FY12 Innovations in Teaching with Technology Awards:
Internet-controlled Cell Printing Platform for Interactive Biomanufacturing in Engineering Curriculum

FY12 Innovations in Teaching with Technology Awards

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<th>Proposal Title:</th>
<th>Internet-controlled Cell Printing Platform for Interactive Biomanufacturing in Engineering Curriculum</th>
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<td>Investigators:</td>
<td>Ibrahim Ozbolat</td>
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<td>Org Unit:</td>
<td>College of Engineering</td>
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<td>Department(s):</td>
<td>Industrial Engineering</td>
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<td>Funding Awarded:</td>
<td>$25,830</td>
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This educational innovation project, which builds upon a previous Office of the Provost funded proposal in laboratory development for engineering undergraduate curriculum, aims at developing a web-access interactive cell printing platform for effective teaching in biomanufacturing and automation systems. If successful, this project will maneuver the efforts towards integration of new technology and development in science into digital teaching.

Dr. Ozbolat has successfully integrated biomanufacturing topic into undergraduate curriculum through laboratory development in part of 056:032 Design for Manufacturing (DfM) course. With the integration of biomanufacturing into undergraduate curriculum, we inspire undergraduate students to get hands-on experience in next generation manufacturing tools and to provide them with knowledge in biomanufacturing systems. Besides, biomanufacturing tools in the DfM content will educate future generation of engineers who are interested in pursuing design, manufacturing and applications of biologically inspired tissue replacement structures in emerging fields. Moreover, Dr. Ozbolat will offer an innovative undergraduate course 056:136 Biomanufacturing in Fall 2012, in which students are expected to gain hands-on experience in a wide array of biomanufacturing processes.

In this effort, Dr. Ozbolat will develop an internet-controlled bio-additive manufacturing system in Biomanufacturing (BioMfg) Laboratory. An industrial dispensing robot and digital fluidic dispensing equipment, funded by Office of the Provost, will be used to develop the system in our clean room facility. A control system will be built to synchronize the communication between the robot and dispenser. Two cameras will be integrated into the system to display real time motion of cell printing platform. One
camera will be stationary that will be placed on the top of the platform and the other one will be remotely controlled through internet that enables students to control camera motion to enhance process visualization capabilities. An interface will be created and integrated into ICON. Users can interact with the platform by sending I/O signals to the platform. Several control commands will be available such as robot start and stop, linear motions in x, y and z directions in ! Cartesian coordinates, dispenser pressure regulator, camera control and system on/off. The system will be fully automated except loading cell-biomaterial solution into the platform while preparation of cell-biomaterial solution needs relative more complex cycle. Cell solution loading will be performed manually prior to system run. The instructor will be interactively control the platform through the internet and demonstrates cell printing facility online to the class. Moreover, control instructions will be available online for students benefit.

Students are expected to get hands-on experience in biomansfuring through assignments performed in BioMFG Lab. A new cell printing process will be integrated into classroom teaching that raises students interest enormously in engineering curriculum. The process will be run in our clean room facility to keep the process safe from any contamination risks with minimum human intervention. The proposed effort thus provides students with visualization and control of the process remotely. Most importantly, students do not have to be present in the lab that eliminates safety issues including any risk of exposure to biological and chemical substances. Normally, students are allowed to practice processes according to Environmental and Health Safety regulations by wearing safety masks, gloves and goggles depending on process requirements. Due to limited lab space, students are accepted in groups that minimize effective teaching and necessitate higher TA time allocation. The proposed effort will not only help us in mitigating these issues, but also assists the instructor as a digital demonstration tool in supporting classroom teaching. Learning and teaching challenges leveraged by the proposed effort are listed as;

Learning Challenges:
-New and recent developments in science can be easily adapted into web-based digital learning
-Student will not be subjected to any risks of hazardous biological and chemical substances
-Remote control in the clean room facility will eliminate contamination risk and ensures process safety
-Medical images such as MRI can be used to generate CAD models, which can be used directly for postprocessing operation to generate robot path for web-based cell printing to manufacture organs and tissues
-Students will learn and understand how automation system is used to solve biomanufacturing related problems
-Students will rapidly and remotely manufacture tissue/organ replacement parts
How will it improve student learning?

Teaching Challenges:
- In-class demonstration of cell printing process and automation will engage students interests into biomanufacturing significantly
- Enhanced visualization of cell printing process will improve teaching effectiveness compared to physical observation outside the clean room facility
- The effort will eliminate the issue of accessing BioMfG Lab, which is located at ERF building
- Online training tools will reduce the need for teaching assistants, which is limited due to departmental budget issues

Size of Audience: On average, enrollment to DfM is 60 students in fall and 120 students in spring. With expected number of students enrolling in Biomanufacturing class, there will be 240 students getting benefit from the proposed effort annually. Considering the size of audience, proposed effort will enhance our teaching effectiveness significantly. The contribution of the project will not be limited to College of Engineering. Students from College of Dentistry and College of Medicine are also expected to get benefit while their enrollment to DfM has increased in the last few years.

Assessment: If successful, the project plan will be deployed to DfM and Biomanufacturing courses in Spring 2012 and Fall 2013, respectively. The success of the project will also be evaluated through yearly conducted ABET assessment and ICON quizzes. Proposed project will be integrated as a component to current ABET rubric. While only industrial engineering students are considered in the ABET assessment plan, we will be expanding the same assessment plan to entire undergraduate student list as a project evaluation tool. Besides, online quizzes has been prepared and integrated into ICON to ensure that students use online training for internet controlled cell printing platform. A score 80% or above will be set as a passing score to be able to work on their laboratory assignments. DfM currently offers 3 online safety quizzes as a part of safety regulations. Enriching current quizzes with new ones related to the the proposed effort will promote effective learning, enables us keeping track of their success and ensures safety.

What resources will you need?

A graduate student will be assigned to develop the internet controlled cell printing platform that can be accessible through ICON system. The student has been serving as a DfM teaching assistant for two years and he has hands-on experience in the use of wide array of manufacturing tools, machines, software and biomanufacturing processes. Besides, he has deep knowledge in systems control and electronics. His expertise in design, manufacturing and biomanufacturing, and his skills in control and electronics will leverage the success of the proposed work. During the 11 months
project timeline (including development, testing and refinement), from February 1st to December 31st 2012, the graduate student will be appointed as 1/4 RA. In addition, we need electronics equipment and controller for control system in addition to motion cameras and lenses, and related auxiliary equipment. Previously supported equipment will be used in construction of the entire automated platform.

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<th>Rough estimate of costs</th>
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<td>Tuition and salary of the graduate student: $19000</td>
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<td>Two motion cameras and lenses: $7000</td>
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<tr>
<td>Controllers and auxiliary equipment: $3000</td>
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<td>Total rough cost: $29000</td>
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ITSupport Information

For more information on the Innovations in Teaching using Technology Awards, please send an email to: Innovation Strategies for Teaching & Learning.

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