Reflection Tools in Modeling Activities

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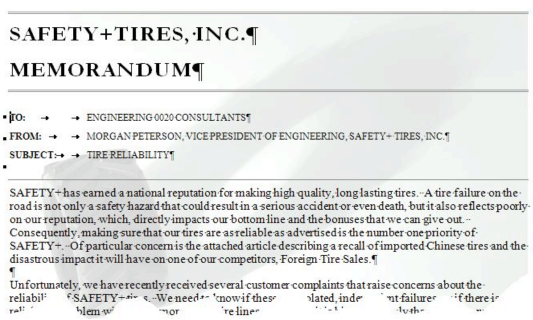
Reflection and self-regulated learning are important skills for college level students to learn. We have developed Model Eliciting Activities (MEAs) to integrate these activities while teaching students engineering concepts. A multi-tier design approach is used with MEAs as an element of change for students, instructors and researchers. Three generations of reflection tools have evolved to document how student teams' work on resolving a posed problem and what have they learned from the experience.

Introduction

Reflection is seen increasingly as a valuable part of a portfolio of self-regulatory competencies in learning. One of the most promising research topics in fields such as complex reasoning, problem-solving, critical thinking, or modeling involves reflective activity. This poster addresses research on reflection in modeling. A focus on modeling in problem-solving (creating structured and manipulable representations of a problem-situation) has proven productive in research on mathematical cognition in applied or real-world settings, including engineering. In particular, the paper reviews how devices called Reflection Tools, or RTs, have been conjectured to improve modeling competencies, or the abilities of students to draw upon, use, and change models in mathematical and engineering team problem-solving.

A companion website (http://modelsandmodeling.net/icls2010) furnishes a fuller set of modeling scenarios and the data to which this paper refers. The research is supported by a Type III Collaborative Scale-Up grant from NSF's Course, Curriculum and Laboratory Improvement (CCLI) Program (NSF Award 0717861). The instructional improvements sought involve the use of model-eliciting activities, or MEAs – in undergraduate learning. MEAs are specialized problem simulations that are treated at length in numerous sources recapped at http://modelsandmodeling.net. They were originally developed as tools to understand the micro-evolution of mathematical cognition. That is, they were used to trace how, in small teams, learners expressed conceptual models as ways to describe a problem, and then manipulated or revised their models to create a better fit to the problem and to test solutions to it. Over the course of a first generation of research in modeling eliciting activities, several crucial observations became foundational to the current generation of research. One is that although MEAs were useful for exposing conceptual models and their evolution, they also proved to have intrinsic instructional value. That is, as students participated in MEAs, they grew in the modeling competence. Indeed, some of the strongest performance changes came from youngsters for whom little was expected in terms of mathematical achievement. The applied problem-solving settings of model-eliciting activities and the opportunity to express, test and revise models nourished and expanded mathematical skills while students were serving as research subjects. Eventually, MEAs were developed for engineering students, and introduced in the first year curriculum of one of the largest engineering programs in the nation, at Purdue University, as an instructional approach. Not only did students develop new expertise as they were immersed in MEAs, but teachers and professors who focused on learner modeling and changes therein changed their own approaches to instruction. A third observation is that the various research teams began altering their own models of modeling. The collective observation of multiple dynamic levels of progress towards greater expertise (in modeling by students; in focusing on student modeling and development by teachers; and in recasting the type of emphases on problem-solving studies by researchers) eventually gave rise to what has been referred to as multi-tier design methodology.

One other observation became incorporated into current model-eliciting-activity research. Students engaged in MEAs began sharing reflections about modeling in small groups that mimicked, at a metacognitive level, the phenomena of teachers become more astute observers of student learning. That is, as students became more sophisticated in reflecting on their


SAFETY+TIRES, INC.¶
MEMORANDUM¶

TO: → → ENGINEERING 0020 CONSULTANTS¶
FROM: → → MORGAN PETERSON, VICE PRESIDENT OF ENGINEERING, SAFETY+ TIRES, INC.¶
SUBJECT: → → TIRE RELIABILITY¶

SAFETY+ has earned a national reputation for making high quality, long lasting tires. A tire failure on the road is not only a safety hazard that could result in a serious accident or even death, but it also reflects poorly on our reputation, which, directly impacts our bottom line and the bonuses that we can give out. Consequently, making sure that our tires are as reliable as advertised is the number one priority of SAFETY+. Of particular concern is the attached article describing a recall of imported Chinese tires and the disastrous impact it will have on one of our competitors, Foreign Tire Sales.¶
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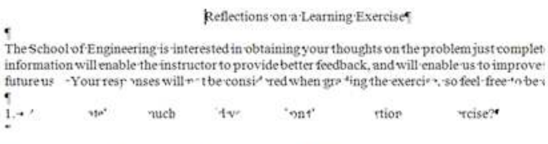
Unfortunately, we have recently received several customer complaints that raise concerns about the

Figure 1: The Tires Reliability MEA
(fully appearing at http://modelsandmodeling.net/icls2010)


Reflections on a Learning Exercise¶
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The School of Engineering is interested in obtaining your thoughts on the problem just complet information will enable the instructor to provide better feedback, and will enable us to improve

Figure 2: Reflection Tool (Generation 2)
(all forms fully appearing at http://modelsandmodeling.net/icls2010)

modeling, they became more sophisticated modelers. This led to theorizing about the role of guided reflection and theorizing about using formal reflection tools as part of or subsequent to modeling activities. The focus entails emphasizing how representations of the structure of a problem-situation – that is, a model - can evolve through short-term cycles of expressing, testing and revising the representations in a team.

The Tires Reliability MEA and Associated Reflection Tool

The Tires Reliability MEA depicted in Figure 1 entails a set of reliability statistics that a team of three students are expected to analyze in advance of preparing a report on the safety of a line of automotive tires. The website for this work-in-progress paper includes the full problem, data, reflection tool versions, and student reflections. The Tires MEA requires students to develop a general model for determining if a tire production run meets acceptable reliability and then apply that model to specific cases: three different grades of tires to determine if they are within a "gold" standard. Students must use the data set to determine the shape of the distribution, use probability plots and fully understand the concept of variance. A grading rubric is also available on the website. Of interest here is the use of a reflection tool that evolved through three generations of administering the MEA. Table 1 reflects each generation of the tool, the rationale for revising the tools, and the strengths and weaknesses that emerged from the revision. We are using reflection in two ways: both as a learning intervention and as an assessment tool.

As instructors and researchers we are searching for deeper understanding of the use of reflection tools in concert with MEAs. Do student reflections help researchers suggest the most productive ways to guide students and when to let them struggle with ambiguity? Can reflection tools be designed to provide a fuller picture of the team problem solving and modeling processes? The revision of the reflection tools will also help researchers elaborate on whether and to what degree reflection tools help students think about modeling, and whether it leads to stronger modeling competencies.

Table 1: Summary of Revisions in Three Generations of a Reflection Tool

Refl. Tool →	Generation 1	Generation 2	Generation 3
Where Used	Technical elective, upper class students, during lecture time; experienced instructor to MEAs	Stats course, required for some students; new instructor to MEAs	Required Stats course, sophomores; experienced instructor to MEAs; also branched out into other engineering courses
Characteristics of reflection tool	Focus on team process, through Wiki statistics (number of contributors, number of edits, questions posed in postings, number of drafts)	Concept learning assessed through exam questions; in process assessment; on paper; 6 question format, See Figure 1	Identify misconceptions in learning; pre/post concept inventories used; provide high quality and timely feedback to students; focus on modeling skills; 12 question format online.
Strengths	Rubric focused on: iteration (express-test-revise), ethics, mathematical concepts, problem solving)	Individual reflections blended into team narratives; short, concise; drawing graph and label it provided rich insight	Learning experience for student; defined important terms; guides students' thinking of teamwork, concepts learned and skills used; reinforcing targeted concepts
Weaknesses	Instructor interpretation of process	In process assessment very difficult; used unfamiliar terms with open ended questions, wide variety of responses; closed question made assumptions about student feelings	Long, almost all open ended questions with multiple parts
Reason for new generation	More insight needed into team process ; try to use repetition to move students from novice to expert problem solvers	Move to standardization and easier implementation; move to electronic version	Reintroduce draw team progress chart and description

References

E. Hamilton, R. Lesh, F. Lester, and C. Yoon. (2007) The use of reflection tools to build personal models of problem-solving. In R. Lesh, E. Hamilton, J. Kaput, J. (Eds.), Models & Modeling as Foundations for the Future in Mathematics Education., Lawrence Earlbaum Associates, NJ, Inc.

Shuman, L.J., and M. Besterfield-Sacre "E-MEAS: Introducing An Ethical Component To Model Eliciting Activities", *2009 ASEE Annual Conference & Exposition*, Austin TX, June 2009.

Yildirim, T.P., L.J. Shuman, and M. Besterfield-Sacre, "Model Eliciting Activities: Assessing Engineering Student Problem Solving and Skill Integration Processes," accepted for publication *International Journal of Engineering Education*.