Panel: Integrating Requirements Engineering Education into Core Engineering Disciplines

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***Abstract*—Requirements engineering (RE) provides a set of techniques and tools to *'EASV'* (elicit, analyze, specify, and validate) the capabilities a product must have in order to meet user needs, solve definite user problems and deliver expected values to users. RE courses are usually designed to focus on software and computer hardware products, and are thus taught in software engineering (SE), information systems (IS) and computer science (CS). But RE tools and techniques are also intrinsically applicable and essential to other engineering disciplines, since those disciplines also develop and deploy products. For instance, products can be a motor control center (MCC) developed by electric engineers or aircraft engines developed by mechanical engineers. Successful development of any of these products requires techniques to precisely ESAV user needs and capabilities required to satisfy those needs. Therefore RE should be an essential component of engineering curriculum. This panel aims to bring together faculty and practitioners from engineering and computer science disciplines to identify and discuss challenges, benefits, and strategies for integrating RE course into engineering curriculum.**

I. Description and Rationale

In a typical requirements engineering course, students acquire knowledge and skills to *'EASV'* (elicit, analyze, specify, and validate) products requirements. By 'requirements', we mean the capabilities a product must have to meet user needs. A capability can be a function, feature, constraint or quality attribute of a product [1, 2]. RE education helps learners to acquire knowledge and develop skills in the four[1] main phases of requirements development, these include requirements elicitation, analysis, specification, and validation, see Figure[2]1. Requirements elicitation skills support the discovering and clarification of user needs and product capabilities. These needs and capabilities are then classified, represented and refined using skills and knowledge acquired from requirements analysis. Requirements specification skills supports the documentation of product capabilities and user needs in a format comprehensible by all stakeholders. Finally, these capabilities are verified and validated through testing, prototyping, peer review and other skills acquired from requirements validation [3].

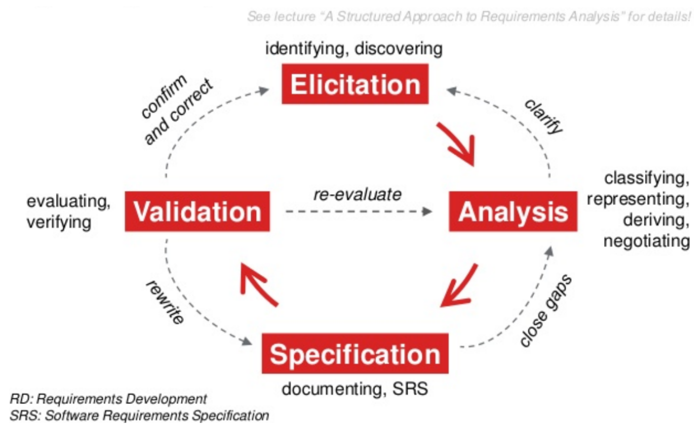

Fig. 1: Requirements Engineering Process; Source: https://tinyurl.com/y7ge8e5n

Traditionally, RE courses are designed to focus on software and computer hardware products, and are thus taught in software engineering (SE), information systems (IS) and computer science (CS) majors [4]. But RE tools and techniques are also intrinsically applicable and essential to other engineering disciplines, since they develop and deploy products. A motor control center (MCC) developed by electric engineers is a product; so also is a bridge developed by civil engineers or aircraft engines developed by mechanical engineers. Therefore RE should be an essential component of engineering curriculum in universities and colleges; so that engineering students can acquire skills and knowledge to 'EAVS' the product they design, develop and deploy to users.

RE techniques, such as use case analysis and feature tree modeling, can potentially benefit students in other engineering disciplines. Use case analysis can be used to derive user activities and functional capabilities of a product. Feature tree model is used to represent and classify the features of a product. Electrical engineers can apply use case analysis to derive and negotiate user activities or functional capabilities of a motor control center (MCC). Likewise, a mechanical engineer can use a feature tree model to represent and classify the features of a customized jet engine. However, most universities have not integrated these and other useful RE techniques into their

[1]https://tinyurl.com/y7hv7bsz

[2]This Figure is taken from a lecture delivered by Prof. Dagmar Monett Diaz. For details see: https://tinyurl.com/y7ge8e5n

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engineering curriculum.

II. Goal of the Panel Session

In this panel, we aim to identify, analyze and discuss the challenges, benefits and strategies for integrating RE into engineering curriculum. We intend to encourage multi-perspective of ideas, thus we will invite both educators and practitioners from engineering, computer science and information systems background. Attendees will be expected to participate in group activities. A group will consist of between 3 to 5 participants from both computing and core engineering background. There will be 3 activities of 15 minutes each.

In the first activity, participants will be expected to identify, discuss and analyze the possible challenges and limitations to teaching RE as a major in other engineering disciplines. Participants will also be expected to describe possible ways of overcoming these challenges. The second activity will focus on identifying and describing the potential benefits of teaching RE to students in other engineering disciplines. Such benefits will be considered from both education and industry perspectives. In another activity, participants from engineering background will be expected to identify knowledge and skills needed for successful design, development and deployment of engineering products. Afterwards, their counterparts from computing background will discuss how and which RE tools and techniques are applicable to those skills and knowledge. Finally, participants will develop effective strategies for integrating RE into engineering curriculum.

III. Topics to be Covered in the Panel

In order to organize a more focused discussion towards achieving the goal of this panel, we structure our topics as a set of questions. We expect these questions to be answered through active engagement, discussion and sharing of ideas by participants:

- Q1: What are the possible limitations and challenges of integrating RE into engineering curriculum?
- Q2: How does product development process in other engineering disciplines relate to software and hardware development process?
- Q3: Are all RE tools and techniques relevant to product development in other engineering disciplines?
- Q4: What are the potential benefits of integrating RE into core engineering curriculum?
- Q5: What effective methods can be used to teach RE course to engineering students?

IV. Anticipated Audience

The goal of FIE conference is to encourage innovations in engineering and computer science education and research. To support this goal, our primary target audience are engineering and computer science instructors, professors, and researchers. For instance, a sample of our anticipated audience is shown in Table **??**. Additionally, we understand the importance of building strong synergy between industry and academia. Accordingly, we aim to invite computer science and engineering practitioners from the industry. To encourage wider impact of ideas, we intend to invite and accommodate a secondary audience; which will include anyone with a keen interest in RE education and engineering product development. Other people, such as students, who want to learn more about the application of RE techniques to product development will also be encouraged to attend and participate in this panel.

V. Related Panel

This proposed panel is different from a related panel organized in FIE 2017. This previous panel [2] highlights various changes in software technologies and industry trends [5]; and discussed how RE education can be re-aligned to meet these changes. During the plenary discussion in this previous panel, one of the panelists argued that given these recent changes, RE education techniques and principles can be beneficial to other engineering disciplines. Thus RE should be integrated into core engineering curriculum. Other panelists agreed to this, and noted that future research and panels in RE should investigate this further. Although different from the previous panle [2]; the goal of this proposed panel (see Section II) builds on the previous panel to analyze and discuss strategies, as well as challenges, for integrating RE as course into the curriculum of other engineering disciplines.

VI. Proposed Peer-reviewed Full Papers

The organizers of this panel are authors and/or co-authors in the following related proposed peer-reviewed full papers:

A. Implementing Project Based Learning: Some Challenges from a Requirements Engineering Perspective

Project based learning (PBL) is gaining increasing traction among educational development, scholars and practitioners. The dominant argument suggests that by engaging in real world projects and research, students can acquire valuable critical thinking, team work, problem-solving, and improved communication skills. The application of PBL as a beneficial pedagogical method has remained largely a theoretical proposition with limited empirical evidence to demonstrate how it enhances student performance; and the attainment of these skills post-implementation. This gap is particularly evident in requirements engineering (RE) education. Hence, this work-in-progress paper aims to fill this gap by investigating the effects of PBL on student performance in an RE course. Students were divided into 5 project groups; each group carried out a RE project that addresses a real-world problem. The project deliverable for each group is a complete software requirements specification (SRS) document; a user interface design; and software development project management plan. Following the completion of the project, structured feedback were elicited from the students via questionnaires. The results were combined with the final student grades to evaluate the effect of PBL on their combined performance. Preliminary results show that PBL can benefit RE courses, especially by enhancing students performance. Yet, certain challenges, e.g., stakeholders engagement and team cohesion, must be addressed before these benefits can be fully realized.

B. Applying Product Manufacturing Techniques to Teach Data Analytics in Industrial Engineering: A Project Based Learning Experience.

The amount of data generated from industrial processes has increase dramatically in recent times. As a result, data analytics skill has become an essential requirement for industrial engineering jobs. To meet this requirement, universities and colleges are beginning to integrate data analytics into industrial engineering curriculum. However, teaching and learning data analytics to industrial engineering students is by no means an easy task, since both programs have diverging focus. Industrial engineering focuses on process and systems optimization while data analytics focus on the application of information technology and mathematical models to visualize and extract useful information from raw data. To support teaching and learning of data analytics to industrial engineering students, this innovative practice full paper reports a pedagogical method that extrapolates product manufacturing processes to teaching and learning data analytics. We selected product manufacturing because it is a core course in the industrial engineering curriculum. The proposed pedagogical method is developed by first analyzing and comparing product manufacturing processes and data analytics techniques. Afterwards, we used the result of this analogy to develop a teaching and learning method for data analytics. For implementation and validation purposes, we adopt a project-based learning approach where students used our methodology to complete real-world data analytics projects. Data from students' grades shows that this approach improved their performance.

C. Do Instructional Methods have Significant Impact on Student Performance in a Flipped Classroom?

Flipped classroom is a pedagogical approach that emphasizes a paradigm shift from the traditional classroom model. In a typical flipped classroom, lecture contents are delivered outside the classroom as pre-recorded multimedia, while students use the class time to actively participate in homework, assignments and projects. A key motivation to this approach is its potentials to enhance student performance. However, the exact impact of flipped classroom on student performance is controversial in the available literature. Some studies claim that flipped classroom has a positive impact on student performance, others claim that it has a negative impact, while others found no significant impact. To resolve this controversy, it would be useful to consider other factors that can also impact on student performance in a flipped classroom. Towards this end, this research full paper reports an experiment to investigate the impact of instructional methods on student performance in a flipped classroom. In this experiment, we registered 38 students in the same course and divided them into two classes (01 and 1E) taught by the same professor. Class 01 (experiment group) was taught with flipped model while Class 1E (control group) was taught with the traditional model. Using data collected from three sources, namely students' evaluation, students' grade and questionnaire, we analyze how instructional methods impact on student performance in a flipped classroom. This paper complements a previously reported article on the effects of learning styles on student performance. We expect this research to be useful and informative to higher education instructors who adopt or plan to adopt flipped classroom in their courses.

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