Provost’s Learning Innovations Grant for Faculty
Request for Full Proposal
2007-2008

Please hand-deliver your completed grant proposal (4 pages, plus attachments),
the original plus 12 copies, to:
Susan DeWoody, 1530 Wallace (5)
by 4:30 p.m.
No hand written proposals will be accepted.
Notification of awards will be made by Friday, April 13, 2007.

**Project Title:** *Interactive Visualization as a Means of Learning Science*

**Applicant(s):**

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<tr>
<th>Name</th>
<th>Telephone</th>
<th>Dept.</th>
<th>College</th>
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<tbody>
<tr>
<td>Paul A. Craig</td>
<td>475-6145</td>
<td>Chemistry</td>
<td>Science</td>
</tr>
<tr>
<td>Richard L. Doolittle</td>
<td>475-5972</td>
<td>Medical Sciences/Biological Sciences</td>
<td>Science</td>
</tr>
<tr>
<td>John Schull</td>
<td>738-6696</td>
<td>Information Technology</td>
<td>GCCIS</td>
</tr>
<tr>
<td>James Perkins</td>
<td>475-2443</td>
<td>Medical Illustration</td>
<td>CIAS</td>
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PLIG Adaptation and Implementation
Project Title: Learning Science Through Interactive Visualization

1. Summary of proposed project

Creation of virtual environments to help students understand principles and concepts beyond what one can normally view with the naked eye has helped to extend the classroom and laboratory experience across the sciences. Over the past 18 months, the principal investigators have worked with a variety of students from across the campus to generate scientific images and animations within a number of formats. These original graphic products have been demonstrated on the national and international scale and, without exception, audiences have reacted with great enthusiasm and interest. Our greatest hurdle has been to find a way to bring 3D, virtual reality graphics to the average user without requiring that they possess sophisticated hardware, software, or unfashionable glasses. We plan to develop tools and graphic applications to make this modern day technology accessible to students and faculty, both on individual computers and in larger classroom and auditorium settings. This cultural shift in pedagogy will prove beneficial to students and faculty with the desire and ability to take advantage of the growing power of visualization technology irrespective of their discipline.

In developing this project, user resources will be built on two levels. First, we will focus on a specific application - changing and updating our courses in Biochemistry (two distance learning classes), Human Gross Anatomy; and Anatomy and Physiology I/II; courses with a strong history of success with “immersive pedagogy”. On a broader scale, we will create a web site with tools for building visualization resources that can take full advantage of a number of emerging 3D visualization facilities on our campus. In addition to creating resources for individual desktops, we will also develop tools for creating resources for the stereo visualization lab (room 05-A400), for multiple projector immersive visualization (08-1250) and the dome housed in the Gosnell atrium using a new, multi-projector display system called “Watchout”.

2. Targeted learners or population (include cluster, departments, year level, number of learners impacted).

Students enrolled in distance learning course in Biochemistry (35 students/quarter, run 3 times per year) and in campus classes of Human Anatomy & Physiology I/II (120 students in fall/115 students in winter), Human Gross Anatomy (8-12 students in fall/winter quarter;24-48 students in spring;45 students in summer) will be direct and immediate beneficiaries. Those involved in the project as research students will also derive educational benefits and experience as part of the development “team”. To-date, this team has included students from biological science and chemistry (COS), medical illustration (CIAS), new media and information technology (GCCIS), mechanical and software engineering (KGCOE). Long-term benefits will accrue to all students and faculty who use online resources or visualization in their courses.

3. Is this for a current course or new course?

New tools for displaying 3D structures and images will be used to support current courses as described above. Additionally, the principal investigators plan to launch a new, project-based general education course (“Images in Science Discovery”) that will bring students from many different programs across the campus to create multidisciplinary, “science visualization” teams as part of a capstone experience. Anticipated outcomes from this new “course” will include a well-defined set of virtual reality, 3D graphics with an interface designed to demonstrate a specific type of scientific, biological, or pathological process. For example, each team will be assigned a particular disease process (such as a heart attack) and will create a means of understanding the sequence of events in the disease down to the molecular level based on readily available research. Teams will present their projects in an open forum at the end of the quarter.

4. Anticipated impact on teaching and/or learning.

We will produce online materials needed for Biochemistry Conformation & Dynamics, Biochemistry Metabolism, Human Anatomy & Physiology I/II, and Human Gross Anatomy. These materials will be in pdf and ppt formats suitable for use with Macromedia Breeze and freely available to students through MyCourses dedicated space. Creating opportunities for students to view graphics in 3D has been difficult, at-best, given restrictions in hardware and space suitable for display. In all of our courses, an ability to show all sides and all aspects of scientific structures from varying degrees of magnification is a tremendous advantage over static 2D alternatives. This ability to be fully interactive with a scientific image provides students the opportunity to go well beyond existing capabilities of current classrooms, laboratories, and textbooks.
5. How will your project impact student success (i.e., retention)?

As a result of the boom in gaming systems, today’s average millennium generation student is able to maneuver through virtual worlds with ease. To date we have found that students identify quickly and with enthusiasm when viewing scientific images and animations through a similar game-like virtual world. There is little doubt in our minds that students will thrive if given the option to learn by becoming immersed in an interactive, virtual world of science applications.

6. How you will measure the impact, how you will report your findings, and what you will share about your project in a faculty forum.

We will document a pipeline that will enable all RIT faculty, staff and students to incorporate virtual reality and 3D images from a variety of formats in a variety of virtual and physical facilities on our campus. Additionally, we will test and identify formats and system architectures that can be easily implemented, those that are difficult (but possible), and image formats that are not compatible with this system. We will evaluate our project by these measures:

a. Assessing student interest. We will create a survey for students using these materials to find out (a) if they could open the files, (b) if they could manipulate the embedded animations/virtual reality images in the files once they opened them, and (c) if these were helpful in the learning process.

b. Testing student learning. We will prepare practice quizzes in each course (meaning that these will not affect their grades) where three subsets of students enrolled in a course are provided with different resources prior to taking a quiz. Three levels of resources will be provided: (a) static images, (b) animations that require students to download and install additional software and (c) animations that are embedded in pdf or ppt files. A total of three such quizzes will be given in each course and the groups will be rotated such that each group is exposed to all three levels of resources. Grades on the practice quizzes will be compared between groups and between resource level. For example, students in the biochemistry course will have three quizzes: protein structure, catalytic mechanisms and regulatory mechanisms. The static images will be jpg files taken from the textbook. The second group will explore protein structures using the PyMOL molecular visualization program. The third group will explore images generated from PyMOL that have been embedded into pdf and ppt files. These three sets of resources will be developed for all three quizzes and student performance will be compared.

c. Evaluation of facility implementation. We will conduct a campus-wide survey to identify the number and type of people with interest in or knowledge of how to produce or distribute 3D or immersive images online or on-campus. During the winter 2007-2008 term, we will we will demonstrate the resources we have developed at a workshop in the stereo and immersive campus facilities. Upon entering the workshop, faculty will answer a brief survey which asks them to imagine ways they could use 3D visualization in teaching and learning. They will then complete the same survey at the end of the workshop. We will then track usage of the web site that contains the tools for building visualization resources.

7. Present a rationale for your project, as it ties to the intent of the grant, including:

a. why it is not part of regular college business

This project is focused on finding, exploiting and building computer software and hardware solutions that will enable RIT teachers and learners to take full advantage of the latest visualization technology.

Software: RIT has many smart classrooms where a presenter can use a laptop to present almost anything they can make on their computer: Powerpoint slides, images, computer animations and simulations. While the Powerpoint slides and images are portable to most computer systems, complex animations and simulations usually require specialized software programs with steep learning curves. We will implement a pipeline to take output from these specialized programs and send them to standard formats such as Adobe Acrobat or Flash, enabling all users to take advantage of them.

Hardware: RIT now has facilities for stereo visualization (room 05-A400), and for multiple projector immersive visualization (08-1250 and the dome currently housed in the Gosnell atrium). These facilities currently receive very little use in courses offered at RIT. We will create tools and present seminars that make these facilities accessible to interested faculty (first adopters) in hopes of creating momentum on campus to include a significant portion of our curriculum.
b. its relevance to required cluster, college, and/or department competencies

It could be argued that visualization is a critical aspect of education in all fields (“A picture is worth a thousand words”), but we will focus on the natural and physical sciences. Studies ranging from human anatomy to protein structure to the forces of gravitation around black holes are better understood through images, animation and simulation. This applies to both the novice, who is seeing things for the first time, and the expert, who may be able to see or imagine aspects of a problem that have not previously occurred to her or him. Expanded capabilities in scientific visualization are essential to deeper and broader learning in the sciences.

c. describe how your project is relevant to other faculty and what you think it would take to transfer your success to other faculty

The most immediate impact will be on faculty in our own departments who wish to adopt the software and hardware solutions we are developing. For example, Suzanne O’Handley and Tom Kim (from the Chemistry Department) teach the same biochemistry courses as Paul Craig. They have expressed a keen interest in learning to apply stereo molecular visualization of proteins and nucleic acids as they teach these courses. In the coming year, Paul will teach them how to use the software and hardware required for the stereo visualization lab (05-A400). Similarly, Richard Doolittle has been using the virtual human images and animations of the pancreas, kidneys, liver and heart that we have developed in teaching human anatomy. Many other courses in the biomedical disciplines, both for majors and non-majors alike, could also benefit from the use of advanced scientific imaging capabilities.

d. relevant credentials, experience of involved faculty/staff

The project team members will have the following roles: Paul Craig and Dick Doolittle will oversee content development for the campus and distance learning courses mentioned above. Jim Perkins will oversee technical aspects of moving animations and simulations from a variety of illustration programs into pdf and Powerpoint formats. Jon Schull will direct development of a web site and some new tools for moving visualizations from individual computer desktops to stereo and immersive environments on campus and online.

e. describe how this innovation is in your discipline or program

We are developing applications for visualization with a range of at least 20 orders of magnitude, moving from molecules ($10^{-9}$ m) to cells ($10^{-6}$ m) to organs ($10^{-2}$ m) to planets ($10^{8}$ m) to galaxies ($10^{20}$m). These scales encompass all aspects of science. Student comprehension will improve if they (or their instructors) can move through all levels of complexity.

8. Provide a timetable of the development of the project.

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<th>Objective</th>
<th>Deliverable</th>
<th>Assessment</th>
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<td>07.07 to 08.07</td>
<td>1. Develop tools for placing animations and simulations in standard online formats 2. Immersive visualization content in biology, chemistry and astronomy 3. Develop online course materials</td>
<td>1. Instructional tutorial on resource creation 2. Instructional tutorial on immersive visualization 3. Online course materials</td>
<td>1. Testing among team members: faculty and students 2. Review by online learning</td>
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<td>09.07 to 02.08</td>
<td>1. Implementation of online learning courses 2. Refinement of immersive visualization</td>
<td>1. Complete courses in biochemistry and anatomy 2. Content for immersive visualization</td>
<td>1. Review by students taking the courses</td>
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<td>03.08 to 06.08</td>
<td>1. Campus wide workshops on stereo visualization and immersive visualization</td>
<td>1. Workshop materials and an interactive web site 2. Implement new course in Science Visualization and Discovery</td>
<td>1. Faculty surveys (entry and exit) 2. Content development and facility use</td>
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Appendix: Results of Prior PLIG Funding

Funding for the previous two years has resulted in innovative resources for our courses; presentations at the local, national and international level; and formation of additional multidisciplinary teams on our campus.

Courses. Resources have been developed and used to better explain the function of the healthy and diabetic pancreas in several courses: Biochemistry Conformation & Dynamics, Metabolism and Anatomy and Physiology I and II.

Presentations. We and our students have been invited to give a number of seminars.

- On campus: Brick City Festival, the College of Science Undergraduate Research Symposium, a meeting of the RIT trustees, the P.I. Institute
- At national conferences: the American Association of Anatomy, the Canadian Association of Pharmacy Distribution Management
- At the Slice of Life conference for medical multimedia, July, 2006, Lucerne, Switzerland
- One of our images was on the cover of the July/August 2006 issue of Advanced Imaging.
- The American Institute of Physics created a 2 minute news clip on our work that has been offered as a special interest science topic to local television stations and has been aired in at least one market to date.

Multidisciplinary teams. Each time we offer a seminar describing this project, new faculty approach us to work collaboratorively to combine compelling visualization with the latest research in science and engineering. After our presentation at the P.I. institute, Jay Yang (Computer Engineering) asked to join us in building a dynamic, time-dependent model of a human disease and we have begun discussions which will lead to at least one M.S. thesis. We are also working with a large team from Engineering, led by Risa Robinson, on combining human visualization with engineering models to better understand air flow in normal and diseased lungs. This collaboration has also led to a publication.

Appendix: External Funding Opportunities in Scientific Visualization

The efforts supported by the PLIG program are directly connected to other funding opportunities. The following list includes past NSF funding, current NIH funding and two current Requests for Proposal.

1. Our initial PLIG effort at RIT was developed concurrently with NSF-ATE grant 0402408. Over a two year period, some of the NSF-ATE funds were used to support students working on the virtual human project, both at the organ and molecular level.

2. One of the outgrowths from the NSF-ATE project was NIGMS 1R15GM078077-01, Structural Biology Extensible Visualization Scripting Language, a collaborative grant with Herbert Bernstein at Dowling College. Our focus is on the molecular level, but it will benefit the project at RIT.

3. We have communicated with Jerry Fong, PI from NSF-ATE project 0402408, and we are planning to submit another collaborative NSF ATE proposal in October, in which RIT will be the lead institution. This project will involve students from three or four other four-year colleges and community colleges on our campus for 8-10 weeks for each of three summers. Visualization in science will be the theme of the proposal.

4. We plan to submit our work to the NSF Scientific Visualization contest. This does not involve funding, but provides RIT with a chance for more favorable publicity, including a cover of Science.

5. This team may also apply for an NSF Research Coordination Network grant.