Global Perspectives in Curriculum Reform

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Global Perspectives in Curriculum Reform

Abstract
In this paper, we describe a curriculum reform project that aims to improve the industrial engineering curriculum through a web-based learning environment that engages students in active and collaborative learning. This environment focuses on engineering problems solving, increased information technology content, and the higher order cognitive skills that are needed to be a successful engineering problem solver. The project has several goals, one of which is to address the need for engineering students to understand how global and societal issues impact the problem solving process and potential solutions. We are addressing this goal by conducting an international team project, where teams consist of students from Iowa State University and the University of Strathclyde in Glasgow, Scotland. In particular, a module has been developed for a course in production systems, offered at both universities, where project teams made up of two students from each university were formed to work on a challenging problem with global consequences. In this paper, we describe the design of this module, discuss our experience with this international collaboration, and place it in context of the large curriculum reform project.

Keywords
Curriculum development, globalization, engineering problem solving, metacognition

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Global Perspectives in Curriculum Reform

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Abstract
In this paper, we describe a curriculum reform project that aims to improve the industrial engineering curriculum through a web-based learning environment that engages students in active and collaborative learning. This environment focuses on engineering problems solving, increased information technology content, and the higher order cognitive skills that are needed to be a successful engineer problem solver. The project has several goals, one of which is to address the need for engineering students to understand how global and societal issues impact the problem solving process and potential solutions. We are addressing this goal by conducting an international team project, where teams consist of students from Iowa State University and the University of Strathclyde in Glasgow, Scotland. In particular, a module has been developed for a course in production systems, offered at both universities, where project teams made up of two students from each university were formed to work on a challenging problem with global consequences. In this paper, we describe the design of this module, discuss our experience with this international collaboration, and place it in context of the large curriculum reform project.

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1. Introduction
In an increasingly global economy, engineers must be able to adapt their problem solving strategies to new and unfamiliar environments. Developing such skills is rarely part of the current engineering curriculum, and requires new methods for teaching. Being able to solve engineering problems while considering the global implications can be viewed as one aspect of adaptive expertise in solving of ill-structured problems. This is a difficult challenge to students, who usually have difficulty comprehending problems in unfamiliar contexts, and are unable to represent such problems in a manner that enables them to apply their knowledge. Furthermore, engineering students are not accustomed to thinking about global consequences in solving problems.

Some engineering problems are easily recognized and have solutions that can be easily implemented by those with the relevant experience. For such problems, the declarative knowledge describes the fundamental precepts and facts relevant to the context. The procedural knowledge includes the methods and tools that exploit the declarative knowledge. Once a student has mastered such problems, that is, has acquired some expertise, relatively little learning occurs, amounting to incremental knowledge of some perturbations of a problem context. The more difficult problems are open-ended, ambiguous, and ill-structured. Here the decisions become difficult because there is no direct experience in solving the problem. While procedural and declarative knowledge are helpful for various aspects of the problem, they are insufficient because the solutions are unknown. Developing expertise in such problems is sometimes referred to as adaptive expertise (Bransford, 2000) and acquiring such adaptive expertise requires a new kind of learning environment.

Some of the complexities that engineers are increasingly faced with today have to do directly with globalization. When solving problems in a global environment, engineers must deal with social and cultural issues at the same time as they solve the engineering problem itself, which is typically ill-structured. Thus, they must constantly weigh the global impact of their decisions. For such ambiguous, open-ended, and ill-structured problems, the emphasis needs to shift to higher order cognitive skills and in particular metacognition.
Metacognition refers to higher-order thinking that involves active control over the cognitive processes engaged in learning. Metacognitive processes may involve numerous activities such as, planning how to learn, monitoring one’s comprehension, and evaluating progress. The metacognition literature shows that students tend to be unaware of how well they are learning material, experiencing what Bjork (1999) described as illusions of comprehension. Cohen (2001) recognized the need for reflection in critical thinking for ill-structured problem scenarios. Students often assume that whatever enhances performance in the short-term will enhance performance in the long-term, but in fact, circumstances that make initial acquisition more difficult may improve later performance. A focus on metacognition may fall into that category. Numerous studies have shown that good problem solvers (experts) differ from poor problem solvers (novices) in their use of metacognition. Although few studies have directly assessed whether the relationship is causal, the assumption is that as students become more aware of their own thinking and problem solving process and of the effectiveness of different strategies, their learning will be enhanced.

In this paper, we report on a new learning environment that is used to teach students to solve ill-structured problems and enhance their metacognition. In particular, we describe a module developed for this environment where students collaborate with students in another country to solve a global supply chain problem. The paper is organized as follows. In Section 2, we describe this new learning environment. In Section 3, we motivate the need for students to solve problems in unfamiliar venues, such as global settings. In Section 4, we describe the new global module and our experiences with using this module, and finally, Section 5 contains some concluding remarks.

2. The Engineering Learning Portal
The Engineering Learning Portal (ELP) is a new learning environment that focuses on teaching ill-structured problems. The goal of the ELP is to develop students’ higher order thinking skills and in particular metacognition. The system includes a set of modules and the information infrastructure necessary to (1) provide problem scenario information based on student-initiated requests, (2) structure the problem solving process, (3) collect information on cognitive processes, (4) collect work in multiple formats from each student team, and (5) provide feedback to teams on their progress (Olafsson et al., 2003). After connecting to the ELP, students have access to specific information for a scenario. This information can take the form of reports, spreadsheets, design specifications, drawings, pictures, or streaming video. The problem solving process is structured by the ELP in the following manner.

- **Objective**: Students describe what they are trying to achieve before they begin the solution process and what measures they will use to evaluate their achievement of the objective. Students also justify their decisions at this stage by stating the reasons for choosing their objective.

- **Plan**: Teams construct plans for solving the problem that consist of major problem-solving steps called student actions. The students apply their declarative and procedural knowledge from related domains. The team provides justification for each action in the plan.

- **Solution**: After completing their plan, students describe their solution based on a list of possible alternatives. A justification of the solution must be provided in order to submit the solution.

- **Performance**: A scenario-specific simulation model provides a representation of the system under the solution parameters selected by the team. Performance measures for the system are provided at pre-defined time periods. Students can use the results to modify their solution.

The ELP encourages the metacognitive processes of planning, reflecting, and evaluating one’s own progress. Along with each choice of objective, action and solution element, students give reasons for their decisions. One component of student reflection is a self-evaluation based on rubrics that must be completed at the end of each stage (Huba and Freed, 1999). The instructor uses the same rubrics in assessing the work. To support metacognition, the evaluation criteria can be viewed prior to completing each stage. Another way in which the ELP explicitly encourages metacognitive development is by asking students to justify key actions, which causes them to both reflect on and evaluate their actions.

3. Engineering Problem Solving in Unfamiliar Venues
One of the deficiencies that the ELP project aims to address is students’ lack of ability to apply the content knowledge gained outside of the classroom environment where it was learned. This includes both other courses in the curriculum and new and unfamiliar situations where problems must be solved. In particular, we feel that currently students do not apply content knowledge from other courses when it is relevant (that is, they do not
integrate the knowledge), and students have difficulty working outside of traditional engineering domains, including both solving problems in a global context where societal and cultural considerations must be addressed.

One of the key deficiencies of the current curriculum identified above is that it does not prepare students to adapt to new and unfamiliar environments, and thus they find it difficult to apply the skills and content knowledge that they acquire to solve problems in new contexts. The sources for this difficulty are complex: (a) Students have difficulty comprehending problems in unfamiliar contexts. (b) Students find it difficult to structure or represent such problems in a manner that enables them to apply their knowledge. (c) Students do not think about global consequences in solving problems.

Thus, students must be given the relevant experiences to learn to understand and structure problems in a global context, as well as think about the consequences of their solutions in such environments. Although direct experience through international programs is clearly desirable for all students, it is equally clear that full participation is not possible. However, the ELP infrastructure can be used as a vehicle to expose students to problems in global contexts, and can be used in required courses so that all students benefit from this exposure.

We have developed an ELP module for understanding how global issues impact the problem solving process and potential solutions for a course in production systems. This module involves international project teams, each team including students from ISU and the University of Strathclyde in Glasgow, Scotland. This module will be described in the next section.

4. Solving Problems in a Global Context

In Fall 2004, the Industrial and Manufacturing Systems Engineering (IMSE) Department at Iowa State University (ISU) and the Design, Manufacture and Engineering Management (DMEM) Department at University of Strathclyde (UoS), Scotland, provided a joint global supply chain project in their production systems courses. The project was done as an ELP module and also utilized an Internet-based platform called Lau Lima (a TikiWiki platform developed by UoS) for student communication and collaboration (e.g., internal message and file gallery features). A total of 140 students, 52 from ISU and 88 from UoS participated in the course project. For the first 26 teams, each team consisted of two students from ISU and two from UoS. For the remaining 9 teams, each team consists of 4 students from UoS only.

A few weeks prior to the official start of the project, for ISU students who were unfamiliar with Lau Lima, UoS provided a tutorial using Skype (real time voice delivery) and Radmin (Web screen remote control). Next, just before the start of the project, for UoS students as well as ISU students who were unfamiliar with ELP, ISU provided a joint tutorial using Skype and Radmin. Throughout the project, the instructors communicated and collaborated closely on topics ranging from student monitoring and technical problems to grading. By the end of Fall 2004, all teams were able to submit the final solution and complete the project even though the resulting grades were somewhat widely distributed.

This student project formulates and analyzes pricing, production planning, and transportation issues for a global supply chain of a Scottish food product called haggis, which has significant differences with respect to culture and regulation across different nations.

To make this problem more concrete, we introduce a fictitious haggis company called McBain Food Products Ltd. based in Scotland, and its global partners in USA, India, and Australia.

To introduce the problem gradually with an increasing degree of complexity, the project question is divided into two parts. Part I: Individual National Plans and Part II: International Consortium Plan. In Part I, pricing, production planning, and distribution issues are examined within an isolated nation. In Part II, the same issues are examined for an integrated global supply chain emphasizing cultural and regulatory constraints.

Each part requires comprehension of the problem, appropriate formulation (e.g., mixed integer nonlinear programming formulation to be solved by LINGO), and subsequent solution, which are all gradually outlined in ELP. In ELP, we also provide the relevant rubrics identifying key performance criteria for students’ as well as instructors’ grading purposes.
We now proceed to elaborate on the organization and contents of ELP as the course project input/output are delivered to/from the students via ELP.

For ELP, there are six sections. Namely,

A. **Company Description:** the project problem information is provided via memos of three internal divisions, operations, logistics, and marketing.

![Figure 1. Marketing Department Information Web Page of Engineering Learning Portal](image)

B. **Problem Description:** the scenarios of national and international plans for pricing, production planning, and distribution issues are provided.

C. **Objective:** the students are to define the objective of the project, based on their understanding of the sections of Company Description and Problem Description.

D. **Actions:** various possible actions (e.g., “derive an expression for profit”) are provided. Students are to choose and complete actions that are necessary to solve the project problems.
E. **Propose solution:** solution templates are provided so that students can fill out their decisions on pricing, production planning, and distribution as well as their justification for the solution.

F. **Performance:** the performance of the students’ solutions with some randomness in demand is provided. This section shows the impact of such randomness on the performance of the students’ solutions.

Finally, for grading of this project, we used the following formula for each student:

\[
\text{Project Grade} = (\text{Objective} + \text{Action} + \text{Solution}) + (\text{Project Log})
\]

Objective, Action, and Solution are graded using pre-specified rubrics. For example, the Solution rubric contains performance criteria of Objective, Constraints, and LINGO Modeling. Project Log is based on each individual’s contributions shown in the project log of each team.

6. **Concluding Remarks**
In this paper we have described the design and web based implementation of a production systems course module that aimed at improving students engineering problem-solving skills. Specifically, the details regarding the web based learning environment, ELP, and its significance to improving students metacognitive abilities were provided. In addition, how the module was used to provide students with better understanding of global and societal issues in engineering problems were also discussed.

Moreover, the contents of the module, which were a student project analyzing pricing, production planning, and transportation issues for a global supply chain, were briefly presented, and the output expected from the students, in terms of problem identification, formulation and solution were also discussed. Finally, how students’ work was
graded was explained, and how we facilitated the deployment of the module simultaneously in two universities via Lau Lima as well as ELP were presented.

Currently, we are analyzing the data gathered from this project to measure the impact of this international collaboration on students. In the near future, we will also be collaborating with other universities from countries with other languages. For example, some of the critical information necessary for conducting this project will be in Chinese (i.e., some sections in Figure 1 are in Chinese). This will strongly encourage mutual reliance and collaboration among international student teams.

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