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The Redesign of Mechanical Engineering 574: An Exploration in Deductive and Inductive Methods

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ABSTRACT

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Changes in the engineering industry have motivated the redesign of engineering curriculum in recent years. This report documents the redesign of Mechanical Engineering 574, a graduate course in engineering offered at Brigham Young University. The redesign was divided into four phases and used a design narrative to report the design process. Research conducted by the instructor and designer informed the main content of the course. Although the course originally used mainly deductive methods of instruction, by the final phase of the project, the instruction evolved to be primarily inductive in strategy.

Keywords: deductive, inductive, design, engineering

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Introduction

Changes in the engineering industry caused by global influences have motivated the redesign of engineering curriculum (Tryggvason, Thouless, Dutta, Ceccio, & Tilbury, 2001). This report documents the redesign of a graduate course in Mechanical Engineering at Brigham Young University that was redesigned in order to better prepare students for practice in industry. The motivation for this work comes from observations made by the instructor of the course during 25 years of consulting and the growing body of publications and work in the engineering education community.

Since the 1980s, changes in the engineering industry have focused increasing attention on the need for reform in engineering education. Among the most influential of these changes in the engineering industry are commercial competition, rapid growth of information technologies, environmental issues, and globalization of both manufacturing and service delivery, to name only a few (Prados, 1998). Engineering education in the United States has been under intense scrutiny in recent years (Olds and Miller, 2004). William A. Wulf (1998), president of the National Academy of Engineering, has asserted that engineering education has not kept up with the accelerating pace of such changes, leaving engineering students unprepared for entrance, survival, and success in industry.

As industry practice reflects a much expanded global market, economy, and social environment, the interconnectedness of political, social, cultural, and economic globalization becomes increasingly apparent (Dicken, 2003). Indeed, Bugliarello (2005) asserted that the effects of modern globalization are unprecedented in both their magnitude and their reach. Increasing globalization introduces new elements of geographic and cultural diversity into business and engineering teams—teams, which, according to Brannick and Prince (as cited by

Helquist, Walker, & Cox, 2009), are conducting more and more of the work in businesses. This diversity, Ancona and Caldwell (1992) noted, can prevent social integration and cohesion within teams, making relevant educational preparation all the more critical. Such education must not only address engineering topics, but must relate them to larger societal issues, promoting cultural and economic understanding as heavily as technological expertise (Rugarcia, Felder, Woods, & Stice, 2000; Wulf, 1998).

Rugarcia et al. (2000), as well as Wulf (1998) recognized the disparity between the kind of engineering practice for which students are being prepared and the engineering practice that actually takes place in industry, explaining that, while circumstances in industry are different now than those in the past and even more different from those to come in the future, students are still being prepared to practice engineering in a world that no longer exists, or that at least is not what it used to be. As technological advances, commercial competition, environmental concerns, and globalization evolve and become increasingly prevalent, thus changing the environment of applied engineering practice, the engineering curriculum must likewise evolve (Tryggvason, Thouless, Dutta, Ceccio, & Tilbury, 2001).

According to Felder, Woods, Stice, and Rugarcia (2000), the superiority of alternative instructional methods in achieving cognitive as well as affective educational outcomes has been illustrated in several instances, but the predominant methods in engineering courses at most institutions continue to involve passive lecturing and convergent problems which hinder students in gaining the skills necessary for solving multidisciplinary problems such as critical judgment and creativity, among others.

Other weaknesses of engineering graduates and engineering curriculum include poor critical thinking skills, poor communication skills, minimal exposure to or familiarity with multidisciplinary problems, limited focus on active learning, unrealistic problem sets/scenarios, minimal exposure to complex problems as encountered in industry, and failure to address feelings and attitudes of engineering students. Although changes in industry are placing ever-increasing demands on engineering graduates, development of these skills and characteristics seems unlikely given the current and traditional instructional practices employed (Prados, 1998).

It was in light of these observations that the design work pertaining to Mechanical Engineering 574 took place. Mechanical Engineering 574 was a graduate level course offered to seniors and graduate students in the Mechanical Engineering degree program at Brigham Young University. The course was offered for six years under the title of Product Development and Automation until the spring term of 2007, when the course redesign presented here began. This report will discuss in detail the need for and purpose of the redesign, the design process, implementation, and outcomes.

Project Origination and Background

Client

My work with the client began during the spring term (May-June) of 2007. Dr. Cox, the client for the project, was working at the time as associate professor in the Department of Mechanical Engineering at Brigham Young University and head of the Advanced Product Development Laboratory. Responsible for several different areas of research within the department, as well as at least two courses each semester, Dr. Cox employed me as a research assistant to collaborate with him in his work relating to virtual product development, one of the main topics of Mechanical Engineering 574, the graduate course he taught at the time.

Having taught at the university level for twenty years, with approximately twenty-five years of experience as a consultant within the aerospace industry, Dr. Cox sought to implement content into the 574 graduate course that he had observed through his professional experience which was particularly relevant for engineering graduates preparing to enter into professional engineering practice. As the companies for which he consulted experienced increasing globalization, Dr. Cox recognized a potential need among engineers not only for additional skills, but for increased cognizance and understanding of global issues relating to physically diverse geographic locations and their associated cultural, economic, and political practices and policies. In essence, he experienced firsthand phenomena similar to the observations made by Brannick and Prince (1997), Dicken (2003), and Ancona and Caldwell (1992), as discussed previously.

Although originally I was hired to assist in this research because of my background and degree in Geography and Global Studies, the research and work evolved in such a way that my experience in the Instructional Psychology and Technology program became important and useful as well. As part of the evolution of our initial research, Dr. Cox requested specifically that I work with him to redesign the 574 course in an attempt to address the aforementioned observations.

Course

Mechanical Engineering 574 is a graduate-level course offered as a technical elective for undergraduate students and as a regular graduate course to graduate level students at Brigham Young University. The course was created as a special topics course initially to be a test-bed for teaching advanced concepts in engineering process modeling that were coming from the consulting and research of Dr. Cox. Engineering companies were eager to cooperate with BYU by providing sample problems from their practice that would also further their research interests and provide students with opportunities to work with and solve real world problems. Mechanical Engineering 574 seemed an ideal course for doing this, as the majority of students enrolling in the course were more likely to have the advanced computer and automation skills as well as the necessary understanding to attempt the automation projects.

The course was very popular initially since it provided contact to potential employers and provided an industry perspective as well as cutting edge techniques. The course was first named Mechanical Engineering 576: Computer-aided Process Modeling, and as it matured the name and number were changed for department alignment to be called Mechanical Engineering 574: Process Automation.

Evidence of Need

A significant portion of the evidence of the need for the redesign of Mechanical Engineering 574 came as a result of the research and consulting done by Dr. Cox prior to and during the course redesign project. While consulting with large and small engineering companies, it became clear to Dr. Cox that the students graduating from Mechanical Engineering did not demonstrate adequate understanding or appreciation of global geographic issues associated with work in global engineering teams, as observed also by others in the field (Prados, 1998; Tryggvason et al., 2001; Wulf, 1998). Nor were they prepared to understand and direct process improvements in the engineering companies since they did not understand the product development processes or the environments within which the processes were being executed.

Dr. Cox's research was associated with his concurrent consulting experience and therefore focused on methods of modeling global engineering processes. One of the significant gaps in his research involved the incorporation of global geographic issues into the process models and methods that he was developing. Dr. Cox brought me into his research to help in the development of methods and models using global geographic issues. As the research progressed, we realized that the practices we were using to develop process models did not provide for the incorporation of global geographic issues into the models and calculations. We needed new methods to develop the process models, and it was important that we teach these methods as part of the course content for Mechanical Engineering 574. As the research developed by Dr. Cox and I constituted the main motivation for changes in the course, an understanding of the research and its evolution is necessary in order to be able to appreciate the need for the course redesign.

Before I began working with Dr. Cox, his research focused primarily on virtual product development process modeling, automation, and optimization. The objective of this research is to convert a somewhat arbitrary human process for executing product development into a standardized and automated process. As explained by Walker and Cox (2008a), virtual product development is used to create models and simulations of product development deployment. These reconfigurable network models can be perturbed to identify all possible deployment configurations, combining actors from the organization with tasks in the specified process. Using a secondary calculus of metrics based on such business-related issues as production costs, time to market, precision, and quality, each resulting configuration can be scored, and the optimal deployment identified.

Because it is possible to assign to process models specific metrics that measure issues having a potential impact on process execution, these models are especially useful as corporations expand internationally (Subramaniam & Venkatraman, 2001). As mentioned previously, the work of Dr. Cox as a consultant to international aerospace organizations such as Pratt & Whitney, Honeywell, and others exposed him to a variety of product development processes and their associated challenges. Specifically, as the aerospace organizations acquired international facilities, teams, and resources, new challenges arose, such as language differences and communication difficulties, environmental impediments, and cultural differences. Such challenges were often times unanticipated or overlooked prior to product development deployment (Walker & Cox, 2008b).

Seeing this trend within – but not limited to – the aerospace industry, Dr. Cox and I developed the ideas behind virtual product development and process automation further to include a process whereby the metrics of a process model would represent the challenges presented by global, diverse teams and processes such as those cited by aerospace company representatives (Walker & Cox, 2008b). The new models incorporated the global issues using metrics assigned more to represent trends than to exactly represent the cost or impact of the global issue. These new models allowed engineering firms to do sensitivity studies (e.g. how sensitive is the process cost to the amount of vacation time taken by employees for cultural holidays? How sensitive is the total process execution time to the impact of language differences?) to ascertain the potential impact of a specific global issue on a proposed product development process launch. Helquist, Cox, and Walker (2009) provide examples of these modeling techniques and their application in business settings.

The ability to develop these models represents a significant advantage to the students at BYU, particularly since they were more likely to have had global geographic experiences than typical university students, due to missionary service. However, another aspect of the consulting and research that was troubling was that many of the programs and projects that Dr. Cox had reviewed had failed not only due to lack of methods for predicting potential impact, but because of the attitudes of the engineers and teams of engineers involved in the project.

Dr. Cox's extensive experience in the engineering field and particularly in the area of modeling and managing global engineering teams indicated that mechanical engineering students needed exposure to these topics in order to be current in their engineering skills and that they needed to experience attitude changes with respect to global issues. The attitude changes involved developing an appreciation for the diversity of the differing geographic regions as well as the potential strengths and weaknesses of those differences, and also learning to work effectively with fellow team members when engineering teams are formed that incorporate members from differing regions.

Mechanical Engineering 574 had been a course focused on teaching process automation methods without any attempt to create new process models or incorporate global geographic issues into those models. North American engineering companies had been using this course as a vehicle for training students for work in their companies as well as a test bed for attempting process automation projects. The course needed to be updated to include process modeling and focus on global geographic models and issues. The hope was that in redesigning Mechanical Engineering 574, the experience in the course could also cause significant changes in the students' attitudes.

For a more in-depth explanation of virtual product development process modeling, automation, and optimization, as well as additional applications, see Daley (2007), Walker and Cox (2008a, 2008b), and Helquist, Cox, and Walker (2009).

Circumstance and Constraint

The redesign project for ME 574 was conducted as part of the work assigned to me during my employment in the product development laboratory directed by Dr. Cox. My original tasks were focused on research but were split to focus on research as well as the redesign of the course. This meant that I could focus 10 hours a week on the redesign during the semester. Between semesters and in the spring/summer terms that hourly activity increased to 20 hours per week. Dr. Cox also focused a portion of his time on the redesign project. Several other graduate level students provided help in preparing materials used for lectures and exercises.

There were several constraints that were important in the redesign. The course redesign had to remain within the current ME 574 structure. It could not expand into two courses. The redesign had to also maintain the traditional delivery methods since there was no budget or support for a “field” type course. Finally the redesign could involve the refocusing of the course description as long as the department and university curriculum committees could approve the changes.

Detailed Preliminary Analyses

Target population analysis. The target population for Mechanical Engineering 574 is made up of engineering students at Brigham Young University. There are approximately 1000 students majoring in mechanical engineering, and Mechanical Engineering 574 serves as both a technical elective for undergraduate students (generally seniors in the program) as well as a course for Masters and PhD students.

The implications from a target population analysis were important in informing the redesign of the course. For example, we determined, as indicated in Table 1, that the students were not familiar with geography as a topic of study. Therefore, we felt we needed to introduce basic elements of geography as content in the new course. We also needed to present geography to the students as a topic of study. Connections between geography and the other aspects of engineering also would need to be identified. Though these issues would need to be addressed in the redesign, we felt that only a brief review of the basic elements of geography would be sufficient, with the main focus devoted to the connections between geography and engineering process modeling.

Another result of the analysis indicated that students lacked familiarity with global geographic regions. In order to address this implication, we determined that the students should be immersed in the study of at least one geographic region through independent activities such as studying current events or tracking engineering businesses within a specific region during the semester.

The third and final implication in this analysis indicated that the students came into the class already familiar with the concept of process modeling, allowing us to revise the course content to focus less on basic, introductory concepts and devote more time to the incorporation of geographic issues into the process models, as well as other advanced process modeling topics. Table 1 provides additional insight into the analysis of the engineering student population.

Current training and resource analysis. The original curricular structure and strategy of Mechanical Engineering 574 involved a traditional lecture-based, deductive approach (Prince and Felder, 2006) with individualized homework assignments and occasionally industry-sponsored projects. The course lectures focused on introducing students to automation techniques and process modeling. The homework and projects reemphasized these topics by requiring the students to implement these automation techniques in scaled-down versions of real-world problems.

Students participated in a traditional engineering-type course, and experienced some exposure to the problems of industry through the projects. Typical engineering courses in the Mechanical Engineering program at BYU involve lecture on theory, followed by homework sets that students complete outside of class. These homework sets are traditionally textbook problems that are solved using the theory and equations introduced and explained in lecture. A teaching assistant is often required to give students some mentoring in demonstrating how to apply the theory to the homework problems. Table 2 provides an analysis of the resources and training available previous to the redesign.

Table 1

Target Population Analysis for Mechanical Engineering 574

Characteristic	Finding	Source	Implications
Familiarity with geography as a topic of study	Little awareness of geography as it relates to other fields	Accreditation review	Basic elements of geography must be included as part of content. Geography as a topic of study must be clearly defined Connections between geography and other fields need to be identified
	Moderate familiarity/ awareness	Instructor observation	Only brief review of basic elements necessary as part of content; more time can be spent discussing the actual issues of potential impact
	High familiarity/ awareness	Personal observation	Potentially involve these students in the teaching of concepts related to geography
Familiarity with global geographic regions	Little familiarity	Personal observation	Students given practical problems specific to certain world regions that require them to immerse themselves in the specified region
	Moderate to high familiarity	Personal observation	Students given opportunity to familiarize themselves with at least one geographic region of the world through independent projects focusing on one region
Existing knowledge of process models	Moderate to High familiarity and experience	Prerequisite classes provide exposure and experience with process modeling	More instruction time can be spent focusing on global geographic issues and their incorporation into process models than on the basics of process modeling Only a review of basic concepts relating to process models is necessary Complexity may be introduced and incorporated into process models as part of instruction

The analysis shows that because of the relative newness of the integration of geographic issues into process models, there were no textbooks available to address this integration. The implications pointed to a remedy in which readings in multiple textbooks that were devoted to the individual topics would be identified. A long-term implication would be that a new textbook would need to be written that addressed this integration of geography and engineering process modeling.

Another implication from the study indicated the lack of relevant case studies. Because the instructor was active in consulting and interacting with companies, we determined that he needed to develop effective case studies that could be used in the course. In the mean time, the existing case studies should be used and revised to provide as much relevant information as possible.

A final implication was that a more long-term solution might be to develop instructional modules that could be incorporated into the engineering curriculum throughout the undergraduate program. These modules would, ideally, better familiarize students with geography, with case studies of engineering companies, and with the problems associated with global geographic differences in engineering teams.

Existing product/competition review. Programs attempting to offer similar content and experience to that presented in Mechanical Engineering 574 exist not only on other college campuses but within Brigham Young University as well. One such program, known as PACE (Partners for the Advancement of Collaborative Engineering Education), involves the strategic selection of academic institutions worldwide to which PACE provides software licenses, and participating engineering students then work on teams using that software to design a project.

In 2005, for example, Brigham Young University was selected to participate as the lead

Table 2

Current Training and Resource Analysis for Mechanical Engineering 574

Topic	Finding	Source	Implications
Resource: Textbook(s)	Textbooks treat topics separately – textbooks that discuss both global geographic issues in conjunction with engineering process models are unavailable	Personal research	Excerpts from multiple textbooks may be given as reading assignments in order to address topics in engineering and geography/ globalization Only diagrams, examples from textbooks may be used in lecture and class discussion Create a specific text for the class that treats the topics of geography and engineering/ process models as they relate to each other, incorporating case studies as well
Resource: Case Studies	Most Case Studies currently available provide only partial examples of process models incorporating global geographic issues. There are a few case studies available that incorporate process modeling as well as global geographic issues	Personal interviews with engineering industry representatives	Need to create examples as realistic as possible for the purposes of illustration during instruction so that students can see the step-by-step method of quantifying a global geographic issue for representation in a process model. Use the few case studies that *are* available to provide as much example as possible and use for demonstration. Use to demonstrate process as a real-life example
Current Training as part of the university education: Global Geographic Issues	Little ‘training’ is available to students outside of the option to enroll in geography courses as part of general education; the majority of engineering students do not enroll in GE geography courses	General observation; Client observation/ experience	Potential for creation of an instructional module that may be implemented in various courses, especially prerequisite courses to the class. The instructional module must also be incorporated into this course of instruction

university in a global design project sponsored by PACE which involved over 140 students attending thirteen universities in eight different countries. Through this program and others like it, students have the opportunity to work on a global team in a collaborative design process. Although the PACE program does provide valuable experience on a global team for participating students, the program at BYU was unfortunately terminated during this design project because of a lack of funding and is no longer available to students.

Other similar programs that are offered specifically to engineering students at Brigham Young University with the idea of increasing global awareness in the students can be found through International Study Programs. Study abroad course offerings such as Globalization in China and International Product Development and Design in Singapore attempt to help students gain exposure and develop experience in cross-cultural teaming and involve them in field trips to local companies dealing with engineering processes. Additionally, these programs seek to help students understand globalization and technology issues and to acquire necessary skills for participation in and management of engineering activities in a global environment. Unfortunately, because of the cost associated with travel expenses and residence abroad, these types of programs are not as readily accessible to the general body of engineering students.

Design Narrative

It is important to understand that this project spanned several semesters, during which the design was continually evolving. Typically, Dr. Cox and I would work together to brainstorm and explore different possibilities in terms of our approach and practice, and determine based on our collective experience what we thought would “work” while concurrently and continually referring to relevant research from the field of instructional design.

As the purpose of this project was to improve the design of the course through a series of cycles, I will use the design narrative approach, as described by Hoadley (2002), to describe this redesign project in terms of the tools, the context, the activities and practices, and the evolution of the context in relation to the tools, activities, and practices employed. As Hoadley (2002) suggested, "narrative may omit details, but important agents, events, causes, and results are relayed…it does communicate compactly and effectively how a design came into being" (p.454). Given the iterative nature of this design project and its evolution over time, the design narrative approach seems most appropriate for describing the associated process.

Design Process

It is important to understand that Dr. Cox had taught the course for approximately six years previous to my beginning work with him. Mechanical Engineering 574 (or 576, as it was called during that time) was therefore fairly well established and well developed by the time I was introduced to the course and its associated research. In order to provide an idea of the scope and context of the redesign project, I will first provide a description of the course prior to my involvement with it, followed by similarly structured descriptions of each of the subsequent iterations or phases of the design process. These phases are divided sequentially and discussed in the following order:

1. Phase I: Course design prior to the BYU Winter semester of 2008
2. Phase II: Course design during the BYU Winter semester of 2008 (January – April 2008)
3. Phase III: Course design during the BYU Fall semester of 2008 (September – December 2008)
4. Phase IV: Course design during the BYU Fall semester of 2009 (September – December 2009)

Description of each of the above listed phases will discuss relevant pedagogical issues considered in the design; provide a brief course overview including structure, strategy, and methods; provide and examine representative examples of courseware and other instructional materials used; discuss relevant instructor and designer observations that also served as a means of evaluating the course design; and finally, discuss the implications and learnings of each phase and how they informed the subsequent designs, where appropriate. Figure 1 provides a graphical representation of the timeline and key phases of the project.

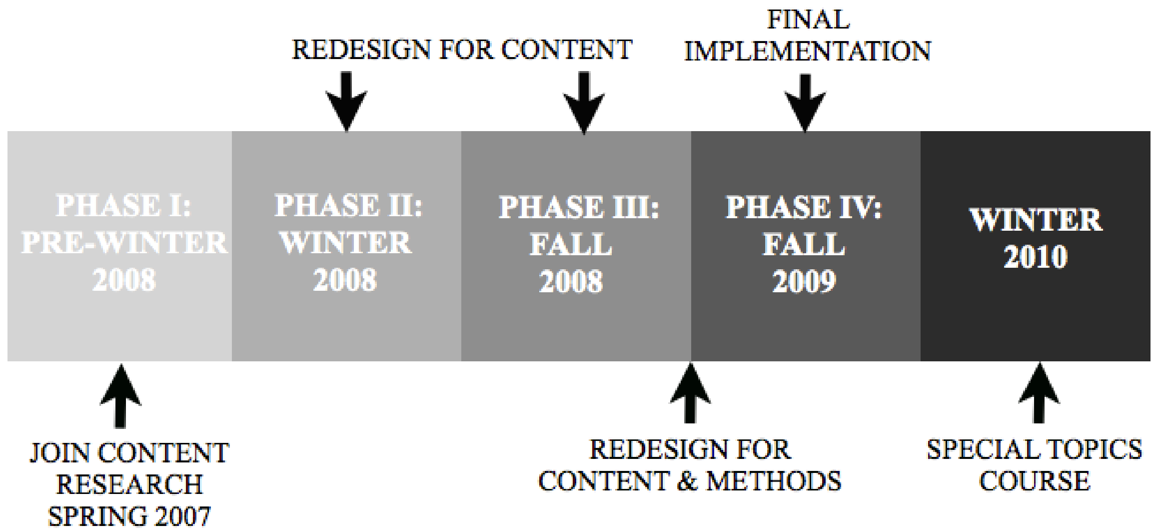


Figure 1. Timeline of the Mechanical Engineering 574 redesign project.

Phase I: Pre-Winter 2008

Pedagogical considerations. The course instructional approach followed a deductive strategy, as described by Prince and Felder (2006). This involved using scaffolding in a master-apprentice learning paradigm applied in the context of project-assisted learning, as defined by Monash University and discussed in the work by Mills and Treagust, (2003). These pedagogies were coupled with an understanding of Bloom's Taxonomy, which characterizes learning into at least three different types: cognitive, psychomotor, and affective. The emphasis in this course was placed on the first of the three – cognitive content and development of cognitive skills. There was no intentional attempt to develop psychomotor skills or influence affective learning.

The master-apprentice learning paradigm, discussed by Blumenfeld et al. (1991), focused upon a method of transferring the knowledge gained from 25 years of consulting experience of the professor to the novice students with little or no experience in the engineering profession. The scaffolding involved, for example, the use of predefined templates, created by the professor, for building automation tools used in industry. The students could later use these tools as the kernel for creating more advanced and customized automation tools to meet the needs and fulfill the requirements of the industry projects.

The industry projects were presented using a project-assisted learning approach in which heavy emphasis is placed on the use of projects and exercises, and the instructor delivers as well as controls the content. These projects were provided to the professor by company contacts in the engineering industry and reflected real and authentic problems the companies were interested in solving.

Course design overview. The purpose of the course was to introduce students to the art and science of creating process automation tools. By teaching modeling techniques and then applying them to simplified exercises, students would, ideally, be prepared to apply their new knowledge of modeling to real world problems and projects provided by engineering companies. Through their application of modeling techniques, students generally were able to produce custom automation tools specific to the engineering companies.

The course was naturally divided into two sections. The first section focused on teaching modeling practices through lecture and simplified exercises. The second section focused on practical training and experience through the use of industry problems. Lectures were given during the second section of the course as well to provide additional information about advanced techniques.

The instructional delivery method involved three 50-minute lectures per week and homework assignments for the first half of the course. Readings from a textbook written by the instructor entitled, *Process Automation and Knowledge Capture for Engineering Design* augmented these lectures and homework assignments. The second half of the course involved the assignment of a major project that the students worked on both independently as well as during portions of the class periods. Additional lectures were provided during class periods to enhance the students' learning with respect to more advanced topics.

Homework assignments involved exercises designed to teach fundamental cognitive skills that built upon each other to form a comprehensive skill, which students then demonstrated through a simplified automation project. This simplified project was assigned as homework during the first half of the course and served as an assessment of the students' learning of the cognitive skills necessary to complete a process automation tool. A major industry-based project was then assigned in the second half of the course. The major project was typically too difficult for a single student to complete and so often involved teams of students working together.

Courseware and materials. The course syllabus for Fall 2005 is provided in Appendix A, and is an accurate representation of the course syllabus for any given semester prior to Winter semester 2008. Scheduled delivery of lectures and readings is shown as well as the introduction of the final project and the final presentations to industry representatives.

The lecture presentations were delivered using Keynote slides, and involved instructor narration as well as class discussion. The lecture slides emphasized graphical representations of concepts with little or no textual information. Students were encouraged to take notes to translate the graphics into more concrete explanations.

Examples of process automation in industry were presented to students in what were called, “company profile lectures.” These presentations (usually organized through Keynote or PowerPoint) were intended to provide an overview of relevant industry examples and situations for the students. These company profiles were used to increase the students’ awareness of and familiarity with industry examples, as well as the differences among various company-specific process automation tools.

Industry project descriptions that were used for the major projects are provided in Appendix B. The project descriptions are for two projects provided by Honeywell Corporation during the Fall 2005 class. A midterm exam provided in Appendix C illustrates the formal assessment of student skills and understanding that was used in determining student readiness to proceed with the second half of the course. Upon successful completion of this assessment, the students were given the project descriptions and assigned the final projects.

Homework was graded and used to determine the level of student understanding of concepts and topics being taught. The pace of the course was then determined from the homework and project assessments. A mid-term assessment that consisted of two parts: first, the completion of the simplified project to demonstrate skills; and second, a written assessment, or midterm exam, was used to determine the level of student mastery of content and skills, and readiness of the students to proceed to the major project.

The final course assessment was typically a design review conducted by the professor together with project leaders from the engineering companies that provided real world problems/projects, which constituted the students’ final project assignments. Successful projects normally elicited funding for graduate research projects, hiring of students, or internships sponsored by the partnering engineering organization. During the first 5 years of the course offering, more than 10 student internships occurred and 2-3 full-time employment opportunities resulted, and partnering organizations provided over $100,000 in research funding.

Evaluation. This section provides reflections made by the course instructor – Dr. Cox – based on his personal, informal observations, as well as his experiences interacting with the students before, throughout, and often times after the course's completion at the end of the given semester. According to such observations, this course was typically one of the first exposures to industry-type projects for the students, and they (the students) were usually very interested in being better prepared to enter the professional workplace.

The master-apprentice learning approach seemed somewhat new to the students – as the majority of their program courses are more traditional in nature – and they struggled to adjust to the new approach. Rather than finding information in a textbook, the students were required to interrogate the instructor and this was not a skill the students had developed, for the most part.

The second half of the course was often the most enjoyable since the students were working on real-world problems. However, the unstructured aspect of the project meant that students had to carefully organize their time and accurately anticipate the workload for the project or else they would be unsuccessful in completing it.

According to Dr. Cox's observations, there was little or limited understanding on the part of the students of real world issues that impact engineering processes. Having so little experience with the profession, generally, it was difficult for students to understand the complexities of the process automation problem.

In the course evaluations conducted by the university over the 5 years before Winter 2007 the course ratings averaged 5.6 and the instructor ratings averaged 5.9, both on a scale of 7. Unfortunately, complete course evaluation results are no longer available and therefore will not be included in full in this report.

Implications and learnings. When I began working with Dr. Cox in the Spring term of 2007, he was concerned that the students' overall lack of real world understanding negatively impacted their ability to create process automation tools. Based on his experience in industry, his own research, as well as research in the field of engineering education, industry processes are largely impacted by issues of culture, communication, elements of human and physical geography, geo-political contexts, and other influences of which the students demonstrate limited comprehension despite their multi-cultural exposure due to missions and other travel and experience.

Student motivation, as observed by Dr. Cox, seems to be driven by their sense of need for exposure to professional practice. This is consistent with the conclusions of Albanese and Mitchell (1993), as well as Prince and Felder (2006), which indicated that people are most powerfully motivated to learn things they clearly perceive a need to know. In the context of 574/576, students are anxious about their careers and opportunities for employment during and following completion of the program, and therefore often give more time and attention to the 574/576 course because they perceive it will have greater impact on their ability to secure a job and be successful in that job. This motivation is a powerful force behind this course in particular, as 574/576 is normally available to students who are preparing to graduate soon or have recently graduated and are preparing to enter the industry. The course content and instruction, therefore, needed to be carefully managed so that the students are better prepared for industry and professional practice without being overloaded.

While the consistent excellent ratings of the instructor and course through evaluations administered by the University provided helpful feedback, other considerations had to be made in determining if and how to modify and improve the course. Dr. Cox felt that the exhibited levels of student motivation and enthusiasm were important indicators that needed consideration as he attempted to modify and improve the course. He also felt the responsibility to provide effective training and preparation for the students based upon their perception of the course. That being said, he made his decisions about the course before Winter semester 2008 based on his belief that this responsibility, coupled with student enthusiasm and motivation, was just as important as the positive student evaluation feedback in driving course development, if not more so.

Phase II: Winter 2008

Pedagogical considerations. As a result of Dr. Cox's observations during his involvement with the engineering programs, students, and more specifically the 574/576 course, he and I worked together prior to the Winter 2008 course offering to make changes to Mechanical Engineering 574 (its course number having officially changed to 574 by that time). Much of our focus was devoted to incorporating new content into the course relating to geography and global studies, rather than to more carefully examine instructional delivery methods.

Consequently, the instructional approach remained the same as before and was again largely deductive. In spite of previous observations regarding student motivation and instructor responsibility, new material was presented to students without a meaningful context – unrelated to previous course learning and unexplained in terms of its importance for future learning and practice. Felder et al. (2000) called this the "Trust Me" approach, as in, "trust me – what I'm teaching you may seem pointless now but in another year or perhaps in four years you'll see why you need it." Most engineering courses are taught using this approach, stimulating "neither interest nor motivation to learn" (p. 4).

This, however, is not to say that no attempts were made on the part of Dr. Cox or myself to make changes to the instruction or to follow established principles of educational psychology. Prior to the Winter 2008 semester, Dr. Cox attempted to more carefully outline his objectives for the course, as well as lecture schedules and assignments, this time paying more attention to the divisions of Bloom's Taxonomy. A sample outline for the month of January 2008 can be found in Appendix D.

There are, to be sure, flaws in the approach, as his classification of assignments and activities into the three categories (cognitive, psychomotor, and affective) shows his misunderstanding of their meaning at the time. For example, Assignment I, which would require the students to "use graph theory to model real systems," would not fall under the category of Psychomotor, but rather under Cognitive. Though the outlines and calendars are incomplete and show evidence of some misunderstanding, they do illustrate Dr. Cox's attempts to be more deliberate in using fundamental concepts of instructional psychology to guide his instructional design decisions.

Course design overview. Being at the time fairly unfamiliar myself with instructional psychology principles and theories, our first attempt at revising the course design was somewhat feeble, in that we focused primarily on content addition with little attention to the instruction itself. Hindsight is of course 20-20, and it is easier to recognize the missteps in retrospect, but it is important to acknowledge missteps as well as those in the right direction.

Once again, the course was divided into two sections, with a focus on process automation during the first half of the semester, and then shifting to process modeling during the second half. Although in this iteration more time was devoted to discussing process modeling techniques and activities, the course still followed a fairly traditional outline of lectures introducing new topics and principles, illustrative applications of the principles, practice problem sets and homework assignments, and a midterm and final project used for assessment purposes.

A key difference in the course came as a result of the development of our research. Since Spring term 2007, Dr. Cox and I had been developing our research further to include representations of global geographic issues, and methods for incorporating those issues into product development process models. In an attempt to represent this in the course content, we inserted additional lectures to introduce the topic of geography, its basic tenets, and basic methods for representing geographic elements within process models. Additionally, all of the lectures were redesigned to incorporate global geographic content as well as to present the integration of the geographic content into the process modeling techniques.

As before, the course continued to be taught in three, one-hour class sessions per week. The lectures followed the same format as the majority of the other lectures used in the course, making use of either Keynote or PowerPoint presentation slides, with some additional explanation provided using the available whiteboard or chalkboard space when necessary to demonstrate modeling methods.

Homework assignments remained much the same – problem sets and practice exercises were employed to familiarize students with the concepts and skills discussed in lecture, gradually culminating in a simplified automation project completed during the first half of the semester. Similarly, an industry-based project was used in the second half of the semester, in which students worked from a case study to develop product development process models and incorporate global metrics, according to the methods and principles they had been taught through lectures.

Courseware and materials. The course syllabus for Winter 2008 can be found in Appendix E. The syllabus reflects little if any change in the course outline, but Dr. Cox and I tried to be flexible with the sequencing of the course, and a course calendar was generally intended as a guideline rather than a rigid schedule.

Nearly all of the lectures were updated in terms of restructuring the content and media using new backgrounds and organization in the slides. Integration of global geographic content and presentation of its role and integration in process modeling was incorporated as well. Portions of Lecture 1 and Lecture 2 from the course are included in Appendix F so that a comparison can be made between the various phases of course design. A significant amount of global geographic content was added to the lectures.

It is also worth noting that, during March of 2008, I was able to meet with a BYU engineering graduate who worked at the time as the corporate manager of global programs and Product Lifecycle Management at Honeywell, Inc. Specifically, our interview was an opportunity for him to discuss the company’s efforts to participate in engineering processes with global, diverse teams. At the time, the company was transitioning into the role of system integrator in a multi-billion dollar project supplying controls and accessories to the new Airbus A350 aircraft. During the interview, this manager indicated that the company had launched multiple programs with global engineering teams, with none of the programs considered entirely successful upon completion. According to him, the cultural barriers and insufficient educational training prevented the teams from completing the required work both on time and within budget.

Additional interviews similar to that with Honeywell, Inc. took place with representative engineers and managers from Pratt & Whitney, a jet engine development company, as well as Goodrich, a developer of aircraft safety systems (see Walker & Cox, 2008b, for a full description of the Goodrich case study). Both echoed conclusions similar to those of the manager at Honeywell, Inc., identifying poor communication skills, language barriers, limited cultural understanding, and insufficient training as the foremost reasons for program failure.

Using the information provided in these interviews, Dr. Cox and I were able to generate presentations of the various case studies to show to the class, and use as examples to discuss modeling principles and theories in a specific, real world context. Sample slides from one such presentation as well as an example lesson plan for the instructional module covering the application of graph theory to building process models are provided in Appendix F, and samples of course lectures are provided below in Figures 2 and 3 for ease of comparison.

Note that the organization of the lesson plan does not differ significantly from pre-2008 courseware except in the content of the lecture. Whereas pre-2008 the lecture focused on a methodology for modeling engineering product development processes, in Winter 2008, the method for presenting the material focused on presenting the concepts of ontologies, levels of abstraction and graph theory, all formalizations of the previous methodology. Thus the methodology was presented in a more formal structure with connections to established work, which gave the students connection to outside work and additional materials.

Evaluation. During the Winter 2008 semester and following the completion of the course that term, Dr. Cox and I noted several observations. First, students expressed their skepticism as to why we added content to an already difficult course; especially content that was not, in their minds, clearly connected to the main topics.

Dr. Cox indicated that he had hoped that the students would be able to make the

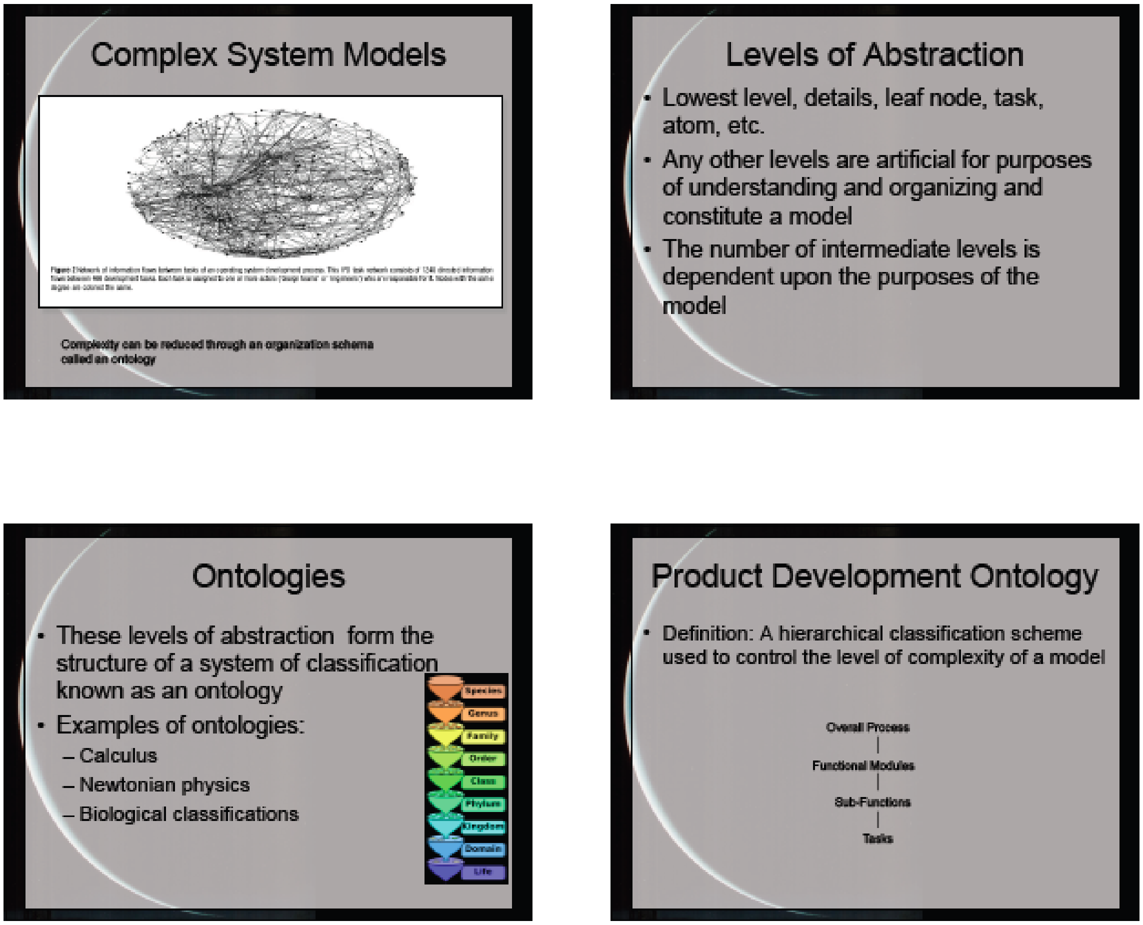


Figure 2. Winter 2008 sample lecture slides

connections between the global geographic content and the process modeling content, especially the human geographic issues, but was disappointed when the students seemed unable to do so by themselves and without heavy assistance from the instructors. For example, one student expressed upon completion of the course that he thought the course was “interesting,” but later related that he finished the class feeling uncertain as to its relevance or application to his profession.

The changes in the process modeling portions of the course seemed to be an improvement, considering that the students progressed further than they had before as evidenced by their ability to generate thousands of process options using the software tools provided for the final project.

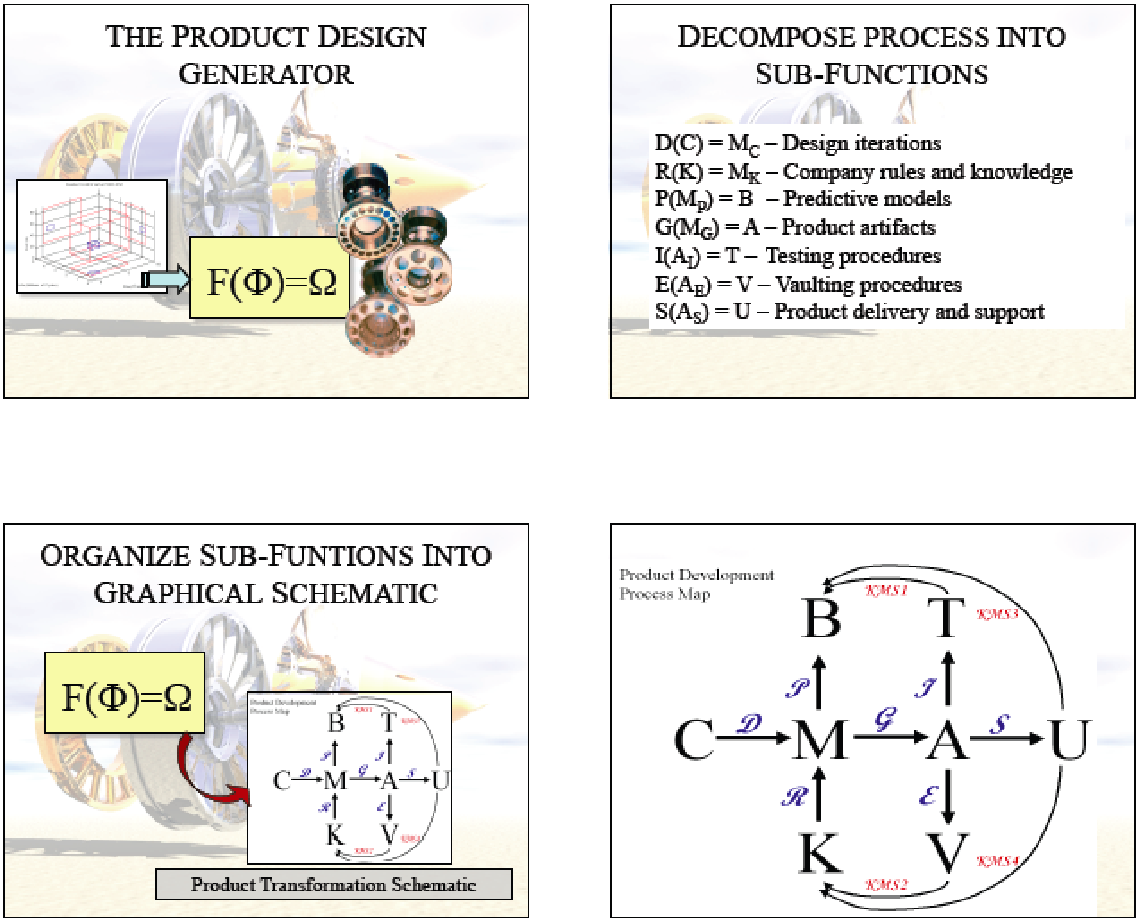


Figure 3. Pre-2008 sample lecture slides

This performance improvement was encouraging, but observing the students' challenges in recognizing the importance of global geographic issues in the process modeling was disconcerting and caused us to rethink our course and instructional strategy.

Implications and learnings. In retrospect, it is not difficult to see that the changes that we made for the Winter 2008 course were somewhat disconnected from the observations made by Dr. Cox. The course design did not change significantly during that semester, in spite of intentions to do otherwise, though some changes were implemented which addressed the process-modeling portion of the course.

The addition of global geographic content had not been sufficient to address the affective learning of the students, nor to help them recognize their need for understanding its relevance, a need that might have served as an important motivator in their learning. Just presenting the material, even in the context of process modeling, could not produce the change in attitudes and generate the understanding of their significance in the accuracy and effectiveness of process modeling. At this point, we began to question the deductive approach we used in our instruction, and felt it important to consider more dramatic changes in our design in order to help students make the necessary connections in their learning, as well as increase their motivation.

Phase III: Fall 2008

Pedagogical considerations. During the time between the end of Winter semester 2008 and the beginning of Fall semester 2008 (April-August), Dr. Cox and I worked to brainstorm together possibilities for incorporating global geographic issues – and their associated instructional activities – into the course design in a more cohesive and engaging way. Feedback from students from the previous semester (observed and informal, such as impromptu conversations, comments made in class to the instructor or to peers, etc.) indicated the need for more serious and deliberate revisions to the current course design.

In response to such feedback, and in an attempt to “think outside the box” and not limit ourselves to traditional approaches used in the engineering program courses, I contacted a number of faculty I knew from the Department of Geography at Brigham Young University and explained the work in which I was involved at the time, and expressed interest in using their course outlines and syllabi as a reference in our redesign of Mechanical Engineering 574. Several faculty responded, sending copies of project descriptions, assignments, syllabi, and lists of media resources. In this case, Dr. Cox and I were working from the recommendations of instructors experienced in teaching geography, rather than a particular pedagogy or attempting to hold to a specified instructional approach.

Course design overview. Whereas originally the purpose of the course was to introduce students to the art and science of creating process automation tools, including product development process models, the purpose of the course evolved just as well as the design did. The original learning objectives did not change considerably from one semester to the next, but in addition to the original objectives, students were also expected to demonstrate proficiency in and understanding of how to identify, characterize, and represent global geographic issues in product development process models.

In order to facilitate this, we first of all changed the structure of the course to more fully integrate the two main topics taught. In the previous semester, the course was divided into two sections, the first focusing on automation, and the second on process modeling and the impact of global geographic issues on those processes. This semester, however, we began by teaching right away the topics of globalization and process modeling, incorporating lectures relating to geography all throughout the semester.

Moreover, several new learning activities were built into the course design, adapted from activities and assignments used by faculty from the Department of Geography in their respective courses. For example, students were required as part of a course assignment to subscribe to an international news source and follow coverage of a world region of their choice throughout the semester. This culminated in a final project that was intended to help them make connections between the geographic characteristics of their selected region, and the processes of engineering organizations within that region.

Additionally, students completed seven map quizzes throughout the semester, having to identify and label, by name, specified countries on a map. Activities such as these were considerably different from other activities and learning experiences to which students were exposed in the engineering program, and distinguish this iteration of Mechanical Engineering 574 during Fall 2008 from any of the previous iterations. For a detailed description of the Fall 2008 assignments and projects, see the Fall 2008 Syllabus and Final Project description in Appendix G.

Evaluation of the course was limited mainly to informal evaluations derived from student feedback through conversations with the instructor, responses to questions asked by the instructor throughout the course to ascertain student attitudes and motivation, and student performance in formal and informal assessments. In addition to these more informal methods, feedback provided in the course evaluations administered by the University at the end of each semester was used to inform decisions regarding course revision and improvement. Unfortunately, as noted previously, course evaluation records and documents are no longer accessible and are therefore not included in full in this report. However, the overall ratings of the course and instructor did not change and remained excellent and above excellent, respectively.

Courseware and materials. The syllabus of the Fall 2008 course offering of Mechanical Engineering 574 underwent significant change following the Winter 2008 semester. Whereas previously we had attempted to continue teaching the "old" content in a new light, this semester we also introduced into the course much greater amounts of content relating to globalization and relevant geographic issues. This is not only evident in the Fall 2008 course syllabus found in Appendix G, but in the sample lecture materials found in Appendix H.

New textbooks were implemented for use in the course reading assignments, such as

Global Shift by Peter Dicken (2003). Student assignments involved a more strategic approach in that they were required to expose themselves more consistently to geographic issues in a specified world region of their choice by subscribing to an international news source. Having selected a particular world region to study, students were responsible to find and read articles about current events in or affecting the region, and submit weekly articles to Dr. Cox summarizing the article and discussing its relevance to their profession and field.

Further, to assist students in their projects and to augment their news source reading assignments, lectures were built into the course design to focus specifically on geographic features and issues that could potentially impact engineering processes. These were divided into several lectures/presentations that focused on one region of the world at a time. Sample slides from the introductory lecture, the lecture discussing the readings from *Global Shift*, and an outline of the lecture addressing geography and globalization are provided in Appendix H.

As is evident from the Lecture 1 sample slides, from the outset of the course during the Fall 2008 semester, we attempted to provide the students with a context for the topics we would address during the rest of the semester. Rather than waiting until the second half of the course, or even midway through the first half to introduce students to the concept of globalization and geographic issues as they impact product development processes, we wanted to begin right away with an overview and a context. We did this in the hopes that the students would more easily and naturally connect all of the material presented thereafter with the concepts of globalization and geography that were fundamental to understanding the research and associated modeling methods.

Evaluation. The introduction of a much more integrated content where global geographic issues were presented in the context of process modeling and automation improved the students' ability to use global issues in the models of processes they could construct at the end of the course, as they demonstrated in their final projects and through informal assessments. However, it was clear that they did not understand why they were doing it or the significance of the global geographic issues in the process models. The students' attitudes were also lacking in appreciation for the difficulty and complexity of conducting engineering processes in global contexts.

For the most part, students expressed their feelings that the course was like any other graduate level engineering course, only with geographic material integrated into the content. They therefore had to learn the geographic content in much the same method of learning as they applied to the engineering material. It was the lack of any significant change in the students' attitudes that left us feeling that we had not yet achieved our objectives in the course.

Implications and learnings. As was noted previously, Dr. Cox and I questioned the effectiveness of our deductive approach during Winter 2008 and intended to make changes in the course design to address that issue the following semester. Though significant changes were made to the course design with the introduction of new content in fairly large amounts, we realized that as a whole, our methods of instruction had not changed.

Still using traditional approaches, albeit with new materials, we wondered if an inductive strategy, as discussed by Prince and Felder (2006), would be more effective in helping students appreciate the relevance of the course topics and subsequently their need to know and understand them. It was at this time that Dr. Cox and I decided we needed to, in essence, go "back to the drawing board," and attempt a whole new approach. Changing the content, either by adding more, modifying the existing, or a combination of the two, was not sufficient to facilitate the accomplishment of our objectives.

These objectives, we also realized, became more clearly defined throughout the process of redesign that took place during the semesters of Winter 2008 and Fall 2008 – and perhaps it was the lack of more clearly defined objectives in our redesign process that contributed to our dissatisfaction with the resulting iterations during Winter and Fall 2008.

Phase IV: Fall 2009

As a preface to the discussion of the design of the Fall 2009 course, it is helpful as well as interesting to note that what we felt was by far the most successful experience of the course design is also now the most difficult to capture and articulate. Some designers would attribute the success of the experience of the Fall 2009 course to our having found the "secret sauce." Even the best-laid design plans, it seems, fall short of capturing all that occurs in a given instructional experience, in part due to the fact that they are "carried out in the messy situations of actual learning environments" (Collins, 2004, p.19). The following discussion is an attempt to describe the experience of the students as well as the instructors during Fall 2009, as observed by Dr. Cox and myself.

Pedagogical considerations. As mentioned previously, the objectives of the redesign of Mechanical Engineering 574 became clearer as the design process progressed. These objectives involved creating a new instructional experience for the students by modifying the structure and flexibility of the course, increasing cultural and geographic awareness in the students, helping students integrate engineering work and processes into global contexts, engaging the students in solving multidisciplinary and ill-structured problems, and motivating students by illustrating their need to know and understand certain concepts and practices.

Time was spent with Dr. Andrew Gibbons, chair of the Department of Instructional Psychology and Technology at Brigham Young University, to explore various instructional approaches and methods that would facilitate the attainment of the outlined objectives. After multiple discussions and brainstorming various possibilities, Dr. Cox decided it would be best to make the following changes in order to accomplish the identified objectives:

1. Invert the order of the topics presented so that global modeling would be perceived as a primary objective of the course
2. More fully integrate together the automation and global modeling into a single course
3. Incorporate multimedia learning materials into the course design to facilitate affective changes in the students
4. Include case studies in instructional and learning activities
5. Eliminate the more menial activities such as map quizzes, weekly journal entries, etc.

In addition to these objectives, we also wanted the course design to address outcomes similar to those pursued by Olds and Miller (2004) and characteristic of successful learning communities as noted by Tinto (2000). These included the students' formation of self-supporting groups, active involvement in classroom learning, and enhanced quality of student learning. It is important to note that the course outline, including instruction, activities, assignments, etc., was designed with a class size of approximately 20-25 students in mind, as that had been the average size in previous semesters.

It has already been noted in previous sections that we reconsidered the effectiveness of the deductive approach in achieving the objectives of the course. In light of these new, more clearly defined objectives, we turned our attention to what Prince and Felder (2006) called inductive teaching and learning, in which the instruction begins with specifics, such as a case study or a complex real-world problem to solve, and students generate a need for "facts, rules, procedures, and guiding principles, at which point they are either presented with the needed information or helped to discover it for themselves” (Pp.1-2).

According to Prince and Felder (2006), a range of instructional methods fall under the practice of inductive teaching and learning, such as project-based learning, problem-based learning, and case-based teaching, to name a few. All of these are considered to be student-centered, and according to Felder and Prince (2006), are variations of constructivism in practice. Student-centered learning, according to Hmelo-Silver and Barrows (2006), is founded in social constructivist theories. According to Bereiter and Scardamalia (as cited by Hmelo-Silver & Barrows, 2006), student-centered learning involves the negotiation of knowledge among learners, with a more knowledgeable group member facilitating the process. Additionally, they asserted that in order for learning to be student-centered, the students must be “active and intentional learners” (p. 23).

In light of these characteristics, we wanted the course design and the learning to be student-centered, and to provide students with valuable preparatory experience in that it exposed them to real and ill-structured problems, such as those they would confront in industry practice.

Additionally, in saying that we wanted to give the students an instructional experience that was different from any of their prior experience in traditional engineering courses, we wanted as much as possible to minimize the elements of competition and isolation that were so prevalent among the students as they participated in other engineering courses. We determined that, from the outset of the semester in Fall 2009, we would divert from the typical emphasis on individual achievement by telling the students to, in essence, forget about their grades and focus on learning. The effects of such an approach will be discussed in later sections.

Although we were unaware of this at the time, what we were hoping to facilitate with our design was what Johnson and Johnson (1991) called positive interdependence, one of five components essential to cooperative learning. Johnson and Johnson (1991) defined positive interdependence as the students' perception that they are linked to the other students in a way so that they cannot succeed unless the other students do, and vice versa. It was this type of interdependent relationship we wanted the students to experience in the course, not only because it differed so greatly from the experience of other engineering courses, but because we believed it would enhance their learning experience and attitudes as well.

Course design overview. It is important to recognize here that, in spite of our intentions to move away from emphasis on individual achievement, as well as a deductive approach, our design plan at the start of the semester did not entirely reflect this, though we thought that it did. We had modified activities, assignments, outlines, calendars, etc., but so many of the methods were still individualized enough that we did not realize until we began teaching the course and implementing our plans, that they needed further modification. As the semester progressed, we attempted as much as possible to modify the modules and activities to address not only the progress of the students, but the dynamics of their group as well.

More than in any other semester, the design of this course changed concurrently with its implementation. Following nearly every class period, Dr. Cox and I would review together the class session as it went that day and make decisions regarding the activities, structure, and topics of the next class period. This went on all semester, so that not only were the students having an entirely different experience from students in previous semesters, but Dr. Cox and I were also experiencing a fairly different design process.

For example, we provided a group problem to the class in the form of a case study in which students had to identify the geographic aspects of a region using the five themes of geography as a context. Denver was chosen as the location and the students worked during a class period to complete the project. As the students worked together and struggled to distinguish the five themes in their application, it became apparent that they needed more practice and exposure to problems like this, and the students asked for as much. Dr. Cox and I therefore met following that class period and discussed options for aiding the students in their learning and providing more activities as they had requested.

Consequently, we introduced two additional case studies into the instruction in the class periods immediately following, using slightly different problem contexts. Presenting them with a different strategy for identifying and classifying different geographic elements, we then asked the students to characterize the geographic issues relating to an engineering problem in Europe. Once again, observation of the group as they worked to solve these problems indicated the need for continued practice with a third case study. Taking a different approach this time, we presented the students with a more open-ended, ill-structured problem in which they were to act as consultants to an engineering company and solve a specific problem in Asia. These types of problems, or projects, more closely mirror the professional behavior of an engineer, according to Mills and Treagust (2003), as opposed to the “chalk and talk” methods employed in the past (p. 2).

Generally speaking, the design of the course evolved quickly to take a just-in-time approach, meaning that the instruction was given ‘as needed,’ including at the right time and in the appropriate context. This concept, coming originally from the manufacturing industry, was established for use in instruction by the Cognition and Technology Group at Vanderbilt in the *Adventures of Jasper Woodbury* project (1997). “Just-in-time” teaching is embedded in the instructional video materials, and the students can refer to it for information relevant to the problems they are solving. In the context of Mechanical Engineering 574, we would adapt our lessons to address the needs for new information that arose as students worked to solve problems and complete projects.

Courseware and materials. In addition to providing projects, problems, and case studies for the students, we also felt it important to incorporate various types of media into the instruction throughout the semester in an attempt to steer away from the instructional approach typically used in engineering courses. The idea was not to use media simply for the sake of using media, but to add variety to the classroom experience of engineering upper-classmen, and to engage the students in ways that previous courses and curriculum had not. Also, by carefully selecting media resources, we hoped to be able to assist them in expanding their views to consider elements outside of engineering that would provide insight in their problem and project work.

Because the course content deals with topics and issues that can be more easily conveyed through audio and visual tools than can the technical topics addressed in most engineering courses, Dr. Cox felt that it would be important to seize that opportunity to not only address the issues more effectively and engage the students on multiple levels, but also to vary the type of instructional and learning activities employed. We believed that this would also help increase the affective learning of the students.

This approach connects closely with the multimedia learning theory discussed by Mayer (2003), which is based on the idea that verbal-only methods of instruction are somewhat ineffective. According to Mayer, students who listen to (or read) explanations that are presented solely as words are unable to remember most of the key ideas and experience difficulty in using what was presented to solve new problems. Mayer asserted that, “students learn more deeply from well-designed multimedia presentations than from traditional verbal-only messages, including improved performance on tests of problem-solving transfer" (p. 127). According to this learning theory, multimedia instruction has the potential to foster deeper learning in students because its messages can be designed in ways that are consistent with how people learn, serving as an aid to human learning.

In previous semesters, when audio/visual products had been used in the course, students responded positively and demonstrated greater understanding in their various assessments. Of course, the use of multimedia products in instruction in and of itself was not what produced the positive response. The content of the media products had been chosen carefully, and feedback from students at the end of the previous semester indicated that certain media products that had been used in class towards the end of the semester finally helped to tie together the two seemingly different topics that had been the main focus of the course. Based on that feedback, Dr. Cox and I decided to launch the instruction at the beginning of the semester with the specified media products as well as an expanded selection of new products.

The multimedia products were selected by first approaching the Geography department faculty to obtain a list of geography based multimedia. These included videos and interactive simulations. After reviewing these products, additional products were obtained through personal research using the library and World Wide Web. The selection of the multimedia to be used was based on several criteria: first, it had to address multiple geographic issues and their interplay; second, it had to also present an integrated context of business, engineering, and geography rather than treating any one of these separately.

Case studies provided in geography textbooks, problems and projects based on real world industry problems, and a practical consulting experience with a local skilled nursing facility constituted the main materials of the course. Map quizzes, international news source assignments, and other projects from previous semesters had been eliminated and replaced by more practical and hands-on activities and experiences. Much of the materials used in lecture presentations were preserved (though updated or improved in terms of presentation), but the timing and use of the lectures was based on the students' need as they worked through the various problems and projects. Sample slides from the lecture given to introduce the students to basic elements of geography can be found in Appendix I.

Evaluation. As part of a formal evaluation process, students were asked to participate in two written evaluations at strategic points in the semester. Approximately halfway through the semester in mid-October, the University's Center for Teaching and Learning assisted in administering a mid-course evaluation. Once students had submitted their responses and Dr. Cox and I had reviewed them, we gave the students the opportunity to further express their views in a class discussion. Evaluations had a 100 percent response rate. With respect to the first statement ("I am learning a great deal in this course"), the average rating was 7.4, with 8 being the highest. In response to the second statement ("course materials and learning activities are effective in helping me learn"), the average rating was 7.3, with 8 being the highest.

While these were helpful, the more helpful information gained from the evaluations were the students' responses to a set of five questions determined by Dr. Cox and myself and appended to the standard university mid-course evaluation form. These can be found in Appendix J, and student responses will be discussed in greater detail in later sections. Their feedback provided helpful guidance as we moved forward with the course that semester.

The second formal evaluation was given the second to last week of the course in the form of a questionnaire made up of four questions. These questions can also be found in Appendix J. Upon completion of the questionnaires, the students again were able to discuss their responses further in a subsequent class session dedicated to reflecting and discussing the course and their experience in it.

In the initial phases of the redesign during this semester, Dr. Cox and I decided together to only structure the course minimally. Not fully structuring the course before implementation allowed for greater flexibility throughout, and provided opportunity for the instructor to make changes to the design if necessary based upon student response and progress.

Normal enrollments in the course typically range between 20-30 students. During Fall of 2009, only seven students enrolled. With only seven students enrolled in the class, Dr. Cox decided on the first day to bring them back to his office, which had a table large enough for all of the students to sit around, and was equipped with a projector and sound system for the use of various types of media. After meeting once in the office, the students expressed that they were comfortable with meeting there as opposed to a large classroom, and for the rest of the semester the class was held in the smaller space of Dr. Cox's office.

This unexpected change in venue provided interesting observations regarding topics not originally or intentionally addressed by the redesign of this course, but that may be of some value for further research and investigation. Although it is difficult to determine decisively at this point without any experimental evidence to support an assumption as to the cause, the interaction between members of the class, the instructor, and the designer differed significantly from that of previous semesters.

The first few instructional modules were presented to the students and the assessments and activities were in general designed to be completed individually by each student. However, the class discussions began to be more active with all students fully participating. There began to be a rapport between the students that had not occurred in previous semesters until much later in the semester, if at all. Because of this rapport, the instructor decided to modify one of the assessments and reinforcement activities to include the entire group of students. This was so successful that the students began to ask that all future activities be group activities, causing the instructor and designer to redesign the remaining modules so that the activities were mostly group-oriented.

The sequence of topics had been inverted from previous semesters and the automation portion of the course was presented about halfway through the semester. This portion of the class has traditionally involved highly individualized activities, with each student developing their own problem solutions. However, because of a reduced class size, and the resulting interaction between the students, one design change that was made involved a shift from individual assignments and activities to group activities and assignments. The Fall 2009 group requested that the project normally required individually be required of the group instead. The instructor was reticent to allow the students their request. However, in an attempt to allow the learning community to influence its own learning, we assigned the project to the group as a whole.

The students organized themselves and spent evenings working on the project and when it was presented, demonstrated that not only had they all participated, but all were familiar with the entire project and not merely that portion to which they had been assigned by the group. Students were given more time to interact together as they engaged in activities intended to aid them in achieving the objectives of the course. They became a community of learners that worked to solve problems and construct knowledge together, and this shift in activity and collaboration became a significant element of the design that had not been anticipated in previous implementation phases or stages of the design process.

Students appeared to be not only more enthusiastic at this point to work through the problems presented, but also expressed their desire to take ownership of their work and their learning. For example, one student wrote in his/her mid-course evaluation response:

> I'm enjoying very much how the class is being tailored to fit the dynamics of the group. The relaxed nature of the instruction allows me to focus on what is being taught instead of how to jump through the hoops to get the required grade. For once, I feel like I am actually free to dig into things and learn.

Other students reflected similar ideas, responding, "I like that I didn't feel pressured by grades, which allowed me to learn how to do it rather than meet the requirements for a grade. I worked hard because I wanted knowledge, not a grade." With themes such as desire for continued group work, student-centered instruction, and increased motivation arising out of the various evaluation responses of the students, I worked with Dr. Cox to consider options for adapting our instruction as the semester continued to focus on these and other themes that we discovered in the students' feedback.

For example, the instructor evolved to become more of a coach, observing the interactions and progress of the group, interjecting himself periodically as he saw the need to provide guidance, and then extricating himself to allow the group to continue again on their own. In other words, the instructor acted as a "guide on the side" instead of as a "sage on the stage," placing students at the center of the learning process, as described by King (1993, p. 30). While still presenting course material, the instructor's role adapted from one of transmitting knowledge to facilitating the students' interaction with the material and with each other. In encouraging the students' interaction with each other, the instructor also reemphasized the component of positive interdependence as discussed previously. The students later indicated that his approach was helpful in providing navigational corrections to the group as they attempted to learn collectively. A sample lesson plan constructed during the second half of the semester as the students prepared for their first consultation with the local skilled nursing facility can be found in Appendix K.

Another common theme among student evaluation responses addressed the structure of the course. Several responses indicated that the students felt uncomfortable with the more loosely structured course outline and instructional approach. No syllabus was provided to the students at the beginning of the course or at any time during the course, and some expressed an interest in knowing the “end goals” as well as the criteria for doing well in the class. At the same time, interestingly enough, some students admitted in their evaluation responses that even while they were asking for more structure and increased accountability (through structured assignments, rubrics, etc.), they also felt that it was their responsibility to be proactive in learning regardless of the structure of the course.

Although I considered the possibility of introducing a more rigid structure into the course design in response to the students’ feedback, Dr. Cox and I discussed the options and felt that the expressions of discomfort by the students were not necessarily negative, but were rather more representative of an instinctive rebellion because of how they had been conditioned to approach their traditional engineering (and perhaps general education) courses. In retrospect, it seems that what we were observing in the students’ responses is similar to the phenomenon described by Albanese (2000) as he discussed the transition of medical education students from a traditional, deductive curriculum to a problem-based, inductive curriculum:

> Those who support PBL [problem-based learning] often consider the traditional teaching methods to be outmoded relics of the past, dinosaurs if you will. If that is the case, medical students represent the tyrannosaurus rex (T. rex) of that Jurassic

> curriculum. They have not only survived a brutal `Darwinian' selection process, but thrived. Expecting students who are selected through a process which ensures survival in a traditional curriculum to perform even better in a PBL curriculum seems like transporting a T. rex from the Jurassic period to modern times and expecting it to thrive in a petting zoo. After a few `kiddie' meals, it should be clear that simply relocating a lean, mean killing machine to a more docile environment will not change its eating habits. (Pp. 731-732)

The students in Mechanical Engineering 574 during the Fall 2009 had no doubt survived the “selection process” of the Jurassic era, and their expressions of discomfort with the lack of structure and their desire for a set of defined criteria were merely manifestations of their struggle to change their “eating habits.” Their achievement in lecture-based, competitively graded courses apart from 574 was not necessarily the type of achievement that would ensure their success in this course. Considering that it was that type of attitude Dr. Cox and I hoped to deemphasize through the course design, we actually viewed the student responses regarding the structure as positive indicators that we were accomplishing our objective in that regard. We had hoped to provide the students with an experience different from those in other courses, and they recognized a difference between this course and their more typical, traditional courses.

The instruction looked much more like inductive teaching than deductive, but the resulting experiences were a cross between project-based, problem-based, and case study methods, with some lectures still following a deductive approach. Different methods were employed throughout the course of the semester, depending on the perceived needs and interests of the students based on informal assessments, class discussions, student progress in assignments, etc. While the instructor did not fulfill strictly the role of the typical facilitator in problem-based learning at all times throughout the semester, he did often act as a coach and a tutor to the students in their learning process, as they solved problems, developed proposals, and engaged in tackling the various elements of the projects presented to them.

It is difficult to know how to ultimately name the process or approach that evolved in this final iteration of the design. So much of the design evolved because of the students' excitement and enthusiasm not only for the topic, but also for the opportunity to direct their learning, and their motivation in doing so was unlike any that we had observed among the 574 students previously. The structure of the course, as well as the physical environment, the size of the class, and the attempt to vary the content and methods all contributed to the students' interest, motivation, and participation.

Their response, in turn, allowed Dr. Cox and I to incorporate new content and new methods into the design, resulting in a helical effect. In fact, as the semester of Fall 2009 came to an end, the students requested the creation of a special topics course the following semester that would allow them to continue the work they had begun during Fall 2009 and continue learning not only about the topics we had addressed in 574, but also continue in the same learning environment in which they had been participating all semester. All but two students signed up for the special topics course and continued into Winter 2010.

Implications and learnings. The enthusiasm and engagement of the students, while we had hoped for it and sought to encourage it in our design, was greater than we anticipated and more than we had observed in previous semesters. This response led us to consider the implications as well as the elements of our design that were either impacted by it or that may have elicited such a response. Student feedback from course evaluations was helpful in identifying elements of the course design that the students enjoyed or that helped to increase the students' interest and motivation, such as group work, student-centeredness, and new and relevant content. These elements are not novel instructional practices, but were fairly uncommon in other engineering courses.

In fact, during the initial phases of the redesign, Dr. Cox and I met with representatives from the office of the Dean of the College of Engineering and Technology and presented to them our research as well as our plans to develop a course that implemented that research meaningfully so as to better prepare students for practice in industry. The representatives, including the dean, expressed excitement and interest in the idea, asking for a module design or some type of template that could be used to implement the content and instruction into other engineering courses as well. At the end of Fall 2009, having seen such a positive response from students and their motivation to the point of requesting further instruction and experience in the course, we considered the potential implications in terms of creating a module for engineering courses that included such key elements as the group interaction, student-centeredness, and key content.

Another implication of the experience of Fall 2009 that we considered is that, under the "right" circumstances, students are willing and able to convert from a deductive learning approach to an inductive one, and based on our students' response, they seem to prefer inductive learning. This is not to say – and it was not our experience – that the students will transition without putting up a fight. There is almost definitely a struggle in the conversion process, as it requires a different process, practice, and mentality, as was described previously by students' evaluation responses. One question that inevitably arises, however, is, what are the "right" circumstances? No doubt the circumstances are not entirely under the instructor's, or the designer's, control. We simply faced a classic question of instructional psychology in the microcosm of our experience, and were we to implement the same design in the 574 course another semester, it is not clear that we would achieve the same results.

In the shift from deductive to inductive learning and instruction, another question that arose dealt with the impact of the physical learning environment on the students' ability to transition from one to the other. Because of the small class size, we were able to move the students from a more traditional engineering classroom with rows of individual desks and a designated front of the classroom to a smaller classroom with a single conference table. The structure of the classroom itself was somewhat more flexible, creating in essence what Conway (1993) described. "The classroom should be a very flexible environment…with maximum flexibility for interaction between and among teacher, student and information. In short, classrooms should be designed to provide interactive teaching and learning environments" (Conway, 1993, p. 3). With large whiteboards, a projector screen, and a single conference table that accommodated all of the students in the class, the students commented on the more relaxed setting and its impact on their experience, with one student concluding in the final course evaluation that, "the classroom and table set helps with our relationships with each other."

Dr. Cox and I wondered at times if the rapport between the students and their interactions in class discussions and while working on assignments would have been the same had we spent the semester in the original, traditional classroom where the students would have been separated by desks and the feeling of the room was less intimate because of its size. Additionally, we wondered what the impact was of physically moving the students from a traditional classroom while at the same time moving them "instructionally" from a traditional deductive approach to an inductive approach.

Another observation that comes from the Fall 2009 experience deals with the role of the instructor. Some educators would look at what took place during Fall 2009 and claim laziness on the part of the instructor because of the lack of structure, and the amount of student control in the learning process. Though our design was not entirely in line with a total problem-based learning approach, the role of the instructor often reflected the same attributes and skills. As a facilitator of learning, the instructor as a guide in the learning process, models good strategies for learning and thinking, monitors the discussion and implements appropriate strategies as needed, and pushes students to think deeply (Hmelo-Silver and Barrows, 2006).

Although problem-based learning is highly student-centered, the facilitator is just as important to the learning process. In some aspects, instructors find that teaching (or facilitating) a student-centered class is almost more difficult than a traditional, instructor-centered class because it is just as important that the facilitator recognize when to abstain from providing guidance or instruction, as it is to recognize when intervention is necessary and helpful. Knowing when to intervene as well as when to refrain from intervention, how to guide, and what information to provide were only a few of the aspects of the inductive approach that were somewhat unfamiliar to us.

This reflects similar issues addressed by Moust, De Grave, and Gijselaers (1990) in their discussion of the tutor's role in problem-based learning, a type of inductive approach. A study reported by Moust et al. (1990) described participating tutors as experiencing the same difficulty – namely that they struggled with "keeping their knowledge to themselves" (p. 147), and in adjusting to contributing indirectly to the students' learning process. As the instructors for the course, Dr. Cox and I found that we had to adapt in the same ways to the new, inductive methods, and to the adjustments in role relationships. The students also expressed their struggle to adapt to these adjustments. With this approach, our roles were fairly different from what they had been in previous semesters where the predominant strategy was deductive.

Needless to say, the transition to an inductive approach proved to be rich in the reflections and insights it generated. With so many changes to consider in the roles and experience of the students as well as the instructors, the course content, the classroom setting, the structure, and the design process, it is easier to see why Collins (2004) called the learning environment a “messy situation” (p.19).

Results and Conclusions

A project of this scope and extent has the potential to provide a variety of insights into the practical aspects, the design process, and the theories underlying the design and practice decisions. In the following sections I will discuss those insights, which, for me, were not only most valuable, but also that were most characteristic of the entire experience. This discussion is in no way exhaustive, but seeks to capture what I perceive as the more important take-aways of the experience.

Practical Insights

Let me first say that the value of careful documentation in an academic process has become more apparent to me throughout this project, and more particularly in the reporting of it. Although I attempted, especially in the later phases of the redesign project, to keep a design journal and capture what took place both in and out of the classroom/instructional setting, I regret my own lack of diligence in doing so. The recordings I did make are helpful and have provided direction in this report, but – and I believe this will almost always be the case – greater specificity in those recordings could have provided valuable insights into the design process and the instructional experience. Additionally, because of the length of time spanned by this design project, more detailed recordings could have served as helpful reminders of specific experiences that have clouded as the design evolved and the project continued.

All of that being said, I am still careful to caution against excessive rigidity that can result in a project like this from too much reliance on detailed documentation such as plans, schedules, and assignments. As discussed previously, for example, the final iteration of this design project that took place during Fall 2009 did not include a course syllabus or calendar. While some students found this lack of structure frustrating, the instructor and I felt it important to avoid presenting the students with a course outline and calendar from the beginning. Obviously, calendars, when used, do not have to be set in stone and generally are not, but based on the objectives of our design and our understanding of the attitudes typical among the engineering students, we felt our best option was to forsake the traditional approach that often engenders rigidity and corner cutting among students within our target population.

In light of this, I would add that pushback can be expected when introducing change to students, especially in an area of their lives so demanding and influential as academics. Graduates and seniors coming into our course, by that time, had participated in the academic system long enough that they had developed attitudes, perceptions, and strategies regarding their approach to their education, and by introducing a new method into their academic lives, we were in essence potentially disrupting those attitudes, perceptions, and strategies. It is not surprising, then, that the students expressed frustration and uncertainty and at times requested a return to the "old" methods to which they were accustomed.

What we had to resist as the designer and instructor was the temptation to give in to their requests when we could see the potential for greater gains by proceeding. Because one of the main objectives of inductive methods is, as Moust et al. (1990), explained, to increase students' autonomy and control over their own learning processes, it was important for us to proceed as we intended with the seemingly loose structure. By so doing, we were able to allow the students more active roles in their own learning and foster relationships that may not have otherwise been built. These conclusions are based mainly on observation, and the instructor must use his/her best judgment in each unique situation in determining to how to proceed. For us, the decision to continue along the spectrum toward inductive methods produced positive results.

These observations lead to an additional insight in terms of practice: a successful instructor must be flexible. I would argue that an inflexible instructor, in most cases, has removed the students from the instruction and learning equation, however counterproductive that may seem. Since their instruction is (and should be) directly connected to the students' learning and progress, it then follows that flexibility is an essential element of both instruction and learning. Whether we were operating in a content-driven, highly structured course design or a student-centered, process-driven approach, our ability to be flexible and make adjustments to pacing, schedules, and assignments was crucial.

In terms of implementation, this project was valuable in that it demonstrated the importance of a gradual conversion in a redesign. In the case of Mechanical Engineering 574, a complete break from deductive methods to focus entirely on inductive methods would have been problematic for both the students and the instructor, but more particularly for the instructor.

Because new groups of students enroll in the course each semester, it would be impossible for the students to compare one iteration of 574 to another. True, it would likely be difficult for them to participate concurrently in other engineering courses that follow a deductive strategy while participating in a completely inductive course within the same discipline, but the instructor would have experienced the greatest challenge in the transition. Although it would not have been impossible in this case, for example, for Dr. Cox and I to adopt inductive methods suddenly as opposed to gradually, we would have experienced a strain and even a loss of time as we overcame the learning curve with the new strategy.

As a final insight into the practical aspects of this project, I would add that the insertion of content alone does not necessarily result in a new design. Dr. Cox and I spent much of our time during the initial phases of the project focusing on content modification and incorporation into the existing design, but soon recognized that the experience for the students was not changing as we had hoped. While they may have been exposed to new topics and concepts, instructionally they were having more or less the same experience that other students had had in previous course offerings.

Design Insights

In terms of design, this project was especially useful in helping me to appreciate the importance of iteration in design. Because of the nature of this project – it being a redesign that spanned several semesters – it afforded the opportunity to experience multiple iterations of the design. As designer-instructor, I was able to participate in multiple aspects of the design and particularly its implementation.

It was easier to see throughout the development of this project that the phases of the design process, such as analysis, implementation, development, etc., are not always clearly divided. Much like the boundaries of formal geographic regions represent transition zones rather than hard divisions, the phases of the design process overlap as the design is implemented, analyzed, and developed further, and this process is repeated as often as necessary until, as Collins, Joseph, and Bielaczyc (2004) described it, "all the bugs are worked out" (p.19). During the final semester in which we were analyzing, revising, and teaching the course concurrently, divisions between the different stages were grayer than they were black and white.

Perhaps my experience and personal investment in this design project increases my bias, but it is difficult for me to imagine a design process – or at least, a successful one – that is not iterative. Hoadley (2002) affirmed this idea:

> Good design is iterative. The process of creating something to address a goal is repeated many times as the design artifact or process is tested, observed, and refined…By repeatedly creating, implementing, enacting, and improving our interventions, one begins to understand intuitively and empirically what works and what doesn't, and also which features of the design are essential and which are irrelevant to the goals. (p. 2)

This observation leads me to an additional insight I gained through this design experience, that I do not believe I fully appreciated previously. In past design projects, I created a design document providing plans, instructions, materials, and other design artifacts for the person or organization that would be responsible to implement the design. At that point, my involvement with and exposure to the design and the resulting experience was at an end, and I was not personally involved in the experience that evolved out of the design in practice.

In this project, however, I was there in the middle of all of the phases, including implementation. I not only observed, but participated directly in the experience that resulted from the implemented design. It is because of this difference that I now appreciate the fact that no design document or final product, however detailed in description and instructions, can adequately capture or convey the instructional and learning experiences that take place as a result of or in concert with the design plans.

Even now, looking at the materials and courseware provided, accompanied by lengthy descriptions in this report, I recognize the disparity between what is represented in the documentation and designs, and what actually took place. If it were possible for me to take all of the same design materials, resources, media, tools, and environment, with the same instructor and students and travel back in time to Fall 2009 to somehow duplicate the original experience, I could not do so. Although the design plans and artifacts are exactly as they were, each implementation creates a new experience, and those experiences are incredibly difficult to represent and impossible to replicate.

Finally, I would add that the design process was just as important, if not more so, than the final design product. The journey we took to arrive at our destination was as much a destination for us as the final product itself. As instructors and designers, our final design cannot be separated from our design process. Dr. Cox as the instructor and as a co-designer expressed after the course that he would not have been prepared to shepherd the learning of the students in the Fall 2009 course had we not participated and worked through the previous iterations. In essence, this design project represents as much of a change in the learning and instructional experience for the professor as it does for the students, and those changes would not have been as effective or as influential had we not participated in the design process itself.

Theoretical Insights

In light of these observations and learnings, I am led to conclude that, regardless of the theoretical and pedagogical underpinnings a designer may claim, so much of design and instruction is intuitive, and that intuition is enhanced with experience. In saying that I do not intend to discount the importance of understanding the theoretical perspectives that attempt to explain psychological phenomena in learning and instruction. The power to positively influence learning that comes from an understanding of fundamental concepts, most often couched in learning theories, cannot be overestimated. But my experience in this design project, as well as in other instructional settings, tells me that expert teaching practices are not exclusive to experts in theory.

I had the privilege during this project of observing a talented and effective instructor who had limited knowledge of and exposure to theories of educational psychology. As mentioned previously, he was somewhat familiar with basic principles such as Bloom's Taxonomy, but even that understanding was erroneous in some aspects. Nevertheless, his ability to recognize student needs, perceive student interests, and respond with appropriate, useful practices did not appear to be hindered in any way by any lack of knowledge or exposure to relevant theories.

He was working off of approximately twenty-five years of experience in teaching, making judgments and decisions based on his own observations and experience. Without any cognizance on his part or the ability to necessarily label his practices as such, he was employing scaffolding, acting as a facilitator, practicing cognitive apprenticeship, etc., and helping to create very positive experiences for his students. Additionally, this redesign process was an important evolution for him as an instructor, as he was learning, along with his students, to adapt to new methods and make them as successful as possible.

While knowledge of theories and names of practices/techniques is not always necessary for successful experiences in learning and instruction, I have also seen through this process how helpful it is to provide a framework and a language for describing, discussing, and understanding what takes place in those experiences. When I began this design project, I was as yet extremely unfamiliar with the field of instructional psychology and the associated vernacular and theories. As the project developed, I continued in my coursework and learning concurrently and now recognize the richness that my own personal academic experience affords in being able to observe, analyze, evaluate, and discuss the evolution of the project.

One final conclusion I would address here deals with the student achievement outcomes that resulted after the final iteration of the design in Fall 2009. As evidenced by the prevalence of traditional, deductive methods, most inductive teaching methods are largely opposed by faculty in a variety of fields from medical education to engineering because of the cost in terms of faculty time and resources. Among the problem-based learning community in particular, there is constant debate as to the viability and the cost of implementing the inductive curriculum – if students from the inductive arena demonstrate no significant differences in performance from their deductive counterparts, is a more widespread implementation of the inductive, problem-based learning methods really worth the cost?

In a study presented by Albanese (2000) of medical practitioners graduating from a problem-based learning curriculum at McMaster University, the graduates demonstrated a greater desire to affiliate. This is consistent with a separate finding that students and faculty in problem-based learning schools enjoy the educational process more than students and faculty from traditional learning schools, and that they were more likely to engage in lifelong learning.

Although a rigorous study was not conducted to compare groups in the case of Mechanical Engineering 574, the observed student responses, and the instructional experience of the Fall 2009 semester indicated a finding similar to that discussed by Albanese (2000). The students and the faculty enjoyed the educational process more during the semester in which inductive methods like problem-based learning were implemented than did the students and faculty during the semesters when the instruction was mainly deductive.

Seeing the differences in student responses, especially with respect to their engagement, enthusiasm, and motivation in learning, Dr. Cox and I were surprised more by the levels of these affective responses than the responses themselves. When the students further reiterated their excitement and enjoyment in the course by requesting to continue the following semester of their own accord, we knew that something had changed, and it was nothing that we had observed in our previous, deductive experiences.

In light of these observations, I am led to conclude, as Albanese (2000) did, that if the inductive methods can facilitate such a response in the students, even if their performance levels in terms of assessment and other cognitive measures are not significantly different, that the investment required to implement inductive methods is worthwhile. Students who left the Fall 2009 course demonstrated and expressed an enthusiasm for their field, a confidence in their ability to solve difficult problems and engage in industry practice, and a motivation to continue learning that previous deductive methods did not produce.

Promoting lifelong learning by engaging the students in meaningful problems and activities and allowing them to take a more active role in their learning, is, as Albanese (2000) suggested, "a worthwhile goal in and of itself" (p. 737), and one that I am determined to pursue as a result of this project.

References

Aglan, H.A., & Ali, S.F. (1996). Hands-on experiences: An integral part of engineering curriculum reform. *Journal of Engineering Education*, *85*(4), 327-330.

Albanese, M.A. (2000). Problem-based learning: why curricula are likely to show little effect on knowledge and clinical skills. *Medical Education*, *(34)*, 729-738.

Ancona, D. G., & Caldwell, D.F. (1992). Demography and design: Predictors of new product team performance. *Organization Science*, *3*(3), 321-341.

Bereiter, C., & Scardamalia, M. (1989). Intentional learning as a goal of instruction. In L. B. Resnick (Ed.), Knowing, learning, and instruction: Essays in honor of Robert Glaser (pp. 361-392). Hillsdale, NJ: Erlbaum.

Blumenfeld, P., Soloway, E., Marx, R., Krajcik, J., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist 26*(3&4): 369-398.

Brannick, M.T., & Prince, C. (1997). An overview of team performance measurement. *Team performance assessment and measurement: Theory, methods, and applications*, eds. M.T. Brannick and E. Salas. Mahwah, NJ: Lawrence Erlbaum.

Bugliarello, G. (2008). Globalization and engineering. *The Bridge*, 35(3).

The Cognition & Technology Group at Vanderbilt. (1997). *The Jasper project: Lessons in curriculum, instruction, assessment, and professional development.* Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design research: Theoretical and methodological issues. *The Journal of the Learning Sciences 13*(1), 15-42.

Conway, K. (1993). *Master classrooms: Classroom design with technology in mind.*

Unpublished manuscript, Institute for Academic Technology, University of North Carolina at Chapel Hill, Chapel Hill, NC.

Daley, J.: Autonomic product development process automation, Master's Thesis, Brigham Young University, 2007.

Dicken, P. (2003). *Global Shift: Reshaping the Global Economic Map in the 21st Century*. New York, NY: The Guilford Press.

Felder, R.M., & Silverman, L.K. (2002). Learning and teaching styles in engineering education. *Engineering Education, 78*(7), 674-681.

Felder, R.M., Woods, D.R., Stice, J.E., & Rugarcia, A. (2000). The future of engineering education: Teaching methods that work. *Chemical Engineering Education, (34)*1, 26-39.

Helquist, J.H., Cox, J.J., & Walker, A.J. (2009). Exploring diverse process and team alternatives through virtual process simulation. *Business Process Management Journal, 15*(5), 633-652.

Hmelo-Silver, C.E., and Barrows, H.S. (2006). Goals and strategies of a problem-based learning facilitator. *The Interdisciplinary Journal of Problem-based Learning, (1)*1, 21-39.

Hoadley, C.P. (2002). Creating context: Design-based research in creating and understanding CSCL. Proceedings from CSCL-2002: *Conference on Computer Support for Cooperative Learning: Foundations for a CSCL Community*. Boulder, CO.

Johnson, D.W. & Johnson, R.T. (1991). *Learning together and alone: Cooperative, competitive, and individualistic learning.* Englewood Cliffs, NJ: Prentice-Hall, Inc.

King, A. (1993). From sage on the stage to guide on the side. *College Teaching, 41*(1), 30-35.

Mayer, R.E. (2003). The promise of multimedia learning: using the same instructional design across different methods. *Learning and Instruction, 13*(2), 125-139.

Mills, J.E. & Treagust, D.F. (2003). Engineering education – is problem-based or project-based learning the answer? *Australasian Journal of Engineering Education, http://www.aaee.com.au/journal/ 2003/mills_treagust03.pdf.*

Moust, J.H.C., De Grave, W.S., & Gijselaer, W.H. (1990). The tutor role: a neglected variable in the implementation of problem-based learning. In AM Nooman, HG Schmidt, & ES Ezzat (Eds.), *Innovation in Medical Education: an Evaluation of its Present Status* (pp. 135-151).

Olds, B.M., & Miller, R.M. (2004). The effect of a first-year integrated engineering curriculum on graduation rates and student satisfaction: A longitudinal study. *Journal of Engineering Education*, *93*(1), 23-35.

Prados, J.W. (1998). Engineering education in the United States: Past, present, and future. Proceedings from ICEE-1998: *International Conference on Engineering Education.* Rio de Janeiro, Brazil.

Prince, M.J., & Felder, R.M. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases. *Journal of Engineering Education 95*(2), 123-138.

Rugarcia, A., Felder, R.M., Woods, D.R., & Stice, J.E. (2000). The future of engineering education: A vision for a new century. *Chemical Engineering Education*, *34*(1), 16-25.

Subramaniam, M. & Venkatraman, N. (2001). Determinants of transnational new product development capability: Testing the influence of transferring and deploying tacit overseas knowledge. *Strategic Management Journal*, *22*(4), 359-378.

Thomas, J.W. (2000). A Review of Research on Project-Based Learning. Proceedings from Autodesk Foundation 2000: San Rafael, CA.

Tinto, V. (2000). What have we learned about the impact of learning communities on students? *Assessment Update 12*(2), 1-2,12.

Tryggvason, G., Thouless, M., Dutta, D., Ceccio, S.L., & Tilbury, D.M. (2001). The new mechanical engineering curriculum at the University of Michigan. *Journal of Engineering Education, 90*(3), 437-444.

(a) Walker, A. J. & Cox, J. J. (2008). Incorporating global characteristic data into virtual product development models. *Journal of Computer-Aided Design and Applications*, *5,* 1-4.

(b) Walker, A., & Cox, J. (2008). Virtual product development models: Characterization of global geographic issues. *Computer-Aided Innovation 277*, 119-131.

Wang, F. & Hannafin, M.J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development 53*(4), 5-24.

Wulf, W.A. (1998). The urgency of engineering education reform. *The Bridge*, *28*(1), 4-8.

Appendix A

Sample Syllabus from Mechanical Engineering 574 (576), pre-Winter 2008

MeEn 576
Advanced Product Development

Syllabus for Fall 2005

Professor: Jordan J. Cox (2-3627, cox@email.byu.edu, Office 164B Fletcher)

Teaching Assistant: D. K.

Class Times
MWF 11:00-11:50 132 Snell

Course Description:
Advanced product development addresses the need to adapt products and services to fluctuating markets while maintaining the efficiencies of mass production. This means that personalized or customized goods can be provided to the customer without the premiums typically charged for customization.

The purpose of this class is to teach students how to design and implement product development processes for advanced applications such as mass customization. This entails the capture and reuse of engineering knowledge so as to competitively supply customizable products and services.

The textbook: PROCESS AUTOMATION and KNOWLEDGE CAPTURE for ENGINEERING DESIGN is available in the bookstore and is required for the course. Reading assignments are indicated in the course outline and are due the next lecture following the indicated assignment.

Skills:
Students will be required to make use of current engineering software tools: CAD, CAM, CAE, & Visual Basic. Limited instruction will be given in class. A general knowledge of product development is fundamental (Capstone I, II).

Grading:
Mass Customization is a project-oriented class. The workload will span two projects (one preliminary and one final) and necessary homework assignments. A midterm will be administered to test your understanding of the theory. Your grade will be determined as follows.

Homework	100 pts
Midterm	200 pts
Project 1	100 pts
Project 2	300 pts
Total	700 pts

Grades will be determined using a straight scale: 94-100% A, 90-93% A-, 85-89% B+, 80-84% B, 77-79% B-, 70-76% C, below 70% E. There will be no late work accepted. If there are emergencies please contact me and I will work with you. Once grades have been given, there will be no re-grading, therefore, make sure that all your scores are correct before the end of the semester. Re-grading can only occur within the week the assignment is turned back to you. Re-grading should only occur when you feel a mistake in totaling the points has occurred.

Professional Behavior:
I expect you to be mature enough to recognize your eminent entrance into the profession of engineers. Your behavior should reflect this recognition. I expect you to be in complete compliance with every aspect of the honor code. This course is offered to you through generous donations from the tithe payers of the church. If you are not in compliance with the honor code, I reserve the right to give you a failing grade without prior notice. At this point in your schooling there is no excuse for failure to comply with the honor code. If you have questions about your compliance, first read the honor code, then I will be happy to answer questions.

Summary
This course can be one of the most exciting courses you will take during your schooling career. It represents cutting edge research and techniques in product development. It integrates topics and courses covered throughout your undergraduate education and provides skills and techniques that will impact your activities throughout your professional career. There are often opportunities for summer internships, full time employment and graduate research. If you are interested in any of these, please feel free to come and talk with me. Otherwise, my door is always open for any questions.

Course Outline

Lec.	Date	Topic	Assignment	Due	Pnts
1	8/29	**Adv. Product Development**	Ch. 1 Problems: 1,2,3	9/2	10
2	8/31	Historical Perspective			
3	9/2	**Language of Design**	Ch. 2 Problems: 1,2,3	9/9	10
Labor Day – No school					
4	9/7	Engineering Processes			
5	9/9	Product Domain Space	Ch 3 Problems: 1,2	9/12	10
6	9/12	Project 1: Aspirator	Product Domain	9/16	15
7	9/14	Grammars			
8	9/16	Graphs & Languages	Ch 4 Problems: 1-6	9/23	15
9	9/19	Reusable knowledge			
10	9/21	Planning for reuse	Ch 5		
11	9/23	**Parametric models**	Ch 6 Model Plans	9/28	40
12	9/26	Functional Mappings			
13	9/28	Schematic Mappings	Project 1	10/21	60
14	9/30	Backwards mapping			
15	10/3	Sub-Processes			
16	10/5	Storyboarding	Ch 7		
17	10/7	**Engineering Processes**	Project 1 PTS	10/12	40

18	10/10	PTS			
19	10/12	PDG's			
20	10/14	Building the Application			
21	10/17	Review			
22	10/19	**Mid Term**			200
23	10/21	PDG Presentations	Ch 8		
24	10/24	Ontologies			
25	10/26	Architectures			
26	10/28	**Final Project Introduction**			300
27	10/31	Project Scope & PTS			
28	11/2	Systems of PDG's			
29	11/4	WEB Services			
30	11/7	Hierarchical subdivisions			
31	11/9	Mass Customization			
32	11/11	Optimization			
33	11/14	MD Optimization			
34	11/16	Project reviews			
35	11/18	Team Meetings			
36	11/21	Team Meetings			
Thanksgiving – No School					
37	11/25	Team Meeting			
38	11/28	Team Meetings			
39	11/30	Team Meetings			
40	12/2	Team Meeting			
41	12/16	**Final Presentations**	11:00 – 2:00		

Appendix B

Industry Project descriptions Fall 2005

ME 576 Projects Fall 2005

Turbine disk PDG

The turbine disk PDG was originally developed as a stand alone PDG based on a local server architecture. The process modules and mappings were developed specifically for this PDG with no attempt to design them as web-service library modules. Coordination and support of other PDG's has made it apparent that many of the modules used in the turbine disk PDG could and should be used in other PDG's. Therefore it is desirous to re-architect the turbine disk PDG so that it can be structured into a web-services library. Common modules can then be used in constructing and supporting other PDG's.

The Turbine disk project in ME576 will focus on developing a decomposition strategy and map of the web-services modules. No coding will be done, rather, a decomposition of the basic modules and mappings will be done. The result will be a new version of the PTS that will allow the PDG to be restructured.

It will be necessary that Honeywell provide documentation of the current PDG, including a PTS and schematics identifying all the current modules and mappings used. This can be in the form of written documentation or visits by Honeywell personnel and ongoing telecons.

Front frame PDG

Similar to the turbine disk PDG, the front frame PDG was originally developed as a stand alone PDG based on a local server architecture. The process modules and mappings were developed specifically for this PDG with no attempt to design them as web-service library modules. Coordination with the turbine disk PDG and defining common support for the two PDG's justifies the re-architecting of the front frame along with the turbine disk PDG.

The Front frame project in ME576 will focus on developing a decomposition strategy and map of the web-services modules. No coding will be done, rather, a decomposition of the basic modules and mappings will be done. The result will be a new version of the PTS that will allow the PDG to be restructured.

It will be necessary that Honeywell provide documentation of the current PDG, including a PTS and schematics identifying all the current modules and mappings used. This can be in the form of written documentation or visits by Honeywell personnel and ongoing telecons.

Appendix C

Midterm Exam Fall 2005

MIDTERM ME 576

Case Study I
Ortho-Clinical Diagnostics is a subsidiary of Johnson & Johnson. It is a company that designs and builds blood diagnostics machines. These machines allow samples of blood in test tubes to be analyzed automatically. The machine accesses the blood in the tubes and places a drop on a piece of film. The blood is dried and then optical, infrared, and other scanning techniques are used to test for various conditions. The machine reduces error, automates the process, and increases the number of tests that can be done in a single diagnostic cycle.

The product development process used to develop these machines was derived from the first project. When a new derivative machine is to be built, the typical product development cycle is as follows: the engineering staff develops the new diagnostic technologies (more simultaneous tests or better accuracy) and then a prototype machine is built. The prototype machine then goes through a debugging phase where it is retrofit to fix problems. Once the bugs are eliminated, a design documentation process is executed and the machines are put into mass production.

Case Study II
Environmental Flight Systems is a business unit in the Honeywell corporation. They design and build electronics for military and commercial aircraft that perform a variety of functions including wind shear detection, communications, etc.

The typical product development cycle is as follows: The electrical engineering department develops a design for the circuitry for the product. This involves designing the PCB's, modeling and doing predictions of the PCB's and finally developing the masks to actually produce the PCB's. At this point the mechanical packaging engineers begin designing the housings, cooling, vibration reduction and power portions of the product. Often several iterations result before the electrical and mechanical portions of the design are released for final mass production.

Question I
Select a case study that you will use throughout the exam ___________________________

Question II
Can mass customization techniques be applied to this product development process? Why or why not?

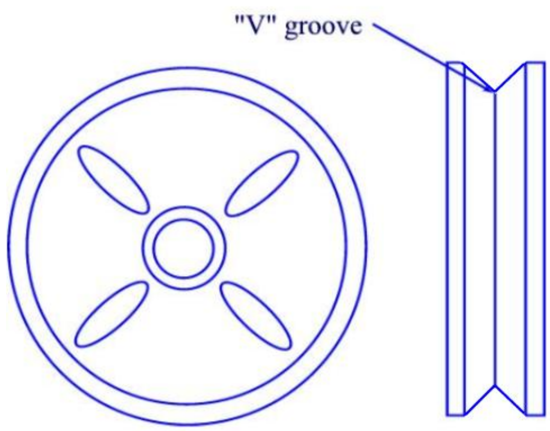
Question III
Map out the process task by task starting from the beginning.

Question IV
Now determine and describe the sets needed to build a framework for mass customization

Question V
Identify and describe the maps between the sets and complete the mass customization framework. Be sure to identify knowledge management strategies that you think will be important.

Question VI
Describe the process you would pursue to develop a product continuum plan for this framework.

Question VII
For the given figure, define whatever you think is necessary to plan a reusable CAD model.



Question VIII
Develop a storyboard for your case study template.

Question IX
Identify and describe the technologies needed to implement your case study template and any phases, classifications, or knowledge structures inherent in your template. Also, describe how your case study could be moved into a mass customization approach.

Question X
Describe the different eras of product development and indicate why the changes occurred.

Appendix D

Sample Courseware from Mechanical Engineering 574, Winter 2008

January Learning Objectives:

I. Students can identify modern trends that are causing changes in their future professions
   I. Cognitive: **Present trends & Ray Kurzweil video (Lecture I) (Reading I)**
   II. Affective: **Discuss effects on future profession**
   III. Psycho-motor: None
- Students can explain what complexity is and identify representation methods
  - Cognitive: **Define complexity & representations, show examples (Lecture II)**
  - Affective: **Discuss effectiveness of each**
  - Psycho-motor: None
- Students can use graph theory to represent complex systems
  - Cognitive: **Define graph theory & show examples (Lecture III) (Reading II)**
  - Affective: None
  - Psycho-motor: **Assignment to use graph theory to model real systems (Assignment I)**
- Students can model product development processes using graph and network models
  - Cognitive: **Show method of modeling product development processes (Lectures IV,V, & VI)**
  - Affective: None
  - Psycho-motor: **Assignment to model a simple PDP (Assignment II, III, IV)**
- Students can develop reusable models
  - Cognitive: **Define reuse and show method of developing reusable models (Lecture VII)**
  - Affective: None
  - Psycho-motor: **Assignment to develop reusable models (Assignment V)**

Appendix E

MeEn 574 Syllabus Winter 2008

MeEn 574

Product Development Automation

Professor: Jordan J. Cox (2-3627, cox@email.byu.edu, Office 164B Fletcher)

Teaching Assistant: Alyssa Walker

Class Times
MWF 12:00-12:50 369 Clyde Building
Office hours
MWF 1:00-2:00pm 164C Fletcher

Course Description:
Design automation, network modeling of design systems, mass customization, agent-based methods, transnational design systems. Aerospace, automotive, and consumer product applications.

Product development automation addresses the need to adapt products and services to fluctuating global markets while maintaining the efficiencies of mass production. This means that personalized or customized goods can be provided to the customer without the premiums typically charged for customization.

The purpose of this class is to teach students how to design and implement product development processes for advanced applications such as mass customization. This entails the capture and reuse of engineering knowledge so as to competitively supply customizable products and services.

The course is divided into two sections. The first section will focus on using graph theory to model complex systems such as product development processes. It will teach how to then reorganize the model into a mass–customizable process that can be implemented using autonomous agents. The second section will then present aspects of globalization and teach how to incorporate these issues into the models and processes of the first section.

Several different books will be used during the course. The first book used will be “The Singularity is Near” by Ray Kurzweil. Copies will be provided by the instructor. If you wish to purchase the book it costs about $12.00 through Ebay. The second book will be an online book on Graph Theory. Actually any book on graph theory can be used and once again if purchased through Ebay should cost about $8.00. The third book will be “Global Shift” by Peter Dicken. Copies will be provided by the instructor. Again if you would like a copy for yourself, they can be purchased for about $5.00 through Ebay. Reading assignments will be given in class for specific chapters since we will not study the entire portion of any of the three books. You are certainly welcome to read them completely regardless of the assignments.

Skills:
The fundamental principles, theories and methodologies presented in this class can be implemented in almost any suite of software tools. Class projects can therefore be implemented in a variety of tools. The most common suite is the Microsoft Office suite of Excel, Word, Powerpoint. Often combining this with visual basic can provide the framework necessary to achieve 90% of the benefit from automation. It isn't quite as exciting as a fully programmed automation module – but we will focus on efficiency and how to get the biggest return for the smallest investment.

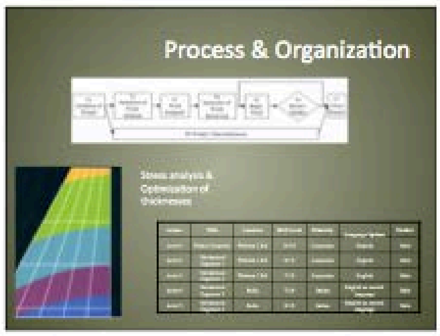
Grading:
This is a graduate course and will not be as structured as an undergraduate course. There will be homework and reading assignments throughout the semester. There will also be two projects. A midterm will be administered to test your understanding of the theory. Your grade will be determined as follows.

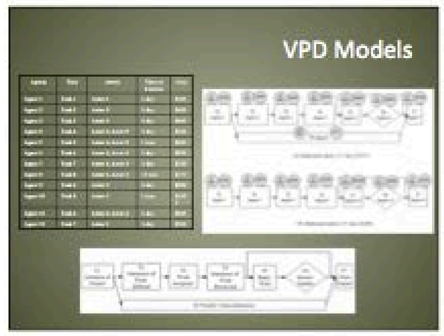
Homework	500 pts
Midterm	300 pts
Project 1	200 pts
Project 2	300 pts
Total	1300 pts

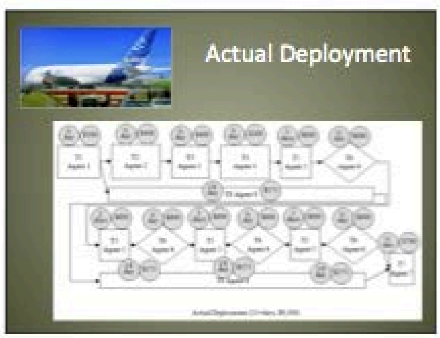
Grades will be determined using a straight scale: 94-100% A, 90-93% A-, 85-89% B+, 80-84% B, 77-79% B-, 70-76% C, Below 70% E. There will be no late work accepted. If there are emergencies please contact me and I will work with you. Once grades have been given, there will be no re-grading, therefore, make sure that all your scores are correct before the end of the semester. Re-grading can only occur within the week the assignment is turned back to you. Re-grading should only occur when you feel a mistake in totaling the points has occurred.

Appendix F

Sample Case Study Presentation and Lesson Plan from Winter 2008







Sample Lesson Plan used during Winter 2008

Learning objectives: Explain how graph theory can be used to model engineering product development processes. Create simplified models of processes at various levels of abstraction.
Instructional delivery:

1. Class period 1:Lecture slides with instructor narration (50 minutes),
2. Class period 2: Interactive demonstration of application to simple examples using whiteboard with student participation (30 minutes), Independent in-class exercises to practice method (20 minutes),
3. Homework assigned application of method to simplified industrial problem due next class period.
4. Class period 3:assessment of homework in-class and instructor feedback with student participation in correcting homework.

Assessment: In-class homework assessment and problems on mid-term as well as performance in final project.

Appendix G

Syllabus for Fall 2008

Mechanical Engineering 574 – Global Product Development and Process Automation, Fall 2008
Instructors: Dr. Jordan J. Cox, Alyssa J. Walker
Class Time: MWF 1-1:50, 393 CB
Office Hours: 2-3 MWF
Office: 164 Fletcher
Email: cox@byu.edu, alyssajanae@byu.net

Text: Apart from a printed or online news source (see Global Geographic issues Journal below), the instructors will provide the texts and other reading materials for this class (The Singularity is Near by Ray Kurzweil; Global Shift by Peter Dicken, and an online book discussing graph theory). Reading assignments will be given in class for specific chapters since we will not study the entire portion of any of the three books. You can thank us later.

Objective: Students should be able to model and automate engineering processes in a global geographic environment and optimize these processes with respect to business and associated global issues.

Requirements	**Topics Covered**
Lecture Attendance/Participation	Globalization and implications
Assigned readings	Process Automation
Global Geographic Issues Journal	Graph Theory
Benua Assignments	Global geographic issues
Extracurricular Assignments	Basic geographic principles
Map Quizzes	Futurist theory
Automation Project	Complexity
Final Project	Process Modeling
	Impact quantification

Summary
This course can be one of the most exciting courses you will take during your schooling career. It represents cutting edge research and techniques in product development. It integrates topics and courses covered throughout your undergraduate education and provides skills and techniques that will impact your activities throughout your professional career. There are often opportunities for summer internships, full time employment and graduate research. If you are interested in any of these, please feel free to come and talk with me. Otherwise, my door is always open for any questions.

Descriptions
Lectures – Because there is no required textbook for the class, the majority of the material will be presented in the lecture. Therefore, attendance is essential and expected.

Homework

Global geographic Issues Journal: Students are to select one region of the world (Europe, Russian Realm, Oceania, Latin America, sub-Saharan Africa, Middle East and North Africa, South Asia, Southeast Asia, East Asia) to follow throughout the semester through daily readings and journal entries of a major newspaper-preferably the New York Times (order form the service desk in the bookstore and pick up daily in bookstore or in front of the SWKT). Christian Science Monitor (sign up in class to have CSM mailed and billed to your home for $25 or go to csmonitor.com to register for a treeless internet edition for half the price) or Washington Post (all three are available in the library and some have internet editions); the Salt Lake Tribune of Deseret News will do if you already have a subscription. There will also be copies available in the lab 164 Fletcher for your use, but must remain in the lab.
As you read the newspaper you should be keeping an electronic journal that documents your learning about geographic elements and the current events that are occurring in your region. To help motivate you, you will be required to submit one of these journal entries each week. Each submitted entry should be approximately one page in length. At the end of the semester you will need to submit answers in your final project relating to specific questions about your geographic region/country (see Final Project description). The length of your answers will in part depend on what had happened throughout the semester. Some regions will have more action or newspaper coverage than others.

Benua Assignments: During the semester students will receive access to a web page containing information and maps of a fictitious continent called Benua. Working individually or in groups, students will analyze the continent using a geographical perspective and then answer questions about the continent. This is a take home assignment and will test your understanding of key ideas from throughout the semester.

Automation Assignments: Students will be given homework assignments that help them understand the process of automation. These assignments will be designed to guide the students in the development of their automation project.

Projects

Automation Project- One of the focuses of this course is the development of automated processes. In place of the midterm exam, students will be required to develop a basic automated process and present it in class. The process will be selected from a typical engineering design and manufacturing process and will include elements of prediction, design, manufacturing, and documentation. The project will involve the development of a process organization plan and its implementation in Microsoft Office components.

Final Project – The final project will consist of both a technical report as well as a presentation. At the beginning of the semester, you will identify/select an international company located outside of the U.S. You will follow the country/region where the company is located in your readings of current events throughout the course of the semester (you are welcome to focus specifically on the country itself, but recognize that it will record your findings in the electronic journal (see Global Geographic Issues Journal description).
Your presentation and report will report will address the following:

-Global geographic issues that affect or are inherent in that company
-The impact of these issues on company processes
-The organizational makeup of the company and associated issues
-Geographic characteristics of the country/region itself, including both physical and human characteristics
-Quantification of a specified number of characteristics that affect processes
-Incorporation of those characteristics into graph model and secondary calculus
-Description of relationship between certain geographic elements (demographics, physical geography, etc.) and company processes – what challenges must be addressed?
-Proposed solutions to address those issues

Additionally, you will need to answer the following questions (be sure to give full citation for any quote):

1. List some interesting/unusual characteristics about your region that you were exposed to this semester from your newspaper readings.
2. How has the physical environment (climate, landforms, soils, water, seas, resources, natural hazards) of your region influenced its human inhabitants and how have the human inhabitants of your region influenced, interacted with, abused, or benefited from the environment this semester? Cite specific examples from your newspaper readings.
3. What factors/events from this semester help explain the level of development in your region? Why is your region more developed or less developed? Cite specific examples from your newspaper readings.
4. Explain in some detail what you think are the most significant current challenges (at least three) your region is now facing? Cite specific examples from your newspaper readings.
5. What would you suggest your region do to overcome its current challenges? Identify at least three specific proposals that would help make a change for the better in your region.
6. Describe the challenges specific to this region, including political policies, education differences, cultural differences, etc. that will affect the work of an engineer.

Quizzes
Seven Map Quizzes: Quizzes will be map identification based on the list of place names available on Blackboard and in the syllabus. I will list 10-15 places that you will need to label by name on the map. Practice maps can be downloaded & printed from http://geography.byu.edu. The seven maps you should use are: Latin America, Africa, Middle East, Western & Central Europe, Former Soviet Union, Greater Monsoon Asia, and Australia/Pacific.

Extracurricular Assignment
As part of increasing your awareness and understanding of international processes, cultures, environments, etc., you will be required to participate in two of the following activities (of your choice):

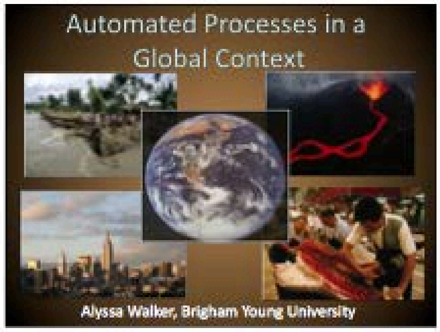
1. Attend an international lecture on campus such as the weekly lectures at the Kennedy center (Wednesday at noon and other times) or an internationally related devotional

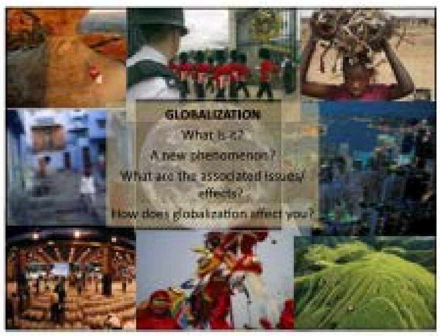
or forum and write a one page response about the lecture including how the topic relates to geography;

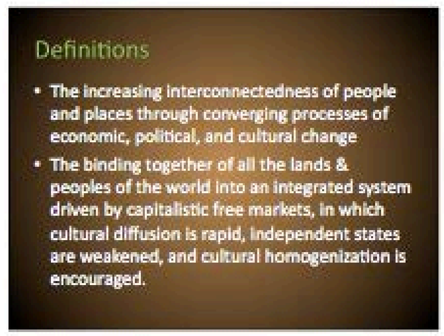
2. Watch Lawrence of Arabia, Gandhi, The Mission, The Last Emperor, Seven Years in Tibet, Journey of Hope or another geography related movie approved by the instructor and write your one page response to the movie including how it relates to geography;
3. Visit Bingham Canyon Copper mine or any Utah National Park and write a one page response about your visit;
4. Contribute at least $25 (via your ward) to the Perpetual Education Fund or LDS humanitarian Services and write briefly how and why your contribution can help less fortunate members/peoples.

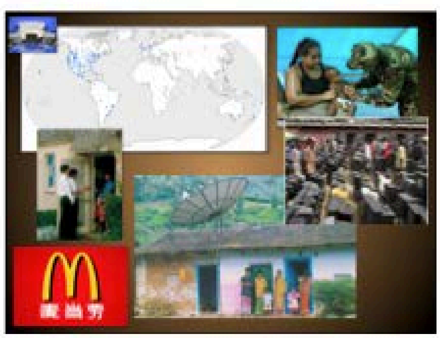
Appendix H

Lecture 1 Sample Slides, Fall 2008

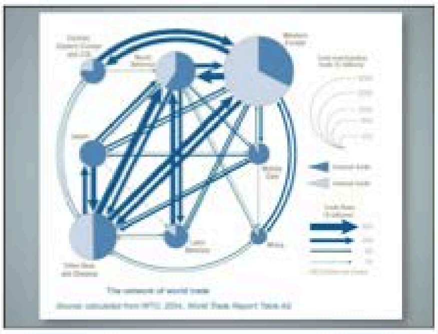


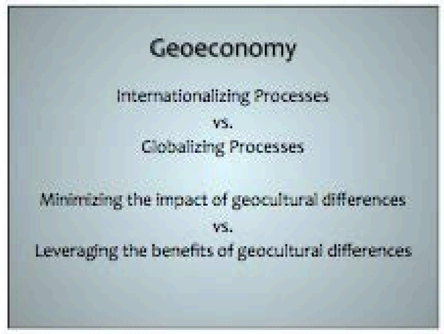


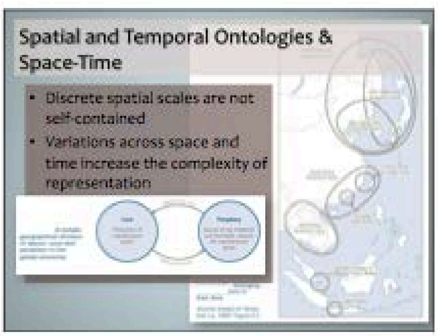




Global Shift Lecture, Sample Slides, Fall 2008







Geography and Globalization Lecture Outline

GLOBALIZATION AND GEOGRAPHY

What is geography?
What do they know about it - and how does it connect to the topic of globalization?
“Describing the earth” – how would you ‘describe the earth’ to a ‘visitor?’
What would you include in the description?
(Back to Definitions slide – where do you see geography in these definitions?)

Interconnectedness
Peoples
Places
Lands
Integrated System
Cultures
CHANGE

Geography in a dynamic state – new fields, studies, subsets (AAG Conference)
The “Why of Where”
WHY GEOGRAPHY?

- Learn where almost all of the countries of the world are located and, more importantly, learn about these “countries and kingdoms” that you might “be prepared in all things” (D&C 88:78-79).
    a. Prepared to build the kingdom (D&C 88: 80, 1 Nephi 14:14).
    b. Prepared to be a productive member of society.
    c. Prepared to be accepting of and friendly towards other peoples, even though they might be different from you.
- Better understand the interconnectedness of the world so we will appreciate those who contribute to making our life so abundant and easy and so we will be more willing to help those who have less (D&C 104: 17-18).
- Become better stewards of the earth (D&C 104: 13) through an increased understanding of how human behavior impacts the environment and affects the lives of others.
- Learn to enjoy the journey by being a more observant, interested, adventuresome and curious traveler.

FIVE THEMES OF GEOGRAPHY
Region – an area that possesses one or more common characteristics that distinguish it from surrounding areas. Boundaries between regions are actually transition zones
Formal Region: area inhabited by people who have one or more cultural traits in common – language, ethnicity, religion – infinite amount
Functional: area organized to function politically, socially, or economically as one unit
City, precinct, ward, farm, bank district
Vernacular: based upon people’s perceptions, “American South”

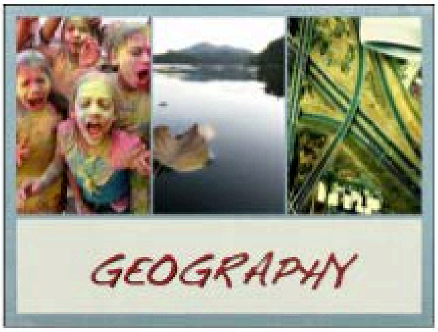
How would you characterize your location in terms of regions? In what physical, economic, and cultural regions are you located? Formal, functional, vernacular?

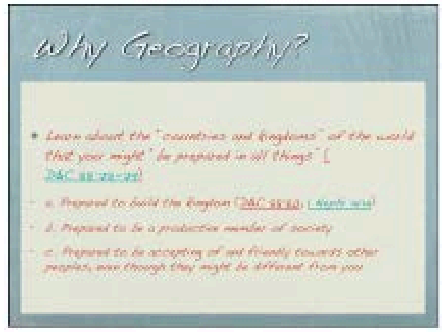
Location – relative and absolute

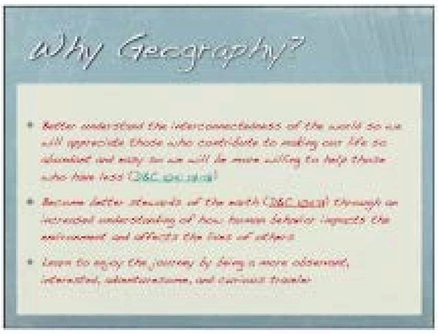
Relative: interconnectedness of places by land, water, technology, interaction that occurs between and among places
Place - attributes of a location, what makes the place unique or distinct from others? Human and physical characteristics
Human-Environment Interaction – adapt to, depend on, and modify
Environmental Determinism: People products of their environment
Cultural determinism: causes of all cultural phenomena are other cultural phenomena
Possibilism: Societies influenced by natural environment but humans are the primary force in the creation of culture
Example: Banana Republic – small country, unstable politically, huge wealth inequality, dependent on limited agriculture, small, self-elected wealthy and corrupt ruling group
Movement – People, goods, ideas, disease, weather systems, etc.
TYPES OF GEOGRAPHY
Physical Geography
Climate, landforms, soils, vegetation, hydrology, etc.
Human Geography
Economic, social, cultural, political systems
Cultural geography of our area, of your hometown – distribution, landscapes, interaction among cultural groups
Cultural Landscape – the visible, material expression of human settlement, past and present. Increasingly integrated due to globalization
(pictures – what can you tell me about the people who live in these places?)

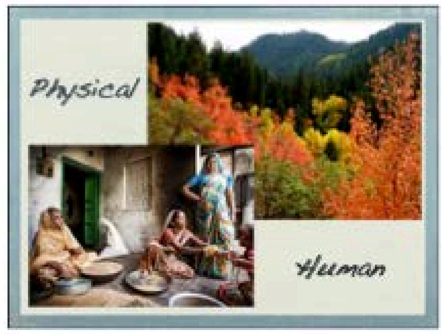
Appendix I

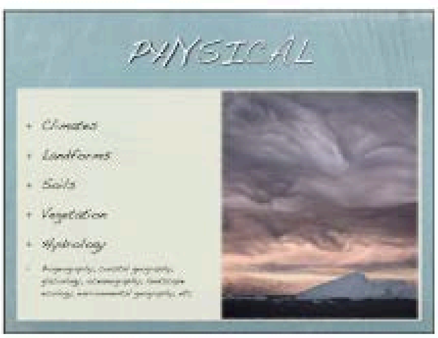
Sample Slides from Geography Lecture Fall 2009, Mechanical Engineering 574











Appendix J

Course Evaluation Questions, Fall 2009

Written Mid-term Evaluation Items for Fall 2009

1. What is going well in class? What contributes most to your learning?
2. What could be improved? How could this course be more effective in helping you learn?
3. This course is rather unstructured, are you finding this to be an effective approach? How is it affecting your learning?
4. What aspects of what you are learning in the course are relevant to your professional preparation?
5. What are the aspects of the classroom environment that could be improved to increase learning?

Written End-of-Term Evaluation Items for Fall 2009

1. What has helped you the most in learning the material of this course?
2. What should we stop doing, what should we start doing, and what should we continue doing?
3. If you could add anything to this course what would it be? If you could eliminate anything from this course what would it be?
4. What can I do better as the instructor of this class and as a mentor to you?

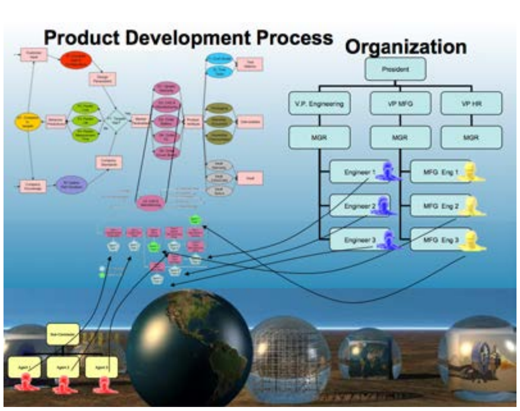
Appendix K

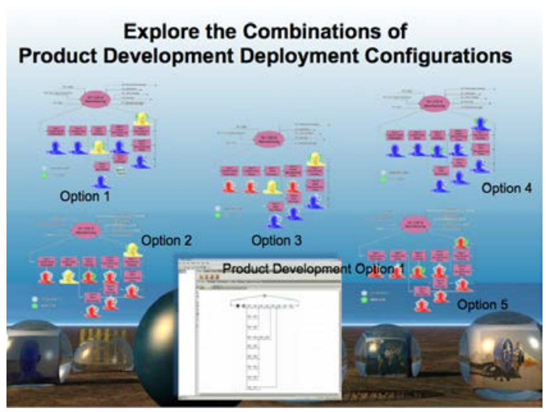
Sample Lesson Plan, Fall 2009

Lesson Plan: Process Mapping of an existing company

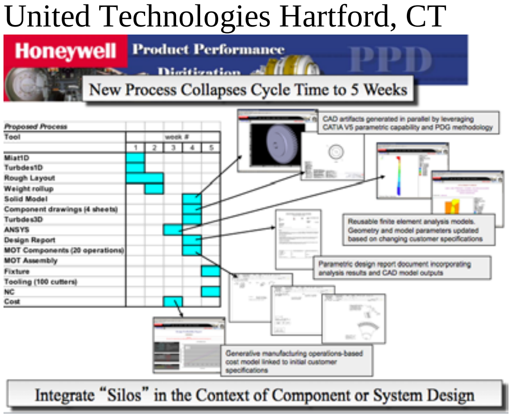
<u>1. Assign students Orem Rest home process mapping assignment (5 mins)</u>
The class has an appointment with the administrative staff at an Orem rest home next week to begin mapping their processes.

<u>2. Review resources available to students (10 mins)</u>
a. Review process mapping slides

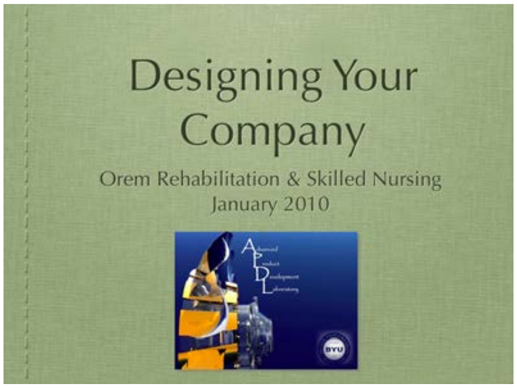




b. Discuss company examples from consulting: Honeywell pneumatics division Tempe, AZ, United Technologies Hartford, CT



c. Orem rest home overview



d. Sample first visit slides

e. Consultation in preparation for company visit

f. Recommendations for first visit

3. Open time for team discussions and learning – Professor available for just-in-time teaching (35 mins)