AC 2007-561: CULTIVATING AUTHENTIC ENGINEERING DISCOURSE: TRANSITIONING FROM AN NSF CCLI PHASE 1 TO A PHASE 2 PROJECT

Louis Everett, University of Texas-El Paso

Louis J. Everett is a Professor of Mechanical Engineering at the University of Texas El Paso. Dr. Everett is a licensed professional engineer in the state of Texas and has research interests in the use of technology in the classroom. His technical research interests include robotics, machine design, dynamics and control systems. leverett@utep.edu http://research.utep.edu/pacelab

Arunkumar Pennathur, University of Texas-El Paso

Dr. Arunkumar Pennathur is Associate Professor of Industrial Engineering at UTEP. He holds a PhD in Industrial Engineering from the University of Cincinnati, with specialization in human factors engineering. Dr. Pennathur's interests are in the science of learning in engineering education. Dr. Pennathur has considerable expertise in human behavioral research methods. He has developed human behavior and performance models in personnel skills and training for advanced electromechanical troubleshooting and fault-finding tasks, disability models in older adults (work funded by NIH), and modeling physical and mental workload for soldier safety and performance (work funded by the US Army Research Laboratory jointly with Fort Bliss and William Beaumont Army Medical Center). These projects have all included extensive instrumentation, calibration, and observational, qualitative and quantitative field data collection and analyses with humans. He edits the International Journal of Industrial Engineering, and is also on the editorial board of a prestigious international journal in industrial ergonomics and frequently serves as a reviewer of research manuscripts for journals in human factors.

Cultivating Authentic Engineering Discourse: Transitioning from an NSF CCLI Phase 1 to a Phase 2 Project

Abstract

The University of Texas El Paso (UTEP) has been awarded a CCLI Phase 2 research-based project that will implement a model based on inquiry and metacognition in the undergraduate engineering curriculum.[*] The project will empower students through a praxis employing the Principles of Learning and Classroom Environments as presented in How Students Learn, a publication of the National Research Council. Using this praxis, students and faculty together will build a community of learners as students move toward becoming informed, responsible learners with faculty who guide the inquiry, questioning, and reflection.

Faculty members from the UTEP College of Education who are scholars in scientific discourse and literacy have joined faculty in the UTEP College of Engineering to develop, implement, and evaluate a process that integrates an iterative process of reflective teaching and learning. Specifically, the focus is on literacy, discourse, and metacognition with content focused on principles such as counter-intuition and model elicitation.

The successful NSF sponsored Phase 1 project (DUE-0411320) focused on student attitudes, study habits and in-class activities. Faculty were involved primarily as curriculum developers and guides. When considering a transition to Phase 2, emphasis was placed on faculty attitudes, teaching habits and reflection in an attempt to elicit desired student behaviors. The faculty and students are modeled as interrelated components in a learning system in which they both reflect on engineering content and the pedagogy for delivering the content in and out of the classroom.

Student learning is viewed as developing Engineering Discourse and Inquiry; that is, learning is developing the ability to see and inquire about engineering as a whole with significant and immediate connections to engineering practice, rather than as disconnected bits of information, homework problems and exams. Discourse experts observe an assortment of student evidence to evaluate progress.

Likewise, faculty are encouraged to develop Instructional Discourse using inquiry. The project supports faculty in this endeavor by having them reflect on their activities. These reflections are reviewed by experts to assess faculty

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development. To support the faculty, the project will implement a "virtual college" using a web-based environment in which faculty from several universities join to discuss reflections and experiences.

This paper describes the methodology used in the first semester of implementation of the Phase 2 project and gives preliminary results.

Introduction

The work reported here is an expansion of an NSF Phase I project reported in[1 2]. Essentially the underlying idea in the previous work was to use active counter-intuitive exercises in a dynamics class to create teaching moments.

Details of the Phase I Project

The main component of the Phase I intervention consists of physical demonstrations used in the classroom employing the following steps:

1. The student teams are asked to predict the results of an upcoming demonstration. The students must also give a reason for their answer.

2. After making predictions, the demonstration runs and typically does something unexpected.

3. After the demo, the students are asked to reevaluate their predictions and discuss them.

4. The instructor presents theory explaining the phenomenon.

One of the first modules used in the dynamics class is the "cars" module in Figure 1. The demonstration consists of a wooden block (the figure shows two) with two wheels on one end. The block is placed on a ramp with wheels forward and again with wheels back. The left block in the figure is "wheels back" and the right one is "wheels front." The students are asked to predict which one will move down the ramp with less rotation of the block. Most students predict the wheels front car, and the most common reason given is the wood dragging behind acts like a "rudder" to steer the block. The rudder concept makes it "obvious" (to the students) that the block with the rudder in front (the left block with wheels back) is not going to go straight.

When the demonstration is performed, the wheels back (the left one in the figure) goes relatively straight, and the wheels front spins about 180 degrees until it is a wheels back block and then it goes straight. To view a video of this go to: http://2020engineer.iss.utep.edu/World1/Forms/AllItems.aspx.

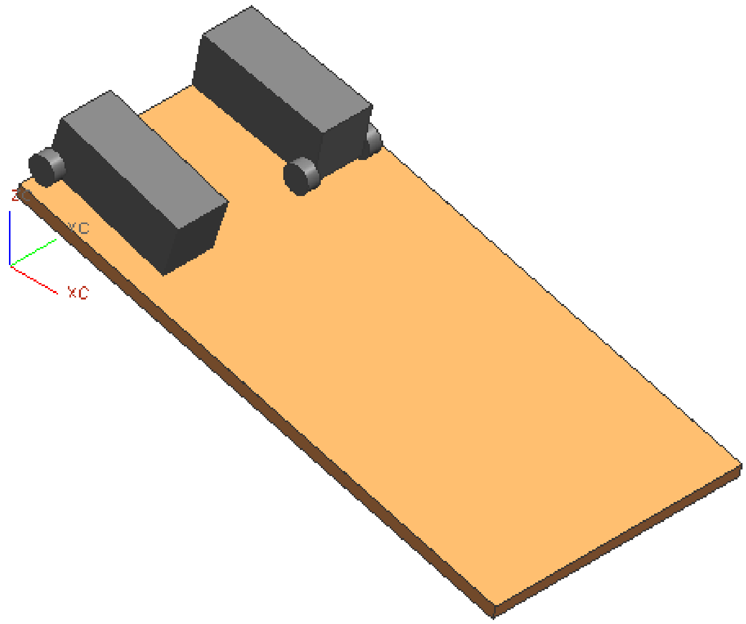

Figure 1 - Two Cars Module

With the majority of the students responding incorrectly, the instructor and teaching assistants facilitate an interactive discussion followed by students drawing freebody diagrams to stimulate their reasoning as they move toward conceptual understanding. Acceptable freebody diagrams are shown in Figure 2. Essentially what happens is the frictional forces from the tires are stabilizing for the wheels back and destabilizing for the wheels front because the friction forces under a rolling, non-skidding tire are predominately sideways and oppose the tendency to slip. The classroom activity is supplemented with software (MSC Adams) to allow students to further investigate the phenomenon.

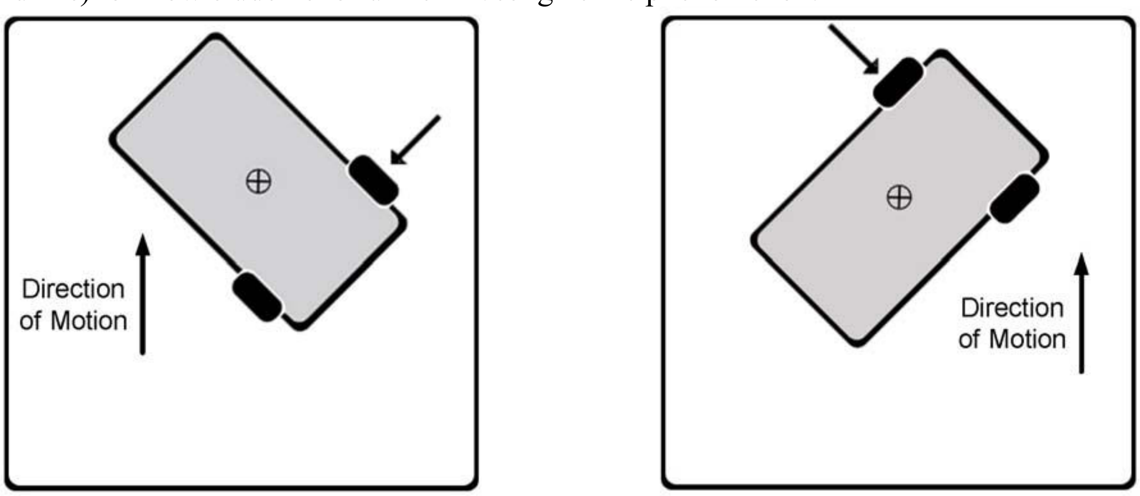

Figure 2 - Freebody Diagrams For the Cars.

To assess whether or not the students have acquired conceptual understanding of the phenomenon under investigation, three more instances are presented where students must make a prediction. In the first instance, the students are asked whether a “tail dragger” or “tricycle” landing gear on an airplane is more stable. These devices are shown in Figure 3 and Figure 4. To answer this question the students must comprehend that the main gear (the two wheels) support the aircraft load while the third wheel skids and slides due to low normal forces. This means the tail dragger has its two wheels up front and the tricycle has its two wheels in the rear. Which means … the tricycle is more stable. Ask a pilot!

In the second instance, the students are asked if a rocket that has fins on the bottom is more stable when it is nose-heavy or when it is tail-heavy. This phenomenon is similar to the car scenario, yet is different in that its focus is on the placement of the center of mass rather than the forces (the wheels).

Finally, the event is concluded by asking the students why “muscle cars” are rear wheel drive. This time the freebody diagram will demonstrate that the forward acceleration “rocks” the car backward increasing the normal pressure under the drive wheels; thus, creating more friction and more forward acceleration. It is also unstable, but a race car driver wants the maximum acceleration and will be sure to drive carefully. These instances allow students to make predictions and then, through discourse and computer simulation, they derive conceptual understanding of the phenomenon under investigation.

One objective of the interventions was to increase the success rates of the students. The average success rate in the Dynamics courses since Fall 2000 is 55.3%. The interventions have been used three semesters with success rates of 60.9%, 73.7% and 60.7%. These data show some improvement but since grades are in the control of the author, little should be drawn from them. Although the author believes standards were maintained in the grading, it is possible that unconscious bias in the grades occurred.

Figure 3 - Aircraft with a Tail Dragger Landing Gear Taken from the Public Domain at http://en.wikipedia.org/wiki/Image:Piper.cub.750pix.jpg.

Figure 4 - Cessna Aircraft With Tricycle Landing Gear, Copied from the Public Domain at http://en.wikipedia.org/wiki/Image:Cessna.152.g-blzh.arp.750pix.jpg

The Phase II Concept

The Phase II concept is an expansion and enhancement of the Phase I idea. First the work is being expanded to include more faculty from more schools teaching a wider variety of courses including science and mathematics. Second, the program is being enhanced by focusing on assessment and reflective processes.

The phase II work will establish a "virtual college" in which selected faculty from several universities will join on-line meetings using Skype [3] or similar software and share files through a Share Point Site [4]. The researchers have collaborated remotely to test its robustness. Although there were occasional bandwidth problems causing delays in real time sharing computer workspaces, voice conferencing and file sharing was nearly seamless.

Beginning in January 2007, the virtual meetings will be extended to other faculty at the University of Texas Pan Am, Prairie View A&M, Baylor University and New Mexico State University. The meetings will be used to discuss teaching methods, assessment methods and general support for each other. Interested faculty can join the virtual college by registering at http://2020engineer.iss.utep.edu/World1/Forms/AllItems.aspx.

In addition to the virtual meetings, a "kick off" workshop will be given in which faculty from the participating universities will meet face-to-face to learn how to construct counter intuitive activities[5], how to encourage student reflection, how to develop their own reflective habit, and about assessment methods.

Another important expansion of the Phase I project is in assessment. The Phase II project uses the analysis of discourse from in-class recordings, journals from faculty and students and interviews. Through this assessment, assessments will be made regarding the progress being made by students. This is critically important because many of the changes we hope to see is an overall academic development and this may not be directly indicated by the course grade. For example, the activities may help a student develop an inquisitive nature yet this development may not progress quickly enough to impact the semester grade. The observations also can provide insight to what students are thinking which will help establish a best practices model.

Program Objectives

The objectives of this project are to adapt a model based on inquiry and metacognition implemented by previous NSF-funded work [6, 7]. This project will empower students through a praxis employing the Principles of Learning and Classroom Environments as presented in *How Students Learn* [8]. Using this praxis, students and faculty together will build a community of learners as students move toward becoming informed, responsible learners with faculty who guide the inquiry, questioning, and reflection.

To achieve this ambitious agenda and ensure integrity in the proposed project, faculty members from the College of Education who are scholars in discourse and literacy have joined faculty in the College of Engineering to develop, implement, and evaluate a process that integrates a bi-directional modality of reflective teaching and learning practice. Specifically, the focus is on literacy, discourse, and metacognition.

Establishing the Virtual College

The objective of the virtual college is to provide a forum to support innovative teaching, faculty reflection and the exchange of ideas. Rarely would any one university have a sufficient number of faculty with teaching interests aligned closely enough to support a long term faculty teaching development program. The virtual college therefore allows small groups of geographically dispersed faculty to interact and support each other in teaching.

To make the virtual college a reality requires technology that is cheap (free), simple to use, and effective. Faculty must be able to easily and securely share files, talk to one another, view demos/simulations and leave messages.

After experimenting with a number of technologies, this research program has chosen to use Sharepoint to share and archive files and Skype to conduct voice meetings. Although Sharepoint is not free, it is necessary that only a single university purchase the software and host a site. Once the site is available, others who are given permission are able to access and post files using a web browser. In addition to hosting files, a Sharepoint site can host meeting agendas, to do lists, announcements and has a number of collaboration tools. Users can receive automatic notification when files are posted and/or changed so they need not check the status continuously.

Skype is free telephone VOIP type software and it can host conversations across computer platforms. Although the free version currently limits the number of users that can be added to a teleconference, a purchased version allows a much larger number of conversations simultaneously. Only the conference originator needs to have the purchased versions; all others can use the free version. The program is trivial to use, requiring minimal training. A high quality headset microphone is the only purchase necessary to get on-line for a meeting. Time delay in the conversation is negligible and the quality can be close to direct connected land lines.

The virtual meetings have been held every week for four months. During these meetings, one attendee was in a different time zone behind a firewall while others were dispersed across campus and behind a second firewall. File sharing used Sharepoint and real time desktop screen sharing was accomplished using Skype. Unfortunately there is a significant time lag when sharing a desktop in real time. The delay was significant enough to hinder activities of that sort.

In the upcoming semester, more faculty, both locally and from dispersed schools will be joining the virtual college. Virtual college meetings will be held approximately once per month and include approximately 16 people.

Standing in the Fish Bowl – A faculty perspective

Beginning in Fall 2006, one faculty member expanded counter-intuitive (CI) examples into a required probability and statistics course for Industrial Engineers. One of the CI activities performed in the course was to have students drop cards from an outstretched arm at shoulder height. Before running the experiment, students believed that the shorter students would be better able to "hit a target" on the floor than would the taller students. What they discovered was there was no significant correlation between height and accuracy.

In addition to the CI activities, the instructor kept a journal or a set of reflections on the activities. These reflections were assessed both by external observers and the faculty member. The self-assessment on this journal process is that the information is incomplete and not as useful as it could be. The essential problem is that the reflections indicate only what happened during the course from the instructor perspective. The problem is that there are many important activities leading up to the class and the reflections do not accurately indicate this. Data that represents how activities were planned for expected outcomes is missing. Furthermore it is possible that the extent to which faculty embrace inquiry-based approaches will depend on the difference between what faculty expect when they plan an inquiry-based activity and what actually happens.

In the next semester the plan is to ask "reflections" to discuss two basic items:

1. The planning and expected outcomes --- i.e., what was the faculty member thinking to do, what outcome was expected and why?

2. What actually happened in class, from the faculty member's perspective.

In the Fall 2006, the project was implemented in one engineering course. In the spring 2006 term, selected components will be implemented in several courses in science, mathematics and engineering locally. This will enable the researchers to respond to problems that arise in the expansion of the project. After learning from this initial expansion effort, colleagues from other universities will implement interventions in courses at their universities. Throughout the implementation, virtual college meetings will be held to help all the faculty learn from the collective experiences.

References

1. Everett, L.J. and E.Q. Villa, Assessment Results Of Multi-Intelligence Methods Used In Dynamics, in ASEE Annual Conference. 2006, ASEE: Chicago.

2. Everett, L.J. and E.Q. Villa, Increasing Success in a Dynamics Course through Multi-Intelligence Methods and Peer Facilitation, in ASEE Annual Conference. 2005, ASEE: Portland, Oregon.

3. Skype Limited. Skype. Take a deep breath. 2006 [cited 2006 December 20]; Available from: http://www.skype.com/helloagain.html.

4. Windows SharePoint Services in Windows Server 2003. 2006 December 14, 2006 [cited 2006 December 20]; Available from: http://www.microsoft.com/technet/windowsserver/sharepoint/default.mspx.

5. Everett, L.J. and A. Pennathur, A Design Process for Conceptual Based, Counter-Intuitive Problems, in ASEE National Conference. 2007, ASEE: Hawaii.

6. Thompson, N.S., et al., Integrating undergraduate research into engineering: A communications approach to holistic education. Journal of Engineering Education, 2005. 94(3): p. 297-307.

7. Donath, L., et al., Characterizing discourse among undergraduate researchers in an inquiry-based community of practice. Journal of Engineering Education, 2005. 94(4): p. 403-417.

8. Felder, R.M. How students learn: Adapting teaching styles to learning styles. 1988. Santa Barbara, CA, USA: Publ by IEEE, Piscataway, NJ, USA.