Systems Thinking: A High Productivity Academic Platform for Innovation and Assessments in Mid-Size Universities

Ravi Shankar
Center for Systems Integration
Florid Atlantic University
Boca Raton, FL

I. INTRODUCTION

Engineering colleges are continuing to graduate students who are ill equipped to adapt to, and thrive in, the 21st century with its networked knowledge economy and a work force that is diverse, global, and multidisciplinary. This disharmony derives from university metrics for faculty members. Metrics drive performance. Faculty members are mainly evaluated on research and teaching (R&T). The well-established metrics for R&T do not provide incentives to tackle real-world complex issues and cutting-edge engineering designs. Failure is not an option; only successes count. There is no reason to undertake hands-on, practical and time-consuming engineering projects. Our students, however, sorely need this mentoring from the faculty members. The society needs this issue to be addressed for our economic welfare and continued leadership in technology and innovation. To address this dilemma, we could look to the third dimension of annual faculty evaluation, viz., service. The service component is currently under increased scrutiny by external auditing entities. We present here an academic platform which can be used to redirect such auditing to identify metrics for use in the service category of faculty evaluation which can motivate some of the faculty members to undertake project oriented courses that can further benefit both students and the society.

II. BACKGROUND

Motorola funded us during 2003-2008 at $1M+ to explore ways to radically increase engineering design productivity. The lessons learned helped us create project based courses in areas of high job growth, viz., smart phones, autonomous robotics, and intelligent web technologies. Careful adoption of the best practices led us to formulate level-appropriate courses to high school, undergraduate, and graduate students, that together help develop marketable applications. Engineering graduate students formed new components; undergraduate students (from engineering, arts, business, and anthropology) prototyped Apps using these components; and high school students creatively extended these prototypes to marketable Apps.

III. THE PLATFORM

Complex system design today is facilitated by concepts of model driven architecture (MDA), agile practices, and object oriented design (OOD). We adopted these and other key concepts, viz., design reuse, incorporation of standards, the separation of concerns, concurrency, and open source community support. Table 1 below shows how we mapped these various technological concepts to advantage in the academic course sequence. A microcosm of the real world was created. Faculty members, mentors, and judges were chosen from various professional backgrounds to make the experience realistic. Our undergraduate courses have involved students and faculty members from different colleges [1], and can easily extend to include others (from nursing, urban planning, medicine, education, etc.,) as App content providers.

IV. PILOT STUDIES

We set up this flow to educate and train students at various levels in various areas of high tech, with the intent to help them acquire advanced knowledge, work in teams, solve problems, gain confidence, and find a good job match. The university gains a pipeline of engineering products that are potentially marketable. We have trained 450 students over the past three years on smart phone app development using Google's Android open source tool suite and phones. A total of 26 marketable Apps have been created. Figs. 1 and 2 included below represent two very different Apps prototyped during our 2012 course offerings.

Fig. 1 shows a nutritional adviser App for young children, disguised as a game. This was a close collaboration of a graphics major with background in health and nutrition, and two engineering undergraduate students. The final paper will document more details on the various fun and social games, and medical Apps developed during the various semesters in the past. Similar course sequences have been instituted for robotics and web applications [2, 3]. We plan to market Apps created by our high school students. Several of their marketing videos are to be found at two of our references [see faculty web pages listed under 1 and 2].

Figure 1: Healthy Kid App, created by a group of engineering and graphics students.

Fig. 2 is from a multi-disciplinary group of 8 comprised of business, graphics, engineering, and anthropology students whose App helps the user make a surreptitious call to the local emergency service provider (for e.g., the campus police) when under a threat of bodily harm. The call is initiated with a sequence of pushes on the power button, which one can launch while the phone is in one's pocket. This group has launched a business to refine the App, customize, & market it to various college campuses. It has already attracted funding. The university may file for a patent on this invention.

Figure 2: Campus Emergency Alert App, an innovation from a group of undergraduates from engineering, graphics, business, and anthropology.

V. METHODS

We suggest that this platform be targeted at mid-size public universities which are now being faulted for not showing excellence in either research or teaching. However, their infrastructure and the faculty ranks do not permit them to focus on one at the expense of the other. Research-oriented universities tend to have state-of-the-art infrastructure and be well-funded to conduct research and advance technology. The Research Impact metric will continue to be well met by such universities [4]. Teaching-focused universities tend to have student-centric faculty members who can rank high as effective teachers [5]. It is the mid-size public universities that seem to be facing headwinds as they try to sort out what their mission and goals ought to be. We propose that such universities focus on excellence in service and identify metrics that show proof of that. We present here an academic platform that can help reason about various faculty service metrics and develop assessment strategies.

VI. POTENTIAL METRICS

First, we will present some obvious candidates for this. One could track, for example, the graduating students and determine their impact on the society. The impact could be measured in terms of their job placement, advanced education, small business formation, patents, awards, etc., on an annual basis. Professional judges can provide feedback on a semester-by-semester basis on the effectiveness of the program and the courses undertaken. Continuous improvement strategies can be evaluated. Marketing of products from the university and revenue generated from that can be another metric. While these ideas may seem reasonable, there are many objections and logistical difficulties in implementing these. We therefore propose the use of Criteria 3 for Student Outcomes from ABET, the engineering accreditation board, as the framework for developing service metrics [6], for engineering faculty members. We expect that similar accreditation schemes for student outcomes exist in other disciplines as well, which can be adapted to evaluate faculty members in those disciplines. Table 2 below lists the ABET Criteria 3 (a) to (k) and indicates how they also represent service metrics for faculty members. This has been presented to initiate a discussion and is no way considered to be thorough and complete.

VII. DISCUSSION

In this paper we have shown feasibility of the whole flow for mentoring and successfully completing student team projects that span multiple disciplines and colleges. This forms the academic platform that can be used to build a close knit community of faculty members and students at a mid-size university that is responsive to trends and changes in the social, technological and other contexts, so our students are always cognizant of the right opportunities to embrace and benefit from. We hope other innovators and practitioners will get involved and refine the concept. Our proposed flow does not preclude those faculty members who still wish to pursue excellence in teaching or research. However, if a reasonable portion of the curriculum can be transformed to address such a new arrangement, perhaps with the help of local businesses (engineering and non-engineering), then a useful model can evolve in the longer run to address US competitiveness and job market needs. This matches well with the desire by the US Federal Government to emphasize the growth of high-paying

Table 1: Mapping of Technology Concepts to Academic Course Sequencing

Technology Concept	Purpose	Academic Mapping
MDA (Model Driven Architecture) and OOD (Object Oriented Design)	Abstraction to Implementation in a structured and organized manner	Typical flow for undergrad and high school students: Story Boarding → MVC (Model View Control) Pattern → Android APIs → Java code
Design Reuse	Use of pre-existing and a priori designed modules and components to build ever more sophisticated applications.	Open Source tools provide a rich array of API libraries. Our engineering graduate students also build more advanced components
Adoption of Standards	Decision on currently popular standards and potential future standards, to provide a stable environment for experimentation	Java and XML are extensively used. Our analysis 3 years ago also showed that Android would garner a major market share. It is free and easy to use and integrates well with Java and XML
Separation of Concerns	Separation of the development efforts of reusable component libraries, platforms, prototypes, and Apps will optimize the process by matching the needs to the right skill sets of the engineers.	Graduate students build components and platforms; undergraduate students from multiple colleges develop App prototypes; and high school students transform these prototypes to marketable Apps.
Open Source tools and languages	Access to the code and architecture of the tools, and experiences and support of the open source community help the user learn the flow faster.	Our students use Android for smart phone Apps, Arduino for robotics Apps, and Jena and other related tools for semantic and intelligent web Apps. Eclipse IDE (integrated development environment) is used across all the courses. Our websites provide transparency on our efforts.
Concurrency	When properly managed, concurrency yields improved performance at reduced cost. Specialized modules for signal processing or communication allow the main processor to off load some of the functionality that is better suited to other modules	Our App prototyping at the undergraduate level involves concurrent and synergistic course offerings in arts, business, engineering, and sociology. Teams of students from all these disciplines together build sophisticated prototypes.
Time to Market	Availability of libraries of components, platforms, and prototypes makes it easy to develop targeted products faster at lower prices	We have 26 marketable Apps arising from these courses. They are well targeted to the teen market as they were created by teenagers.

Table 2: Potential List of Service Metrics for Faculty Members based on ABET Criteria 3 [8]

Criteria	ABET Student Outcome Description	Faculty Service Metric
(a)	An ability to apply knowledge of mathematics, science, and engineering	Authoring of domain-specific review papers and tutorials
(b)	An ability to design and conduct experiments, as well as to analyze and interpret data	Mentoring impact: Evaluation of student team projects by a group of judges from professions in domains represented in those teams
(c)	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	Industry work: From summer jobs / contracts with local or national level companies/ R&D Labs. A deliverable that is published in a practice oriented journal/conference
(d)	An ability to function on multidisciplinary teams	Evaluation by Judges as with (b) , of the faculty team that facilitated the conduct and performance of student team projects
(e)	An ability to identify, formulate, and solve engineering problems	Uniqueness and originality of the individual team projects advised.
(f)	An understanding of professional and ethical responsibility	Transparency of the results achieved; evaluation by the peers in the domain and on the faculty team
(g)	An ability to communicate effectively	Domain specific teaching evaluations by the students
(h)	The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	Cross-disciplinary publications; participation in student-led and other small businesses; and Patents.
(i)	A recognition of the need for, and an ability to engage in life-long learning	Creation of Web sites that provide state-of-the-art information, tutorials, and student designs and documentations
(j)	A knowledge of contemporary issues	Community service with local non-profit entities from a domain perspective.
(k)	An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	Presentation of Workshops and Tutorials at Technological and Educational Conferences

STEM (science, technology, engineering, and mathematics) and STEM-related jobs in the US and build an infrastructure to address that need [7]. As an example of STEM-related jobs, there is increasing appreciation of the role of Arts in STEM disciplines [8, 9].

VIII. CONCLUSIONS

Performance is driven by metrics. We have developed an academic platform that can permit us to discuss and evolve metrics for the service component of faculty evaluation. This will help us define a third kind of an US University with focus on service to both the business and the lay community. This has potential to involve all colleges and departments in inter-disciplinary collaborations both at faculty and student level, to take full advantage of physical proximity of experts in various fields.

IX. REFERENCES

[1] FAU, Website and Faculty Summary Page on Android courses, http://faculty.eng.fau.edu/shankar/research/smart-phone-apps/ and http://android.fau.edu/ , Retrieved on 10/13/2012.

[2] FAU, Website and Faculty Summary Page on Robotics courses, http://robotics.fau.edu/ and http://faculty.eng.fau.edu/shankar/research/robotics/ , Retrieved on 10/15/12.

[3] FAU, Website on the Semantic Web course, http://semanticweb.fau.edu/ , Retrieved on 10/15/12.

[4] M. Klumpp and S. Zelewski, S, "Productivity Indicators in Higher Education," in Proc of the 14th Inl Conf on Concurrent Enterprising, 2008.

[5] D.E. Hall, "Interviewing at a Teaching-Focused University," The Chronicle of Higher Education, http://chronicle.com/article/Interviewing-at-a-Teaching-/45217/ , May 28, 2003, retrieved on October 26, 2012.

[6] ABET, "General Criteria 3. Student Outcomes." ABET website, http://www.abet.org/engineering-criteria-2012-2013/ Retrieved on October 26, 2012.

[7] US Department of Commerce, "The Competitiveness and Innovative Capacity of the United States," Report prepared by the US Department of Commerce in collaboration with the National Economic Council, January 2012, http://www.commerce.gov/sites/default/files/documents/2012/january/competes_010511_0.pdf , Retrieved on October 26, 2012.

[8] K. Chayka, "Can the U.S.'s Science Education Initiative Succeed Without the Arts? A Growing Chorus Says No," Blouin ArtInfo, http://www.artinfo.com/news/story/820916/can-the-uss-science-education-initiative-succeed-without-the-arts-a-growing-chorus-says-no, International Edition, August 23, 2012, Retrieved on October 26, 2012.

[9] S.R. Pomeroy, "From STEM to STEAM: Science and Art Go Hand-in-Hand," Scientific American, http://blogs.scientificamerican.com/guest-blog/2012/08/22/from-stem-to-steam-science-and-the-arts-go-hand-in-hand/, August 22, 2012, Retrieved on October 26, 2012.