Summer 2018

Mathematical Models

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Mathematical Models
Grants Collection

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

Each collection contains the following materials:

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

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Initial Proposal
### Application Details

**Manage Application: ALG Textbook Transformation Grants**

<table>
<thead>
<tr>
<th>Award Cycle</th>
<th>Round 9</th>
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<tbody>
<tr>
<td>Internal Submission</td>
<td>Sunday, April 30, 2017</td>
</tr>
<tr>
<td>Deadline</td>
<td></td>
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</tbody>
</table>

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

- Patty Wagner, Assistant Professor, Mathematics, patty.wagner@ung.edu
- Marnie Phipps, Associate Professor, Mathematics, marnie.phipps@ung.edu

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

- John Cruthirds, Department Head, Department of Mathematics, University of North Georgia
Course Names, Course Numbers and Semesters Offered:
Mathematical Models, MATH 1101, offered fall, spring, & summer semesters

| Average Number of Students per Course Section: | 30 |
| Number of Course Sections Affected by Implementation in Academic Year: | 10 |
| Total Number of Students Affected by Implementation in Academic Year: | 300 |

List the original course materials for students (including title, whether optional or required, & cost for each item):
Graphing calculator required (TI-83, TI-83+, TI-84, or TI-84+ preferred), $100
Required Textbook: Mathematical Application for the Management, Life, and Social Sciences by Harshbarger & Reynolds. Students choose from the following options: 1) UNG custom package with Web Assign code (hardcopy textbook), $165 or 2) Web Assign plus ebook access, $94

Proposal Categories: Specific Top 50 Lower Division Courses
Requested Amount of Funding: 10,800

Original per Student Cost: $194 - $265, depending on textbook options. $194 includes only an e-book and calculator; $265 includes a hardcopy text, e-book, and calculator.

Post-Proposal Projected Student Cost: $0. Our goal is to provide all materials to students at no cost.
Projected Per Student Savings: $194 - $265, depending on textbook option.
Projected Total Annual Student Savings: $58,200 - $79,500

Creation and Hosting Platforms Used ("n/a" if none):
In the planning phase of summer and fall 2017, all materials will be hosted on the University of North Georgia’s shared U drive. This drive is accessible by all UNG faculties regardless of campus location. After one pilot semester, beginning spring of 2018, these resources will be offered to the University of North Georgia’s Nighthawks Open Institutional Repository. At the completion of the project, the resources will also be made available through the Georgia
Project Goals:

Many non-STEM majors enroll in introductory mathematics modeling courses to fulfill general university requirements for quantitative reasoning. In our experience, many of these students experienced difficulty learning mathematics in the K-12 school setting and their affinity for the subject has been severely diminished. The mathematics modeling course is particularly suited for these students because context allows students to consider mathematics from an intuitive, concrete perspective. Through initial explorations and a focus on multiple representations, and with an eye towards building a mathematical toolbox for problem solving, students may come to realize that mathematics is far more than rules and procedures. Unfortunately, our research suggests that many commercial textbooks do not capitalize on these aspects of a mathematics modeling course (Phipps & Wagner, 2017). Rather, textbooks written for mathematics modeling courses tend toward more traditional presentations; one in which mathematics is presented as a way to understand the world rather than the other way around.

Our goals for this project are four-fold. First, we desire to design a course and identify course materials that align with National Council of Teachers of Mathematics' [NCTM] (2014) effective teaching and learning practices. These practices were developed through research in an effort to ensure mathematical success for ALL students. Rather than relying on a traditional textbook format, we will identify and compile effective student and instructor resources that are freely available. Second, our goal is for students in mathematics modeling courses to show progress in productive dispositions (National Research Council, 2001). Specifically, students will find mathematical success attainable, recognize the value in perseverance and productive struggle, perceive mathematics as a discipline involving reasoning and sense making, and view mathematics as a relevant tool for problem solving. Third, our goal is to have students demonstrate content knowledge growth of the essential components of this course as designated by the University System of Georgia [USG] syllabus for mathematics modeling. Students’ growth will be demonstrated both conceptually and procedurally in contexts designed to make sense of worldly phenomena. Last, we want to reduce the financial burden to students by using publicly available resources. Ultimately, this grant will provide an opportunity to incorporate current research in teaching and learning practices to engage students in new and innovative ways, while reducing students' cost to zero.

Statement of Transformation:

We intend to transform our institutional mathematics modeling course from a textbook driven, traditional lecture approach to one that encourages and develops students’ critical thinking and problem solving. As such, we propose to develop resources for the instructor's use as much as the students’. Our materials will suggest ways to ensure that important mathematical concepts are highlighted through in-class work and discussions. We will also suggest websites students can visit for extra practice or information.
Our mathematics modeling course will consist of classwork in the form of high cognitive demand tasks, on which students will work in teams. We may create some of these tasks, but many will be intentionally selected from publicly available resources, including OERs, mathematics-specific organizations, and interested individuals (for example, Arnolds et al., 2007; Mathematics Assessment Resource Service, 2007; and Meyer, n.d., respectively). These tasks will introduce topics from the USG syllabus for mathematics modeling.

For each topic, we will provide a task--or a link to a publicly available task, depending on copyright and licensing requirements--as part of an instructional packet. For each of these tasks, we will create lesson resources that identify appropriate scaffolding questions for students who are struggling. Additionally, we will identify common methods students might use to solve the task and suggest a sequence of presentation for the follow-up whole class discussion. Our lesson resources will suggest connections that can be made between methods and representations and ways to highlight the relevant mathematics. We will also identify appropriate follow-up practice and free technology apps (e.g. www.desmos.com and GeoGebra) that can foster students’ connections between algebraic, graphic and numeric representations. These free technology applications will replace the currently required graphing calculators and are arguably superior to calculators for exploration and developing connections. In this technological age, we anticipate that students will be able to use smartphone capabilities to access applications for spreadsheets, graphing data and functions, and various calculations. Students without a smartphone will be able to rely on campus computers. We will substitute our current WebAssign online practice with in-class work, projects, individual paper-and-pencil practice problems, and online practice websites.

Initially, the transformation has the potential to impact students taking this core class with an instructor who has adopted our materials. We will offer our resources to all instructors of MATH 1101 or similar modeling courses; instructors will gain full access to lesson plans, in-class tasks, Power Points, sample projects, tests, etc. beginning spring 2018.

Beyond the savings in material costs generated by students, we believe that this innovated course will impact students’ view of mathematics as a discipline and their own affinity for it. We also believe that we will see increased student success, particularly among student groups who have traditionally struggled with mathematics. These groups include non-traditional students, first-generation students, and those who have been enrolled in remedial or support courses.

We consider this project an ongoing effort to transform the mathematics modeling course. ALG funds will allow for an intensive initial effort in restructuring the course; however, we intend to continue making modifications and adjustments as a result of program assessments. As we compile evidence supporting the positive impact of our resources and methods, we expect more and more faculty across UNG’s five campuses to adopt them. Our department has launched an open discussion about OERs and their role in teaching and learning. This project will serve as evidence of their effects. We anticipate this course restructure will have a positive
impact on students who might otherwise have struggled to meet institutional quantitative requirements.

We will also share our results and materials at state conferences such as the USG Teaching and Learning Conference hosted in Athens, GA or national conferences such as the Research Council on Learning Mathematics. Exposure through these modes of professional development creates a possibility for impacting mathematics modeling courses within and outside the state of Georgia.

Transformation Action Plan:

The ALG team consists of Patty Wagner and Marnie Phipps. We each earned a doctorate in the field of mathematics education and train future secondary mathematics teachers at our institution. Our pedagogical choices are informed by the literature about how students learn mathematics and how to ensure mathematical opportunity for ALL students. Our interest in this project stems partly from the findings of our recent analysis of mathematics modeling textbooks used in the state of Georgia (Phipps & Wagner, 2017). Noting that these textbooks largely lack characteristics of NCTM’s (2014) effective teaching and learning practices, we brainstormed ways in which the course could be restructured to capitalize on these practices. We noted that excellent resources are already publicly available but need to be identified, modified for the MATH 1101 course, and supplemented with pedagogical decisions. To that affect, our action plan follows.

We will identify our resources and create initial instructional plans prior to the fall 2017 semester. We will begin with our department’s syllabus for the course as written, but will propose changes as needed. We will refer to our department head, John Cruthirds, and the USG Academic Committee’s (2014) Math 1101 Intro to Math Modeling Outline to ensure any proposed changes meet departmental approval and USG guidelines. Following NCTM’s (2014) practices of effective teaching and learning, we will establish unit goals and objectives, with an eye towards what mathematics is to be learned, why is it important, how it relates to prior mathematical learning, and to what mathematical ideas we are heading. We will then create or search publicly available resources for tasks that “promote reasoning and problem solving” (NCTM, 2014, p. 17) and that will serve to meet the unit objectives. As mentioned early in this proposal, course materials under consideration may originate from Mathematics Assessment Resource Service (2007) or Meyer (n.d.) for classroom engagement activities and Arnolds et al. (2007) as practice problems for students.

We are seeking materials which contain wide entry levels and which allow for individual expression and representation. We will select materials that enable students to start with their personal prior knowledge base and expand mathematical learning through scaffolding questions. Scaffolding questions are typically open-ended and designed to help a student focus on the relevant mathematics without taking over the student’s thinking (NCTM). If a selected task does not include suggested scaffolding questions, we will create these to include
in course materials. We will then describe how a follow-up class discussion can connect the various solution strategies in ways that move students toward a conceptual understanding of the relevant mathematics. By connecting strategies and representations to their own experiences, students can develop an understanding from which they can build procedural fluency (NCTM). Our description of the follow-up whole class discussion will include suggestions for sequencing of strategy presentations, open-ended questions to elicit connections between strategies or representations, and ideas for ensuring that the relevant mathematical ideas are emphasized. Finally, we will identify practice problems to help build procedural fluency, projects that make use of the mathematical ideas, and/or links to online student resources.

In fall 2017, as instructors of record, we will each implement the designed course in a single section of MATH 1101. After each instructional session, we will reflect separately on its effectiveness and note changes that should be made. We will meet with each other weekly to compare our qualitative assessments of each task and make appropriate adjustments or modifications. In spring 2018, we will designate a control section of MATH 1101 that will retain the original departmental design. Phipps and Wagner will each teach a transformed version of MATH 1101 using our developed resources. We will conduct our formal assessment of the project during this semester.

The resources we develop will be compiled as lesson plans, tasks, instructional PowerPoint presentations, links to student practice and resources, etc. for each unit in the mathematics modeling course. As such, they will represent a more complete resource for instructors than the typical textbook. We will organize these resources to maximize ease of use by instructors and make them available electronically to all UNG instructors through the institution’s shared U drive in fall of 2017. Additionally, we will make the resources publicly available to the University of North Georgia’s Nighthawks Open Institutional Repository beginning spring of 2018. At the completion of the project, the resources will also be available through the Georgia Knowledge Repository and the GALILEO Open Learning Materials repository. In the following academic year, introductory webinar’s will be offered each semester to instructors using these materials.
Goal 1 is to design a course and course materials that align with NCTM’s (2014) effective teaching and learning practices. Phipps and Wagner (2017) have established qualitative criteria to determine the extent to which curriculum materials meet NCTM’s guidelines. Using this tool, we will measure materials created and designed for Math 1101. This will occur before materials are released for public use the start of the semester in January 2018. Goal 2 is for students in mathematics modeling courses to show progress in productive dispositions. We will create or find an appropriate Likert-scale online survey with questions about views of math, self-efficacy, and dispositions. Surveys will be administered both pre- and post-semester. Additionally, we will conduct short interviews with two focus groups of up to 4 students on their experiences with mathematics and the course. Surveys and focus group interviews will occur fall and spring semesters. Goal 3 is to have students demonstrate content knowledge growth. We will administer pre- and post-tests to measure student growth for specific course objectives to all students in the experimental Math 1101 course and conduct a matched pairs analysis to measure student growth. The pre-test will also be administered to the students in the control course to test for significant differences in incoming ability levels. We will attempt to measure at-risk subgroups within our population; however, small sample sizes may limit the number and kinds of subgroups analyzed. Possible subgroups may include non-traditional students, first-generation students, and those who have been enrolled in remedial or support courses. Content testing will occur in both fall and spring semesters. Goal 4 is to reduce the financial burden to students by using publicly available resources. In the past two academic years, 628 students have taken this course on the Dahlonega campus, spending a total of $121,832–$166,420 for course materials. Enrollment numbers indicate that approximately 300 students complete this course each year on the Dahlonega campus, spending $58,200 -
$79,500 annually. This cost would be completely eliminated.

Timeline:

<table>
<thead>
<tr>
<th>Date</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 5, 2017</td>
<td>Kickoff meeting attended by Marnie Phipps and Patty Wagner</td>
</tr>
<tr>
<td>Aug. 21, 2017</td>
<td>Draft of unit resources completed</td>
</tr>
<tr>
<td>Aug. 21, 2017 - Dec. 15, 2017</td>
<td>Wagner and Phipps each implement developed resources in MATH 1101 course. Informal reflections and assessment of tasks and course materials are noted. Weekly meeting are held to address concerns and make adjustments to the resources. Content and disposition assessments and focus interviews that align to goals 2 and 3 are given. Modifications to measurements are made before implementation in spring semester.</td>
</tr>
<tr>
<td>Jan. 7, 2018</td>
<td>Final adjustments to unit resources completed. Control section of MATH 1101 identified. IRB approval for project assessment obtained. Qualitative assessment of Goal 1 completed.</td>
</tr>
<tr>
<td>Jan. 8, 2018 - May 4, 2018</td>
<td>Implementation of resources in at least two sections of MATH 1101</td>
</tr>
<tr>
<td>Early Jan. 2018</td>
<td>Project status report submitted to ALG</td>
</tr>
<tr>
<td>Jan. 2018</td>
<td>Pretests administered to experimental and control MATH 1101 sections. The pretests will evaluate content knowledge and mathematical dispositions. Participants for qualitative assessment identified.</td>
</tr>
<tr>
<td>Early May 2018</td>
<td>Content and disposition post-assessments administered and analyzed</td>
</tr>
<tr>
<td>Mid-May 2018</td>
<td>Analysis of both qualitative and quantitative measures (dispositions &amp; content knowledge via final exam) completed</td>
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End of May 2018

Final project report submitted to ALG. At the request of the departmental curriculum committee, the final report will be shared with them and our department head.

Aug. 2018 and beyond

Share the results of project measures to all UNG mathematics faculty via departmental colloquium and disseminate results at conferences. Update and revise the material over the next 3 years as needed.

Budget:

Dr. Patty Wagner – Compensation for preparation time --$5,000
Dr. Marnie Phipps – Compensation for preparation time -- $5,000
Travel – Kick-off meeting and conference travel -- $800

Sustainability Plan:

Sustainability for UNG
Faculty at UNG utilize Desire 2 Learn [D2L] as an on-line web interface for courses. In the spring of 2018, when the materials become publicly available, we will set up a basic outline of the course in D2L. Currently these are referred to as sandbox courses because any instructor within UNG can copy all components of the course and tailor the materials to suit their students.

Sustainability outside of UNG
We will work with the Nighthawks Open Institutional Repository at UNG to post and upload all the developed resources and materials. Additionally, we will make these resources available through the Georgia Knowledge Repository and the GALILEO Open Learning Materials repository. We will hold two webinars at the beginning of the fall in 2018 and spring of 2019 to orient instructors to these materials. Once per year, we will update and revise the materials as needed for the next 3 years.
April 12, 2017

Affordable Learning Textbook Transformation Grant
Review Committee

Dear Committee Members:

I am writing this letter in support of the proposal being submitted to you by Professors Marnie Phipps and Patricia Wagner from my department. I am in full support of this proposal because I believe the proposal has strong merit and because these faculty members are talented faculty members who are well qualified to accomplish the goals of the proposal.

Professors Phipps and Wagner have experience teaching the course that is targeted in the proposal. I am excited at the potential financial savings our students could realize, and I intend to lend full departmental support for the work of this proposal. Since we teach multiple sections of these courses every semester, including summer, the potential sustainability of the project will not be a concern. The expansion of the project to other sections of these classes on our other campuses can be accomplished by working through our existing departmental Curriculum Committee which has representation from faculty on all University of North Georgia campuses.

I am in full support of this proposal, and I hope that you will be able to give the proposal every possible consideration. I would be happy to comment further if you so like.

Sincerely,

John Cruthirds, Head
Department of Mathematics
john.cruthirds@ung.edu
706 864-1810
References


Affordable Learning Georgia Textbook Transformation Grants

Round Nine

For Implementations beginning Summer Semester 2017

Running Through Spring Semester 2018
1.1 PROJECT GOALS

List the goals you are trying to achieve with the transformation, including goals for student savings, student success, materials creation, and pedagogical transformation.

Many non-STEM majors enroll in introductory mathematics modeling courses to fulfill general university requirements for quantitative reasoning. In our experience, many of these students experienced difficulty learning mathematics in the K-12 school setting and their affinity for the subject has been severely diminished. The mathematics modeling course is particularly suited for these students because context allows students to consider mathematics from an intuitive, concrete perspective. Through initial explorations and a focus on multiple representations, and with an eye towards building a mathematical toolbox for problem solving, students may come to realize that mathematics is far more than rules and procedures. Unfortunately, our research suggests that many commercial textbooks do not capitalize on these aspects of a mathematics modeling course (Phipps & Wagner, 2017). Rather, textbooks written for mathematics modeling courses tend toward more traditional presentations; one in which mathematics is presented as a way to understand the world rather than the other way around.

Our goals for this project are four-fold. First, we desire to design a course and identify course materials that align with National Council of Teachers of Mathematics’ [NCTM] (2014) effective teaching and learning practices. These practices were developed through research in an effort to ensure mathematical success for ALL students. Rather than relying on a traditional textbook format, we will identify and compile effective student and instructor resources that are freely available. Second, our goal is for students in mathematics modeling courses to show progress in productive dispositions (National Research Council, 2001). Specifically, students will find mathematical success attainable, recognize the value in perseverance and productive struggle, perceive mathematics as a discipline involving reasoning and sense making, and view mathematics as a relevant tool for problem solving. Third our goal is to have students demonstrate content knowledge growth of the essential components of this course as designated by the University System of Georgia [USG] syllabus for mathematics modeling. Students’ growth will be demonstrated both conceptually and procedurally in contexts designed to make sense of worldly phenomena. Last, we want to reduce the financial burden to students by using publicly available resources. Ultimately, this grant will provide an opportunity to incorporate current research in teaching and learning practices to engage students in new and innovative ways, while reducing students’ cost to zero.
1.2 STATEMENT OF TRANSFORMATION

- **Describe the transformation.**

We intend to transform our institutional mathematics modeling course from a textbook driven, traditional lecture approach to one that encourages and develops students’ critical thinking and problem solving. As such, we propose to develop resources for the instructor’s use as much as the students’. Our materials will suggest ways to ensure that important mathematical concepts are highlighted through in-class work and discussions. We will also suggest websites students can visit for extra practice or information.

Our mathematics modeling course will consist of classwork in the form of high cognitive demand tasks, on which students will work in teams. We may create some of these tasks, but many will be intentionally selected from publicly available resources, including OERs, mathematics-specific organizations, and interested individuals (for example, Arnolds et al., 2007; Mathematics Assessment Resource Service, 2007; and Meyer, n.d., respectively). These tasks will introduce topics from the USG syllabus for mathematics modeling.

For each topic, we will provide a task—or a link to a publicly available task, depending on copyright and licensing requirements—as part of an instructional packet. For each of these tasks, we will create lesson resources that identify appropriate scaffolding questions for students who are struggling. Additionally, we will identify common methods students might use to solve the task and suggest a sequence of presentation for the follow-up whole class discussion. Our lesson resources will suggest connections that can be made between methods and representations and ways to highlight the relevant mathematics. We will also identify appropriate follow-up practice and free technology apps (e.g. www.desmos.com and GeoGebra) that can foster students’ connections between algebraic, graphic and numeric representations. These free technology applications will replace the currently required graphing calculators and are arguably superior to calculators for exploration and developing connections. In this technological age, we anticipate that student’s will be able to use smartphone capabilities to access applications for spreadsheets, graphing data and functions, and various calculations. Students without a smartphone will be able to rely on campus computers. We will substitute our current WebAssign online practice with in-class work, projects, individual paper-and-pencil practice problems, and online practice websites.

- **Identify stakeholders affected by the transformation.**

Initially, the transformation has the potential to impact students taking this core class with and instructor who has adopted our materials. We will offer our resources to all instructors of MATH 1101 or similar modeling courses; instructors will gain full access to lesson plans, in-class tasks, Power Points, sample projects, tests, etc. beginning spring 2018.

- **Describe the impact of this transformation on stakeholders and course success.**

Beyond the savings in material costs generated by students, we believe that this
innovated course will impact students' view of mathematics as a discipline and their own affinity for it. We also believe that we will see increased student success, particularly among student groups who have traditionally struggled with mathematics. These groups include non-traditional students, first-generation students, and those who have been enrolled in remedial or support courses.

- Describe the transformative impact on the course, program, department, institutions, access institution, and/or multiple courses.

We consider this project an ongoing effort to transform the mathematics modeling course. ALG funds will allow for an intensive initial effort in restructuring the course; however, we intend to continue making modifications and adjustments as a result of program assessments. As we compile evidence supporting the positive impact of our resources and methods, we expect more and more faculty across UNG’s five campuses to adopt them. Our department has launched an open discussion about OERs and their role in teaching and learning. This project will serve as evidence of their effects. We anticipate this course restructure will have a positive impact on students who might otherwise have struggled to meet institutional quantitative requirements.

We will also share our results and materials at state conferences such as the USG Teaching and Learning Conference hosted in Athens, GA or national conferences such as the Research Council on Learning Mathematics. Exposure through these modes of professional development creates a possibility for impacting mathematics modeling courses within and outside the state of Georgia.
1.3 TRANSFORMATION ACTION PLAN

The ALG team consists of Patty Wagner and Marnie Phipps. We each earned a doctorate in the field of mathematics education and train future secondary mathematics teachers at our institution. Our pedagogical choices are informed by the literature about how students learn mathematics and how to ensure mathematical opportunity for ALL students. Our interest in this project stems partly from the findings of our recent analysis of mathematics modeling textbooks used in the state of Georgia (Phipps & Wagner, 2017). Noting that these textbooks largely lack characteristics of NCTM’s (2014) effective teaching and learning practices, we brainstormed ways in which the course could be restructured to capitalize on these practices. We noted that excellent resources are already publicly available but need to be identified, modified for the MATH 1101 course, and supplemented with pedagogical decisions. To that affect, our action plan follows.

We will identify our resources and create initial instructional plans prior to the fall 2017 semester. We will begin with our department's syllabus for the course as written, but will propose changes as needed. We will refer to our department head, John Cruthirds, and the USG Academic Committee’s (2014) Math 1101 Intro to Math Modeling Outline to ensure any proposed changes meet departmental approval and USG guidelines. Following NCTM’s (2014) practices of effective teaching and learning, we will establish unit goals and objectives, with an eye towards what mathematics is to be learned, why is it important, how it relates to prior mathematical learning, and to what mathematical ideas we are heading. We will then create or search publicly available resources for tasks that “promote reasoning and problem solving” (NCTM, 2014, p. 17) and that will serve to meet the unit objectives. As mentioned early in this proposal, course materials under consideration may originate from Mathematics Assessment Resource Service (2007) or Meyer (n.d.) for classroom engagement activities and Arnolds et al. (2007) as practice problems for students.

We are seeking materials which contain wide entry levels and which allow for individual expression and representation. Students will start with their personal prior knowledge base and expand mathematical learning through scaffolding questions. Scaffolding questions are typically open-ended and designed to help a student focus on the relevant mathematics without taking over the student’s thinking (NCTM). We will then describe how a follow up presentation can connect the various solution strategies in ways that move students toward a conceptual understanding of the relevant mathematics. By connecting strategies and representations to their own experiences, students can develop an understanding from which they can build procedural fluency (NCTM). Our description of the follow-up whole class discussion will include suggestions for sequencing of strategy presentations, open-ended questions to elicit connections between strategies or representations, and ideas for ensuring that the relevant mathematical ideas are emphasized. Finally, we will identify practice problems to help build procedural fluency, projects that make use of the mathematical ideas, and/or links to online student resources.
In fall 2017, as instructors of record, we will each implement the designed course in a single section of MATH 1101. After each instructional session, we will reflect separately on its effectiveness and note changes that should be made. We will meet with each other weekly to compare our qualitative assessments of each task and make appropriate adjustments or modifications. In spring 2018, we will designate a control section of MATH 1101 that will retain the original departmental design. Phipps and Wagner will each teach a transformed version of MATH 1101 using our developed resources. We will conduct our formal assessment of the project during this semester.

The resources we develop will be compiled as lesson plans, tasks, instructional PowerPoint presentations, links to student practice and resources, etc. for each unit in the mathematics modeling course. As such, they will represent a more complete resource for instructors than the typical textbook. We will organize these resources to maximize ease of use by instructors and make them available electronically to all UNG instructors through the institution's shared U drive in fall of 2017. Additionally, we will make the resources publicly available to the University of North Georgia's Nighthawks Open Institutional Repository beginning spring of 2018. At the completion of the project the resources will also be available through the Georgia Knowledge Repository and the GALILEO Open Learning Materials repository. In the following academic year, introductory webinar’s will be offered each semester to instructors using these materials.
1.4 QUANTITATIVE AND QUALITATIVE MEASURES

Goal 1 is to design a course and course materials that align with NCTM’s (2014) effective teaching and learning practices.

Phipps and Wagner (2017) have established qualitative criteria to determine the extent to which curriculum materials meet NCTM’s guidelines. Using this tool we will measure materials created and designed for Math 1101. This will occur before materials are released for public use the start of the semester in January 2018.

Goal 2 is for students in mathematics modeling courses to show progress in productive dispositions.

We will create or find an appropriate Likert-scale online survey with questions about views of math, self-efficacy, and dispositions. Surveys will be administered both pre- and post-semester. Additionally, we will conduct short interviews with two focus groups of up to 4 students on their experiences with mathematics and the course. Surveys and focus group interviews will occur fall and spring semesters.

Goal 3 is to have students demonstrate content knowledge growth.

We will administer pre- and post-tests to measure student growth for specific course objectives to all students in the experimental Math 1101 course and conduct a matched pairs analysis to measure student growth. The pre-test will also be administered to the students in the control course to test for significant differences in incoming ability levels. We will attempt to measure at-risk subgroups within our population; however, small sample sizes may limit the number and kinds of subgroups analyzed. Possible subgroups may include non-traditional students, first-generation students, and those who have been enrolled in remedial or support courses. Content testing will occur in both fall and spring semesters.

Goal 4 is to reduce the financial burden to students by using publicly available resources.

In the past two academic years, 628 students have taken this course on the Dahlonega campus, spending a total of $121,832–$166,420 for course materials. Enrollment numbers indicate that approximately 300 students complete this course each year on the Dahlonega campus, spending $58,200 - $79,500 annually. This cost would be completely eliminated.
1.5 TIMELINE

June 5, 2017: Kickoff meeting attended by Marnie Phipps and Patty Wagner.

August 21, 2017: Draft of unit resources completed.

August 21, 2017 – December 15, 2017: Wagner and Phipps each implement developed resources in MATH 1101 course. Informal reflections and assessment of tasks and course materials are noted. Weekly meetings are held to address concerns and make adjustments to the resources. Content and disposition assessments and focus interviews that align to goals 2 and 3 are given. Modifications to measurements are made before implementation in spring semester.

January 7, 2018: Final adjustments to unit resources completed. Control section of MATH 1101 identified. IRB approval for project assessment obtained. Qualitative assessment of Goal 1 administered.

January 8, 2018 – May 4, 2018: Implementation of resources in at least two sections of MATH 1101.

Early January: Project status report submitted to ALG.

January 2018: Pretests administered to experimental and control MATH 1101 sections. The pretests will evaluate content knowledge and mathematical dispositions. Participants for qualitative assessment identified.

Early May 2018: Content and disposition post-assessments administered and analyzed.

Mid-May: Analysis of both qualitative and quantitative measures (dispositions & content knowledge via final exam) completed.

End of May 2018: Final project report submitted to ALG. At the request of the departmental curriculum committee, the final report will be shared with them and our department head.

August of 2018 and beyond: Share the results of project measures to all UNG mathematics faculty via departmental colloquium and disseminate results at conferences. Update and revise the material over the next 3 years as needed.
1.6 BUDGET

Dr. Patty Wagner – Compensation for preparation time -- $5,000

Dr. Marnie Phipps – Compensation for preparation time -- $5,000

Travel – Kick-off meeting and conference travel -- $800
1.7 SUSTAINABILITY PLAN

Sustainability for UNG

Faculty at UNG utilize Desire 2 Learn [D2L] as an on-line web interface for courses. In the spring of 2018, when the materials become publicly available, we will set up a basic outline of the course in D2L. Currently these are referred to as sandbox courses because any instructor within UNG can copy all components of the course and tailor the materials to suit their students.

Sustainability outside of UNG

We will work with the Nighthawks Open Institutional Repository at UNG to post and upload all the developed resources and materials. Additionally, we will make these resources available through the Georgia Knowledge Repository and the GALILEO Open Learning Materials repository. We will hold two webinars at the beginning of the fall in 2018 and spring of 2019 to orient instructors to these materials. Once per year, we will update and revise the materials as needed for the next 3 years.
1.8 REFERENCES & ATTACHMENTS


Syllabus
Students are responsible for abiding by the entire syllabus found here. All UNG’s university wide policies and procedures apply to this course.

Instructor:
Office Location:
Office Hours:
Contact Information:

Important Dates:

Course changes and late registration: All changes must occur by ____________. Students who register late are responsible for missed information and course material.

Mid-Semester Withdrawal deadline: ________. Dropping a course after this date means an automatic "WF" unless the Dean gives specific approval. Prior to this date, a "W" will be awarded.

Final Exam: ________________ (or as determined by UNG)

Required Textbooks and Other Materials:

This class does not require the purchase a textbook but rather will use a variety of FREE online textbooks. Course topics can be supplemented, and homework will be assigned from resources such as those below (more may be added throughout the semester):


OpenStax College Algebra, College Algebra. OpenStax CNX. Jun 28, 2017 Available at OpenStax College Algebra (http://cnx.org/content/9b08c294-057f-4201-9f48-5d6ad992740d@5.30.)

Other Materials

1. Computer, Tablet, or Smart Phone
Each day you are required to bring and utilize a computer, tablet or smart phone. Although not required, you are strongly encouraged to bring a computer or tablet each day. The following software and apps are FREE and required.

✓ Poll Everywhere. (https://www.pollev.com/ or search Poll Everywhere in app store)

✓ GeoGebra Graphing Calculator (https://www.geogebra.org/ or search GeoGebra in app store)

2. Student Notes
Student notes are available on D2L. You are required to print them each week and bring them to class with you.

3. Other calculators: inexpensive calculators or graphing calculators are welcome but not necessary.

4. Web-based Resources:

<table>
<thead>
<tr>
<th>Website Title</th>
<th>Website Address</th>
</tr>
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<tbody>
<tr>
<td>Purple Math</td>
<td>(<a href="http://www.purplemath.com/modules/index.htm">http://www.purplemath.com/modules/index.htm</a>)</td>
</tr>
<tr>
<td>Math is Power 4u</td>
<td>(<a href="http://www.mathispower4u.com/">http://www.mathispower4u.com/</a>)</td>
</tr>
<tr>
<td>Math is Fun</td>
<td>(<a href="https://www.mathsisfun.com/">https://www.mathsisfun.com/</a>)</td>
</tr>
<tr>
<td>Khan Academy</td>
<td>(<a href="https://www.khanacademy.org/">https://www.khanacademy.org/</a>)</td>
</tr>
<tr>
<td>Careers in Mathematics</td>
<td>(<a href="http://www.ams.org/early-careers/">http://www.ams.org/early-careers/</a>)</td>
</tr>
<tr>
<td>UNG Learning Support Resources</td>
<td>(<a href="http://ung.edu/learning-support/academic-resources.php">http://ung.edu/learning-support/academic-resources.php</a>)</td>
</tr>
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Course Description: This course is an introduction to mathematical modeling using graphical, numerical, symbolic, and verbal techniques to describe and explore real world data and phenomena. Emphasis is on the use of elementary functions to investigate and analyze applied problems and questions, supported by the use of appropriate technology, and on effective communication of quantitative concepts and results.

Credit: 3 hours.

Prerequisite: Regular placement or successful completion of MATH 0099 or MATH 0989.

Co-requisite: MATH 0998 is required if Math 0989 is successfully completed; otherwise, the Math Placement Index is used to determine if MATH 0998 is required.

Course Objectives: Throughout this course, students will develop their abilities to:

1. Use mathematics as a tool to solve real world problems.
2. Communicate and collaborate effectively with peers, including engaging in reasoning and justifying arguments.
3. Use technology to enhance problem solving capabilities and aid in communication of ideas.
4. Develop procedural processes from conceptual understanding.
5. View mathematics as useful and themselves as mathematically capable.
Specific content goals will be provided on a weekly basis on D2L. See documents labeled Mathematical Goals to Focus Learning.

**Linear Functions (3 weeks)**
**Quadratic Functions (4 weeks)**
**Exponential Functions (4 weeks)**
**Logarithm Functions (4 weeks)**

**Methods of Instruction:** This course is designed within an active learner philosophy. This means that you are required to participate fully in all mathematical tasks. These tasks will require exploration, problem-solving, and critical thinking, followed by whole-class or small group discussion. You should assess and monitor your own problem-solving processes to determine when an error has been made or a new strategy should be used. This course contains very little lecture by design. You will be responsible for completing four assessments that reflect a variety of collaborative projects and traditional paper and pencil tests.

**Evaluation Methods:**

<table>
<thead>
<tr>
<th>Assessment Type</th>
<th>Points Possible</th>
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</thead>
<tbody>
<tr>
<td>4 Assessments</td>
<td>400 points possible</td>
</tr>
<tr>
<td>Poll Everywhere Quizzes (at least 10 quizzes worth 6 points each)</td>
<td>60 points possible</td>
</tr>
<tr>
<td>Final Exam</td>
<td>150 points possible</td>
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</tbody>
</table>

Students can earn up to 610 points. Students who earn between 610-540 points will be credited an A; 539-480 points will be credited a B; 479-420 will be credited a C; 419-360 points will be credited a D; anything below 360 is unacceptable and will receive an F. Students may withdraw before the UNG designated date with a grade of W, regardless of test scores. Any student who withdraws after mid-term will be assigned a grade of WF (as described in the UNG bulletin).

**General Expectations:**

Attendance is expected; **this course complies with the UNG’s attendance policy.** This means that you cannot miss more than 10% designated class time. Attendance will be monitored via quizzes and sign-up sheets.

In-class quizzes may not be made up, regardless of the reason for absence; however, a maximum of 66 quiz points will be possible throughout the semester. Only 60 points are needed for full credit on quizzes.

Unit assessments may not be made up, regardless of the reason for absence. However, with advanced approval or proper documentation excusing the absence, the final exam grade equivalent can replace the zero grade on the missing unit assessment. **It is the student’s responsibility to obtain information about any missed class work, notes, and/or assignments.** Ignorance of announcements made in class or course material is not an acceptable excuse for failure to meet course requirements. Please befriend your classmates to keep up with the material in this course.

This class requires extensive use of technology; however, please be respectful of your classmates and complete text messages and phone calls outside of the classroom.
This course is supported by an Affordable Learning Georgia Textbook Transformation Grant (ALGTT). Although the grant has multiple goals, two are of upmost importance to you as the student. First, the principal investigators designed this course and its materials to align with NCTM’s (2014) effective teaching and learning practices. Therefore, the classroom culture and instructional style may differ from what is familiar to you. Second, the principal investigators wanted to reduce the financial burden to students by using publicly available resources. This means that you will use a variety of free resources to aid your learning. The goal of the grant is to provide high-quality materials to you at no cost.

A large component of this class includes on-line homework. You should expect to complete approximately 25 problems each week. You are encouraged to work with your peers on homework and class assignments and to seek help if you do not understand the material. Final exam questions will come directly from this homework. The mathematical tutorial center is in Newton Oakes room #211. The open hours are posted outside the door.

**SPECIFIC DETAILS OF THIS SYLLABUS MAY BE SUBJECT TO CHANGE**

Students are expected to refer to the Supplemental Syllabus for the following information:

(http://ung.edu/academic-affairs/policies-and-guidelines/supplemental-syllabus.php)

**Supplemental Syllabus**

1. Academic Exchange
2. Academic Integrity Policy
3. Academic Success Plan Program
4. Class Evaluations
5. Course Grades and Withdrawal Process
6. Disability Services
7. Disruptive Behavior Policy
8. Campus Carry
9. Inclement Weather
10. UNG Alert
Final Report
Affordable Learning Georgia Textbook Transformation Grants
Final Report

General Information
Date: 5/9/2018
Grant Round: 9
Grant Number: 312
Institution Name(s): University of North Georgia
Project Lead: Patty Wagner
Team Members: Patty Wagner, Assistant Professor, Mathematics, patty.wagner@ung.edu and Marnie Phipps, Associate Professor, Mathematics, marnie.phipps@ung.edu
Course Name(s) and Course Numbers: Mathematics Modeling MATH 1101
Semester Project Began: Summer 2017
Final Semester of Implementation: Spring 2018
Total Number of Students Affected During Project: 85

1. Narrative

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

   • Summary of your transformation experience, including challenges and accomplishments

   The goals for this project were four-fold.

   a. As stated in the project proposal, we desired to design a course and course materials that align with National Council of Teachers of Mathematics’ (NCTM) (2014) effective teaching and learning practices. These practices were developed through research in an effort to ensure mathematical success for all students.

   Our team successfully designed, piloted and implemented these new materials for two semesters. We were successful at using the above practices during the design phase. For example, each unit and lesson has clearly outlined goals to focus learning. Our lesson plans are in-depth and include purposeful questions to assist students in their struggle to learn mathematics. The majority of our problems are presented in real-world context, which allows students opportunities to connect representations and use sense making skills.
b. Second, as stated in the project proposal, our goal was for students in mathematics modeling courses to show progress in productive dispositions (National Research Council, 2001). Specifically, students would find mathematical success attainable, recognize the value in perseverance and productive struggle, perceive mathematics as a discipline involving reasoning and sense making, and view mathematics as a relevant tool for problem solving.

There was some evidence students moved toward productive dispositions. For example, during the student interviews one student seemed appreciative for receiving information about tools and resources in math that a person might actually need. Another student questioned why all math class don’t have this same real-world structure.

c. As stated in the project proposal, the third goal was to have students demonstrate content knowledge growth of the essential components of this course as designated by the University System of Georgia [USG] syllabus for mathematics modeling. Students’ growth was demonstrated both conceptually and procedurally in contexts designed to make sense of worldly phenomena.

Pre- and post-assessment results validate substantial content knowledge growth of the essential components. Furthermore, control and treatment sections were significantly different. The data provides evidence that our methods are notable.

d. Lastly, as stated in the project proposal, we wanted to reduce the financial burden to the students in Math 1101.

Our team was successful and our students had no additional cost beyond tuition. All materials selected were 100% free thanks to the creative common licensing. Students were able to use their personal technologies such as laptops, tablets and smartphones and the free application, GeoGeobra.

• **Transformative impacts on your instruction**

Typically, instructors simply select chapters or sections in a given textbook and then teach context within as presented in the textbook. Textbooks drive instruction and presentation style. In contrast, this grant allowed us to abandon these traditions. Tasks were intentionally selected from the USG syllabus for mathematics modeling and presented in an order which connected them to each other and real-world applications. Collaboration on tasks and assignments afforded us freedom of topic and it allowed us to match appropriate tasks to our students’ prerequisite skills level. After two semesters of implementation we were able to identify scaffolding questions as well as common approaches. This knowledge allowed us to efficiently sequence presentations for whole-class discussions and highlight connections to relevant mathematics.
• **Transformative impacts on your students and their performance.**

The financial impact on students is important. Students were typically spending $194-$265 per person for a textbook, on-line homework, and a calculator. In our ALG-supported courses the price was zero. Additionally, students in our classes performed as well as or better than students in other sections of the same course and our course had a lower withdraw/fail rate.

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

One challenge of our project was meeting the publication timeline. Initially we desired to publish our materials on the Galileo Repository in January after one pilot semester in the fall. Upon reflection, we agreed the quality of materials would increase and a finished product would be more polished if a second semester of implementation occurred. We opted to postpone publication until both semesters of enactment were completed.

Another challenge of the project was learning ADA criteria. Our documents were not originally designed with ADA criteria in mind. This learning experience has taught us that accessibility can change the way in which materials are required to appear. For the future, we would consider ADA compliance as materials are created.

2. **Quotes**

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

  - Student: “I probably would never look at a math book anyway. So I would prefer not to have one, just purely for financial reasons.” (Focus Group Interviews with Phipps)

  - Student: “I would much rather not have a textbook. Textbooks are expensive… If you make what I make, that’s like half a week’s pay; half a week’s work, for a book.” (Focus Group Interviews with Phipps)

  - Student: “I personally loved how structured everything was. It was just great because you go on D2L and everything is right there: the student notes, the homework, it was just all there.” (Focus Group Interviews with Wagner)
3. Quantitative and Qualitative Measures

3a. Uniform Measurements Questions

The following are uniform questions asked to all grant teams. Please answer these to the best of your knowledge.

Student Opinion of Materials

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

Total number of students affected in this project: 85

- Positive: 80% of 25 number of respondents
- Neutral: 12% of 25 number of respondents
- Negative: 8% of 25 number of respondents

Note: 25 respondents gave IRB permission for data use.

Student Learning Outcomes and Grades

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

Student outcomes should be described in detail in Section 3b.

Choose One:

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

Student Drop/Fail/Withdraw (DFW) Rates

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

Drop/Fail/Withdraw Rate:
Depending on what you and your institution can measure, this may also be known as a drop/failure rate or a withdraw/failure rate.

9.3% of students, out of a total 43 students affected, dropped/failed/withdrew from the course in the final semester of implementation.

Choose One:
3b. Measures Narrative

Goal 1 of our proposal was to design a course and course materials that align with NCTM’s (2014) effective teaching and learning practices. We applied the qualitative criteria we developed in a previous study (Phipps & Wagner, 2017), to our own materials to measure the extent to which they met NCTM’s guidelines. Given that our previous analysis had focused on textbooks’ treatment of linear functions, we chose a week of our materials at random from that unit. To reduce bias, Wagner conducted the qualitative study of the materials that Phipps had mainly created. The analysis supported our alignment with the eight elements of NCTM’s effective teaching and learning. One element, *Elicit and Use Evidence of Student Thinking*, is still in progress as we continue to identify student misconceptions and deficiencies.

Goal 2 of our proposal was for students in mathematics modeling courses to show progress in productive dispositions. We administered a pre- and post-semester Likert-scale survey to capture students’ views of mathematics, self-efficacy, and dispositions. We also conducted interviews with two focus groups in our final implementation semester. Statistical analyses of the surveys revealed no significant difference in overall dispositions of students from beginning to end of the semester. In fact, student optimism was greater at the beginning of the semester than at the end as evidenced by more agreement with the statements: *My success in this class is not related to hard work and effort and I think that it is important to complete all homework and assignments for this class*, and less agreement with the statement: *I frequently check my answers to see if they are reasonable*. We are intrigued by the seemingly contradictory implications of changes in beliefs about the necessity of homework and whether effort translates to success. It is unclear whether this is an anomaly or whether students do not consider the completion of homework as falling under the realm of effort.

Our third goal was that students demonstrate content knowledge growth. To measure our materials specifically, we recruited a Math 1101 section to serve as a control against our two sections of experimental course. The control course had 12 students who agreed to participate in the study while the experimental courses yielded 26 total participants. We administered pre- and post-assessments to all participants. Statistical analysis of the pre-assessment revealed significantly greater incoming knowledge among students in the control group (α = 0.05). Despite this, students in the experimental group performed significantly better on the post-assessment (Figure 1). A 95% confidence interval suggests that students using our materials will increase their performance by 30 to 50 percentage points from beginning to end of the semester.
The pre- and post-assessment measured objectives of the course through 12 items. Students in the experimental group scored significantly higher on 10 of the 12 items (Figure 2). Given the small numbers of participants, these results must be considered preliminary; however, the evidence is strong that use of our developed materials is at least as effective as the materials currently in place for Math 1101 at our institution.

Figure 1. Percent of students scoring correctly per post-assessment question.

Figure 2. Number of questions scored correctly per student on pre- and post-assessments.
Goal 4 was to reduce the financial burden to students by using publicly available resources. We were able to successfully implement our Math 1101 course over two semesters using no-cost materials and technology. Students were largely satisfied with this no-cost option. Over the two semesters, 85 students saved $194–$265 each in materials, a total savings of $16,490–$22,525 to students. Importantly, the evidence is that these students met course objectives as well or better than they would have with costly materials.

An important consideration for Math 1101 is course completion rates. In the 2017-2018 academic year, the withdraw/fail rate for Math 1101 averaged 18%. In the final semester of our project implementation, the experimental group withdraw/fail rate was just 9.3% compared to the non-experimental sections’ 22% rate. Grade point averages in the separate sections were similar, with a 2.6 average in the experimental group compared to a 2.7 average in non-experimental sections. It is possible that the lower withdraw/fail rate of the experimental group is due to our attempts to make the content more engaging and relevant.

4. Sustainability Plan
Beginning fall semester, we will present our materials and the results of our analyses to fellow instructors of Math 1101 through our departmental colloquium. Our goal will be to convince instructors that they can adopt our materials without the heavy lifting that usually accompanies such change, given that our materials are pedagogically focused. At least one of our team will teach Math 1101 each semester for the foreseeable future so that we can be an engaged resource to faculty who adopt our materials.

As we teach this course using our materials, we will continue our reflections and updates. These updates will be uploaded to the repositories hosting our materials at least annually. Some of these updates may be minor, such as new insights into student strategies, updated pedagogical questions, or new tasks. Others may be more significant. For example, we have observed that some of the open access resources we use for homework employ mathematical notations or conventions different from our own and often assume graphing calculator technology. We would like to adapt and compile these resources to a more fitting single-access resource for our students. This would be a long-term endeavor that could be made available for individual units as we complete them.

5. Future Plans
- Describe any impacts or influences this project has had on your thinking about or selection of learning materials in this and other courses that you will teach in the future.

This project reinforced research-based practices as suggested by the National Council of Teachers of Mathematics’ [NCTM] (2014) effective teaching and learning practices. To appeal to different learning styles, skill levels, and cultural backgrounds, we need approaches such as the one developed in this mathematics modeling course.
OER’s have the potential to make a positive impact on students’ financial obligations without sacrificing quality. We would consider using OER’s in the future for other courses.

*Describe any planned or actual papers, presentations, publications, or other professional activities that you expect to produce that reflect your work on this project.*

We plan to produce at least one manuscript and several presentations describing this project and the results. One of the presentations will be to share our results with others at UNG and in the USG system. Definitive plans regarding papers and presentations are currently scheduled for the fall of 2018.

6. Description of Photograph

*On the Final Report Submission page, you will be submitting a photo. In this document, list the names of the people shown in this separately uploaded photograph, along with their roles.*

Pictured left is Marnie Phipps and right is Patty Wagner. We worked on this project collaboratively; we both authored materials, served as instructors each semester, and co-authored reports.