Provost's Learning Innovations Grant for Faculty
Request for Full Proposal
2001-2002

Please send your completed grant proposal (4 pages, plus attachments), one original and eleven copies, to
Linda Jones, 4000 Faukman
by 4:30 p.m.
Friday, February 16, 2001.
No hand written proposals will be accepted.
Notification of awards will be made by Friday, March 16, 2001.

Project Title: Integrated Design: A Creative Approach toward
an Enhanced Mechanical Engineering Design Curriculum

Applicant(s):

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Integrated Design: A Creative Approach toward an Enhanced Mechanical Engineering Design Curriculum

1. Summary

This proposal pertains to obtaining faculty release time in the Fall Quarter 2001 (011) for the initiation in the subsequent Winter 2001 Quarter (012) a novel free elective course in the Department of Mechanical Engineering (ME) entitled Integrated Design. The ultimate objective of this course is to provide a seamless cross-disciplinary integration of creativity and analysis into the design process. In addition to traditional mechanical engineering applications, this course will encourage collaborative interests in MEMS, mechatronic systems, and computer engineering.

The course will be offered in a partitioned area of the ME Design Studio Laboratory (9-2130) which will be comprised of 4 networked computer PC workstations. This room is centrally located within the ME department, and the room is large enough to support the lab and leave enough physical workspace for ME senior design projects.

The key component of the proposed course is recently acquired computational software to implement this new design methodology. Software support in the amount of $263,000 has already been acquired by the PI through software grants awarded by Think 3 Corporation, San Jose, CA and by LMS CADSI, Coralville, IA. (Award letters for these software packages are attached on pages 5 and 6). This software has relatively low maintenance, aims to be user friendly, and is compatible with the associated hardware. This software not only promotes the creative design process, but it also possesses the robustness of underlying analytical capabilities for real-world engineering decision making.

The proposed course is anticipated to proceed as follows. A product or system of products would be introduced to the class (originating either from the instructor or from the students themselves), and the only objective given to the class is to deliver an improved product by the end of the ten-week session. The class will be divided into two teams, one team per project, and each team will brainstorm to promote ideas for product enhancement. Concurrent with this brainstorming session, each team will determine individual design responsibilities for each team member. Each team member would become acquainted with a particular piece of software appropriate for his responsibility of the design effort either through the use of tutorials provided by the instructor or tutorials provided by the software package itself. Alternatively, the student might be expected to develop a small piece of software code in support of the overall project goals. Hence, one student might acquire a basic knowledge of ANSYS, while another might need to write a computer program in MATLAB. At the end of the course, the original and improved designs are formally presented.

In order to best stimulate the creative side in the student, this course is intentionally unstructured, which makes it substantially different from other computer-based courses offered in the ME department. Sketches and preliminary designs leading to the end product will be electronically stored; no paper notebooks will be kept. (The only exception would be paper documentation—witnessed and dated—for use in patent invention filing.) This course has no lecture material, and individual grades would be based on how well each student has combined his or her creative and analytical talents to his/her portion of the improved design.

2. Targeted Learners

The first offering of a supporting design curriculum will be introduced to third- and fourth-year undergraduates as a free elective ME Special Topics course entitled Integrated Design. Approximately 8-10 students in a single section would be enrolled in this initial course offering, but additional course sections are anticipated in successive years.
3. Anticipated Impact on Teaching and Learning

The initiation of this course offering within the structure of a design studio will pave the way for RIT to place itself firmly among its peer engineering institutions, such as RPI and Cornell, who have already placed particular emphasis on developing a studio-based learning approach for their undergraduate programs. The studio would bring design to the forefront of discussion, tying in appropriate principles of mechanics where appropriate. The student would be given the required computational tools to investigate different product ideas, and analysis tools would be integrated into the various creative tools to provide rapid assessment of design trends. The simultaneous coupling of the creative and analytical phases will provide for a better product design in a shorter amount of time.

This proposal also provides an excellent fit to the concurrent Provost's Learning Innovation Grant proposal by E. DeBartolo and W. Scarborough of the ME department, where introductory design principles will be highlighted in a cornerstone second-year design course. The Integrated Design course proposed herein will provide a bridge of knowledge and experience for students completing the second-year cornerstone course and entering the fifth-year capstone design course.

The Integrated Design course is also expected to promote creativity in student activities involved with the American Society of Mechanical Engineers (ASME) student section and with the Formula SAE program. The ASME student section (for which the PI is the faculty advisor) participates in local and national design competitions, notably the ASME Moonbuggy competition, and alternative design concepts could be evaluated more efficiently using the design studio. Students in the Formula SAE program design and build a racecar that competes in national and international student competitions.

4. Evaluation Plan

Each project group will formally present their improved product design to a panel of reviewers from both academic and industrial ranks. One possible industrial source is the recently formed ME Industrial Advisory Committee that is planning to meet regularly with the ME faculty and students on curriculum issues as they relate to industry. Personnel from Grants/Contracts will also be invited to advise and evaluate the improved product designs for patent and marketability potentials.

The grading method will also be somewhat novel in that each student will provide a 10-15 minute oral self-evaluation of their participation in the project's success. Each student will provide the professor (in writing) a letter grade that he/she feels that they have earned for their contribution to the project. The instructor will follow with his/her evaluation and a compromise performance evaluation and grade will be determined. Both student and professor will have access to feedback from the review panel. This model of assessment initiating with the student followed by subsequent instructor review and unpremeditated decision making is an evaluation tool used extensively in the professional corporate ranks to determine advancement and salary levels.

Evaluations from the standard RIT form will be solicited from each student. The applicant to this proposal will also construct a separate evaluation form, and it will comprise only of written questions; graded evaluations (poor/good/excellent) will not be part of this second evaluation. Both student evaluations will be compiled prior to the grading process.

Upon completion of the first course offering, the results will be presented to the ME Curriculum Committee, where discussion on benefits and potential improvements will be enacted. In particular, discussion will commence on developing a distinct course number/syllabus and on discussing the means in which this course could be integrated as a required component within the ME curriculum. The course will also be discussed with facilitators of the various ME laboratories to develop ways in which laboratory activities could be added to the Integrated Design course. The course results will be offered as a public lecture (Gleason lecture series, for example) on the role of creative design in the ME curriculum.
5. Rationale

One can define "engineering" as the creation of devices, subject to the constraint of physical laws, that improves or has the potential to improve the human experience. This process of creation is often termed "design", and it remains the fundamental goal of every engineering school to impart this creation process on its undergraduate and graduate students.

Up until the mid 1990s, the traditional way of designing products decoupled the creative process with the analytical resources required to keep the design within the often overlapping constraints of durability, weight, power consumption, speed, and cost. In a typical engineering firm, the "design group" would put together a rough draft of the general shape and key dimensions of a component using either a traditional drafting board or more contemporary computer aided design programs. The component would then be transferred to the "analysis group" who would ensure the component would meet the required stress levels, loading, and weight targets. Suggested modifications to the design were then passed back to the "design group" and the process would repeat itself.

In Arthur H. Burr's 1982 book, *Mechanical Analysis and Design*, he offered what was at the time a new approach to teaching by dividing the book according to the principles of mechanics and relating the design of mechanical products and systems to these key principles. In his "Rules for Design", he emphasized that "analysis is interwoven into the design of a sound and balanced machine or device, and that the creative phase need not be an initial or separate one". However, the limitation at the time was the lack of adequate computing tools in the design process, which by default retained the decoupling of the creative and analytical aspects of design.

The role of computers and associated software has fueled the increase in industrial productivity, and it is especially true in the area of engineering design. In the automotive field, for example, the time from concept to production of an automotive engine has dropped from 60 months in the early 1980s to 39 months today. The newly graduated engineer is thus expected to possess critical skills pertaining to streamlined manufacturing and product design prior to graduation, as increasing demands on time do not allow for appropriate corporate training.

The current computer-based lab facilities in the Mechanical Engineering (ME) department do not provide a well-defined space devoted exclusively to this creative design process. The ME PC Lab provides students with comparable computational tools, but the lab is required to support a large number of CAD-related course offerings, mechanical engineering (drafting, computational methods, finite elements), making it difficult for a team of students to brainstorm ideas and conduct creative efforts in an essentially standalone setting. The ME System Dynamics Lab is also focused toward specific undergraduate instruction in a manner similar to the ME PC lab. The ME Computational Fluid Dynamics Lab is meant to support undergraduate and graduate education in the Aerospace program with computational tools primarily devoted to issues related to fluid mechanics.

In contrast, Computer Aided Engineering (0304-618) (also taught by the PI) combines lectures, lab exercises, and short two- to three-week projects toward specific understanding of basic CAD concepts and implementation of one specific a high-end CAD program. Hence, the design effort and the design projects are necessarily time-limited.

In Senior Design I and II (0304-630/631) and Interdisciplinary Product Design I and II (0302-610/620), a combined capstone design and fabrication effort is conducted by student teams under industrial fiscal constraints. On the other hand, the proposed Integrated Design course places stronger emphasis on coupling the creative aspects of design with the analytical requirements, as the fabrication process would be omitted. The role of budget management emphasized in the capstone design course will be de-emphasized in the interest of creativity. The idea is to promote design breakthroughs, not incremental improvements that are often the result of current industrial budgetary models. More interaction time with advanced topics, such as optimization, structural contact, and dynamic simulation can be accomplished by the students. In fact, this proposed course can only serve as an excellent prerequisite to the capstone design course sequence, as it would give the student early design and teamwork experience.
The credentials of the faculty and staff in the ME department, including the applicant to this proposal, have had extensive design experience in various academic and industrial settings. In particular, the applicant to this proposal has had over 15 years industrial experience prior to his current teaching role at RIT, and he is currently a joint partner in Tribology Associates which provides consultation and software tools related to fluid-film bearing design to various industrial interests.

6. Project Responsibilities and Timeline

September 1, 2001
Associated hardware and software will be functional by this date. The applicant to this proposal will use his one course release time in the Fall quarter 2001 (011) to develop user-friendly tutorials for the various software packages that will be installed on the 4 PCs. Additional support is requested for a part-time undergraduate student ($10/hour 10 hours/week for 10 weeks), to provide feedback on design tutorials, assist on computer system issues, and to assist in tutorial development.

September 15, 2001
The formation of a faculty and industrial review panel will be initiated.

October 1, 2001
The course will be advertised as a Special Topic Course in Mechanical Engineering: Integrated Design (0304-600) for the Winter quarter 2001 (012). One section with 8-10 students is expected.

November 1, 2001
The initial group of students that will have registered for the course will be solicited for design project ideas.

End of November 2001
Tutorials will have been completed by this date. The Integrated Design Course is offered for the first time.

Early March 2002
The results of the course will be presented to the ME curriculum committee and the review panel.

April 2002
The results of the course will be offered as a public lecture (e.g. Gleason lecture series)

7. Important Attachments

Attached on pages 6 and 7 are Appendices A and B containing the following supporting documents:

Appendix A contains a software grant award letter for $108,500 from Think 3 Corporation, 2880 Lakeside Drive, Suite 250, Santa Clara, CA 95054. This grant represents 25 licenses of the thinkdesign 3-D design software. The contact person is Silvia Pineda, 408-987-6832.

Appendix B contains a software grant award letter for $155,000 from LMS CADSI, 2651 Crosspark Road, Coralville, IA 52241. This grant represents two licenses of the DADS (Dynamic Analysis and Design System) software. each worth $65,500, along with one year of full technical support worth $24,000. The contact person is Keith Moss, 319-626-6700.