Name: Michael Schrlau and Robert Stevens

Email: mgsme@rit.edu, rjseme@rit.edu Phone: Schrlau (585) 475-2139

Department/College: Mechanical Engineering / KGCOE

Department head name and e-mail: Edward Hensel, echeme@rit.edu

Faculty rank: (full-time lecturer, tenured, and tenure-track faculty only): Schrlau (T-T), Stevens (Tenured)

Proposed project name: Inverting Mechanical Engineering Heat Transfer using Pencasts

Total funds requested: (Focus grants of $1,000-$5,000 will be considered): $5,000

Include these statements under the appropriate heading beginning on page 4.

Statement of utility: (two pages maximum)
1. Provide an overview of the project you are proposing, including:
   • Project objectives
   • An explanation of the teaching/learning problem(s) it is designed to address
   • An explanation of the significance of the project to student outcomes and/or the student experience.
2. Provide a brief description of how the project integrates with activity already underway at RIT in the priority area and/or how this approach has been successfully used at RIT already.

Statement of creativity: (three paragraphs maximum)
Provide a brief description of how this is a novel approach, or a new application of an existing mode or model of teaching and learning, or represents an entirely new paradigm. (Please note that special consideration will be given to proposals that demonstrate a new use/application of a model, system, or technology already in use at RIT.)

Statement of efficacy: (two pages maximum)
Provide a brief description of the experiment/research design, methodology, and methods of data collection you will use to gauge efficacy.
## FOCUS GRANT APPLICATION FORM 2013: FLIPPED CLASSROOM

### Budget:

<table>
<thead>
<tr>
<th>Budget item</th>
<th>Amount requested</th>
<th>Amount committed from other sources</th>
<th>Brief statement of explanation/justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel (including course release, consulting support, etc.)</td>
<td>$5,000</td>
<td>$8,000</td>
<td>$5,000 for 2013 investigator summer salary to develop Pencasts and in-class activities. ($2,500, ~40hrs of effort each) $8,000 for 2 teaching assistants in the Fall semester ($4,000 each) to assist in in-class activities and assessment. Committed by Dr. Ed Hensel, ME Dept Head, KGCOE via in-person meeting on 2/22/2013.</td>
</tr>
<tr>
<td>Equipment</td>
<td>$500</td>
<td>$500</td>
<td>$500 for 2 Livescribe Echo pens, paper, and software to create Pencasts. Committed by Dr. Ed Hensel, ME Dept Head, KGCOE via in-person meeting on 2/22/2013.</td>
</tr>
<tr>
<td>Licenses (i.e., software)</td>
<td></td>
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<tr>
<td>Travel</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Other Resources (specify)</td>
<td>20 hrs of captioning for Pencasts</td>
<td>Committed by Rob Klingenerberger, Video and AT Specialist, Innovative Learning Institute via email on 2/25/2013.</td>
<td></td>
</tr>
<tr>
<td>Other Resources (specify)</td>
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<td>Other Resources (specify)</td>
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<tr>
<td><strong>Total</strong></td>
<td>$5,000</td>
<td>$8,500 + 20hrs of captioning</td>
<td></td>
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</tbody>
</table>

### Proposed timeline:

<table>
<thead>
<tr>
<th>Task</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project plan complete</td>
<td>June 1, 2013</td>
</tr>
<tr>
<td>Preliminary findings complete</td>
<td>September 1, 2013</td>
</tr>
<tr>
<td>Summary of final findings complete</td>
<td>January 15, 2014</td>
</tr>
<tr>
<td>Final budget accounting complete</td>
<td>October 1, 2013</td>
</tr>
<tr>
<td>Course, activity, or tool (re)design complete (design and development support may be provided by the ILI Teaching &amp; Learning Studio)</td>
<td>August 1, 2014* *Model of entire inverted course</td>
</tr>
<tr>
<td>Faculty Teaching &amp; Learning Commons entry complete (development facilitated by the ILI Teaching &amp; Learning Studio)</td>
<td>January 15, 2014</td>
</tr>
<tr>
<td>Participation in faculty panel event complete (event to be planned and facilitated by the ILI Teaching &amp; Learning Studio)</td>
<td>January 15, 2014</td>
</tr>
</tbody>
</table>

Please note that the timeframe for milestone completion must align with the PLIG timeline.
Dissemination agreement:
By completing this grant application, I agree to provide the materials described here, in support of disseminating what is learned from this project to other faculty at RIT.

I also agree to return all/a portion of the funds that I receive for this project to RIT if I fail to complete or provide the materials described here.

- Project plan (including roles and responsibilities, milestone dates, and pertinent project details)
- Overview of preliminary findings (may include experiment/study design, lessons learned, initial data collection, and/or literature review summary)
- Final project summary (including data collection, lessons learned, implications for further study, and which may be in the form of an article abstract, conference presentation outline, or short report)
- Course, activity, or tool (re)design (Materials that will allow other faculty to adopt the mode of model of teaching and learning effectively and efficiently. Design and development to be supported by the ILI Teaching & Learning Studio)
- Faculty Teaching & Learning Commons entry (excerpts from research findings summary, the development of which is facilitated by the ILI Teaching & Learning Studio)
- Participation in faculty panel event (presentation of a brief summary of project and lessons learned and response to faculty questions. Event is planned and facilitated by the ILI Teaching & Learning Studio)
- Final budget accounting (reconciliation of budget provided with your application and the actual project expenses)

By submitting this application through my RIT email account, I accept this agreement.
Statement of utility: (two pages maximum)

PROJECT OVERVIEW

Heat Transfer, a core engineering course for 3rd and 4th year Mechanical Engineering undergraduate students, utilizes fundamental engineering principles to analyze and design complex thermal systems. The course builds upon previous core engineering courses, mainly Thermodynamics and Fluid Mechanics, to develop and practice the critical thinking skills and foundational understanding needed to analyze, design, and solve real world challenges. The current Heat Transfer course utilizes classroom time to balance the delivery of technical content and provide faculty-student and student-student interactive problem-solving activities. From course evaluations, students highly value the interactive problem-solving component of the course, ranking these activities among the most important to their learning. When asked how to improve the course, students often ask for more problem solving to be done in the classroom with the instructor and with their peers. The proponents agree more interactive activities would significantly enhance the education of the students but currently struggle to do so because of the limited time in the classroom.

To address these issues and enhance educational effectiveness, this project will take the initial steps toward inverting the Heat Transfer course in the 2013-2014 academic year. The inversion will be accomplished using Pencasts, interactive PDF files containing audio synchronized to hand-written notes, to convert traditional course lecture notes into captioned audio, visual, and written online content. Students will be required to review the Pencasts before class time and class time will be dedicated to interactive problem-solving activities and summative assessment. The inverted Heat Transfer course will accommodate faculty-student and student-student interaction in the classroom, provide consistent multi-media content to all students, and serve as a model to invert other on-campus and on-line core engineering courses.

PROJECT OBJECTIVES

The goal of the project is to enhance student performance, learning, and technical proficiency by inverting the course, Heat Transfer, a core engineering course for 3rd and 4th year Mechanical Engineering undergraduate students. The overall goal will be accomplished in 4 stages: In Stage 1 (Preparation, Summer 2013), modular Pencasts and in-class activities will be created for 35% of the Heat Transfer content. In Stage 2 (Pilot Phase I, Fall 2013), a 35% inverted classroom will be piloted. Modular Pencasts and in-class activities will be created for 70% of Heat Transfer. In Stage 3 (Pilot Phase II, Spring 2014), a 70% inverted classroom will be piloted. In Stage 4 (Implementation, Summer 2014+), the entire Heat Transfer course will be inverted for the next academic year.

The main objective of this project is to create and evaluate an inverted Heat Transfer course in the 2013-2014 academic year by piloting 35% of the course as an inverted classroom in the Fall semester (Aug 2013 – Dec 2013). To this end, the project focuses on completing Stages 1 and 2 over the upcoming Summer and Fall terms. Although outside the scope of this project, the intent is to pilot 70% of the course in the Spring semester (Jan 2014 – May 2014) and invert the entire course for the 2014-2015 academic year.

ADDRESSING TEACHING/LEARNING PROBLEMS

Accommodate more in-classroom time for interaction: Students value the interactive problem-solving component of the course, ranking these activities among the most important to their learning. When asked how to improve the course, students often ask for more examples and problem solving to be done in the classroom with the instructor and with their peers. The proponents agree this could significantly enhance the education of the students but currently struggle to do so because of the limited time in the classroom. An inverted classroom would allow for more interaction during class and
allow for more frequent assessment and coaching.

**Provide consistent multi-media content to all students anytime, anywhere:** Using Pencasts to invert the classroom significantly enhances student learning and the educational experience. Pencasts provide consistent multi-media (written, audio, captioned, visual) course content to all students to support different learning styles and abilities. Pencasts provide students with substantive electronic course material that can be downloaded from myCourses and reviewed at their convenience and as many times as needed to master the material. Furthermore, students are able to save the electronic content and refer to it throughout their education and beyond.

**Contain and reduce the cost of higher education:** The inverted classroom and the use of Pencasts will help contain and reduce the cost of higher education across the department, college, and institute. The Pencasts developed to invert the classroom require a small investment to generate multi-media electronic content (approx. $250 from Livescribe). Pencasts can be reused meaning faculty will spend less time preparing to deliver content in class and dedicating more time to student success and retention. With simple, low-cost pre-class content delivery and effective interactive in-class activities, faculty can teach more students, more efficiently. Moreover, the development of such material and teaching strategy would support future online course offerings.

**SIGNIFICANCE TO STUDENTS**

In addition to the student benefits gained by addressing the above problems, the project is significant to students for the following reasons:

**Higher return-on-investment for students:** Students will get more for their educational investment with an inverted classroom because it will provide more interaction and engagement with RIT faculty, allowing them to benefit from their expertise and coaching. Additionally, Pencasts provide students with substantive multi-media electronic course material that can be reviewed at their convenience during the course and be used for future reference.

**Affordable and accessible higher education through technology:** Pencasts have a very high return-on-investment as a means to create multi-media electronic content to support on-campus and on-line learning. First, the financial and time investments needed to create Pencasts are low (approx. $250 for the technology and 4 hrs to produce a polished 1 hr Pencast). Second, the produced Pencasts can be reused semester after semester by any instructor and easily edited and appended, allowing faculty to serve more students, more efficiently. Lastly, Pencasts can be used directly or as supplements for online courses to better serve on-campus or remote students.

**PROJECT INTEGRATION**

The project fits well with several Mechanical Engineering departmental activities already underway: (1) ME piloted an inverted freshmen course this academic year (Engineering Mechanics Lab, MECE 102). The class served over 200 students and the interactive components were ranked most important to learning; (2) ME is currently developing a complete online Mechatronics Certification Program (sponsored by Knorr Bremse – Bendex). The program currently serves 20 remote, national and international, multidisciplinary students with plans to triple enrollment in the next year; (3) ME provides core graduate courses simultaneously to on-campus students and, through an online format, to RIT students on co-op and RIT Dubai students. The class currently serves 80 multidisciplinary students (50 students on-campus, 4 RIT students on remote co-op, 26 RIT Dubai students); (4) ME partners with NTID to improve the education of deaf and hard of hearing engineering students by adopting Universal Design concepts. One of the investigators (Schrlau) is a co-PI on an NTID-funded seed grant to investigate how to implement case studies to engaging all students of ability.

The technology used and the content and strategies developed in this project can be directly applied to these and other planned initiatives. For instance, the modular Pencasts can supplement the Mechatronics Certification Program, while the model developed to invert a core engineering course can be utilized to invert other core courses and provide online course offerings to serve more students, whether on-campus, on co-op, from other RIT campuses, or from other institutions or companies.
Statement of creativity: (three paragraphs maximum)

Provide a brief description of how this is a novel approach, or a new application of an existing mode or model of teaching and learning, or represents an entirely new paradigm. (Please note that special consideration will be given to proposals that demonstrate a new use/application of a model, system, or technology already in use at RIT.)

The project will invert a core Mechanical Engineering course by converting existing written lecture notes (currently used to successfully deliver content in class) into multi-media electronic content (written, audio, captioned, visual) available to all students of ability before class. This will be accomplished by creating modular captioned Pencasts. In contrast to other sophisticated electronic formats that require many hours to produce electronic content (e.g., Adobe Presenter and Captivate), Pencasts require minimal financial and time investment to create electronic content to facilitate the inversion of a classroom. Moreover, Pencasts can be incorporated into these more complex electronic content formats later if needed.

Being able to quickly but effectively invert a classroom with Pencasts, instructors are able to concentrate on the more important aspects of education and start utilizing classroom time in more impactful ways. For instance, instead of spending time preparing to deliver content, instructors can develop better activities that will help students learn technical concepts and build problem-solving skills that will be more beneficial to the student. The instructor can use classroom time to relate content to real-world problems or applications, develop problem solving skills of students, and test students’ deeper understanding of fundamental concepts.

Pencasts have a very high return-on-investment as a means to create multi-media electronic content to support on-campus and on-line learning. In addition to the small investment required to generate them, the produced Pencasts can be reused semester after semester by any instructor and easily edited and appended, allowing faculty to serve more students, more efficiently. Pencasts can be used directly for or as supplements to online course offerings.
Statement of efficacy: (two pages maximum)

The goal of the project is to enhance student performance, learning, and technical proficiency by inverting the course, *Heat Transfer*, a core engineering course for 3rd and 4th year Mechanical Engineering undergraduate students. The main objective of the project is to create and evaluate an inverted *Heat Transfer* course in the 2013-2014 academic year by piloting 35% of the course as an inverted classroom in the Fall semester (Aug 2013 – Dec 2013). Although outside the scope of this project, the intent is to pilot 70% of the course in the Spring semester (Jan 2014 – May 2014) and invert the entire course for the 2014-2015 academic year. The goal of the project will be accomplished in 4 stages:

**Stage 1: Preparation (Summer 2013)**
- Create 15-30 minute long modular captioned Pencasts for 35% of *Heat Transfer* content.
- Develop faculty-student and student-student interactive classroom activities.
- Generate formative and summative assessments for the inverted classroom.

**Stage 2: Pilot Phase I (Fall 2013)**
- Pilot inverted classroom for 35% of *Heat Transfer* content.
- Conduct formative and summative assessments and compare to the traditional course.
- Develop Pencasts and in-class activities for 70% of *Heat Transfer* content.

**Stage 3: Pilot Phase II (Spring 2014) – *stage is outside the scope of this project***
- Pilot inverted classroom for 70% of *Heat Transfer* content.
- Conduct formative and summative assessments and compare to the traditional course.
- Evaluate overall effectiveness of inverted classroom.

**Stage 4: Implementation (Summer 2014 +) – *stage is outside the scope of this project***
- Develop Pencasts and in-class activities for 100% of *Heat Transfer* content.
- Prepare to invert the entire *Heat Transfer* course for the 2014-2015 academic year.

**INVERTED HEAT TRANSFER COURSE STRUCTURE**

The inverted classroom would follow a basic weekly model, where concepts are introduced in the beginning of the week and get more difficult or complex as the week progresses. The following is an example of a potential weekly model if the 3 contact-hour-per-week course was given in two, 75 minute classes each week:

**Pre-class #1 (30-60 minutes):** Students review Pencasts that introduce a new concept, covering definitions and simple application problems. After reviewing, students take an online quiz.

**Class #1 (75 minutes):** Students are given 4-5 conceptual questions and asked to first answer them individually then discuss amongst each other. Small teams of students will then be given one team problem to work out together. These activities and discussions will be interactive with and facilitated by the instructor. Problem solutions will be evaluated and feedback provided before next class, ensuring missed concepts are addressed earlier on.

**Pre-class #2 (30-60 minutes):** Students review Pencasts that build upon the new concept, adding complexity to concepts and working out examples of difficult application problems. After reviewing, students take an online quiz.

**Class #2 (75 minutes):** Students are given 2 team problems, one problem of medium difficulty and one complex problem requiring the identification and retrieval of missing information. In each, students will be asked to work individually at first and then work together to solve the problem. These activities and
discussions will be interactive with and facilitated by the instructor.

EVALUATING PROJECT EFFICACY

**Initial Assessment:** The proponents will gather statistics on overall student performance (homework, exams, etc.) in *Heat Transfer* over the last 3 years (9 total quarters). Course evaluation data will be compiled from the last 3 years to highlight deficiency areas for comparison against the inverted classroom. Specific feedback, as discussed earlier, has already been gathered by the proponents and serves as the motivation for this project. This data has been gathered by the ME Department for all core engineering courses and is readily available and accessible. The data will highlight the students’ perceived need for an inverted classroom.

An initial questionnaire will be developed and given to the students asking what has helped them learn in past courses and what would they have changed or what more they would like to see. The questionnaire is only given to gauge student expectations and perceptions.

**Formative Assessment:** As mentioned above, develop and give an initial evaluation to the students asking what has helped them learn in past courses and what would they have changed or what more they would like to see. A similar assessment will be conducted at the middle and end of the course. Since only certain portions of the course will be inverted during the next academic year, the formative assessment at the end of the course will be used to compare student experiences between inverted vs. non-inverted courses.

**Summative Assessment:** Several summative assessments will be created to evaluate efficacy of the inverted classroom. By piloting 35% portion of the course, the same student population will experience both traditional and inverted class structures, which will be helpful in contrasting the two approaches.

- **Online Quizzes:** Allows the instructor to assess the level of student review of online materials before coming to class. These short, graded, multiple choice questions are intended to encourage and enforce student review of online material before coming to class.

- **In-Class Quizzes:** Allows instructor to assess student comprehension of material covered in Pencasts and help students assess their own comprehension of material in real-time instead of waiting for mid-term exams. Quizzes will be graded, multiple choice or true/false questions, short work out problems, or short answer questions.

- **In-Class Problems:** Allows instructor to assess students’ problem solving ability and allows students to assess their level of technical proficiency. Students will be given problems to work out in-class as individuals and as a team. Problems will be randomly graded.

- **Exams:** Provides assessment of students’ overall comprehension and technical proficiency of material. Grades will be compared to grades from previous years that covered similar content.

- **Project:** Assesses the students’ mastery of the material and understanding of relevance to real-world problems and applications. The quality of projects will be compared to previous years.

PROJECT MANAGEMENT

The proponents, Schrlau and Stevens, have worked together for the past two years refining the *Heat Transfer* course curriculum and utilized Pencasts and other multi-media technology to create online content for courses; the technical risk is low. Schrlau and Stevens will equally share the development of Pencasts, in-class activities, and assessment tools. Pencasts and other multi-media content developed in this project will be captioned by the Innovative Learning Institute (courtesy of Rob Klingenberger) at no cost to this project. The project has been reviewed and approved by Dr. Edward Hensel, Department Head, Mechanical Engineering and Dr. Risa Robinson, Associate Department Head and Group Leader of six core engineering courses, including *Heat Transfer*. 