools, obtaining consents, administering surveys, collecting data, and conducting data analysis. She will assist with compiling reports and in organizing materials for dissemination purposes.

Dr. Siva will be involved with some content development as described in the breakdown of topics covered. He will be primarily tasked with integrating computer programming with a suitable language like Python or Octave into the course curriculum through a cohesive approach to coding, algorithms, and their implementation and analysis. He will be involved in providing examples and project assignments that are applicable to information technology. He will also assist Kathy Pinzon with project assessment using his experience with longitudinal (multi-semester) student performance at GGC.

Dr. Pragel will be involved primarily in developing content, assignments, and end-of-section exercises for many of the mathematical topics in discrete math, such as propositional logic, combinatorics, graph theory, and modular arithmetic and number representation systems.

Dr. Roberts, will be involved in content development as described in the breakdown of topics covered above. However, his most significant contributions should be to develop quality videos for the major topics in the course and for the targeted impact areas, namely proof techniques including mathematical induction, propositional logic, and analysis of algorithms.

Travel: $800.00

Funds are requested for two team members to attend the kick-off meeting at $400 each. Travel will cover mileage, lodging, per diem, and other travel requirements.

Total: $25,800.00

Sustainability Plan

MATH 2300 Discrete Mathematics is a required course for all IT majors at GGC. There are about 10 sections taught each academic year (plus an additional two sections in the summer). The PIs (Drs. Jamaloodeen and Pinzon) and team members plan to test the proposed open source learning materials in at least three sections taught each semester. Dr. Jamaloodeen, being the chair of faculty, can ensure that all math project team members get to teach the necessary sections. The PIs expect that this project will impact student achievement by eliminating textbook and software costs, increase student engagement in the material inside and outside the classroom, improve academic performance, which in turn improves retention in this course. Considering these benefits, the team will propose to standardize these resources for future offerings of MATH 2300. Both PIs' involvement in the discipline, the team members' extensive involvement in the running of this course, and the initial data collected during this project should help the PIs make a case for adopting these materials for long-term use. The materials will be made available to GGC faculty in a central and easy-to-access location such as D2L. The PIs, along with GGC faculty teaching the course in the future, will continue to maintain and update the learning materials created.

A centralized location, such as a wiki page, will allow non-GGC faculty and students to access the materials easily. The PIs also see an opportunity to request and use additional mini-grant funds in the future to add emerging technologies to the curriculum.

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

School of Science & Technology

1000 University Center Lane
Lawrenceville, GA 30043
Phone: 678-407-5602
www.ggc.edu

April 1, 2019

Re: Affordable Learning Georgia, University System of Georgia

Dear Grant Selection Committee:

I am pleased to write this letter to support Drs. Jamaloodeen and Pinzon as PI's and Drs. Sebastien Siva, Dan Pragel and Joshua Roberts as team members, for an application for the ALG Textbook Transformation Grant Round 14.

The proposal focuses on the creation of no-cost-to-students learning materials to replace current textbook for the math course Math 2300 Discrete Math. This will lower costs of students taking this course and will most likely increase our retention and success rates in this course.

Drs. Mohamed Jamaloodeen, Kathy Pinzon, Dan Pragel, and Joshua Roberts have been teaching this course for a several semesters. They have the knowledge, skills and experiences needed to successfully perform the action plan and meet the obligations of the grant. If awarded the grant I will work with them to coordinate the distribution of their award and provide necessary resources to facilitate their activities in developing the proposed learning materials.

Thank you for your consideration and please let me know if I can provide any additional information.

Sincerely,

Thomas Mundie, Ph.D.
Dean, School of Science and Technology
Georgia Gwinnett College

Affordable Learning Georgia

Textbook Transformation Grants, Round Fourteen
(Summer 2019 –Summer 2020)
Proposal Form and Narrative

APPLICANT, TEAM, AND SPONSOR 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.

Institution(s)	Georgia Gwinnett College
Applicant Name	Mohamed Jamaloodeen
Applicant Email	mjamaloo@ggc.edu
Applicant Phone #	678-472-5338
Applicant Position/Title	Associate Professor/Chair of Faculty Mathematics
Submitter Name	Cathy Hakes
Submitter Email	chakes@ggc.edu
Submitter Phone #	678-407-5875
Submitter Position	Executive Director, Office of Research and Sponsored Programs

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.

	Name	Email Address
Team Member 1	Mohamed Jamaloodeen	mjamaloo@ggc.edu
Team Member 2	Katherine Pinzon	kpinzon@ggc.edu
Team Member 3	Sebastien Siva	ssiva@ggc.edu
Team Member 4	Daniel Pragel	dpragel@ggc.edu
Team Member 5	Joshua Roberts	jroberts7@ggc.ewdu
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.

Dr. Thomas Mundie, Dean of School of Science and Technology, Georgia Gwinnett College

PROJECT INFORMATION AND IMPACT DATA

Title of Grant Project	No Text Transformation of Discrete Mathematics
Type of Grant	No-or-Low-Cost-to-Students Learning Materials
Requested Amount of Funding	$25,800
Course Names and Course Numbers	Discrete Math, MATH 2300
Final Semester of Project	Summer 2020
Average Number of Students Per Course Section Affected by Project	28
Average Number of Sections Affected by Project in One Academic Year	13
Total Number of Students Affected by Project in One Academic Year	336
Average Number of Students Affected per Summer Semester	56
Average Number of Students Affected per Fall Semester	140
Average Number of Students Affected per Spring Semester	140
Title/Author of Original Required Materials	Discrete Math and Its Applications, Kenneth H. Rosen
Original Total Cost Per Student	$205.55
Post-Project Cost Per Student	$0
Post-Project Savings Per Student	$205.55
Projected Total Annual Student Savings Per Academic Year	$69,064.80
Using OpenStax Textbook?	No

NARRATIVE SECTION

1. PROJECT GOALS

A) Improve student success in MATH 2300 (Discrete Mathematics) by creating no-cost Online textbook and materials.

The transformed course will have materials that not only align with all the course objectives but also address specifically three-course objectives which students are known to find particularly challenging. They are: **i)** Reasoning mathematically — being able to understand and construct mathematical arguments; **ii)** Demonstrate algorithmic thinking — verifying that algorithms work and analyzing the time required to perform specific algorithms; and **iii**) Use appropriate technology in the evaluation, analysis, and synthesis of information in problem-solving situations. The team will develop quality content materials and audio-visual ancillary materials to replace the current textbook. These materials will be designed to be more appropriate for the type of students in information technology (ITEC) programs such as those at GGC. The design of the materials will be accomplished by integrating algorithms and their analysis and implementing their code throughout the course. Through the development of substantive audio-visual materials and a significant depth of accessible and applied examples than are currently found in the standard commercial discrete math texts, the proposed textbook will address topics students are recognized to have particular challenges with. These challenges include algorithms and their analysis, and the more abstract proof techniques involved in mathematical induction. One drastic consideration that has been a reality at several institutions is that information technology (IT)/computer science (CS) programs are increasingly displeased with the discrete mathematics courses that math departments are servicing their majors with and have, in some cases, taken back these courses into their own departments in order to service their IT and CS majors better.

B) Encourage the wider use of free online textbooks within the GGC math program. Currently, the GGC math program subscribes to several very expensive commercial vendor textbooks and platforms in their multiple section courses. A major project goal, then would be to use the success in transforming the textbook in a multiple section course like MATH 2300, discrete math, as a pilot to stimulate conversations about low/no cost options in multiple section math courses, such as MATH 2450 linear algebra, MATH 2220 multivariable calculus, and potentially even high student enrollment courses like MATH 1113 precalculus. Particularly in MATH 2300, students often do not buy the textbook or wait until very late in the semester to purchase. At times, they download pirated versions of the textbook. This is true in other courses as well. Through the ALG Textbook Transformation grant, the project team will be able to create a model or template for the conversion of multi-section courses to free online materials.

C) Provide curated audio-visual materials, especially on the targeted topics that students generally struggle with. GGC students in MATH 2300 complain that materials to support learning in discrete math are scarce, especially at the IT sophomore level. This is particularly the case with the topics of mathematical induction, and algorithms and their

computation analysis and implementation. All audio-visual materials developed as part of this project are intended to be made available as open courseware type content, available to the entire USG community and ideally the public also.

2. STATEMENT OF TRANSFORMATION

Overview of the Transformation

Expensive textbook costs are often associated with students not buying the textbook at all, buying the textbook late, and even piracy. Textbook costs are always a big concern to the students at GGC and GGC MATH 2300 is no exception. The current textbook used in the course costs a student $206. While this cost in itself is an issue, all the instructors of MATH 2300 agree that the textbook has some major weaknesses that also align with the Mathematical Association of America's (MAA) review of the text (Stenger 2015). Stenger mentions that the textbook is comprehensive, has extensive end-of-chapter exercises, and may serve usefully as references; however, its major weaknesses lie in the paucity of motivated examples with complete explanations. Students complain that many of the examples are not inspiring, poorly explained with key steps missing, and focused mainly on computer science rather than information technology and related real-world applied areas. The treatment of algorithm analysis and their performance is also limited. The complexity of a few algorithms is presented in outline, whereas students would rather see them in a real-world programming language such as open source Python, R, or Matlab/Octave.

Discrete Math or GGC MATH 2300 is a required course for all GGC Information Technology (ITEC) majors. Serving also as a co-requisite for GGC ITEC 2150 Intermediate Programming, GGC MATH 2300 is a high impact course. It plays an important role in student success in the IT program and is a cross-disciplinary course serviced by the math program. By eliminating the textbook and using open educational resources, we propose to lower costs for students, deliver a more focused curriculum, and provide students with real-world applications and experience on a more powerful database management system. As reported by the team, the percentage of students receiving a grade of D, F, I or Withdrawing (DFWI rate) from this course since 2016 through the end of 2018 is 42%. The project is designed to provide quality content and supporting materials for the entire course coverage with a focus on targeted high impact areas of the course—algorithms and their analysis, and proof techniques especially mathematical induction. The goals are to provide materials at no cost to the general student population of the course, which also addresses student progression in the ITEC program and the DFWI rate.

Transformation description

To bring about the transformation of the MATH 2300 course, we will develop materials that align specifically with the objectives of the course, especially the three high impact course objectives we know the students in the course struggle with as described in the project goals above. Again, these are **i)** Reasoning mathematically - being able to understand and construct mathematical arguments; **ii)** Demonstrating algorithmic thinking - verifying that algorithms work, and analyzing the time required to perform specific

algorithms; and **iii)** Using appropriate technology in the evaluation, analysis, and synthesis of information in problem-solving situations.

The team will develop quality content materials, and audio-visual ancillary materials to replace the current textbook. These materials will be designed to be more appropriate for ITEC programs such as those at GGC. We will accomplish this task by integrating algorithms and their analysis and by implementing their code throughout the course. We plan to utilize a number of Open Educational Resources (OER) in the discrete mathematics/discrete structures domain and create content that will address topics that students find especially challenging. By developing substantive new materials and resources, students will be better prepared to tackle more demanding subjects of the course and progress to the next level of their studies.

Stakeholders affected by the transformation

The main stakeholders affected by the transformation will be approximately 336 undergraduate students enrolled annually in the discrete math course at GGC. Discrete math is a required General Education course, falling in Area F of all four IT program concentrations at GGC. Not only that, but it is also a pre/co-requisite for students wanting to move into programming and software development classes beginning with ITEC 2150 Intermediate programming. At GGC, students majoring in the B.S Mathematics (Pure Math Concentration) are required to take an ITEC programming class, such as ITEC 2120 in their program of study and encouraged to take the discrete math course MATH 2300 as their Area F additional course. Thus, the course is cross-disciplinary.

The other stakeholders are faculty members. We envisage that faculty in the University System of Georgia (USG) and across the nation who teach an introductory course in discrete math or its variant discrete structures can benefit from the materials developed and curated for this course.

Project's transformative impact on the course and department

Impact of this transformation on stakeholders and course success**.** The transformation is aimed at eliminating the need for students to purchase the textbook for the course. Its aims are also to develop materials that align with the course objectives and to enhance specific targeted areas of the course curriculum that students are known to struggle with. Taking an integrative perspective of programming and algorithms as they fit into the course will help improve student success and engagement in the course and better position them for their ITEC programming curricula in courses like ITEC 2150 (Intermediate programming) and ITEC 3150 (Advanced Programming). Finally, we will connect the topics covered to real-world discrete mathematics applications beyond hard computer science, which is the emphasis in the current Rosen text (Rosen 2012).

Project's transformative impact on the institution

Transformative impact on the program, department, institutions, access institution and/or multiple courses. MATH 2300 is a general education requirement, in Area F, and is a course required for all ITEC majors at GGC. This is generally the case for all information technology and computer science programs in the nation. Quoting from Information Technology Curricula 2017 "The IT 2017 task group recommends that a robust information technology program should have at least discrete structures (mathematics) and a variety of other mathematical experiences to prepare a competent IT professional for the mid-2020s." (Association of Computing Machinery 2017, page 52)

We will adopt a no textbook model and this approach where applicable can be replicated in other math courses at GGC. Given the rising cost of textbooks for students, we believe this model can serve as an example for other access institutions across the nation.
In particular, we will develop content, by way of examples, solved exercises, and end-of-chapter exercises for each of the major sections of the course. We plan to develop programming code for each of the important solved examples along the lines of the Textbook Companion Project for the Rosen text (Sai 2017) but to better align with our developed materials. We plan to develop high-quality audio-visual materials to accompany each of the important sections and/or examples along the lines that one of our current investigators, Dr. Josh Roberts, has been involved with and also as available at Open Courseware Sites, but edited and adapted for the GGC Discrete MATH 2300 course.
Finally, we will identify open educational resources and will plan to adapt and to link these materials with our discrete math course objectives. In addition, we will develop materials that consist of outline course notes, PowerPoint, programming labs, homework, and active learning activities that can be used by USG faculty teaching courses in discrete math/discrete structures. In addition, we believe that an active learning method, coupled with a cooperative learning approach and real-world application integration will result in improvements in student engagement and success.

3. TRANSFORMATION ACTION PLAN

There is currently a Schaum's Outline Series Discrete Math Text (Schaum 2009). While this is a low-cost option, we plan to adopt a **no-cost transformation** in our project. Moreover, we have found the current Schaum's Discrete Math text is not suitable for the GGC ITEC students for several reasons, but mostly pertaining to the fact its treatment of algorithms is not aligned in an integrated way to programming/coding. There is, for example, no description of the standard sorting or searching algorithms, like bubble sort, or merge sort. As a result, we plan to develop these no-cost materials:

- Brief accessible, section summaries/outlines for each of the major course topics that use Schaum's outline series
- Solved examples, both conceptual and applied, to accompany each summary section and each major topic section

- End-of-section exercises, comparable to the solved examples and solved exercises, with some problems for topic extensions for each major topic section
- Complete program (Octave/Python) code and/or pseudo code for each major topic section examples
- Comparable programming (Octave/Python) assignments and/or projects for each end-of-topic exercise section

The course materials will be collected from a number of online sources. The following is a list of the resources that we plan to use in the course. We will be creating weekly modules in D2L and will be including the links to the specific area within these sources that students can click on to gain access to the resource.

- GGC library resources (http://www.ggc.edu/academics/library/
- Open Textbook Library (https://open.umn.edu/opentextbooks)
- BC Open Textbooks (https://opentextbc.ca/)
- Merlot (https://www.merlot.org/merlot/viewMaterial.htm?id=293413)
- W3 Schools (https://www.w3schools.com/sql/
- Khan Academy (https://www.khanacademy.org/)
- Oracle Docs (https://docs.oracle.com)

Specific resources we plan to link to and/or augment or adapt include:

(a) Open discrete math textbooks:

- Oscar Levin text: https://www.merlot.org/merlot/viewMaterial.htm?id=1209141
    - Excellent, well-curated, mathematical text.
    - No discussion of Algorithms and Algorithm analysis

- Cusack text: https://cusack.hope.edu/Notes/Notes/Books/Active%20Introduction%20to%20Discrete%20Mathematics%20and%20Algorithms/ActiveIntroToDiscreteMathAndAlgorithms.2.6.3.pdf
    - Good discussion of algorithms, and their analysis and integration with Java Programming language
    - Good interactive approach to discrete math
    - Good discussion of graph theory
    - Not well curated/ peer reviewed

- Hammack text: https://www.merlot.org/merlot/viewMaterial.htm?id=1374816
    - Good discussion of algorithms, and their analysis
    - Good exercises
    - Very limited treatment of graph theory

- Doer Levasseur text: https://www.merlot.org/merlot/viewMaterial.htm?id=740675>
    - Good integration with SAGE open source system and Mathematica
    - Very limited treatment of modular arithmetic and number representation systems,

a major component of the GGC discrete math course.

(b) Videos:
Dr. Josh Roberts: https://www.youtube.com/playlist?list=PL8rEwockjR-rITNMrZYj0pDM1YlV3JUr5

Used by GGC professor Dr. Josh Roberts currently teaching MATH 2300 Spring 2019

Links to videos collected by Dr. Josh Roberts students in Discrete Math fall 2018:
https://docs.google.com/spreadsheets/d/1L27xkOZqAhhHzajcbwtROwweN_cayJ8sX8EoZzsDh2U

Used by GGC professor Dr. Josh Roberts students currently in MATH 2300 Spring 2019
Professor Shai Simonson: http://www.oercommons.org/courses/discrete-mathematics/view

Videos and lecture notes that can be used and/or adapted for our course.
MIT OCW: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-042j-mathematics-for-computer-science-fall-2010/video-lectures/

https://www.merlot.org/merlot/viewMaterial.htm?id=1126630

(c) Open courseware:

- MIT OCW Principles of Discrete Applied Mathematics: https://www.merlot.org/merlot/viewMaterial.htm?id=555485>

Course and syllabus instructional design/redesign necessary for the transformation
The instructional design of the course will center on organizing the contents into modules in the learning management system D2L. The syllabus and all materials used in the course will be made available in D2L for the learners. There will be links that are set to open in a new browser window for all the OER resources used in the course. The course syllabus will be modified to reflect the no textbook format and will include a list of the major open educational resources that will be used in the course. The added Python/Octave programming assignments will be graded components. The contents covered in the course will be mapped to the course objectives.

Team members' roles

Team member and PI Mohamed Jamaloodeen: Associate Professor of Mathematics will serve as a subject matter expert, instructional designer, and project manager. He regularly teaches this course at GGC. He is also the Chair of Faculty in the Mathematics discipline. He will assist with identifying, gathering and developing custom course materials especially designing solved examples, solved exercises and end-of-section exercises and programming assignments and/or projects. He will work on the programming-related materials with Dr. Sebastien Siva who has domain expertise in the programming component of the ITEC major. He will also coordinate

with content with all members of the team including Dr. Josh Roberts who will be mainly tasked with developing the supporting audio-visual materials, especially videos on the major topics of the course and the targeted impact areas of mathematical proofs and mathematical induction, and programming and algorithm analysis.

Dr. Jamaloodeen has extensive experience adopting open course materials and developing supporting materials such as videos to help students understand the materials. For example, in AY 2010-11, he taught the inaugural Math 2220 multivariable calculus course at GGC. He made use of a free (public domain) online text by Michael Corral (http://www.mecmath.net/calc3book.pdf). Group projects were an integral component of the course and students were encouraged to use computer Algebra systems like Maple or Scientific Workplace on these projects. Students worked in teams of two and were given separate oral defense examinations on their projects. He developed videos to supplement class material using Echo 360 and SmartBoard Video capturing tools. Students gained much from these videos, were very appreciative, and wrote to the Dean's office commenting on them. He also has experience in developing assignments. As a consultant to a statistical certification body in summer 2011, he developed assignment items for a graduate online statistics course. He wrote 88 mixed problem assignment items, with solutions, for non-parametric tests, logistic regression modeling, and one and two-way ANOVA. He wrote 83 discussion assignment problems, with solutions, and SPSS output for non-parametric tests, logistic regression modeling, one and two-way ANOVA and bootstrapping methods for inference. He also developed a final project with 2 scenarios with different data sets for 10 students involving bootstrapping inference. Finally, he has done much research on integrating computer programming into the GGC math discrete courses and has presented his findings at several conferences including ICTCM 2018 and the Joint Math Meetings in Baltimore 2019 (Jamaloodeen 2018).

Team member and Co-PI: Kathy Pinzon: Associate Professor of Mathematics will serve as a subject matter expert and instructional designer in the course. She has taught the course on several occasions at GGC. She has used a class discussion board called piazza, which supports discussions using mathematical symbols when teaching the course. She plans to incorporate this type of feature into the no-text course. She will also assist in developing practice problems and course materials like section outlines and PowerPoint and assignments for several of the major course topics.

Dr. Pinzon has extensive experience with surveys and assessment data analysis from Course-Embedded Research Experiences (CUREs) grants she has run and with her being a major developer and overseer of the Mathematics Peer Supplemental Instruction (PSI) program at GGC. She is considering the possibility of extending the GGC math PSI program to the discrete math class and so can help with designing, administering, and analyzing this project. She will also assist the effort to identify, gather, and map OER resources to the course objectives. She will assist Dr. Jamaloodeen and lead the evaluation effort for the project. This will include obtaining IRB approval, creating assessment tools (surveys, common assessment questions for each goal), obtaining consents, administering surveys, collecting data (from students, faculty,

and Banner), and conducting data analysis. She will work with Dr. Jamaloodeen to compile the necessary grant reports. She will also help in organizing the materials so that they can be easily shared with stakeholders at GGC and outside of GGC.

Team member Dan Pragel: Assistant Professor of Mathematics will serve as a subject matter expert and instructional designer in the course. He is one of the primary instructors of this course and has served as one of its coordinators. As a graph theorist, discrete math is his primary domain of research and he has published academically in discrete math journals. He will assist with developing practice problems, course materials like section outlines, PowerPoint, and assignments for several of the major course topics particularly in the areas of graph theory, combinatorics, logic, proof theory, and modular arithmetic and number representations systems. He will also oversee all pedagogical aspects of this project through piloting modules as they are completed in the fall of 2019. Dr. Pragel is scheduled to teach two sections of MATH 2300 discrete math in the fall of 2019 and will be assigned to teach the course in Spring 2020, should our grant application be successful.

Team member Josh Roberts: Assistant Professor of Mathematics will serve as a subject matter expert and instructional designer in the course. He has taught discrete math at GGC over several semesters beginning in the fall of 2018. He brings new and valuable insights on how to transform the course. Dr. Roberts has been a Mathematical Association of America *Project NExT* Fellow and, as a Fellow, learned about and developed videos and video notes for his students in many of his classes including discrete math, college algebra, quantitative reasoning, statistics topology, and complex analysis. His main role will be to develop quality videos for all major topics of the course. He will assist, as needed, with developing practice problems, course materials like section outlines, PowerPoint, and assignments for several of the major course topics. Dr. Roberts has experience with this type of activity. In graduate school, he assisted a professor in writing a low-cost textbook for college algebra. He helped write some of the sections as well as most of the exercises. Dr. Roberts will also assist Dr. Pragel in overseeing all pedagogical aspects of this project through piloting modules as they are completed in the fall of 2019. Dr. Roberts is scheduled to teach two sections of MATH 2300 discrete math in the fall of 2019 and will be assigned to teach the course in spring 2020 should our grant application be successful.

Team member Sebastien Siva: Associate Professor of Information Technology will serve as a cross-disciplinary subject matter expert and instructional designer in the course. He will incorporate programming assignments into the course. He is the author of the ITEC 2120 open source textbook in which he has incorporated the Python Code visualizer enabling students (in a web browser) to write and visualize the execution of Python code. He has experience also in teaching ITEC 2140 (programming fundamentals) and can judge the appropriate coding level of programming assignments for this course. In the last decade, he has developed over 200 different coding assignments and projects for a variety of coding classes with many automated approaches to grading both inside and outside of D2L.

He will also assist Kathy Pinzon with project assessment. As far as data analysis goes, he has considerable experience in longitudinal (multi-semester) analysis of student performance at GGC. This will allow us to examine how our course modifications impact students in down-the-line courses such as ITEC 2150 and ITEC 3150.

Below is a breakdown of the major topics covered in the course and role of the PIs:

- Propositional Logic, Applications of Propositional Logic, Propositional Equivalences, Predicates and Quantifiers, S Nested Quantifiers [Dr. Pragel, Dr. Jamaloodeen]
- Sets, Set Operations, Functions [Dr. Pragel, Dr. Jamaloodeen]
- Pseudocode, Algorithms, The Growth of Functions, Complexity of Algorithms [Dr. Jamaloodeen, Dr. Pinzon, Dr. Siva]
- Divisibility and Modular Arithmetic, Integer Representations and Algorithms [Dr. Pragel, Dr. Roberts]
- Mathematical Induction , Recursive Definitions and Structural Induction, Recursive Algorithms [Dr. Pragel, Dr. Roberts, Dr. Pinzon, Dr. Siva]
- The Basics of Counting, The Pigeonhole Principle, Permutations and Combinations [Dr. Pragel, Dr. Siva]
- An Introduction to Discrete Probability [Dr. Jamaloodeen]
- Divide-and-Conquer Algorithms and Recurrence Relations [Dr. Jamaloodeen, Dr. Siva]
- Relations and Their Properties, n-ary Relations and Their Applications, Representing Relations [Dr. Pinzon]
- Graphs and Graph Models, Graph Terminology and Special Types of Graphs, Representing Graphs and Graph Isomorphism [Dr. Pragel, Dr. Roberts]
- Applications of Trees, Tree Transversal [Dr. Pragel, Dr. Siva, Dr. Pinzon, Dr. Roberts]

Plan for providing access

The course materials developed will be hosted in GGC's Brightspace (D2L) (https://ggc.view.usg.edu/d2l/home). Students who enroll in the course will have free access to the materials in the course. The PIs will also make the course materials available at the GGC Wiki page http://wiki.ggc.usg.edu/wiki/Main_Page. This will result in broader access to course materials for educators and students across the nation.

4. QUANTITATIVE AND QUALITATIVE MEASURES

The project team will request IRB (Institutional Review Board) approval for the project's evaluation plan.

GOAL 1: Improve student success in MATH 2300 (Discrete math) by creating no-cost online textbook and materials.

Qualitative Measure, Methods, and Tools

The PIs will survey the students at the end of each semester to evaluate the effectiveness of the proposed open source resources, the active learning activities, and the cooperative learning activities. The questionnaire will ask students to rate questions on a Likert scale of

Strongly Disagree to Strongly Agree, and will consist of questions focusing on the following main ideas:

- The materials will be easily and reliably accessed at all times.
- The materials are well-organized so that the necessary information can be found quickly.
- The materials clearly explain concepts and are useful to learn the content.
- The materials have enough exercises and examples to support students' learning needs.
- The active learning activities were useful and engaging.
- The collaborative learning experience improved my ability to work in teams.

The questionnaire will also include open-ended questions, such as:

- What did you like about the new course materials?
- How can the new course materials be improved?
- Did the availability of free online textbook help improve your success in the course? If so, how did it impact your learning and success in the course?
- Any other comments?

Quantitative Measure, Methods, and Tools

The PIs will collect the following data regarding students' performance in the course:

1. Student performance on common assessment questions in the final exam corresponding to each learning outcome of the course. This data will be gathered from faculty teaching the class.

2. Student grades on a final common assessment in all sections of the course. This data will be gathered from faculty teaching the class.

3. Grade distribution in all sections of the course. This data will be gathered from Banner and will be compared with existing historical grade distribution data for this class.

In addition, the PIs will compare the cost of the current textbook with the cost of the new learning materials (expected to be free).

GOAL 2: Increase adoption of no/low-cost materials in other multiple sections GGC math courses.

Qualitative Measure, Methods, and Tools

We will send a short questionnaire (1-2 questions) to faculty who have expressed interest or decided to use our materials. Our plan is to ask them about their experiences in utilizing the textbook and/or resource materials. The questionnaire mentioned in the evaluation of Goal 1 above will be adapted for statements of GGC Math 2450, Math 2600 and Math 2220 instructors to rate, such as:

- I am likely to participate in a project transforming the required text in my Math

2450/Math 2600/Math 2220 to a low or no-cost option based on my teaching the transformed MATH 2300 course.

Quantitative Measure, Methods, and Tools

Course coordinators in Linear Algebra (MATH 2450), Math Modeling (MATH 2600) and Multivariable calculus (MATH 2220) will be encouraged to teach a section of the transformed MATH 2300. Through carefully designed Qualtrics surveys, we will ask these instructors at the end of the project about their impressions and the likelihood of their implementing similar low/no-cost transformations in other sections or math courses. We will track this information in order to provide us with quantitative data on the effectiveness of this project as springboard to leverage affordable learning across more multiple section Math courses.

GOAL 3: Encourage the wider use of the free online textbook within the USG by disseminating the course materials and informing colleagues in the field of best practices and lessons learned.

Goal 3 will result in presentations at conferences and sharing of materials online.

Qualitative Measure, Methods, and Tools

We will send a short questionnaire (1-2 questions) to faculty who have expressed interest or decided to use our materials. Our plan is to ask them about their experiences in utilizing the textbook and/or the resource materials.

Quantitative Measure, Methods, and Tools

We will track the number of presentations we conducted to disseminate information on the project, as well as the number of faculty members who have expressed interest in utilizing our materials.

5. TIMELINE

The project will be piloted in 2019 and full implementation will be in spring 2020 semester.

Summer 2019: The team members will use summer 2019 semester to identify, gather, and map OER resources to the course objectives. This will include developing content material, audio-visual ancillaries, applied examples, solved exercises, end-of-section exercises, programming assignments, and projects.

Fall 2019: The team members expect to create more supporting materials for the course in Fall 2019, including completing the creation of materials from summer and also work on common assessment questions, quizzes, and other materials.

The organization of all of these materials in D2L will start in summer 2019 and is expected to be complete in fall 2019. Some of the materials developed in summer 2019 will be piloted in fall 2019 in multiple sections with ~28 students per section, impacting 140 students. Initial

feedback from students will be obtained. Evaluation plan and instruments will also be developed during this semester.

Spring 2020: All of the learning materials are expected to be ready and organized by the end of fall 2019 and will be used in all sections of the class in spring 2020, which will affect 140 students in five sections. More data will be collected at the end of spring 2020.

Summer 2020: The team members expect to continue using the new materials in summer 2020 in two additional sections that will affect 56 students, and collect more data. There might be minor tweaks to the material during this time, based on student feedback from fall 2019 and spring 2020. Data analysis for fall and summer semesters will also happen during this time. A report will be created and submitted by the end of the grant period. Lastly, PIs expect to work on dissemination efforts this semester by presenting at conferences to reach off-campus faculty and by reaching out to on-campus faculty at course coordination meetings and discipline meetings.

6. BUDGET
(a) Type of Grant: Large Scale Transformation--all-section, math discipline-wide transformation

(b) Total request: $25,800

(c) Budget and Justification

Funds are requested for:
Personnel: $25,000.00
Funds are requested to cover the compensation and fringe (FICA/SS, FICA Med, Retirement) of Drs. Jamaloodeen, Pinzon, Pragel, Roberts, and Siva at $5,000 each.

Dr. Jamaloodeen will serve as project manager. He will lead in the further identification, gathering, and mapping of OER resources to the course objectives. He will participate in developing course content and assignment materials as described in the breakdown of topics covered. Having developed computer programming activities, he will support Dr. Siva in the programming content and design of programming assignments and exercises. Having developed videos previously, he will coordinate with Dr. Roberts on developing videos and other audio-visual materials and also work on developing the supporting materials for the three targeted high impact areas. He will also coordinate the development of all assignment and end-of-section exercises.

Dr. Pinzon will be primarily involved with developing content as described in the breakdown of topics covered and assist with identifying, gathering and developing custom course materials. She will lead the evaluation effort for this project, including obtaining IRB approval, creating assessment tools, obtaining consents, administering surveys, collecting data, and conducting data analysis. She will assist with compiling reports and in organizing materials for dissemination purposes.

Dr. Siva will be involved with some content development as described in the breakdown of topics covered. He will be primarily tasked with integrating computer programming with a suitable language like Python or Octave into the course curriculum through a cohesive approach to coding, algorithms, and their implementation and analysis. He will be involved in providing examples and project assignments that are applicable to information technology. He will also assist Kathy Pinzon with project assessment using his experience with longitudinal (multi-semester) student performance at GGC.

Dr. Pragel will be involved primarily in developing content, assignments, and end-of-section exercises for many of the mathematical topics in discrete math, such as propositional logic, combinatorics, graph theory, and modular arithmetic and number representation systems.

Dr. Roberts, will be involved in content development as described in the breakdown of topics covered above. However, his most significant contributions should be to develop quality videos for the major topics in the course and for the targeted impact areas, namely proof techniques including mathematical induction, propositional logic, and analysis of algorithms.

Travel: $800.00
Funds are requested for two team members to attend the kick-off meeting at $400 each. Travel will cover mileage, lodging, per diem, and other travel requirements.

Total: $25,800.00

7. SUSTAINABILITY PLAN
MATH 2300 Discrete Mathematics is a required course for all IT majors at GGC. There are about 10 sections taught each academic year (plus an additional two sections in the summer). The PIs (Drs. Jamaloodeen and Pinzon) and team members plan to test the proposed open source learning materials in at least three sections taught each semester. Dr. Jamaloodeen, being the chair of faculty, can ensure that all math project team members get to teach the necessary sections. The PIs expect that this project will impact student achievement by eliminating textbook and software costs, increase student engagement in the material inside and outside the classroom, improve academic performance, which in turn improves retention in this course. Considering these benefits, the PIs will propose to standardize these resources for future offerings of MATH 2300. Both PIs' involvement in the discipline, the team members' extensive involvement in the running of this course, and the initial data collected during this project should help the PIs make a case for adopting these materials for long-term use. The materials will be made available to GGC faculty in a central and easy-to-access location such as D2L. The PIs, along with GGC faculty teaching the course in the future, will continue to maintain and update the learning materials created.

A centralized location, such as a wiki page, will allow non-GGC faculty and students to access the materials easily. The PIs also see an opportunity to request and use additional mini-grant funds in the future to add emerging technologies to the curriculum.

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