MUSE – Multi-University Systems Education Mini-Workshop

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Abstract – **This mini-workshop will thoroughly explore the MUSE instructional method that emphasizes systems thinking and that creates a learner-centric environment appropriate for today's engineering students. By tapping unique expertise at multiple institutions in the timely area of wireless sensor networks, implementing an inverted classroom instructional method, and involving open-ended, hands-on experiences, the MUSE approach has been shown to provide a unique pedagogical experience. The mini-workshop will not only present the MUSE approach and results to date but also is designed to encourage participants to develop new MUSE collaborations based on other complex-engineered systems.**

Index Terms – Communication systems, Wireless networks, Systems engineering, Systems thinking, Complex engineered systems, Tablet PC, University partnership.

INTRODUCTION

This century's problems—energy production and climate change, declining civil infrastructure, plummeting biodiversity, and uncertain supplies of potable water and food—pose unprecedented scientific and technological challenges. There is growing recognition that if these complex problems are to be tackled successfully, innovative approaches are needed to educate engineers with new and different skill sets and attitudes. MUSE (Multi-University Systems Education) is an NSF-sponsored CCLI project that has been developing a new approach to engineering education so that graduates are better prepared to addresses such problems head-on. The approach emphasizes *systems thinking*, a set of skills rarely taught in undergraduate engineering curricula, and only learned sporadically and informally in graduate school or industry. Systems thinking centers around the ability to conceive and design complex engineered systems—the very systems that will be needed to solve the aforementioned problems. These systems tend to be multi-layered and multi-faceted, with distributed interacting components requiring interdisciplinary thinking across multiple levels of abstraction.

The MUSE project has thus far involved five Universities and has focused on developing systems thinking skills in the context of wireless sensor networks (WSN). Such networks will be a critical component of a wide range of complex-engineered systems, especially when extended to systems that not only sense, but also perform autonomous or semi-autonomous inference, decision-making, and control or actuation. WSN directly incorporate almost every sub-discipline in electrical engineering, computer engineering, and computer science, from transducer technology to human interface design and furthermore must be designed to meet a variety of operational constraints that vary by application (Fig. 1).

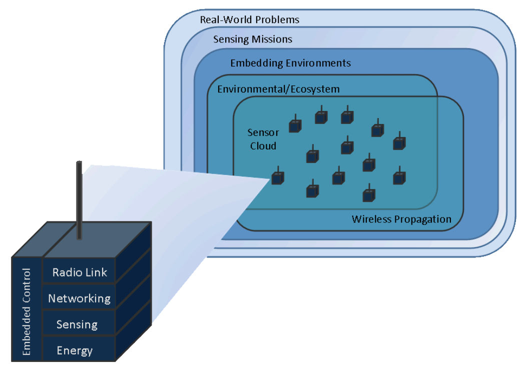

FIGURE 1
WIRELESS SENSOR NETWORKS AS AN EXAMPLE OF A COMPLEX ENGINEERED SYSTEM

The mini-workshop will use our results to date as a case study to encourage open discussion about: (1) curriculum development that is centered on systems thinking; (2) multi-instructor and/or multi-institution collaborations; (3) methods and successes in the use of alternative delivery approaches, such as hybrid on-line/in-class techniques that facilitate flexible use of material across multiple traditional courses; and (4) the integration of hardware and software hands-on projects that address systems-centric learning.

MINI-WORKSHOP OBJECTIVES

This mini-workshop will present a model for a new approach to learning that combines innovations in content as well as delivery. Key objectives are:

- To increase awareness of the importance of systems thinking in engineering education

- To demonstrate how to expose students to exciting real-world systems that motivate study of fundamental concepts
- To illustrate how to weave seemingly disparate disciplines in the study of complex engineered systems
- To motivate adoption of the MUSE approach in other engineering disciplines
- To leverage audience participation with an active question-answer format and hands-on activities to significantly enhance the potential outcomes of this session

MINI-WORKSHOP AGENDA

Six components, each lasting ~15 minutes:

1. MUSE Course on Wireless Sensor Network Design

Facilitators:
Paul Flikkema (Northern Arizona University - NAU)
Tom Weller (University of South Florida - USF)

The understanding of complex-engineered systems requires both students and instructors to reach beyond the boundaries of traditional courses and specialized expertise. We will kick off the workshop by discussing the motivation for using wireless sensor networks as an example complex-engineered system and how we wove together traditionally stove-piped topics found in separate courses into a single semester-long offering.

2. Discussion

A key objective of this workshop is to encourage participants to identify and begin to develop MUSE spin-off collaborations. As noted, many current societal problems will rely on complex-engineered systems to address them. Each of the systems could form the basis of a new MUSE track. Examples include: power systems, environmental systems, transportation systems, and bioengineered systems. During this portion of the mini-workshop we will engage the audience to identify these and other areas and will regroup the participants according to the topics identified.

3. Multi-University Course Development and Assessment

Facilitators:
Jeff Frolik (University of Vermont - UVM)
Carol Haden (Magnolia Consulting)

This portion of the workshop discusses the means by which content was developed across universities to support a single MUSE course in wireless sensor networks. The approach involves developing online video lectures using Tablet PCs and Camtasia screen capture software. The content is presented as modules that can be utilized as needed by the instructor. We will also present results from a comprehensive effort to understand the overall effectiveness of the approach both from the faculty perspective and that of the students.

4. MUSE Adaptations and Adoptions

Facilitators:
Wayne Shiroma (University of Hawaii - UH)
Rhonda Franklin (University of Minnesota)

This portion of the workshop discusses lessons learned in adopting the MUSE curricula at other institutions, and addresses questions such as:

- Is the curriculum set up for adoptability in portions, or is it necessary to adopt the entire curricula for continuity?
- Is the curriculum modular enough so that it can be presented in a different order than its initial set up by the originators?
- What are the reactions of students learning the material from multiple professors: the live one in the classroom and others they've never met via online modules?

5. Demonstrations

In this portion of the workshop we will provide participants the opportunity to experience both the online content development methodology (Tablet PC + Camtasia) and hands-on experiments (hardware and software) that we have brought into our MUSE course. The latter, Experience the MUSE, is an approach that leverages the latest generation of engineering design and simulation tools that students can take with them to learn anytime and anywhere they have a laptop. This approach maintains the flexibility of the inverted classroom, but poses special challenges. We detail those challenges, our responses to them, and report on how (and how not) to integrate laboratory-based learning.

6. Next Steps

We will conclude the workshop by getting feedback from the participants as to how best to proceed with establishing new MUSE collaborations. In particular, we expect to leverage this workshop to identify investigators who would participate in a NSF TUES Type III proposal that is currently in development. We will use the remainder of the time to answer specific questions related to the MUSE approach.

INTENDED AUDIENCE AND OUTCOMES

The overarching themes to be addressed are highly relevant to engineering students and the technological challenges of today and tomorrow, and are thus are an excellent match for FIE attendees and their interests. Our intended audience will consist of STEM faculty interested in integrating systems-level concepts into existing or new courses. In particular, the multi-university approach benefits educators in small programs looking to team with faculty at other institutions to share expertise. The approach also can be leveraged by multi-disciplinary research collaborations wishing to disseminate their work at the undergraduate level.

The National Academy of Engineers has clearly emphasized the significance of understanding complex-engineered systems in solving the major societal challenges we are facing. As such, there must be a new emphasis in undergraduate engineering education to develop effective curricula that properly train our students, and in turn a broad community of faculty that are motivated and prepared to address the problem. To do so indicates there is a clear need for faculty from diverse disciplines and institutions to pool resources and combine expertise in developing new content and learning experiences. The expected outcome of this mini-workshop is to add to this community of faculty members.

FACILITIES REQUIRED

To best engage the audience and group discussion, we envision the workshop setting will consist of tables in sufficient number to seat an expected 40 participants. In addition, the facilitators will require two additional tables for the demonstrations. Standard A/V equipment and network connectivity will be needed. We will prepare materials for 40 participants.

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FACILITATOR INFORMATION

Paul Flikkema, Professor of Electrical Engineering, Northern Arizona University; received the B.S. degree in Computer Engineering from Iowa State University in 1981, and the M.S. and Ph.D. degrees in Electrical Engineering in 1984 and 1992, respectively, from the University of Maryland, College Park.

Rhonda Franklin, Associate Professor of Electrical Engineering, University of Minnesota (UMn); received the B.S degree in Electrical Engineering from Texas A&M University and M.S. and Ph.D. degrees from the University of Michigan. She was an assistant professor at University of Illinois at Chicago from 1996-98 then joined the Department of Electrical and Computer Engineering at UMn in 1998.

Jeff Frolik, Associate Professor of Engineering, University of Vermont (UVM); received the B.S. degree from the University of South Alabama (1986), M.S. from the University of Southern California (1988), and Ph.D. (1995) from the University of Michigan all in Electrical Engineering. He worked at Hughes Aircraft Company in El Segundo, CA, as a satellite communications consultant, and at Tennessee Technological University prior to joining UVM in 2002.

Carol Haden, Senior Consultant, Magnolia Consulting, Charlottesville, Virginia; holds a doctorate in Curriculum and Instruction from Northern Arizona University. For the past seven years, she has worked as an evaluator specializing in K-20 STEM education. She has evaluated numerous STEM projects funded by NSF, NASA, the William and Flora Hewlett Foundation, and the Arizona Department of Education.

Wayne Shiroma, Professor of Electrical Engineering, University of Hawaii; received the B.S. degree from the University of Hawaii, the M.Eng. from Cornell University, and the Ph.D. from the University of Colorado at Boulder. He worked at Hughes Aircraft Company in El Segundo, CA from 1987-92.

Tom Weller, Professor of Electrical Engineering, University of South Florida (USF); received the B.S., M.S. and Ph.D. degrees in Electrical Engineering in 1988, 1991, and 1995, respectively, from the University of Michigan. From 1988-1990 he worked at Hughes Aircraft Company in El Segundo, CA. He joined USF in 1995.