Global Enterprise Perspective Initiative in a Production Systems Course

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Abstract

In this paper, we describe a course and curriculum improvement initiative centered on a production systems course project. This initiative addresses strategic production planning of a global supply chain of a food product subject to local cultural, health regulatory, and trade constraints. The problems are to be formulated and solved by student teams consisting of students from Iowa and Scotland via Internet. For formative delivery of input and output of the project, Internet-based collaborative platforms are developed and used. This initiative is motivated by an ABET outcome assessment item established by the department on the global perspective of enterprise. As a part of ABET activities, the assessment of this initiative includes a global enterprise perspective rubric, which in turn consists of three distinct performance criteria. The progress made thus far in terms of input, process, and outcome will be presented, and the future direction will be discussed.

1. Introduction

In this paper, we present the continuous improvement process and efforts by the Industrial and Manufacturing Systems Engineering (IMSE) Department at Iowa State University (ISU) regarding the ability of the undergraduate Industrial Engineering (IE) majors to have a global enterprise perspective. By the ability to have a global enterprise perspective, we mean the ability to recognize the relationships among local units of a global enterprise, and to understand local regulatory and cultural effects on the global enterprise. This ability is an outcome assessment item designated by the IMSE Department for ABET Criterion 3.

In what follows, we will first describe the background on the ABET outcome assessment efforts by our department and the course project contents. Next, we will explain the project contents addressing a hypothetical global supply chain of a food product and the Internet-based implementation of this course project in collaboration with Design, Manufacture and Engineering Management (DMEM) Department at University of Strathclyde, Scotland. We will then present the outcome assessment results and make concluding remarks.

2. Background on ABET outcome assessment and project contents.

For the Industrial Engineering Program of IMSE Department at ISU, in addition to ABET Criterion 3 (a) through (k) [1], the department has five additional outcome items, (l) through (p) [2]. The outcome items (a) through (p) have been regularly assessed via various means ranging from surveys to rubrics with at least three performance criteria per rubric. Three of the major means of assessment are the surveys of Year 1 alumni (i.e., graduated during one calendar year ago) and Year 3 alumni (i.e., graduated during three calendar years ago), as well as graduating seniors.

In the surveys, each individual is asked how well his/her education in IE at ISU helped his/her abilities (a) through (p) where 1 = not at all while 5 = extremely well. After a careful review of the replies, the following observations were made.

All 2003, 2002, and 2001 Year 1 alumni surveys ranked the outcome item (o) as 16th out of the 16 outcome items. Similarly, 2003, 2002, and 2001 Year 3 alumni surveys ranked (o) as 16th, 16th, and 14th, respectively. Moreover, Spring 2004, Fall 2003, and Spring 2003 graduating senior surveys ranked (o) as 16th, 16th, and 13th. The average score ranged from around 2.5 to around 3.5 on a scale of 1 to 5.

Based on these observations, we concluded that the outcome item (o) has the most potential for improvement, and decided to make substantive and concrete efforts to improve the outcome item (later focus groups and rubric results failed to refute our conclusion).

Specifically, we decided to improve the outcome item (o) by enhancing the students' ability to recognize the relationships among local units of a global enterprise, and to understand local regulatory and cultural effects on the global enterprise. To achieve this enhancement, we also decided to utilize a course project in a required course IE341-Production Systems. This is motivated by the discussion on production systems team projects between our department and DMEM Department at University of Strathclyde, Scotland. We do note that there were other thrust areas in the collaboration project such as team management and effectiveness, even though the global perspective was a primary thrust area.

For the collaboration project, we chose to build the strategic production planning model of a global supply chain around a traditional Scottish food product called haggis, which has significant cultural and regulatory implications ([3] and [4]). Haggis is a Scottish food product consisting of minced sheep meats such as liver boiled with oatmeal [5]. Subsequently, a hypothetical global supply chain with facility planning, production planning, pricing, and distribution problems was developed in the form of a fictitious haggis production firm, McBain Food Products Ltd. based in Scotland, and its global partners in USA, India, and Australia.

The project problem question was divided into two parts. Part I: Individual National Plans and Part II: International Consortium Plan. Each part involved identification, formulation, and solution of the various problems related to the global supply chain for haggis. Furthermore, the students were to identify and comprehend the various resource requirements and constraints related to the production systems. At the same time, relevant rubrics were established so that the various aspects of the project could be graded appropriately. Moreover, in order for a relatively large number of our students to collaborate with the students from the University of Strathclyde simultaneously (140 students completed the project in Fall 2004), we developed and utilized an Internet-based formative input/output delivery system called Engineering Learning Portal (ELP) [6].

Thus far we have described the background on the ABET outcome assessment efforts by our department and the course project contents. Let us now proceed to explain the project contents and the Internet-based implementation of the course project.

3. The contents of the global supply chain project

In Fall 2004, we developed the global supply chain project for haggis involving four countries. As stated earlier, the course project dealt with supply chain problems of a haggis firm, McBain Food Products Ltd. in Scotland and its global partners in USA, India, and Australia subject to cultural, regulatory, and trade constraints. Figure 3.1 depicts the global consortium of the project.

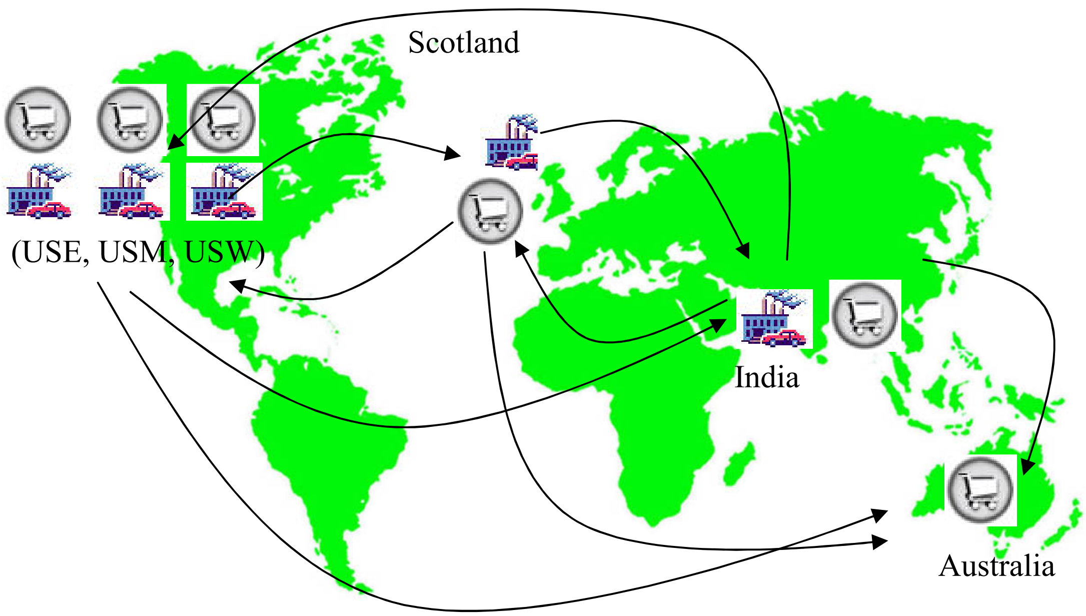

Figure 3.1 Haggis global supply chain

As mentioned in the previous section, the project was divided into two parts. Part I: Individual National Plans, and Part II: International Consortium Plan. The details are as follows.

Part I Individual National Plans

In Part I, it is assumed that trade between the countries was not yet considered. Some required input data for the problem were given in the format of company background, problem description, and in the form of memos sent by various department heads and employees of McBain Food Products Ltd. The input information of each country is as follows.

Scotland: The Scottish company was assumed to have an existing facility. The choices of the product kinds to be considered were Vegetarian, Americanized, and Traditional haggis. The associated production parameters such as fixed cost, variable cost, and maximum capacity of production per year were provided. Price-demand relationships are also provided.

USA: The USA partner was assumed to decide to build or not on three possible locations, East Coast (USE), Midwest (USM), and West Coast (USW). Hence, besides the production parameters and price-demand relationships, there was a transportation component within the national plan of the USA. The regulatory concern regarding the Food and Drug Administration (FDA) ban on sheep lungs in USA, ([3] and [4]), added to the complexity of the problem, and contributed to students' understanding of the global enterprise perspective.

India: India was selected for the experimental market, where the product "haggis" would be introduced for the first time. Culturally, the Indian population had a dietary pattern of being mainly vegetarian. Therefore, meat was unlikely to be popular. Hence, only Vegetarian haggis, customized to meet the Indian cultural preference, would be offered here. Since it was an experimental market, at most one production facility was assumed to be needed. The India partner had to make the decision between building a new facility and renting an existing facility. The associated production parameters and the price-demand function for Vegetarian haggis in India were provided via company memos.

Australia: We assumed that Australia did not have any production facility of its own due to its very small market size. Hence when the trade between any two countries was not considered, there should be no national plan for Australia.

By solving the national plans, the profit for each country was measured in terms of dollars earned in a one-year period. With the national plan, each country aimed to maximize its own profit, where the profit is equal to the revenue minus the cost. The revenue is obtained by selling haggis at an appropriate price. The cost is the sum of fixed cost, variable cost, and transportation cost (if applicable).

We now proceed to present the coordination issue of the global partners as follows.

Part II International Consortium Plan

Coordinating among partners for higher profits and expanding markets where applicable were the motivation for the consortium. There were six possible local markets in the consortium: Scotland, India, USE, USM, USW, and Australia. Since the demand in Australia was assumed to be small, the consortium decided not to build any plant in Australia. Therefore, there were only five possible production facility locations: Scotland, India, USE, USM, and USW. And as in Part I, the new supply chain problem was also subject to the cultural, regulatory, and dietary considerations. Under various input data, McBain had to decide (i) whether to use the existing plant in Scotland, rent the existing building in India, or build the new facility plant(s) in USA, or any of the combination, (ii) which types of haggis and how many should be offered to each market, (iii) and at what prices. At the minimum, through Part II, the students were expected to observe how the additional profits materialized as countries joined the consortium.

In what follows, we will explain the implementation experience of Fall 2004.

4. Implementation of the course project

In Fall 2004, the project contents described in the previous section was implemented in collaboration with University of Strathclyde as follows. Two ISU students and two students of University of Strathclyde formed a team and they collaborated via Internet using a multiple number of communication tools and ELP, a formative delivery tool of inputs and outputs. We will describe ELP first, and then we will describe other communication tools (Lau Lima, Skype, and Radmin). Finally, we will describe LINGO, an optimization modeling software package used in this project.

Engineering Learning Portal

The course project input/output were delivered to/from the students via ELP. The ELP for this course project was based on the course content described in the previous section. There are six sections contained in this course module:

A. Company Description: In this section, the project content is organized into different categories of memos of the fictitious company:

1. **Operations Memos:** The information of investment cost, fixed production cost and variable production cost of haggis in each country.
2. **Logistics Memos:** The information of transportation cost and distribution centers.
3. **Marketing Memos:** The information of price-demand relationship; the regulation of food safety in each country; the cultural difference in taste, etc.

Figure 4.1 shown below depicts the Company Description section of ELP.

Figure 4.1 Company description in ELP

B. Problem Description: In this section, students, acting as the member of the consulting team of the fictitious company, are informed of the problem they are going to solve. Two plan scenarios are being considered to address the company's needs, i.e., a National Plan and an International Plan. Under each scenario, the global enterprise perspective is important.

1. **National Plan:** In this plan, production and distribution occur only within a country (i.e., no trade is involved). Management wants to know how much and what to produce in each location (Scotland, India, and USA). For the USA, the company needs to how to distribute the products within the country.
2. **International Plan:** In this plan, a consortium of Scotland, India, USA, and Australia are involved in production and trade. The company wants to know what to produce in each location and where it should be distributed.

For each scenario, students are expected to do:

1. Facility planning: Determine whether to use the existing plant by adding capacity or build new processing plants.
2. Production planning: Determine the production quantities by each manufacturing facility according to the estimated demand.
3. Pricing strategy: Determine the optimal price, as per the estimated demand.
4. Distribution Decisions: Determine product-shipping quantities from each manufacturing facility to the target markets.

Figure 4.2 shown below is an illustration of the Problem Description section of ELP.

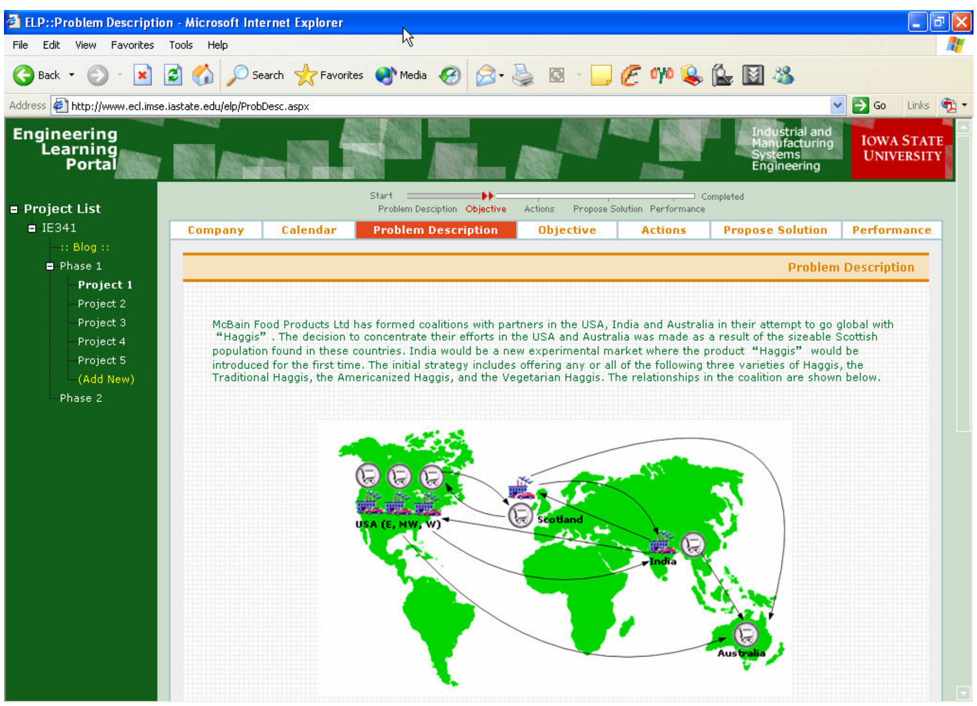

Figure 4.2 Problem description in ELP

C. Objective: In this section, students will define the objective of the project, based on their understanding of the sections of Company Description and Problem Description. The three questions are:

> **What are the assumptions for this problem scenario?**
>
> **What is the appropriate objective for this problem scenario?**
>
> **Why is the objective appropriate for this problem scenario?**

Figure 4.3 shown below represents the Objective Section of ELP.

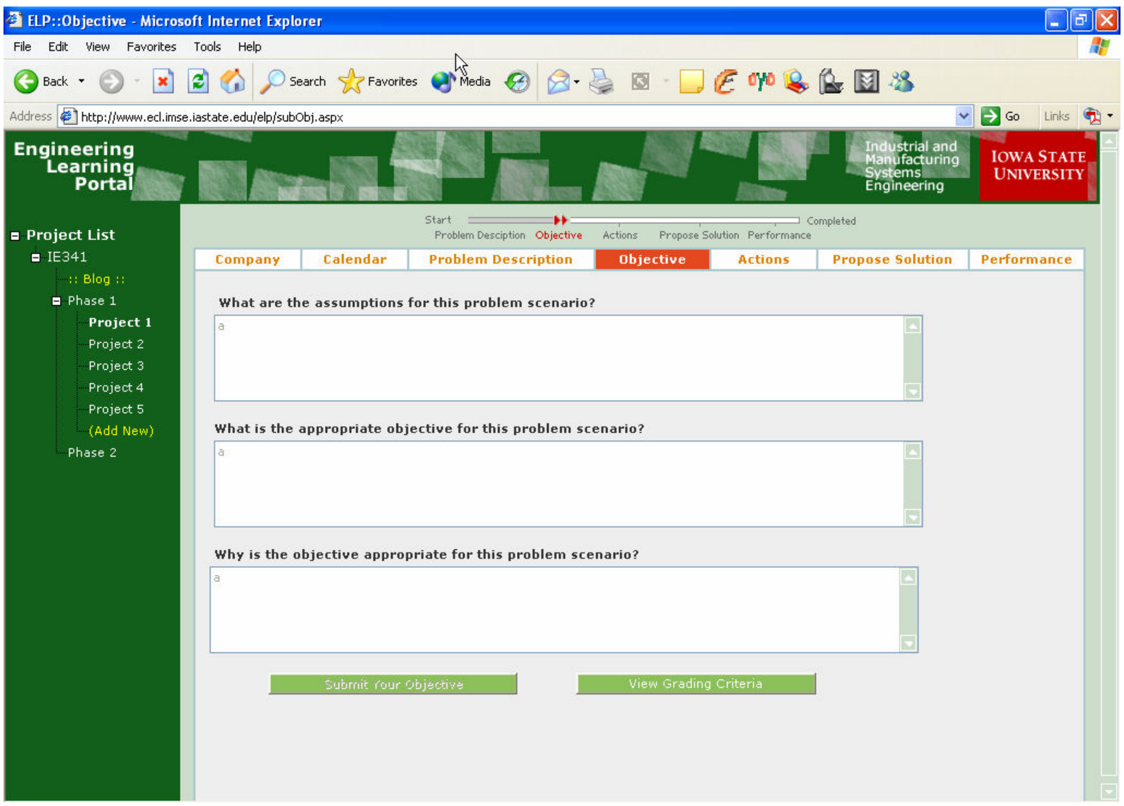

Figure 4.3 Problem objective in ELP

D. Actions: In this section, various actions are provided. Students need to decide which actions are necessary for the completion of the course project. Some actions are irrelevant and need not be considered. Each action has an associated MS Excel template file. For each selected action, students are supposed to fill in the template file and also state the reasons of choosing this action.

The actions are:

1. 'Determine the feasible set of products for a market'
2. 'Determine the assumptions for the model'
3. 'Identify what products should be offered in each market'
4. 'Determine your total budget'

5. 'Derive the price-demand function'
6. 'Calculate the loss function'
7. 'Calculate the fixed cost of building or using a factory'
8. 'Calculate the variable cost per unit of haggis'
9. 'Estimate the capacity of each factory'
10. 'Estimate the turnover'
11. 'Calculate the transportation costs'
12. 'Derive an expression for revenue'
13. 'Derive an expression for cost '
14. 'Derive an expression for profit '
15. 'Derive expressions for constraints'
16. 'Define the math programming model'
17. 'Create a LINGO input file and upload'
18. 'Use the LINGO model to optimize and upload output file'

Figure 4.4 shown below is a representation of the Actions Section of ELP.

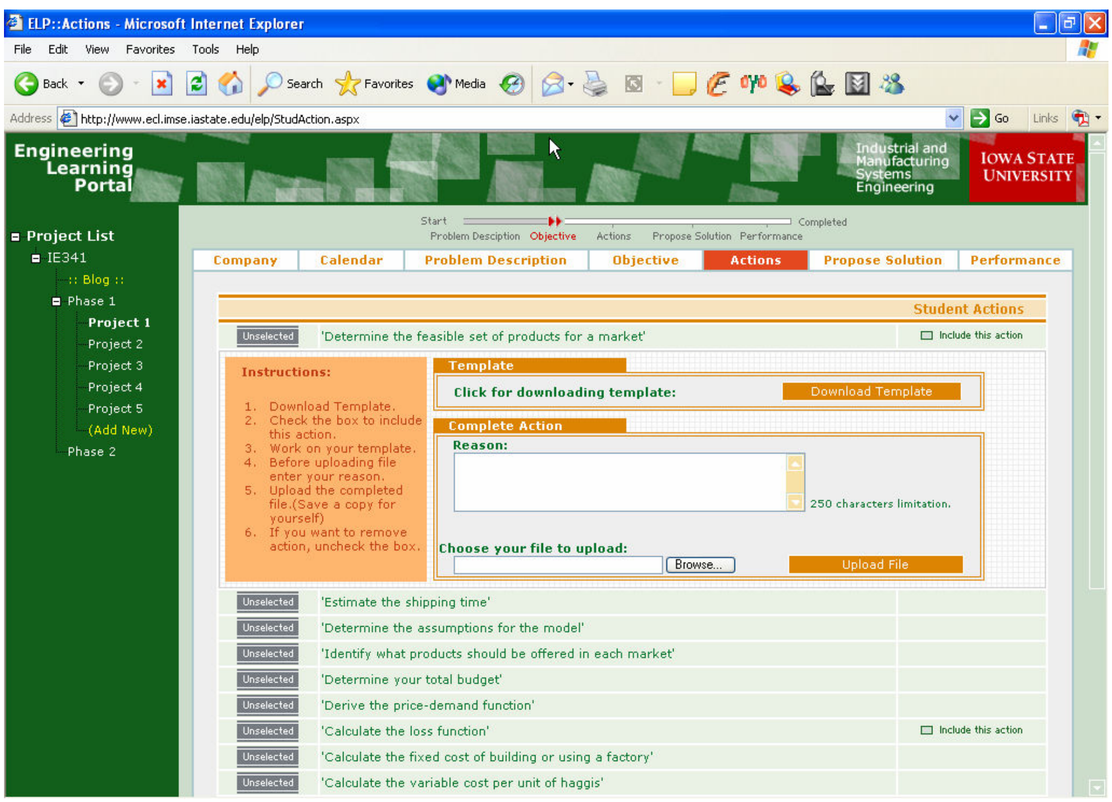

Figure 4.4 Actions in ELP

E. Proposed solution: In this section, a solution template is provided, in which students can fill the decision variables regarding facility planning, production planning, pricing, and distribution. Also students are supposed to submit a summary file, which contains the justification of the solutions.

Figure 4.5 is a picture of the Proposed Solutions section of ELP.

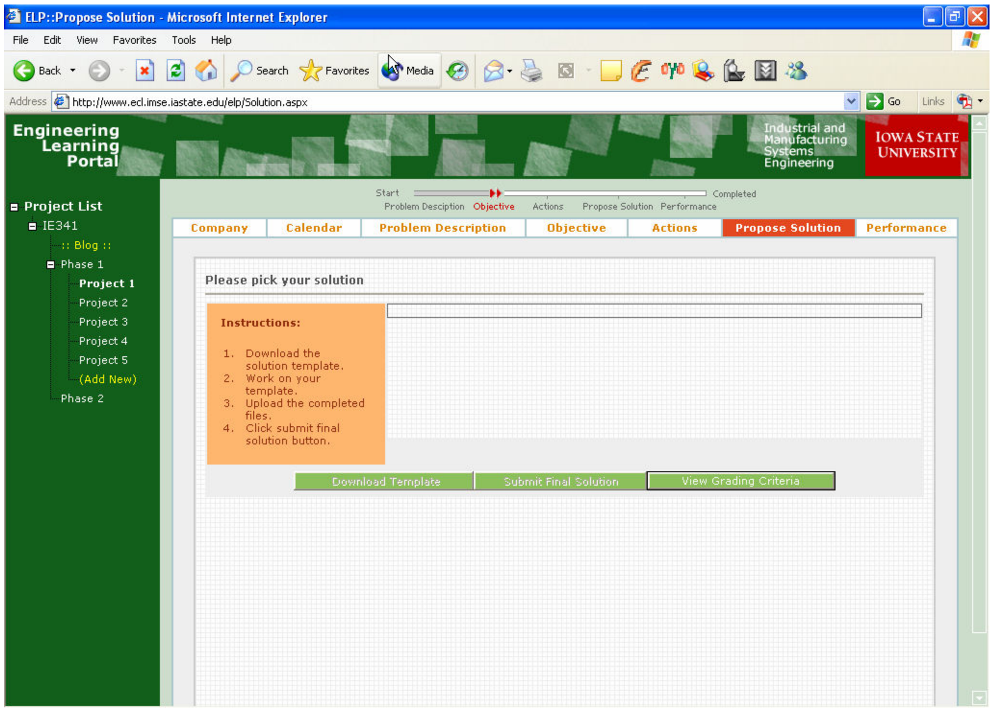

Figure 4.5 Solutions in ELP

F. Performance: In this section, the performance of the fictitious company based on the students' solutions and some randomness are displayed. The randomness occurs in the demand of haggis in each market, which is realistic in many situations. The Performance Section requires no additional student input, and serves only for the purpose of illustrating the impact on randomness on the performance of the students' solutions.

Let us now briefly describe additional collaboration/communication tools utilized in this project.

Lau Lima

Lau Lima is a collaboration/communication system (a kind of TikiWiki) developed and used in University of Strathclyde [7]. A primary function of Lau Lima is to facilitate communication and information sharing among the teammates in a group. Two basic functions are:

Internal Message: Within Lau Lima, each member of the project can send message to teammates or advisors. There is also a bulletin board, which every member can access.

File Gallery: The teammates can share files within the group using a file gallery. All the working files and any project materials they want to share can be kept in the file gallery, which enables the advisors to follow the progress of students' projects.

Skype

Skype is secure PC-to-PC voice communications system, which was developed in Estonia [8]. Voice data is encrypted with strong encryption algorithms to ensure privacy. Skype, combined with Radmin, is used in our project to communicate with University of Strathclyde for project demonstration and software tutorial.

Radmin

Radmin is PC remote control software that allows the user to take control of another PC on a LAN, WAN, or dial-up connection so the user can see the remote computer's screen on his monitor and all his mouse movements and keystrokes are directly transferred to the remote machine [9].

LINGO

LINGO, an optimization modeling software, is used to solve the project problem [10]. Specifically, students are supposed to write the mixed-integer nonlinear mathematical programming formula, transform the formula into LINGO input file, and analyze the LINGO output to obtain the solutions of the project.

Finally, we have the following comments on the grading of the course project.

Grading

We used the following formula to decide the final project grade for each student:

Final Project Grade = Objective Grade + Action Grade + Solution Grade + Project Log Grade

Objective, Action, and Solution are graded using pre-specified rubrics. For example, the Objective rubric contains performance criteria of Consistency, Justification, and Sufficiency (of identifying the underlying assumptions). The Project Log Grade is based on individual's contributions documented in each team's project log.

Finally, we should note that, throughout the implementation phase, the Scottish colleagues contributed tremendously. e.g., introduction of Lau Lima, Skype, and Radmin.

5. Assessment on global enterprise perspective outcome item

Throughout the course, we explored various ways to assess the ability to have a global enterprise perspective, including a post project survey and the rubric-based assessment by the teaching staff (We do note that there does not seem to be a single measure or a single method that will accurately assess the outcome of students' learning or the ability). We will first explain the impact of this project on the outcome item based on the survey, and then the rubric-based assessment as follows.

In Fall 2004, 52 ISU students (and 88 Scottish students) completed the project. Of the 52, 45 were IE majors and 7 were from other departments. During a class after the project completion, IE majors were asked to fill out an anonymous, voluntary survey. Along with other questions, a question (Question Y) relevant to the global enterprise perspective was asked: How helpful has this project been for increasing your ability to have a global enterprise perspective? 1 = not at all while 5 = extremely well.

A total of 42 IE majors replied, and the distribution of scores is as follows in Figure 5.1.

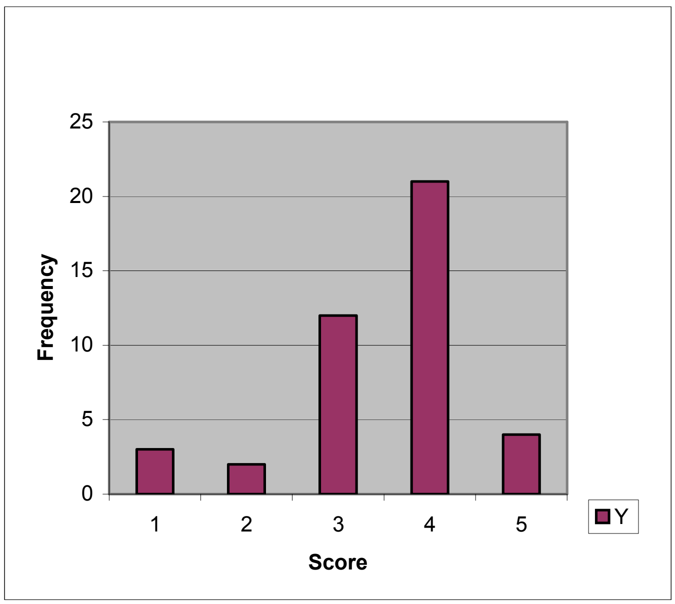

Figure 5.1 Score distribution for helpfulness of the project in increasing ability to have a global enterprise perspective

The average score was 3.5, and more than half of the respondents reported a score of 4 or 5. Hence, from the students' perspective, the project has had an overall positive impact on increasing their ability to have a global enterprise perspective.

In addition to the student survey, we also tried rubric-based assessment by the teaching staff. Table 5.1 depicts the rubric applied to students' answers in the ELP format.

Item	Exemplary 5-6	Acceptable 3-4	Poor 1-2	Score	Comments
Understand the relationships of the units of a global enterprise	Understand the units, objectives, and constraints of an enterprise.	Understand the units. Some objectives, relationships, or constraints are missing	The units are not understood or some major objectives, relationships, or constraints missing		
Understand the effects of culture on a global enterprise	Determine correctly cultural effects on decision-making and performance of an enterprise.	Cultural effects on decision-making are correctly determined. Some aspects of performance analysis are missing or incomplete	Cultural effects are missing or poorly determined.		
Understand the effects of international regulations on a global enterprise	Determine correctly international regulatory effects on decision-making and performance of an enterprise.	International regulatory effects on decision-making are correctly determined. Some aspects of performance analysis are missing or incomplete	International regulatory effects on decision-making are missing or poorly determined.		
Total					

Table 5.1 Rubric used to grade global enterprise perspective

To complete the project, the students worked in groups of four, of which two were from ISU while two were from University of Strathclyde. Only teams with at least one IE major were selected. This provided us with 25 teams. These 25 team reports were graded on a scale of 1 to 6 using the 3 performance criteria expected in the attainment of a global enterprise perspective. For the performance criterion, "Understand the relationships of the units of a global enterprise," the average score received by the teams was 4.64 while for the performance criterion, "Understand the effects of culture on a global enterprise," the average was 5.04. For the third criterion, "Understand the effects of international regulations on a global enterprise," the average was 4.92. The global enterprise perspective total was on average 14.6 out of 18.

All in all, this batch of data indicates that there are few students performing poorly. On the other hand, with just one batch of data, it should be prudent to wait for more accumulation of data. We do believe that at least the proof-of-concept is now complete as far as the rubric-based assessment is concerned, and these data will form an initial set of benchmark numbers from which a continuous improvement process can begin.

6. Concluding Remarks

In this paper, we showed how we identified the global enterprise perspective as the outcome item to be improved. We then showed how we developed the course contents for the global supply chain project, and described how this project was implemented. Finally, we presented the outcome assessment by the students and the teaching staff at the end of the project where the outcomes were positive (from students' perspective) and at least not negative (from teaching staff's perspective).

We do note that the continuous improvement process can be gradual and takes time. Therefore, persistent efforts will be applied. At the same time, given the post-project outcome assessment, we hope that the scores from graduating seniors as well as Year 1 and Year 3 alumni will increase in the near future.

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