Final Report of the

College of Arts Science and Engineering Education Technology Committee

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1. Executive Summary

Major research universities are uniquely positioned to re-imagine what higher education does, and how it does it. Unprecedented amounts of student debt, rising tuition costs, dwindling sources of government funding, the rise of online education, and a protracted recession all contribute to anxieties about what this moment will mean in the long run. While there is cause for concern about the future, we now have an exciting chance to respond to the needs and wants of students and faculty in innovative ways.

Rapid advances in digital technology enable the residential college experience to become more transformative for both students and faculty than it presently is. Faculty, students, and staff have already begun to take advantage of the ways in which digital technologies can make teaching and research not only more efficient, but also—and more importantly—more effective. These efforts urgently demand easily accessible institutional support if we want to make them a central part of our educational culture.

In what follows, we focus on three major themes that will allow us to efficiently use technology to improve teaching effectiveness:

1. Adopt technology to facilitate *learning by doing*

Effective teaching means embracing *learning by doing*. The committee has repeatedly emphasized the need to embrace a philosophy of *learning by doing* across the curriculum. The classroom is a space where students master a given body of knowledge *and* integrate conceptual learning with concrete experiences and outcomes. Learning by doing can take many forms, but the indisputable strength of a residential institution such as UR is that it can provide direct, collaborative engagement in faculty research projects *across* the arts, humanities, engineering and sciences by allowing students and faculty to interact--from the lecture hall and seminar room, to the laboratory and studio.

Learning by doing is not merely a way to involve students in faculty research. Handled ethically, it allows students to integrate their academic, scholarly and co-curricular activity into their future lives as citizens and professionals. Digital technology makes it easier for students and faculty to create tangible evidence of educational achievements. We support curricular structures (such as the proposed portfolio curriculum) that allow students to articulate the value of their education at UR to the wider world.

2. Improve technological resources available to faculty

It needs to be easy for a STEM professor to produce a series of videos that supplement her lectures. It needs to be simple for a humanist to collaborate with devoted staff on digital projects that bring cultural data into the classroom. It needs to be uncomplicated for an anthropologist or art historian to run a seminar with world-class faculty and students at other campuses. It needs to be clear to students where they go with concerns about how to advance their technical literacy in assignments that are increasingly "born digital." It has become obvious that faculty and students at UR face large hurdles in pulling together the support they need to achieve any of these aims. In light of this we need to develop centralized virtual and physical spaces on campus—in conjunction with efforts of the Center for Digital Scholarship — that empower individual and collective solutions. We need to make it easy for faculty and

students to bring technology into their efforts when they want to do so, embracing the ethic of open source. This will require accessible, centralized, full-time technological assistance to faculty and students; a full-time programmer with access to more resources, including programming staff and designers who can help with teaching and research alike; ample and accessible server space for everyone on campus; and funding for courses and projects that bring technology into teaching and learning.

3. Create incentives for faculty to embrace technology

Faculty members recognize that new technology can make their research and teaching more effective and efficient, but creating new formats for classes requires a significant amount of up-front time and energy that is not encouraged or recognized under the current system of professional incentives, and is therefore seen as an ineffective use of faculty time. We recommend that UR consider new incentive structures that encourage tenured and untenured faculty to innovate as researchers and teachers. This might include: course relief to promote the start-up of innovative courses; credit for teaching innovation and effectiveness in salary, tenure, and promotion decisions; the hiring of faculty with explicit emphasis placed on innovative, effective teaching and/or the unification of teaching and research. Alongside this, we recommend a strong emphasis on faculty involvement, which might include an archive of "model" projects, and increased visibility and recognition of achievements.

In this report:

- We present a vision of what a University of Rochester education could look like in the very near future by making use of readily available technologies.
- We discuss ways that technology can be employed to improve learning in large introductory courses while simultaneously reducing the time burden on faculty, thus freeing up more faculty time to create an expanded array of technology-enabled, active learning opportunities.
- We also propose the use of online student portfolios to document and showcase the products of students' engagement in active and project-base learning experiences.
- We present a list of proposed pilot projects, which certainly are not meant to be exhaustive or exclusive of other faculty ideas, but merely representative of some of the specific ideas from the members of our committee.
- And finally, we discuss the required infrastructure and faculty incentives to encourage and support the innovations presented here.

2. Imagine …

Let's take a moment to imagine a "day in the life" of a student at the University of Rochester in 2015:

Monday 10:00 AM – Attended my AME140 (Fundamentals of Audio and Music Engineering) class. Today's class was on sampling and quantization of sound, and we used our tablet computers to run Matlab simulations during class to learn about (and hear) the effects on digital sound quality by using different sampling rates and bit depths. Running the Matlab simulations and being able to change parameters on my own computer during class really helps me to understand what is going on, and it gave me a good head start on the lab this week, and if I have problems with the lab I can go back and view the on-line video lessons to help.

Monday 11:00 AM – Went to MTH161 (Calculus) Lab/Workshop to meet up with my study group at one of the library's collaborative learning rooms we booked online earlier in the week to work on derivatives using the chain rule. The on-line video tutorials I watched at home yesterday helped and I was able to do 10 out of 10 drill problems in Mathworks but I was still unsure how to apply related rates methods to the group mini-project on manufacturing supply chain optimization that we're working on this week. Working on real-world applications of calculus in addition to the drill problems and learning when and how to apply calculus to solve practical problems really helps me to understand the techniques that we're learning. The TA was a lot of help with the project and our group will get together tonight in one of the libraries collaborative learning spaces to finish up this week's project due Friday. The chance to practice our presentation using the AV equipment in the room lets us practice in preparation for Friday.

Monday 2 PM – Attended a course in my Film and Media Studies cluster, FMS 227 (Poetics of Television). We're working on a project to incorporate a new research tool developed by our teacher for analyzing digital film clips. Helping to refine the new research tools by using them in our projects feels like we're contributing to the research project. We're working in the Digital Humanities Lab in the Library with the help of their staff on the video editing workstations to create new data visualizations of narrative tempo for television dramas.

Monday 3 PM – Meet up with my BCS152 (Language & Psycholinguistics) project group to do a final review of the protocol for our second mini on-line experiment on language processing and learning that we will be running using the Crowdsourcing platform Mechanical Turk. Our experiment goes live next week and we're hoping for at least 1,000 on-line responses within the week. It looks like we'll be well within the research budget of $200 allocated to our research group. We're participating in a worldwide replication project that seeks to assess the reliability of experiments in the social sciences. Our experiments will be submitted to an online database and the best ones will be published on a science blog, so that other researchers can benefit from our results.

Monday 4:30 PM – I'm working on a section of my UR Digital Portfolio that I use to reflect on progress toward my integrated learning goals. I had time to stop by the shop in Rettner Hall to put another coat of lacquer on the electric guitar that I'm building in AME140; I can't wait to play it at the end of year AME140 project expo/jam-fest. I plan to add video of that event to my guitar project page in my on-line digital portfolio as an example of how I'm working on a learning goal of integrating engineering, music and hands-on understanding of musical instrument design. I'll be able to produce a finished high quality video using the multimedia production tools and help available in the library.

Monday 5:00 PM - Attended my WRT 105 (Writing Seminar) to go over student critiques of last week's writing assignment. I really like the system where we all submit our assignments on line every Wednesday and then critique each other's essays on-line (anonymously) by each Friday. In class today the instructor critiqued a few of our essays and then she talked about our comments on each other's essays. We learn as much from that as we do when she just grades our own essays.

Monday 7:00 PM – Re-watched the AME140 videos on sampling, quantization and dither and wrote a Matlab program for the AME140 lab this week building on what we did in class earlier today.

Monday 9:00 PM – Checked the Student Research Themed Project Website, Sustainable Energy and the Community, to see if students are meeting up next week with our community organization collaborator and continue work on our project.

This fictional account of a day in the life of a student at the University of Rochester illustrates a variety of ways that existing technology could be employed to transform the residential college experience. Currently students spend about 12 hours per week in traditional lectures, and although the structure of attending regularly scheduled lectures can be helpful in keeping students on track and engaged in their studies, it is an unusual student who does not either fall behind, may not engage with the material so that understanding of concepts or gaining of skills is achieved, or perhaps becomes frustrated by a lack of connections with real world problems. Thus, we are led to ask if there are alternative strategies, enabled by available technologies, that can be more effective in supporting student motivation and learning and which make more efficient use of the time of both students and teachers.

In our committee's discussions we have looked beyond the more obvious uses of technology in learning, such as on-line courses, to explore two areas. The first was to ask how technology can be employed to improve learning outcomes in large introductory and skills building courses, while simultaneously improving the efficiency of instruction. The second area considered was to ask how the faculty time freed up by the first initiative could be productively spent to leverage technology to create new active learning opportunities for our students. To achieve deep learning, ideas must be explored, transformed, integrated into broader intellectual landscapes, and creatively applied. Active learning experiences that bring ideas to life for our students in these ways should be a central goal of a University of Rochester education. This report presents that vision and outlines concrete strategic paths for embodying that vision in University of Rochester undergraduate programs.

3. Employing Technology to Transform Undergraduate Education at the University of Rochester

Given the rapidly changing landscape for higher education in the U.S. and internationally, particularly as that landscape is reshaped by online learning initiatives by several of our peers, many U.S. colleges and universities are carefully considering strategies and actions to respond to this changing landscape. The University of Rochester is compelled to consider its potentially changing position in the competitive field of higher education as well, and the Dean of Arts, Sciences and Engineering has formed committees to take a step back and consider these questions: As a residential, Research I, liberal arts institution, what are the key value-added contributions that we make to our undergraduates' **residential** educational experience that are unique and irreplaceable, and how can we employ available learning technologies to enhance those contributions to our students' academic, personal and professional development?

Let's start by accepting a basic premise about the face-to-face experience of a residential, Research I undergraduate education. The myriad of rich, productive academic experiences and related support that make up the residential campus life of an undergraduate at the University of Rochester - receiving guidance and mentoring from teachers, advisors and other students, the very human nuance of collaborations in the development of seeds of creative ideas, and the deep, authentic learning that occurs from thinking through challenging, intellectual questions with world class faculty both in the classroom and through research

cannot be replaced by an online course experience. We must ask, however, that if we break down undergraduate education into its components, what parts can or should be replaced or improved by employing technology, thereby freeing up more time for richer experiences and student-teacher interactions? A recent observation about online versus residential education at research universities by MIT's President Rafael Reif may point toward an answer:

> "Online technologies are good at teaching content, and they will get even better. The residential campus model is best at teaching the skills one learns through human interaction, such as how to compromise, inspire, persuade; how to build a life of high ethics and moral value; how to work creatively with people of different backgrounds; when, and how, to speak — and when, and how, to listen. The residential research university of the future should offer the best of both worlds, integrating the best ways to learn online with the best ways to learn in person." (MIT President's Inaugural Address, September 21, 2012).

So, in a search for the "best of both worlds" we must ask ourselves several questions. First, if the greatest value of a Rochester education is in the positive and productive mentoring relationships between students and their teachers and advisors, how can we explicitly define and organize these kinds of learning occasions to best achieve the goal of helping our students to develop into independent critical thinkers and creative pioneers across the intellectual landscape? At the same time, how can we best employ learning technologies to design those components of undergraduate education that are more focused on the students' development of basic knowledge and skills? If we separate out content learning and skills building, which perhaps may be achieved in large part by employing on-line teaching methodologies, we must make the remaining elements of a UR education explicit, worth the price, and we must make the UR value proposition loud and clear.

A recent article by Randy Bass at Georgetown University challenges us to think about these questions as well. ("The Problem of Learning in Higher Education," *Educause Review*, March/ April 2012, p. 23-27). He argues that large lecture courses are, in general, simply content delivery. He adds that all genuine, deep learning occurs through experiential activities. Here, students and their mentors collaborate together in carefully designed and integrated learning experiences where students gain understanding of and some mastery of that knowledge and skills of his or her field and how it applies in the world. He recommends that courses should be designed from the ground up with a team of experts working with faculty to design those deep, experiential learning activities with student learning as the central goal.

However there clearly are design constraints that must be considered as we embark on such efforts: faculty time, organization structure, and money. The University of Rochester is a research university with a stellar faculty whose time is already stretched to include research, teaching, advising, and service. With the research enterprise taking more time than in the past due to increasingly competitive grant processes and teaching taking more time as undergraduate enrollment grows, what are the appropriate incentives for faculty to take on more work? Given the reward structure, faculty on the tenure track wisely may determine that time invested in curricular innovation is not in their best interest. Furthermore, there are economies of scale in the large lecture course that cannot be achieved by other means given the current organizational structures of most colleges and universities, UR ASE among them. Finally, there is money. Making major educational changes costs money and time (and time is money) in terms of expert staff or appropriate faculty incentives, such as summer salary or relief of

teaching time cost. New hardware or classroom redesigns cost money. Perhaps the most important issue is risk: What if, after it's all spent and done, there is no payoff?

Our students (and their parents) clearly are seeking more from an undergraduate education than the traditional offerings of disciplinary courses and an array of co-curricular activities. In student interviews several themes are recurrent; students said that in addition to well designed and delivered courses and productive interactions with faculty, they seek opportunities to put what they learn into practice through independent research, projects and participation in other creative endeavors that help them find their voice and make a difference. Given the high price of undergraduate education, these are not unreasonable requests.

Another interesting set of questions has arisen with the creation of MOOC's, Massive Open Online Courses and the overwhelming reception that certain MOOC's have received warrants thoughtful consideration. A free and open course in Artificial Intelligence offered in the fall term of 2011 by Sebastian Thrun and Peter Norvig at Stanford enrolled more than 160,000 online students, although only a fraction of those who started actually completed the course. Given the virtually unimpeded flow of information in the present age as illustrated by this example, we must be thoughtful about how we regard the materials and products of our educational endeavors.

One of the most successful aspects of digital/networked technologies is the potential for unfettered collaboration, sharing, and user-driven customization of information - what you might call a sort of open source ethos. One can observe this ethos in many of the Internet's most exciting and successful emerging models e.g., crowd sourcing, crowd-funded start-up companies and other social initiatives, creative commons licensing, free and open software, etc. Anyone with a laptop, phone, and WiFi can generate content on the Internet. In certain ways the Internet and new media technologies circumvent the need for an institutional arbiter. We need to consider how accessing and creating content through a U of R education can be worthwhile. How can we differentiate ourselves and create the type of technologically enhanced environment that will continue to attract students into the foreseeable future? One answer is for the university to begin to embody an open-source ethos whenever practical and possible – especially with regards to digitally networked educational technologies.

What the institution can offer in an age of rapidly emerging on-line technologies is great credibility. Through its faculty and their roles as experts who drive and filter content and information, the University can be known as an exciting and important hub of information. However attempts to control access to or to make rules that impede the creation or distribution of that content go against the very nature of networked media and in turn create a closed system that might eventually diminish our relevance. Besides, as said above, the information itself is not the only value added by the institution.

New initiatives that embrace educational technology cannot be annexed or subsumed by hierarchical or old media institutional models. Some members on the committee questioned the word "Center" because with the Internet there is no center or place of authority but instead hubs of expertise where knowledge unique to our institution is allowed to flow unfettered and unstuck. Therefore any new initiatives must function in antithesis to the traditional top-down model by making it open and easy on the faculty and students generate and share their own content. Any supporting infrastructure should be staffed with trained individuals who embody

the open-source ethos, i.e., staff who understand the need for networked technologies and resources to be freely accessible to everyone.

So in moving forward with whatever initiatives ultimately are selected we must keep in mind that the University does not need to attempt to recode new media in its own image. We need to allow space for new media to recode the university - in certain ways that involve and empower individual, efficient user-driven solutions.

In summary, harnessing the creative energies of our faculty and staff to significantly transform learning at the UR is essential to maintaining and enhancing our position among the elite institutions of higher learning. This report outlines a path forward that is informed by the rapidly changing landscape, recent research on authentic learning experiences, constituent demand, and realistic institutional constraints. To accomplish the goal of "bringing ideas to life" for our students requires, more than anything else, vision and a will to affect change. The enabling technologies are readily available and relatively inexpensive, and we have the resident talent and skill in our current faculty and staff needed to make these changes. The main challenges then, are to achieve a clear common vision, to carefully plot the path forward and to commit our resources to reaching our goal.

4. Report organization and overview

The remainder of this report is organized into four sections, each one dealing with a major theme and containing specific recommendations.

Section 5: We begin by presenting blended learning curricular models for two primary types of undergraduate courses: large enrollment courses, many of which are entry-level courses, and smaller, upper level courses and seminars. In each type of model, we present a framework for delivering content and assignments in a variety of formats to meet learner needs both in and outside of the classroom, as well as scenarios and how they could be enabled and/or enhanced by a combination of active learning pedagogies integrated with the use of appropriate technologies in the classroom. Several of the examples provided are based upon an admittedly incomplete sampling of current practices at the University of Rochester, however we believe that these examples are representative of the various broad categories of technology-enabled active learning. Yet others are proposed models for courses in each of these categories.

Section 6: We recommend establishing a new and distinctive curricular structure in the College of Arts Sciences and Engineering with the centerpiece being an Online Digital Portfolio that every student will build over the course of their studies. The digital portfolio will be closely tied with integrative "portfolio-worthy educational experiences" proposed in the Research Committee's report. The two part digital portfolio will include a section for students to develop integrative learning goals and to tie these to learning experiences in courses during their four undergraduate years. The presentation portfolio will permit students to choose and polish some of this material and place it in a public section for external audiences. This two-part portfolio provides the scaffolding from which to build a set of rich active learning experiences for our students. It also provides our students a distinctive vehicle (other than the traditional transcript) to communicate their accomplishments to the world.

Section 7: To make the proposed new learning initiatives successful they must be fully supported. Simply showing our faculty new ways to employ technology to enhance student

learning and hoping that individual faculty members will find the time in their already full schedules to re-design courses and other student learning experiences is insufficient. Thus we strongly encourage the creation of a support center to bring faculty and specialists together to develop course materials and tools. We highlight the need for *one* centralized service center for educational innovation, whose mission we do not currently see sufficiently covered by any of the existing entities in the College. The new "Center for Learning Innovation Initiatives" would serve as the launch pad for pilot projects such as those proposed in this report. Project teams coordinated through the center would include faculty members, learning specialists, and technical and content support specialists. These integrated teams would work together throughout the project to design, conduct and assess new or revised courses and other new learning activities. We believe that this resource could be staffed by existing College staff members with staff loaned to the center on an as needed basis depending on the specific project needs.

Section 8: Finally we propose a number of mechanisms designed to create an environment where the innovative use of technology to improve the efficiency and effectiveness of instruction in the College are encouraged, supported and rewarded.

Finally, In the **Appendix** we conclude with a list of proposed pilot projects.

5. Models for Integrating Learning Technology into Undergraduate Education

We suggest that one can think about undergraduate education as being made up of three broad types of learning experiences as students move from freshman to senior year: introductory, advanced, capstone (for some majors). Within each course level, in the ideal, a student is exposed to materials and assignments that support development of abilities from simple recognition of terms to comprehension, analysis, evaluation and creative synthesis (following Bloom's taxonomy). Yet many courses and curricula are not effectively structured to move students from novice to the mastery required for creative synthesis.

In the idealized world of perfect efficiency where time is gained in the teaching of these large enrollment courses through the use of technology, faculty may have more time to spend on developing and teaching advanced courses, conducting seminars or leading students in research and more project oriented experiences.

Technology tools, used with clear intent and embedded seamlessly into courses, can improve the engagement of students with one another, with content and with faculty. In this manner, students' learning can be enhanced and student motivation to learn is also improved. The following table summarizes some examples of how we can achieve this.

GOAL	WHY	TECHNOLOGY ROLE
Increased levels of peer interaction	1. peer and near-peer instruction complements the teacher's efforts (not redundant!) 2. taps into "free" source of extra instruction without increasing instructor's burden 3. increased sense of common purpose/belonging	Internet provides platforms (blogs, twitter channels, discussion boards, peer reviewing) for groups of students to interact with course material outside of (and in addition to, not instead of) physical classrooms – **but most instructors don't use them**
More relevant out-of-classroom instructional resources (that students will actually engage with!)	- Static textbook cannot capture all course content (we hope!!) - Students benefit from re-watching detailed explanations, with pauses - Instructor may want to provide "followup" comments beyond class, on the spur of the moment	Makes it possible for instructor to produce, post, and organize video segments for on-demand viewing (a la Khan Academy) – **but almost no instructors at UR do this, and we don't have the resources to do this on a large scale**
More feedback-based teaching	I. allows instructor to identify and address the most pressing needs of that particular group of students II. less pre-set lecturing, more "just in time" discussion/mentoring III. students become stakeholders in where the course goes IV. more active classroom	Technology provides many ways of gathering and organizing student input, either before class or during: BlackBoard surveys, in-class polling, Twitter backchannels, online group markups of primary sources **– but the technical requirements (particular for in-class techniques) are a major barrier for all but the "heroes"**
More holistic assessment of students' progress through their majors	V. "portfolios" build a richer picture than grades and recommendation letters alone VI. increase in student self-awareness (and pride?) VII. helps students progress towards whatever lies beyond college	Online is the logical place to preserve, organize, and render (most types of) student work for the individual, the instructors, and outside parties (e.g. employers) **– but UR currently has no infrastructure to support this if a department wanted to do it**
Richer engagement with tools of scholarship	VIII. faculty model how to use technology for scholarship (e.g. simulations, online surveys, textual markup, crowdsourcing, apps) IX. students get experiential learning experience directly from course assignments X. entire class can do a project	Self-evident: the tools being used are technological **– but the instructors who introduce them in class generally require unsustainable levels of technical staff support**

5.1 Ideas for Large Enrollment Gateway Courses

We recommend development of courses using two blended learning models: supplementing current course curricula and replacing current course curricula.

Supplemental: In this model, additional materials are added to supplement traditional course lectures and tests so that student learning is improved. Online lectures, short expository videos on core concepts, and practice problems permit students to learn and practice outside of lectures. Student workshop groups or students working alone or in informal groups can have more and well-chosen or developed materials readily available rather than randomly found materials from the course textbook or the Internet.

Replacement: In this model, lecture materials and practice problems are developed to replace portions of a lecture-based course. While students generally still attend two one-hour lectures per week, 1 lecture per week is online. Students are required to complete practice problems and review quizzes to ensure that they viewed the lecture and comprehended content.

If we consider just introductory level courses in STEM disciplines, these courses generally focus on "lower order" learning skills such as comprehension, explanation or application as the most efficient means of teaching large enrollment courses. In these courses, we might gain significant efficiency and effectiveness if we can improve the delivery of course lectures and testing, while supplementing the course materials with targeted materials that enable deeper learning of concepts and higher order skills. Supplementary materials might include well-chosen practice problems, video modules that focus on core concepts or methods, and experimental case studies that highlight experimental methods and analysis. In addition, we could replace some large lecture activities with specific on-line videos (in the style of Khan academy perhaps) that are closely linked to practice problems.

We would integrate the above innovations with current faculty efforts to improve student learning in STEM courses. Several faculty have long been experimenting with pedagogies to address development of "higher order" skills in STEM introductory courses. The workshop model used in BIO110 and CHM131, both introductory level courses, have used challenging thought problem solving in groups led by peer leaders to develop such skills. Testing students' development of analytical and critical thinking skills has been a focus of BIO110 for a number of years.

This model applies as well to large enrollment courses in economics, political science, and psychology.

5.2 A Sample Calculus Course

We propose the development of integrated group tutoring sessions and digital learning tools for students' math foundation courses, the area that causes students perhaps the greatest difficulty in their path as engineering and science majors.

Recent studies of student performance in calculus courses suggests that four areas for education innovation have the greatest positive impact on student performance: reviewing lecture videos again in order to review concepts and create personal study notes, practice problems to build essential calculus method and problem solving skills, conceptual understanding of calculus concepts from a visual perspective, and connecting calculus methods and concepts to applications.

We propose to build a series of web-based tools to support and improve student learning and performance in calculus. These web-based tools would integrate a currently used

tool, Webworks, with new tools developed for this project. Faculty lectures in calculus will be videotaped, indexed, and placed on the calculus website for students to review. The Webworks tool is one that supports student practice of calculus methods by presenting them with many problems and solutions. The tool has been shown to improve student performance on skill based calculus problems. A second tool, a calculus concept visualization tool, developed by Seeburger at the Monroe County Community College as part of a recent NSF project, will be used by faculty in lecture and in tutoring sessions to equip students with conceptual understanding of the methods of calculus. Finally, a series of application and design problems, which are connected to different branches of science, engineering, and the social sciences will enable students to build strong connections between the material in their calculus courses and their various other fields of study.

Often students' struggles in calculus are rooted in poor preparation in pre-calculus mathematics, sometimes going all the way back to basic algebra. It is important to identify these deficiencies early on, through skills assessment testing, and to remedy these deficiencies through tutoring, which may be achieved using the extensive video tutorials made available by the Khan Academy. To instantiate such a plan would require designing skills assessment methods (perhaps employing Webworks) that would automatically point students to the appropriate video tutorials in areas where deficiencies are found.

The tools will be closely connected to and used in a series of tutoring group sessions developed for students in the learning community. As students progress through their first year calculus courses, students will review lectures with their tutor, and be able to ask questions and work practice skills and visual concept problems together. As students progress and as pre-existing deficiencies are remedied, the focus of the tutoring group sessions can shift to applications of the mathematics to deepen the students' grasp of the concepts and methods.

5.3 Deep Learning, Creativity and Synthesis

The key distinctive element of an undergraduate education at a liberal arts university focused on research is providing students with rich opportunities for learning how to use the frameworks and tools of their disciplines for creative synthesis. When one thinks of mastery of any course or discipline, it is that point where a student gains sufficient conceptual and practical hold on a subject to begin to use that core to ask new questions, frame fresh arguments, and create new ideas or objects.

What if we were able to design courses where we could judiciously choose or design supplementary course materials and assignments not possible with paper and pen? What if this choice of digital materials was not just extra material added without clear instructional intent, but so that the course was designed to achieve that holy grail of student learning, creative synthesis.

Education Technology Committee members provided examples of what this ideal learning experience could look like. These examples from humanities, arts, sciences and engineering and from introductory level courses illustrate that students do not need to be seniors to be ready for deep engagement of course concepts, deep learning, and creative synthesis.

5.3.1 Jaeger course in behavioral science

BCS152 currently is a relatively large lecture-based introductory class (ca. 105-140 students) on Language processing and language acquisition. For many students, it's the first science class they take. In addition to traditional content-delivery, the class has two major goals. First, a variety of guest lecture expose students to a representative sampling of the local expertise in psycholinguistics and related fields, allowing students to determine research opportunities to pursue in future semesters. Second, the class seeks to give students a taste of the behavioral sciences. Students read primary literature (rather than textbooks). They are also exposed the process of hypothesis-testing via experiments, both in the class and in through assignments in which students conduct their own web-based experiments.

So far, these miniature experiments make up for a small optional component of the class. However, Prof. Jaeger and his lab have developed and successfully employed crowdsourcing paradigms for the study of language processing as part of undergraduate individual study course. The advantages of this new technology are i) participant costs can be cut by up to 80%, ii) the time it takes to collect data from participants is reduced by several orders of magnitude (up to 99.9%). Previous individual study students in the Jaeger lab have presented their work at international conferences and published in high impact journals (e.g., Cognitive Science, Journal of Experimental Psychology, Frontiers in Psychology), thereby adding to their portfolio (see Section V; see also an upcoming article in Rochester's online student magazine *The Buzz*, in which two students report on the value of their experience – both now at prestigious graduate programs in the cognitive and neurosciences).

Student feedback on one of Professor Jaeger's courses, BCS 152 Language and Psycholinguistics, was positive on the clarity of lectures use of supplemental simulations, schematics, and clear explanations. Online course discussions help students ask and develop answers to the course's big questions. Students gain credit for participating in discussions. The course also uses online journal articles rather than a text, but faculty break down each article with students via presentations and discussions so that they gain understanding of dense concepts and the use of research methods in the papers.

5.3.2 Peppermint course - participatory, media-rich experience in research and practice

In the course, Nature 2.0, Professor Peppermint uses digital media and tools to guide students through a series of assignments in which students can see the world through new frameworks and lenses, critique that world and create works using course tools. The following course assignment illustrates this approach:

> **Research and Play**
> Read **"Introduction to a Critique of Urban Geography" by Guy Debord located at nothingness.org.**
>
> Go for a walk using ecoarttech's urban hiking art-app Indeterminate Hikes+ or Mark Shepard's Psychogeographical app Serendipitor. When you are done upload your newly created hike to the server. Post 1-2 paragraph response along with a link to your new hike on the class blog. Consider ways in which artistic strategies can interrupt the prescribed consumer use of new media devices and their common function as tools of communication and productivity. Questions to consider: How was this experience

different than your typical use mobile technologies? Does the app have an express goal? Did time seem to slow down? Can everyday environments be sublime?

Studio Production

1. Create your own Google map that seeks to reinvent and bring into question dominant ideas of how technologies of digitally networked mapping function. How will your map defy our expectations? Prompt us to consider our immediate environments in which we dwell? Question the popular use of new media technologies as tools for efficiency, business, communication, and production? Slow down our experience of space and time?
2. Link your completed Google Maps project to this class blog along with one paragraph that contextualizes your ideas and approach.

5.3.3 Burges course - Digital media- asking new questions, using new tools

Burges wrote: In my Poetics of Television class, I was interested in accomplishing three things: a) getting the students to really understand how the form of television works and how time on television relates to those formal workings by using digital technologies, data visualizations, and a collaborative research and writing model; b) linking these more empirical and technical methods to some of the more speculative and qualitative modes of inquiry that inform the humanities; c) involving students more directly in faculty research, at least by way of class, as a way of seeing what happens when you try that in the humanities. I have attached the prompt for the first part of the final project. There will be a second prompt, in which students are guided into data visualization and being asked to interpret what they see using some of the much bigger concepts, hypotheses, and issues we have been discussing in class itself. I want to stress that this project is a very different approach for a humanities class. Details on project: As part of the course's collaborative research project project, student groups use a new research tool developed out of an idea I had for measuring how time works on TV and what the nature of televisual time is--how it has shaped our experience of time since 1945. Students can then explore concepts from the course, and uniquely integrate quantitative and qualitative data from TV series clips they review as part of the project.

Student feedback on the Poetics in Television course experience was very positive. Students felt that they were able to deeply explore concepts and frameworks of contemporary media studies through the comprehensive lectures and discussions, and collaborative research projects using digital analysis tools, that improved learning and motivation. Students felt that the faculty supported their using the framework of poetics to analyze scenes. In all, students felt that they had productively contributed to the research project.

5.3.4 LaVaque course - Project based learning in an interdisciplinary environment

Robert Lavaque is an adjunct instructor who teaches AME193, an audio engineering course in sound design. Students take the course in a computer lab with each student sitting at a computer workstation. Mr. Lavaque, a professional audio engineer, takes students through mini class projects where students learn a concept and then immediately apply it to a problem given by the faculty. Students then analyze and compare results, discuss difficulties and misunderstandings, until everyone gets it. At that point, they move on to the next concept and mini-project. The course is a project based course where each mini project is a step toward completing the final project.

Student feedback on the course was very positive. One student mentioned that he was a music student who switched to engineering. With a moderately strong math background, the student was worried. However, the project based learning style used for the course, and linking the difficult mathematical models of audio engineering to project work, has greatly supported his understanding.

5.3.5 Computing in Class – Bringing lab into the lecture

In computer science as well as in other disciplines that involve computer simulations and computation, technology can bring the lab into lecture, allowing students to interactively try out concepts with the lecturer in class in real-time. For instance, Michael Scott of the Computer Science Department said, "When I taught CSC162 - Art of Data Structures, I kept a live Python interpreter up on the screen almost all the time. It was a small class, with a lot of discussion/interaction, and we were able to try things out -- and even debug -- on the fly. Worked well."

Jeff Bingham also of the Computer Science Department had this to add, “I encourage students to bring laptops into class in order to try what we're covering as we're covering them. For topics for which it makes sense, I'll demonstrate on my laptop as I'm covering new concepts and students will often follow along on their own. A challenge is to balance between interactivity and slowing down too much to attend to problems individuals encounter, but generally I've found this to be quite useful.”

This method has been employed to advantage in other disciplines as well, such as enabling students to conduct Matlab simulations on their own computers in Optics and Electrical and Computer Engineering lectures. We encourage wider exploration of this method and more broadly, in ways to more actively engage students during traditional of engaging students

5.3.6 Eaves course - Text and Medium: Theory of the Book and the Future of Reading

Both sections were asked to consider print literacy in the context of the digital revolution, which we explored through the history of language and communication technology. The courses were organized around a series of readings, written assignments, and projects that (usually) involved teams of 2-4 students. The most obvious additional structural feature was a “humanities lab”—which required from all students an extra 1-credit hour in a computer lab. In the lab sessions the grad students and undergrads met together for technology demos and project workshops. Sometimes the labs were used for on-campus visits to local resources, such as the Special Collections (rare books) Library or the Robbins Library, and for guest lecturers (for example, then-dean-of-the-libraries Susan Gibbons lectured on e-books circa 2009). For week-to-week reading/writing, we used a combination of Blackboard and Nfomedia (free social networking utility designed to enable blended or hybrid learning for higher education courses—which gave us a blog and journal capability that we used regularly—to share links, video clips, etc., related to contemporary debates on literacy, e-readers, the future of the book). We used off-the-shelf software—DreamWeaver, PowerPoint—to create timelines, timemaps, and manuscript transcriptions. We tried (and generally only half succeeded) using publicly available software designed for similar courses elsewhere, such as UC Santa Barbara, which offers a “toolkit” of software. Our projects included:

1. A journal

2. A class blog (an experiment in collaborative authorship)
3. An individual bio (from the perspective of the preoccupations of the course)
4. An individual media timeline (detailing the student's use of media from birth to the present)
5. Problems in writing (team project for presentation in class): chosen from a menu of options (Dead Sea scrolls, Archimedes Palimpsest, Library at Alexandria, etc.).
6. The Virtual Bookshelf (team project mapping the history of a very early printed book from then till now)

Committee members also envisioned future courses in which education technology can shape unique learning experiences:

5.3.7 Reichman course - International research site connections

Anthropological fieldwork is difficult to incorporate into undergraduate classes, because it often requires a researcher to spend a significant amount of time away from campus. What if we could use technology to bring the field to the classroom? Prof. Reichman imagines an anthropological research methods class in which students communicate with researchers all over the world electronically. Students could use Skype (or a similar tool) to observe and interact with real research being conducted all around the world, and could even become active participants in the research through online interviewing. In sum, it would be a "virtual field school."

5.3.8 Eaves course- Meeting via Skype with renowned English researchers

Actually it would be a normal subject-matter course (for example, British Romantic Literature or Radical Romantic Aesthetic Theory, both of which I'll be teaching in the spring), but it would be designed so that about once a week we would have a video conference with an off-campus expert in some aspect of our subject. For example, Morton Paley (UC Berkeley) recent published a book, *Samuel Taylor Coleridge and the Fine Arts*, and Alexander Regier (Rice) and Stefan Uhlig (Cambridge) recently edited a collection of essays, *Wordsworth's Poetic Theory: Knowledge, Language, Experience* (2010). I'd like to recruit them for class discussions on those subjects. Sometimes the video conference might involve only a single poem, passage, picture, or idea—and it might last only 10-15 minutes. Or it might take an hour, depending on the needs of the subject and the availability of the expert. But I see the technique as a useful way of energizing the classroom by opening it to the world of specialized expertise that lies beyond our local scene. Typically—I mean in such a class now--we'd read a scholarly essay and discuss it in class. With the addition of weekly video conferencing we would probably do the same, but we'd then add the opportunity to talk over the essay with the person who wrote it.

6. Digital Portfolios and the portfolio-centered curriculum

Drawing on the "Portfolio Model" proposed by Professor Mark Bocko (M. Bocko, "Portfolio Model," UR Working Paper, August 2012), we propose the integrated development of a digital student portfolio infrastructure and portfolio-worthy learning experiences in ASE. The first part of this initiative will be to design in integrated educational experiences into the Rochester curriculum that support learning and practice in and outside of the classroom that will have portfolio-worthy outcomes. The second (nuts and bolts) part of the project will provide the required resources to build and host student on-line digital portfolios - the web-

space, on-line portfolio creation tools, and any needed technical assistance. The second part of the project will support students' personal reflection on integrated learning and enable them to communicate their unique achievements to others.

Education studies of student learning portfolios have been shown to enable students to develop metacognitive skills in tracking their own learning progress. When students are able to articulate with guidance their learning goals, and choose supporting materials that illustrate progress and accomplishments, students are better able to identify areas where they need work. They are also better able to identify and articulate areas of academic and career interest that improves their engagement in academic work. Finally, when students are able to find and make connections between coursework with experiential learning opportunities, they are often more motivated and gain more confidence in their ability to progress in their field of study.

The student portfolio is not a new idea. For example, schools of Art and Architecture have always employed student portfolios to showcase their students' abilities and accomplishments. However, we believe that extending the notion of a Portfolio across all disciplines to encompass student learning development as well as finished products from a broad range of student active learning engagements in research, design projects, community service and other entrepreneurial activities broadly defined, provides a framework to support significant changes in how our students learn.

6.1 Portfolio experiences

Many of the kinds of "portfolio-worthy" experiential learning activities that would be reflected in student portfolios already exist at the UR, such as student engagement in research, senior theses and capstone design projects. However, along with the Dean's Research Committee, we propose expanding these activities in courses throughout the curricula of the majors or shared by majors, as well as experiences tangentially connected with majors or courses (see details of this proposed idea in the Dean's Research Committee Report). Doing so would support students' opportunities to related course learning with contextual, integrative experiences that are "portfolio-worthy" and which can then be further developed in a student's Digital Portfolio. As a result, in addition to the traditional transcript as a record of a student's college achievements, every UR student would also build an on-line digital portfolio to both develop and showcase his or her accomplishments.

We believe that the Portfolio framework will enable us to develop an educational experience for undergraduate students in Arts, Sciences and Engineering at the University of Rochester that achieves the following goals:

- Enables students to combine traditional and practice-driven learning experiences both in and out of the classroom to enhance student development of abilities and motivate engagement
- Enable students to explore knowledge and develop interests at the boundaries of disciplinary learning
- Enable students to integrate what they are learning in their major, clusters and co-curricular experiences so that they are able to develop learning and development trajectories shaped by individual interests
- Support students' reflection on their learning and development as they progress through their undergraduate experience

- Support their ability to communicate undergraduate achievements and distinctive knowledge and abilities to external audiences

Portfolio experiences will enable students both to learn and practice what they are learning. Such "portfolio worthy" experiences should be identified via faculty survey and at the department level; we do not presume to know what constitutes portfolio worthy experiences across all disciplines. Such experiences will be identified via faculty survey and new ones will receive curriculum and development support in the areas of:

- Theme-driven freshman seminars and projects (see ASE Dean's Research Committee proposal)
- Project-based learning throughout the four years of studies – both integrated into regular courses and in specific portfolio courses
- Co-curricular academic experiences such as volunteer work or social or economic entrepreneurship activities
- Planning of experiential learning activities in study abroad semesters – for example in addition to taking formal courses while abroad students could volunteer in a school or a social services organization, or perhaps intern a few hours a week in a company to gain a deeper experience and appreciation of a foreign culture
- Senior capstone project courses and senior theses

To make the portfolio system work will require the following:

- A pre-major advising process to support integrated learning and portfolio development – this should start in the freshman year
- A system to help students to identify co-curricular projects and build teams to pursue these projects
- A resource summarizing courses related to themes of interest – perhaps similar to our Cluster search engine

6.2 Digital portfolio system

The digital portfolio system will enable students to:

- Demonstrate their ability to master key knowledge areas and abilities of major, cluster and co-curricular activities (study abroad, internship, service learning, research)
- Provide evidence of how key abilities have evolved over time
- Develop and refine articulation of personal and professional goals and interests that may cross disciplinary boundaries
- Choose experiences that best represent personal and professional strengths and integrated interests
- Articulate and link experiences and achievements across courses and co-curricular activities
- Self-analyze and reflect; to develop their own learning curve; increase levels of self-understanding and confidence (of individual students) as well as clarity of purpose and levels of motivation (in the classroom)
- Use a wide range of digital and multimedia technologies to demonstrate technical competency and design and presentation skills; publish electronically; gain ownership

- Be more proactive in planning and pursuing their educational and post-graduate opportunities
- Secure future employment or admission to graduate school; record experiences for later, more systematic use in résumés or applications to employers or graduate schools

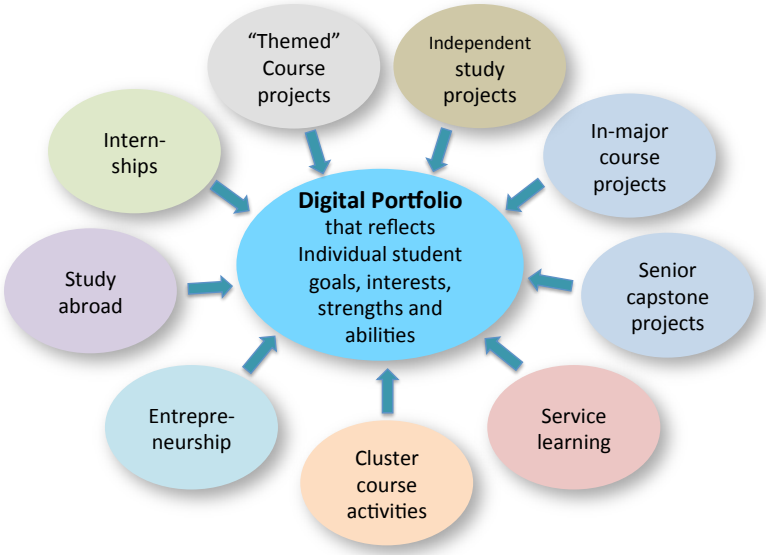

Figure 1 - Sources of Student Portfolio Content

The system will require a structured online platform that includes embedded questions appropriate to each level, frosh to senior, that students can use to develop and evolve goals and interests, choose curricular and co-curricular activities, reflect on learning, and present accomplishments. The system will also include a simple platform for students to use in mounting a variety of media and links to materials, projects, courses, or programs that represent their undergraduate ASE journey. In order to be successful, the platform must be intuitive to use (e.g., because it resembles technology and user interfaces that students are familiar with, such as Facebook). Such a platform will require resources and expertise to be developed, but it also holds the potential to become a product that other educational institutions are interested in.

There will be 2 separate sections of the portfolio for a student to use. The learning portion of the portfolio will be used by students for development and reflection. The presentation portfolio will be used for presentation of specific works for external audiences. The 2 sections will be integrated so that students can select materials from their working portfolio and move them to the presentation portfolio when complete.

Learning portfolios are shaped by several connected learning tasks including goal setting, learning, practice, documentation, collaboration and reflection. The portfolio questions will ask students about past, present and future learning goals and interests. Questions may include: What does a student want to achieve and what plan has he or she formed to achieve those goals? Over time, what has a student done to achieve those goals inside and outside of classwork? What personal, academic and professional abilities has a student focused on?

There are many tools than can be used to provide a Portfolio development platform for student use, from completely on-line web-site creation tools to off-line tools like iWeb, Rapidweaver, and Dreamweaver for which custom portfolio templates could be developed. Organization tools will enable students to design and manage their portfolio content, and organize documents as their portfolios are built. The system would be coordinated with a search tool that students can use in seeking courses or co-curricular activities in areas of interest. The tools could be designed to guide students through the portfolio building process with a series of queries and this would be coordinated with an enhanced pre-major advising process where advisors can help students develop interests and make coordinated choices.

6.3 A Specific Portfolio Example

To illustrate how the Portfolio model can be closely integrated into the curriculum of a major we give the example of the new Audio and Music Engineering program. There are portfolio-suitable projects starting with the first-semester introductory course (AME140 – Fundamentals of Audio and Music Engineering) in which students build electric guitars and amplifiers. This is followed by three audio content creation courses (AME191, AME192, AME193) in which students complete major audio recording and sound design projects. These three courses are taken concurrently with core content and skills development courses in math, science, programming and engineering science to keep students engaged in creative applications throughout their first two years. In the second two years in addition to core courses the students take 3 different 2 credit portfolio courses that are devoted to doing research and design projects in acoustics, audio electronics and digital signal processing. Student projects such as the acoustic design of a recording studio or concert hall, building a vacuum tube guitar amplifier, or a digital effects audio processor are a few examples. Students also complete a major audio software design project in another required course. In the senior year students take a one-year long capstone design course where they complete a project of their choosing. By the time students graduate they should have completed a minimum of 9 major projects including research papers, design projects, recording and other sound design projects.

Our committee encourages each department in CASE to consider adding discipline specific portfolio oriented learning experiences to their curricula. This could include the addition of new portfolio building activities to existing courses and adding new, dedicated portfolio specific courses to their majors.

7. Infrastructure: The Center for Education Innovation Initiatives

The piloting, rollout, testing and full implementation of the Education Technology Committees' learning initiatives, as well as other initiatives from the Research Committee, will require the engagement of many faculty and several units in the College. Given our goal of reinventing undergraduate education in Arts, Sciences and Engineering, yet still achieving this goal in a highly efficient and effective manner, the committee members encourage the formation of a new center, the College Center for Education Innovation Initiatives. The center would not duplicate tasks or personnel from various other college or departmental units, but rather it would oversee and coordinate targeted project teams composed of faculty members, learning and assessment specialists, experiential learning units, and technical support specialists to plan, organize and conduct new courses, other new learning activities and to develop new

learning tools proposed in the committees' reports. In this manner, the committee members feel that the goals will be best achieved. Moreover, the committee members feel that this model ensures a deep level of faculty oversight and participation as well as ensuring that appropriate resources, both financial and personnel, will be most productively deployed.

We envision a Center with a physical space a Director and a small permanent coordinating staff to bring together faculty and staff members as needed for specific projects, which may last from several weeks to several semesters. As needed for larger projects staff could be "loaned" to the Center, either entirely or in part, and with explicit relief of some or all of their other duties. A strength of this model is that it will enable us to draw on a larger group (The College) to identify staff members with the most appropriate skill set for specific initiatives. Furthermore, the majority of the staff working in the new Center will be changing continuously - as projects change, which we believe is important to maintain a fresh, innovative atmosphere within the Center.

The tools available at the Center will include resources for video and image capture and creation, tools to develop web-based materials, and access to alternative learning management systems that support more pedagogical formats than Blackboard is currently capable of providing. In addition, the center will offer seminars on the use of technical tools to support student learning as well as on-line resources with examples of model courses and other instructional materials. Over time the Center will build a library of materials such as: a searchable library of digital materials (case materials, video modules on specific topics, practice problems and tests, simulations, data sets, and course projects) organized by discipline, theme, learning objective, and type of material.

All faculty interviewed for this project noted the significant difficulty in the individual effort needed to get these education technology-enabled courses off the ground. One faculty did all of the work himself. Another realized the value of hiring a talented professor of practice to enliven the real world and practice driven aspects of creative synthesis in audio engineering. In all, a curiosity by faculty made the effort worth it, however, most noted that having a trained instructional and IT staff would have made the effort less onerous and would dramatically increase the likelihood that other faculty will participate in similar efforts.

The topic of faculty incentives has been touched upon above, however our committee has discussed the specific resources and accommodations that we believe would be required to encourage faculty to participate. Although many of these needs have been mentioned above we have compiled the following concise list.

- Technical assistants to help manage and set up new courses and other learning mechanisms
- Programmer resources, perhaps managing a pool of student-programmer workers.
- A physical location to go to, meet with project teams, and work together on courses and other activities
- Ample, accessible server space that is easily accessed and managed
- A stipend and funds for the purchase of technology required for the development of pilot courses.
- Faculty release time to devote to innovation center projects
- A stipend and funds for the purchase of technology needed to

integrate amazing pilot course examples into one's own course.

- Finally, there must be professional recognition and rewards (tenure, promotions and raises) for faculty who spend significant time and effort in these initiatives. This may require a fundamental re-calibration of the expectations for tenure starting at the departmental level.

7.1 Request for Proposal Process

There should be a request for proposal each semester to enable faculty to propose new projects. The Center would set up a mechanism to solicit and evaluate proposals and a budget to support selected projects. To encourage faculty participation the initial proposal should be no longer than a single page!

8. Creating an environment to encourage faculty participation

We are not proposing that the University of Rochester be transformed into solely a teaching institution, far from it. Rather, we envision creating an environment in which faculty can achieve a balance between research and teaching, where faculty research informs and inspires teaching and the creation of learning opportunities, where faculty remain dedicated to expanding the boundaries of knowledge in their fields, but also are motivated to share the excitement and satisfaction of research by engaging students in scholarship and learning in a variety of ways, and where students gain a deep appreciation of life-long learning through experiences only possible in an integrated research and learning environment.

We believe that there are three central requirements to create an environment in the College that will inspire and encourage technology-enabled innovation in teaching and learning. These are,

I) To articulate a clear vision and a shared institutional mission to creatively employ new instructional technologies to provide distinctive and superior learning experiences for our students.

II) To build a culture that demonstrates the College's commitment to this vision by providing recognition for outstanding faculty accomplishments in teaching and learning in terms of tenure, promotions and compensation that is equal to that afforded to faculty accomplishments in research.

III) To provide the infrastructure and support needed to amplify the efforts of faculty in technology enabled teaching and learning initiatives.

Clearly, there always will be a range of faculty interests and focus spanning the spectrum from teaching to research and faculty members who are inclined to remain focused on research obviously should continue to be encouraged and rewarded. However, the institution also should encourage and reward faculty who wish to devote more of their effort to improving teaching and learning for our students, especially in new programs and projects that employ technology in innovative ways, are extensible and will have institution-wide impact.

We propose the following specific mechanisms to inspire and support this change.

1. This was discussed above in Section 7 above, but it bears repeating that we must make it easier for faculty to undertake technology inspired learning initiatives by providing the

required staff and infrastructure support. Infrastructure needs may run the gamut from very small-scale individual assignments/projects within courses all the way to entire courses or groups of courses needing such assistance. The former may require the technical assistance of a capable staff person for only an hour or so, but help may be needed right away, which points to the need for an easily accessible campus resource staffed by knowledgeable individuals. More comprehensive projects, such as creating new on-line learning resources for a large introductory course, may require the continuing assistance of a team of specialists with expertise in learning, IT and web programming, and content management. The needed staff could be assigned to these *ad hoc* teams for the duration of the projects, and their other workload should be reduced to enable them to make such projects their priority. Participation in such initiatives must be regarded as more than just extra work and staff members should be recognized and rewarded for their contributions to these innovation teams in terms of compensation, advancement opportunities, publications, and opportunities to attend professional conferences.

2. Create a number (perhaps 10-15) of Distinguished Teaching and Mentoring Professorships in the College. These would be named in recognition of innovation and artistry in teaching, to recognize faculty who integrate their research and teaching activities in innovative ways, and to recognize faculty who mentor significant numbers of undergraduates in research and project-based learning opportunities. Making innovative use of technology to improve the effectiveness and efficiency of teaching would be a particular area of emphasis in these selections.
3. In addition to the great two-way academics who do full-time research as well as teach, UR also creates professorial slots for PhDs who have chosen to focus their talents on training students in their fields of expertise. Such professors naturally will be more able to embrace new teaching-and-learning methods, to the immediate benefit of their students and to the eventual benefit of the entire faculty, who can emulate their pioneering efforts.
4. Create a number (15-25) of research/teaching Ph.D. fellowships. These fellowships would be awarded to Ph.D. students interested in pursuing academic careers and would provide support throughout their studies (5-6 years). In addition to pursuing their research, fellows would contribute to new learning initiatives throughout the course of their Ph.D. studies. It is natural to assume that students applying for these fellowships would be motivated to work with faculty who are educational innovators, so perhaps their advisors would be the chaired Distinguished Teaching and Mentoring Professors. It's important that the Ph.D. fellows be involved in truly innovative and forward looking projects, not just relegated to conventional teaching duties for the duration of their studies.

Appendix - Proposed Pilot Projects

The following list describes a number of potential pilot projects, their anticipated impact and the resources required by each project.

Pilot Project #1

Development of the Digital Portfolio Infrastructure - In this proposed project we will build the infrastructure required to support student digital portfolios. This will include the design of a hosting website, templates, and access to computer based production tools for video, audio and other portfolio content to make it easy for students to create online portfolios with a consistently high-quality look and feel. The infrastructure needs for ongoing web-site maintenance and upgrades to keep archived portfolio content accessible will be addressed as well. The new Audio and Music Engineering major fully incorporates the Portfolio concept into its curriculum with 9 major project opportunities distributed throughout the students' four years of studies. A representative from AME and any other majors/departments interested in participating in this pilot, such as the new Digital Media Studies major, would form a working group to direct this development.

Potential long-term impact – The infrastructure developed in this project will be useable by other departments as they bring more Portfolio directed elements into their majors.

Required support – IT staff support to help design and set up the portfolio web-space and select and/or develop the tools for students to create portfolio entries. The build-out duration will be 1 year with ongoing staff support required afterward.

Pilot Project #2

Formation of a desktop video capture learning group – A group of instructors (the target number being about 10) will be formed to explore how short video tutorials produced with personal desktop software such as Panopto, Camtasia, or other destop/laptop or tablet programs can be employed to augment/restructure their Fall 2013 courses. The group would be formed by the end of the Spring 2013 semester from interested and committed parties. Faculty would be trained by a learning specialist/consultant during a few early-summer workshop sessions. A central aspect of this proposal is that the group would hold regular meetings during the summer and fall for idea exchange, feedback, and support, both technical (recording, uploading) and pedagogical (how to use freed-up class time, how to get students to watch the videos). At the end of the semester, the group would make a campus-wide presentation about their experiences.

Potential long-term impact - (a) Informal: having 10 instructors from a variety of departments would cause many other faculty to hear about the approach and consider trying it. This is how the method has spread at other schools (e.g. Stanford). (b) Formal: the program could be repeated the next semester (or next year) with another 10 instructors.

Requested support - Teaching/learning specialist for the summer training and ongoing participation in the support-group meetings, Software licenses and electronic tablets or laptops for 10 faculty, Technical support person to build the online resources to host the videos.

Pilot Project #3

Undergraduate learning through participation in the development of digital archives for the humanities - We propose to expand undergraduate participation in the development of digital archives for humanities scholarship. This is a concrete example of how students can learn by doing in the humanities. In this pilot project a team of undergraduate students will work closely with graduate students and faculty to contribute to the development of the Blake Archive. With clear goals for the semester, the group would hold weekly meetings using an each-one-teach-one system to learn the required tools and methodologies for the project, track progress and address problems as they arise. The student-produced outcomes of this activity will be lasting contributions to humanities scholarship that can be reflected in student portfolios.

Potential Long Term Impact – The lessons learned from this pilot project will provide an extensible model for project-based goal-directed, collaborative student learning.

Requested Support – Graduate assistant support and technical/content support staff time.

Pilot Project #4

Applet-writing collaboration – In this project, instructors of various classes would be "customers" who supply ideas for educational applets (like the influential ones from the University of Colorado in a variety of science subjects). The "workers" would be students in an upper-level-undergraduate or graduate-level computer science class, guided by an instructor with expertise in creating applets. Faculty would submit ideas prior to the semester, justifying how the applet would be used in their class (e.g. as a simulation tool for a scientific phenomenon being studied analytically in lecture). Student teams would select ideas and work with the professor to create the applet as a semester-long programming project. The applet would then be incorporated into the faculty member's class the next time it is offered.

Potential long-term impact - This proposal gives experiential learning opportunities to the students and an educational tool to the instructor. The course could be offered every semester. All of the applets could be pooled at a UR-sponsored site to increase the prominence of the overall effort (as is done at Colorado) and to disseminate the results.

Requested support - Instructor of the course (possibly adjunct, possibly from the existing CS faculty), computing resources (probably already extant, as the platform would be freeware).

Pilot Project #5

Conduct a trial MOOC – We propose to design and run a trial MOOC (Massive Open Online Course) in one of the UR's signature areas such as Optics, or Audio and Music Engineering - but of course this opportunity should be open to any interested and committed faculty members. As one possible example – we imagine redesigning the course AME140 - Fundamentals of Audio and Music Engineering so that the bulk of the course material will be available in short (~10 minute) video tutorials and perhaps in interactive on-line book format. The course would consist of a limited number of keystone lectures (avoiding the talking-head production style as much as possible!) that dovetail with the short video tutorials along with problem sets and mini-projects.

Potential long-term impact - We believe that designing and conducting a MOOC would be a valuable learning experience for our institution as well as an excellent means to showcase some of our unique programs and to recruit students.

Requested Support - A full-time graduate teaching assistant for one year to assist in the preparation of the videos and other course materials. A teaching/learning specialist to assist in the development of pedagogically effective video content, and the assistance of a technical resource person to assist in the creation of the videos and for building and maintaining the online course.

Pilot Project #6

Blended learning course development project – A group of 5-10 faculty will work with the Director of Education Innovation and Assessment in a workshop extending over several weeks during Summer 2013 to develop new or revised courses in which learning technology tools are used to integrate active and collaborative learning pedagogies into their courses. The group will explore a variety of course examples in depth to understand what did and did not work in the technology/pedagogy blended course design. Faculty will then work with the Director to define learning objectives and to design portions of their own courses employing appropriate integrated technology/pedagogy types. Examples of the types of technology/pedagogy that will be explored and developed include: flipped classroom segments (creation of video lectures/other materials and structuring in class time), online discussion blogs, video modules (for explaining particularly difficult methods or concepts and connecting these to class or workshop problem solving sessions), project based learning (where project work is connected to online collaborations with distant teams or communities). At the conclusion of the summer workshop faculty will have developed the required materials for use in their AY2013-14 courses.

Potential long-term impact - Participants will develop pilot courses for UR students. This model, repeated each term, will train and support faculty in the creation of blended learning courses, which promise to be both more effective learning experiences for the students and more efficient in terms of faculty time. Detailed assessment will be completed.

Requested Support – Director's time, faculty participant summer stipends, laptop computers for faculty use as needed, online course tool licenses, technical support as needed.

Pilot Project #7

Flipped classroom course development project – A group of 5-10 faculty will work with the Director of Education Innovation and Assessment in a summer workshop extending over several weeks in Summer 2013 to develop new or revised courses in which the entire course employs a flipped classroom model. The group will explore a variety of course examples from other institutions to gain an understanding of the flipped classroom model. The group also will learn about and practice with online tools for developing and mounting video lectures/materials and how to structure in-class collaboration time. The group will then develop a course with clear learning objectives and use these to structure a flipped classroom course. At the conclusion of the summer workshop faculty will have developed the required materials for use in their AY2013-14 courses.

Potential long-term impact - Participants will develop pilot courses for UR students. This model, repeated each term, will train and support faculty in the creation of flipped classroom based courses. A detailed assessment will be conducted.

Requested Support – Director's time, faculty participant summer stipends, laptop computers for faculty use as needed, online course tool licenses, technical support as needed.

Pilot Project #8

Suite of online teaching and learning tools for calculus - Spring 2012 research at UR on identified weaknesses in student learning and performance in calculus. The research also identified areas where the current calculus lecture and homework curriculum could be improved and target those identified areas of student learning and performance weakness. To address these areas, a suite of tools would be developed to complement the existing online problem delivery tool, Webworks. The proposed suite of online learning tools would complement the currently used Webworks problem system rather than replace it. Director of Education Innovation and Assessment will develop, in partnership with the Math department, a complementary system of tools, including lecture capture and tagged analysis of lecture content, video modules that focus on specific calculus problem solving methods and application, and applications driven problems that connect calculus methods to engineering, science, and economics problems. Masi will work closely with the UR math faculty who developed Webworks so that complementary online learning tools are seamlessly integrated with the power and structure of Webworks. The suite of tools would be structured into an online learning tool system so that lectures, video models, Webworks, and problem solving method are presented with clarity in support of student learning and performance. The basic platform structure will be used as the basis for development of online learning tools in other UR gateway courses at UR.

The learning tool platform will be developed so that it provides a "baseline" format for use in many UR gateway / introductory courses. The structure will include organized sections for lecture capture with tags, video modules targeted to specific problem types and methods, and modules that help students link current higher level problem to basic high school level content and problems. Online problems for students to work on will be designed to guide student learning from simple to complex problems.

Potential long-term impact - Project would impact all students in calculus courses.

Requested Support - $50K annually for 2 years, shared with math department

Pilot Project #9

Suite of online teaching and learning tools for biology - Director of Education Innovation and Assessment's Spring 2012 research at UR has identified specific areas of weakness in student learning and performance in Biology course, BIO 110. The research also identifies areas where course innovations could be targeted at those areas of weakness. The director will work with Biology faculty in development of a suite of online learning tools that complement current lecture and workshop model so that the online tools developed are targeted to areas of student learning and performance weakness. Online tool platform will follow the clarity of online learning tool structure developed in the calculus learning tool project proposed above.

Potential Long term Impact - Project would impact all students in biology courses.

Requested support - $20K annually for 2 years, shared with biology department

Pilot Project #10

Enriching introductory Social and Behavioral Sciences classes with a lab based component - With appropriate technical and financial support, a software suite could be developed that supports a variety of web-based experimental paradigms with a sufficiently user-friendly interface, further reducing the learning curve and costs associated with providing students with a first-hand experience in the behavioral sciences. With such online-learning technology, BCS 152 and similar introductory classes in the social and behavioral sciences could be enriched with a lab-based component (this component could be optional for those students who decide that this is the topic that they seek more authentic and applied experience in).

Potential Long term impact – Development of a new and more engaging model for introductory courses in the social and behavioral sciences that better ties research to course learning. The software suite developed in this pilot will be useable by similar future endeavors.

Requested support - The required support would include technical support for the development of the paradigm and the design of this new type of class (e.g., through the proposed *Learning Support Center*, cf. Section VI) as well as financial support (e.g., participant costs; development and maintenance of the technology.

Pilot Project #11

Formation of Courses for Visualizing and Interpreting Big Cultural Data in the Humanities – We propose to develop courses that allow students to participate in humanities scholarship trying to visualize and interpret big cultural data using digital tools and computational knowledge (e.g., quantitative studies of trends and genres in literary history; mapping projects around shifting "social networks" over time across cultures; projects organized around producing statistically significant data about and abstract representations of data from the history of cinema and television). In this pilot project, undergraduates would work in research collectives in specific courses guided by faculty and graduate assistants to gather, visualize, and interpret data that allows them to compare qualitative and quantitative modes of inquiry, and that allows them to run experiments that test prevailing conceptual assumptions in humanistic fields such as English, History, Anthropology, Art History, Music, and Film and Media Studies. For example, in Burges's Fall 2012 course "The Poetics of Television," students gathered over 20,000 data points from 28 television episodes about how time works on TV—a project that will be expanded in two future courses should sufficient support be found. Run using a systematic and repeatable model, such courses have the potential to involve undergraduates in the bigger research picture at a major university as they participate in the gathering and interpretation of big cultural data that will be useful to scholars at and beyond the University of Rochester. Such courses also encourage in students a deep synthesis of concrete research and conceptual aims within the parameters of the class.

Potential Long Term Impact – The lessons learned from this pilot project will provide an extensible model for project-based goal-directed, collaborative student learning. It also creates value around research happening at the university for the students by asking them to think creatively about how to talk about and interpret data, and by directly involving them in bigger research projects.

Requested Support – Graduate assistant support and technical/content support staff time. Purchase of technologies and server space for the management of the data assets over the long term so that the research can be appropriately curated by individual faculty and/or by the university. Classrooms that enable the kind of work described.

Pilot Project #12

Formation of Courses that Prepare Students for Multi-Modal Presentations of Research – We propose to develop courses that allow students to develop the skills to present research in a multi-modal—written, oral, and digital—form. These might function on the model of writing courses that teach students the conventions of academic discourse, with the multi-modal classes organized around interdisciplinary issues that demand that students consider how to speak to a number of audiences using a number of media.

Potential Long Term Impact – Students who are better prepared to present fluently and synthetically about a range of issues in the multiple modes that both the university and the world demands of them. The development of expert instructional staff that teach these courses effectively with students' academic and professional futures in mind.

Requested Support – Instructional staff and technical/content support staff time. Classrooms that enable multi-modal classes to function effectively.

Pilot Project #13

Development of Services Catalog Infrastructure - Create an infrastructure for capturing, cataloging and presenting information about services available to students and faculty. The infrastructure can be used to capture services information in various domains such as technology support, facilities, research, instructional design, advising etc. Once captured this information can be presented by user, by location, by stage in the lifecycle or just by need. Information can be made readily accessible and searchable.

Pilot Project #14

Development of Technology Solutions Center - A physical space that faculty, staff and students can associate with getting technology solutions. This office will be staffed with 2-3 people who understand the breadth of technology solutions in the Higher Educational domain. These staff will act as interpreters/analysts to review user needs, to provide users with technology solution options and make sure the users understand how these solutions can be used effectively. The staff will also document the needs and engage the appropriate teams with expertise to implement the components of the solution set. They will also serve as a conduit between the user and the technical teams and will ensure communication of status and any changes going both ways.

Pilot Project #15

Portable Research Project Funding - One of the more radical proposals came from a student; this was to give students portable research/project funding (which actually is done now) but to allow a portion of those funds to go to faculty members as discretionary funds to incentivize the faculty to create and oversee research opportunities for the students. This would constitute a sort of open market research/project system driven by student interests and feedback.