Work in Progress - Ethical Model Eliciting Activities (E-MEA) – Extending the Construct

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Abstract - Mastery of the professional skills is needed if our graduates will continue to excel in the increasingly global engineering environment. To date, much of the research associated with studying ethical decision making in organizations has focused on business and individual decisions with little empirical research focused on team-based ethical decision making specific to engineering. As part of a Phase III CCLI project, we are developing E-MEAs, which are open-ended, realistic problems that challenge student teams to recognize and resolve potential ethical dilemmas embedded within a larger engineering problem requiring skills integration. By extending the MEA construct to ethical situations we are able to better identify and understand the various strategies teams use to resolve complex ethical dilemmas. We are both adapting existing cases and creating our own scenarios that bring out differing perspectives, in order to provide a rich body of work that will enable the analysis of students’ ethical decision making processes in the context of engineering problem solving. To capture needed process data, we are adapting MEA reflection tools and utilizing PDA devices and team Wikis. Further, to assess performance outcomes, we are utilizing two rubrics, one of which (P-MEAR) was developed previously to assess the ethical dimension of student projects. Data collected will be analyzed using cluster and statistical methodologies to classify students according to performance and strategies employed.

Index Terms –Engineering education, ethics, MEA, Model Eliciting Activity, problem solving process, assessment.

INTRODUCTION

We are using models and modeling, specifically model eliciting activities (MEAs), to drive vertical skills integration and problem solving capacity in our upper-level engineering students. Our approach extends the MEA concept, which originated in mathematics education research [1] and was previously introduced into the freshman engineering program at Purdue [2]. With MEAs, student teams create a procedure to solve an open ended problem set in a realistic context. Our project, which is funded by an NSF, four-year, multi-university grant [3], extends the development of MEAs for upper-level students, requiring them to integrate their skills and exercise complex reasoning abilities, thereby serving as Model Integrating Activities (MIAs). Distinctive features of an MEA include an emphasis on testing, revision, collaboration, and thorough and reusable documentation, all professional skills that engineers should master.

The MEAs we are focusing on also challenge students to develop an additional professional engineering skill - an ability to recognize and resolve ethical dilemmas. This MEA extension, known as an ethical MEA, or E-MEA, requires students to resolve ethical dilemmas embedded within a larger, unstructured engineering problem. Engineering scenarios are being designed that elicit differing perspectives on ethical issues, for example confidential information versus public safety or employee loyalty versus whistle blowing. We are extending MEAs in this fashion in order to study the strategies that engineering teams use to resolve complex ethical dilemmas, using process-level assessment of their MEA problem solving activities.

In this paper, we will describe our approach to E-MEAs and provide examples of E-MEAs under development and in pilot use. We will also discuss our process and outcome-level assessment of E-MEA activity, as well as our analysis plans for the data collected.

DEVELOPMENT APPROACH AND EXAMPLES

Our approach to developing an E-MEA begins with a consideration of the engineering course in which it will be used, typically in consultation with other faculty. We then consider the key engineering concept or idea (model) that we wish to target, such as ANOVA, multiple linear regression, or decision modeling. In adapting either an existing ethical case or developing our own, we identify a scenario with appropriate data that both targets the particular engineering concept but also introduces an ethical dilemma that must be addressed by the student team as part of the problem solution. The use of context-based case studies provides ideal subject material for the development of these modeling exercises, which are designed to require the synthesis of intangible concepts such as environmental or societal justice.

An E-MEA that we recently developed and pilot tested involves a situation similar to the “SUV roll-over” case involving Ford and Firestone [4]. We pilot tested this in a second-semester statistics class and targeted the concepts of experimental design and ANOVA. The Ford-Firestone case provided the context that required students to first utilize conceptual knowledge and then address an ethical dilemma. Specifically, we presented the students with the following situation: A major insurance carrier noticed a relatively large number of claims involving SUVs that had rolled over after tire tread separation. The carrier contacted an engineering test firm to design a series of potentially destructive tests on a combination of vehicles and tires to identify a potential problem with a particular vehicle, tire or combination under
various environmental conditions. Students were given costs associated with conducting the experiment, a budget, and were asked to provide an experimental design by identifying the variables to test, their combinations, and any replications. A simulator was developed to provide unique test results to each team based on its submitted design for follow up statistical analysis. However, in the final report, the team was also required to consider the sensitivity of the analysis results, and whether they should maintain confidentiality. That is, each team had to address issues related to non-disclosure versus public welfare and determine under what circumstances public welfare trumps non-disclosure.

For a second E-MEA under development, we constructed a case involving ethanol fuel versus food production [5]. The team must develop a procedure for determining whether an environmentally and socially-conscious “green” Midwest agricultural producer should get involved in the ethanol industry at this time or remain solely in grain production. The team’s procedure must also include a structured method to compare five areas of the U.S. relative to development of an ethanol facility, which can use any of several feed stocks. We targeted decision analysis methods, specifically SMART (simple multi-attribute rating technique). We designed this MEA to challenge students to research issues related to an ethical situation and use them as criteria in a decision analysis. We plan to pilot test this in a sustainability engineering class in the summer of 2008 and a decision models class in the fall.

For a third E-MEA in progress, we developed a case concerning potential investment in countermeasures for reducing hazardous materials spills. The team must create a procedure for determining whether $2M should be spent by a county in Pennsylvania, given a series of spills with unknown material, or tangible, costs that have occurred there. The team is provided with a multivariate national dataset from which a model could be developed to predict the material costs incurred in the county. However, there are known human-related consequences that have occurred there. A valid and ethical cost-benefit analysis would consider all types of consequences. Our scenario is similar in nature to the Ford Pinto case by Harris, et al. [6]. We targeted the method of multiple linear regression (MLR) and incorporated a non-textbook dataset from the U.S. Department of Transportation, for which the necessary MLR assumptions do not hold. Due to the non-traditional nature of the dataset and the questionable fit and quality of the resulting model, this problem is expected to elicit misconceptions, another type of MEA extension under development with our NSF grant.

ASSESSMENT AND DATA ANALYSIS

In order to study the strategies being employed with E-MEAs, we have successfully implemented an approach to capture and assess problem solving processes. This consists of the use of a handheld electronic device (PDA), which prompts the student every 15 minutes to enter the current work element. The elements were based on a taxonomy developed previously to describe problem solving as well as the other ABET outcomes [7]. This process-level measurement was inspired by the Reflection Tools proposed by Hamilton, et al. [8]. In addition to using the PDAs, we are also having students complete a Wiki (as part of Blackboard) to capture their group work and the final report. We are able to deconstruct the Wiki to see what each student added and to better understand how their thought processes changed as they addressed the MEA.

In order to assess performance outcomes, we are using two rubrics. The first rubric assesses solutions based on the four MEA principles that are solution-related: 1) Generalizability/Reusability, 2) Self Assessment/Testing, 3) Documentation, and 4) Effective Prototype. Also, we are scoring the ethical dimension using the Pittsburgh-Mines Ethics Assessment Rubric (P-MEAR) previously developed and validated [9]. Using a combination of outcome and process-level data, we plan to apply cluster analysis to identify types of problem solving behaviors and strategies associated with various performance outcomes of these open-ended engineering problems with ethical dimensions.

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REFERENCES