Educational Implementations at IKT

An Interactive Qualifying Project Report

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Abstract

This project has been prepared for the Engineering College of Copenhagen (IKT). It recommends improvements to educational technology in IKT's Export Engineering Department. Different information technologies were investigated to determine the feasibility and benefit of their integration into an engineering college environment. This research was conducted by a review of written background material followed by student surveys, faculty interviews, and classroom observation at both WPI and IKT. Performing research at WPI and at IKT allowed for comparison between American educational technology and methodology and the corresponding Danish model. After analysis of the research, several innovations were suggested, including Web-based course information distribution, increased use of electronic mail for communication between students and faculty, and increased software instruction.

Executive Summary

The purpose of this project is to formulate recommendations to the Engineering College of Copenhagen (IKT) regarding improvements in their use of information technology and instructional methodology. Background research was conducted, followed by analysis of IKT's current methods. Finally, the analysis was simplified to a set of results that were codified into several concrete recommendations on how to improve IKT's information technology and instructional methodology.

The first activity performed was extensive background research. This research was composed of four separate activities. These activities were examination of written materials (books, journals, Web pages, etc.), interviews with WPI and IKT professors, surveys of WPI and IKT students, and analysis of other materials such as web sites and contacts with persons not specifically involved in the teaching process at either institution.

Initially, the examination of the background material was divided into three major areas. These areas included a general history of educational technology and related topics in Europe and the United States, current implementations of technology in education, and an exploration of future directions educational technologies are likely to take. These areas encompassed a wide range of topics, and assisted with the project in several ways. Initially, the background research helped in providing a general overview of educational technology and methodology. Secondly, this research assisted in tailoring the recommendations to existing policy in information technology and education, allowing

for the incorporation of existing theory in these areas to the remainder of the research and final recommendations.

WPI and at IKT students were surveyed regarding effectiveness of current implementations of informational technology and specific methodologies. The specific questions are located in Appendix B, and detailed analysis can be found within the main document. The questions used in the survey were derived from personal experience as students at an engineering college as well as the information gained in the literature review section of the project.

In general, the surveys suggested the following. First of all, students from both WPI and IKT believe that educational technology is a very significant component of higher education. Students at both WPI and IKT both rely on educational technologies to a greater or lesser degree, although, presently, electronic mail is much more pervasive at WPI than at IKT. According to the student surveys, both institutions have similar access to course-related software packages (e.g. WPI's use of Maple equates to IKT's use of MatLab). Students at both schools tended to feel that the Internet was a very valuable tool, although WPI responses tended to be a bit more specific, citing the value of course offerings on the Web and the availability of other resources. When asked specifically, IKT students were enthusiastic about possible availability of course offerings on the Web. Neither WPI nor IKT students saw significant negative aspects of informational technology, although WPI students cited distractions and excessive dependence on computers as potential negative aspects. Some IKT students cited a need for more experience in using common software packages (Microsoft Excel was frequently mentioned) before these packages are utilized in their schoolwork. Both the WPI and IKT groups surveyed cited group work as beneficial.

Professor interviews were conducted during the second semester of the 1999-2000 academic year. While the group was in the United States WPI professors were interviewed, and in Denmark interviewed IKT professors. Professor interviews were quite useful, and reinforced many of the ideas expressed in the student surveys while providing some new insights as well. Professors in both institutions were enthusiastic about the value of instructional technology. Many faculty members saw educational technology as an excellent time saver, and a method of increasing educational efficiency, which is the ratio of quality-of-education to resources allocated. WPI professors cited course information on the Web as particularly helpful, while IKT professors noted that the Internet in general is an excellent resource due to the vast amount of information available. WPI professors mentioned by name the 'Course Info' software by Blackboard, Inc. as an effective Web-posting tool for course management. Particularly at WPI, professors cautioned against the excessive use of educational technology, or its use as a substitute for fundamental course material. Professors in general supported group work, provided the work is implemented correctly.

IKT professors, when asked what technologies they believe would be beneficial to IKT, also noted that more course information on the Web would be beneficial. Some of them also expressed a need for more audio/visual functionality in the classrooms, and an increased role of computers and relevant software packages in the classroom. Some IKT professors, along with IKT students, expressed a need for software training before students are required to use certain software in the classroom.

Course offerings on the Web at WPI were systematically analyzed to find common elements between different course pages. It was discovered that common information on all course pages were professor/assistant contact information, course schedules and syllabi, homework sets and associated solutions, and directory listings for all pages. Less common information was found in old tests (with or without solutions) and links to associated material elsewhere on the Web. Additionally, some pages contained lecture notes or other associated course material.

After the research and analysis, recommendations to IKT were formulated on improvement of their processes. These recommendations are listed below, and are grouped by area of relevance. Group A deals with instituting software training for new students at IKT. Group B details the need for Web-based course information. Group C recommends the adoption of course management software at IKT. Group D recommends the further use of group work in the classes. Group E discusses further implementation of electronic mail. Group F recommends that IKT anticipate further equipment needs in implementing other recommendations.

> **Recommendation A**: *A course should be introduced to teach students software necessary for classes at IKT.*
> **Recommendation B1**: *All or most courses offered at IKT should have associated Web pages on the Internet.*
> **Recommendation B2**: *Online courses should be implemented via one of two methods: traditional web editing software or a course management program.*
> **Recommendation B3**: *Course Web pages should contain the following material and properties. The page must be easy to locate and access. Each course Web page must include certain specific information. Scanned images must be manageable and clear in order to be effective. A course page should be easily navigable. Students must be aware of the existence of the course page and be notified that much of the course information will be included and distributed through it.*

Recommendation C1: *IKT should utilize course management software.*
Recommendation C2: *A central course management server should be implemented.*
Recommendation C3: *Instructors should be introduced to course management software as a whole in a seminar or series of instructional lessons.*
Recommendation C4: *A system head should be appointed to oversee course management software operation.*
Recommendation D: *IKT faculty should continue to use group work in the classroom and for projects.*
Recommendation E: *E-mail should be more widely utilized among the IKT community.*
Recommendation F: *IKT should anticipate increased equipment needs.*

Discussion of these recommendations can be found in the Recommendations section of the main document. These recommendations, with documentary research, were submitted to IKT as the final product of our project work.

1.0 Introduction

1.1 Project Purpose

This project makes a detailed study of the use of information technology in the American and Danish higher education engineering institutions, specifically at WPI and at the Engineering College of Copenhagen (IKT). IKT proposed this project to gain insight on technological and curricular reform within the classroom. The project liaison, Knud Holm Hansen, simply stated "I teach chemistry to freshman every year and I want to know if I can do something different." In addition, teaching methodology and curriculum will be evaluated as they pertain to possible adoptions of information technology. From this examination we will draw recommendations for the integration of educational technology and teaching practices into the engineering curriculum at IKT.

Because information technology allows teachers to manage their workload and educate students more effectively, there is a strong need to adopt new technologies in the most effective ways possible, both in the US and elsewhere.

Students and faculty benefit from information technology in a number of ways. Foremost, information technology allows students to learn at their own pace while placing the emphasis on individual student learning rather than on the instructor as the center of the educational process. Secondly, information technology enhances efficiency of communication and dissemination of course materials, an obvious benefit to both faculty and students. Also, with information technology, an institution prepares students for the use of similar technology in the workplace. With this information technology, faculty members will gain new tools to teach with and the students will gain access to new, effective methods of learning course material.

1.2 Project Goals

The primary goal of this project is to provide feasible suggestions to the Engineering College of Copenhagen on methods of improving the college's technological and scientific education. These suggestions relate to several disciplines such as instructional methods and course curricula, primarily through the use of educational technology. Suggestions in usage of technology will relate to specific information technologies that are already in use at IKT and general academic attitudes toward the use of technology and the addition of new technology.

The instructional method recommendations focus on departure from the traditional teacher/student lecture interaction and utilization of more interactive methods, while the curriculum section focuses on comparison of WPI and IKT curricula and any discrepancies between the two that could be of assistance in completing the recommendation process. All of this information will be of assistance to the college in updating the current level of educational technology. These goals were specifically reached through literature review, faculty and student interviews at both institutions, and observation of classes at IKT.

1.3 Organization of the Report

In order to devise a set of final recommendations for IKT, several steps were taken. In the overall project report, these steps are divided into chapters.

Chapter Two covers the literature review. This chapter deals with the background research that has been conducted, not only with literature but also with web sites, journal articles, and personal conversations or interviews that have been conducted with faculty members and students at both institutions. In addition to literary research on education and information technology, we have included information on accreditation organizations, curriculum at WPI and IKT, and specific examples of technology utilized at WPI. The final part of the literature review covers successful techniques of technology integration into an educational institution.

Chapter Three discusses the research methodology and analysis techniques used during the project. Each aspect of the project: surveys, interviews, classroom observations, and literature review are described. Plans for application of the analysis are also included.

Chapter Four details the final results of our analysis. It is the end result of the research and analysis that was conducted. Chapter five lists the recommendations formed from these results and analysis. These recommendations are the final product of the project.

2.0 Literature Review

2.1 Introduction to Literature Review

The purpose of developing this background is to present a clear understanding of how teaching styles, methods, and technologies have developed and evolved in the past, and how these changes have affected education in America and Europe. In addition, present-day programs and technologies are investigated, and potential future developments are discussed. The role of technology in teaching, course curricula, and group- and project- work is examined in the context of the past, present and future.

The literature review is comprised of several sections. Section 2.2 discusses the historical context of the higher education model while Section 2.3 divides that model into several classifications, using both classification systems of the US and Denmark. Section 2.4 covers accreditation and curriculum content of one specific classification, engineering schools of which WPI and IKT are a part. The next section investigates current educational methods and Section 2.6 details the specific technologies behind these methods.

Section 2.7 describes the considerations needed when choosing and implementing information technologies. Section 2.8 then covers some steps one must take in actually implementing the information technology.

Section 2.9 moves into future trends of information technology and its role in education. Finally, Section 2.10 discusses case studies that illustrate successful integration of information technology into an educational environment.

2.2 Introduction to Historical Context

Changing the methods of teaching through the use of technology is not a new idea. For example, the printing press reformed the entire educational system of Europe in a short amount of time. More recent methods of teaching with visual media have been traced as far back as 1928 (Oettinger). Another resurgence of these methods was in the 1940s with the advent of radio and television and the subsequent implementation of research and technology into the curriculum of many major American universities (Van Dusen 3). The use of audio and visual technology, and the later use of personal computers, expanded greatly in the latter half of the 20^{th} century. Unfortunately, the majority of these methods ultimately failed to improve education, or did so weakly, due to lack of success integrating classical teaching styles with new-media visual aids. These failures occurred because of resistance to change by instructors, or in contrast by excessive usage of new media to the exclusion of classical methods of instruction.

Efforts to devise a working model that implements new methodology into teaching science and engineering must take into account that while technology is a useful tool, it is not a substitute for faculty attention, lecture halls, and other classical teaching tools (Van Dusen 8). Educational technology and new methods must be an aid to augment the learning experience; they must not supplant the learning experience itself.

2.2.1 Basis for American Education

In Europe prior to the 13^{th} century, learning was constrained by factors of time and distance. Pupils were forced to travel from town to town to hear lecturers and to gather new information. Masters of a subject were often located great distances apart, and other than the monasteries that dotted the countryside, major centers of learning were unavailable. Eventually, this difficulty ended with the institution of the university at the end of the 12th century (Van Dusen 13).

Today's American academic model is based on the 700-year-old "European University model"(Van Dusen 13). This model came into existence in 13th century France, and relies on the central premise that knowledge is passed down through an instructor or professor. Counter intuitively, the professor's power in this model comes not from the power to teach, instruct, or do research, but rather "the power to examine and certify a student" (Van Dusen 13). The examination concept became the centerpiece of this model, over the concept of instruction. Over the centuries, the European model evolved into its current form: primarily some combination of lectures, individual assignments, and examinations. Standard types of curricula were built around this framework, and this model is still utilized by most American and European universities.

The teaching methods used in American higher education have been under constant revision for the past 350 years. Originally, colleges existed primarily for the benefit of students destined for the ministry (Van Dusen 14). Gradually, the emphasis shifted from a religious approach to a more secular approach. Shortly after the Civil War, students returning from universities in Germany brought with them the European academic model, causing the first major shift in teaching methodology in America. This shift caused universities to become geared more toward teaching. At the same time it placed emphasis on learning. Universities tended to do so by utilizing the "lecturer-learner" method.

Ironically enough, it has been stated that "we have known for years that [this method] is not the best way to teach." (Van Dusen 14) A number of factors have contributed over the years to the continuation of the outdated model. Financial issues, lack of an effective alternate curriculum, and general resistance to change have aided in the continuance of the European model. Resistance to change can be especially great in older institutions because of administrative reluctance to relinquish control of the academic process (Van Dusen 15). A key component of positive change is the realization that the successful methods of the past do not need to be abandoned; new adaptations can be put into use along with previous techniques.

2.3 Classifications of Institutions

Both *US News and World Report* and the Carnegie Foundation for the Advancement of Teaching classified academic institutions into several groups (www.usnews.com). These categories are based on whether or not the institution is recognized as a national or regional university and the diversity of programs that the university offers. A smaller college is generally placed into the regional liberal arts category, while state schools are usually classified as national universities. An engineering-specific college would be classified as a specialty school, while a community college would not even be ranked due to its lack of diverse educational opportunities and small enrollment (www.usnews.com). Colleges with enrollments of 250 or less are not ranked.

2.3.1 Classifications of Schools

There are five main institutional classifications used by *US News*. These are the National University, the National Liberal Arts College, the Regional University, the Regional Liberal Arts College, and the Specialty School. Each classification has its own distinctive traits. All of these classifications were based on categories created by the Carnegie Foundation, which conducts its own research on college classification systems.

National University

The National University is a school that offers a broad range of undergraduate majors. Masters and Doctorate degrees are available at these institutions, and emphasis is placed on research. The Carnegie Foundation breaks these into two categories: Doctorate-Granting Universities I and II, and Master's College and Universities. The top national universities in America at this time include the California Institute of Technology (CAL Tech), Harvard, MIT, Princeton, and Yale (www.usnews.com).

National Liberal Arts College

These colleges have a focus on undergraduate, rather than graduate, education. At least 40% of the graduates from a liberal arts college have a liberal arts degree. While post-baccalaureate degree programs are available, they are not emphasized as heavily (www.usnews.com). The national liberal arts college instead produces a well-rounded student with a general education. The liberal arts colleges in the Top 20 (according to US News) include Amherst, Bowdoin, and Smith College. Carnegie created two additional classifications: Baccalaureate Institutions I and II (where the I and II are tiers that divide ranks), much like the national university subcategories.

Regional Universities

Regional Universities are much like their national counterparts, but they offer few, if any post-bachelor programs. The highest degree awarded tends to be a Master's degree, and the emphasis on research is not as heavy. Each region of the US has its own top-ranked schools, as there is no national ranking for this classification.

Regional Liberal Arts College

Less than 40% of the students of regional liberal arts colleges graduate with liberal arts degrees. Colleges of this classification tend to be less selective in the admission process. The strong emphasis on undergraduate education is preserved, but the student selectivity is lowered in order to cater to students pursuing general college degrees (www.usnews.com).

Engineering Schools

Engineering schools are actually part of a classification known as "specialty schools." Specialty schools focus on a certain area of study, such as music, business, or engineering. While they provide extensive education on the specialty subject, their range of programs outside their area of expertise is rather limited. For Engineering, the top schools with a PhD program include MIT, Stanford, California Institute of Technology, and Cornell. The Carnegie Foundation for the Advancement of Teaching breaks this category into simply Research University I and II.

2.3.2 Further Classification Methods

There are alternate methods of categorizing American institutions in lieu of a system conducive to ranking schools. The other methods exist to show the attitude that different schools take towards education and educational methods. They are the research university, the liberal arts college, the community college, and the public university. Each category is analogous to, or an union of, the categories of the *US News* system, but are less specific in degree and size aspects.

The Research University

Shortly after World War I, the "research university" emerged as a distinctly defined category of higher education (Van Dusen 48). At first, many institutions were wary of this new paradigm of learning, however the benefits of scholastic research were immediately apparent in the classroom. Not only did the instructor introduce new material, but also the focus of the class became more student-oriented. Research technology had allowed new methods of teaching to develop.

The American research university focuses on the marriage of technology and faculty/student interaction in a scientific setting. The use of educational technology is typically campus-wide, and benefits the research a great deal. Faculty access to this technology for aid in research allows knowledge to trickle down to the students, improving quality of learning. Technological methods, lessons learned, and improved curricula become evident in the day-to-day operations of the school (Van Dusen 52). Much of the technology and hands-on knowledge accumulated in research makes its way into the classroom, as the instructor relates course material to real-life applications and methods.

The Community College

The community college, while lacking in the technological expertise, material, and financial resources of its larger university counterparts, compensates for these weaknesses with ingenuity and flexibility. The community college makes up forty percent of the higher education market (Van Dusen 19). Because of lower or nonexistent admission restrictions, and a focus on learning rather than research, community colleges are ideal environments to explore new technological teaching aids.

Community colleges often have less "tradition" which would otherwise force them to embrace specific trends and teaching methods. A lack of set teaching styles and a general sense of academic freedom allows each professor and each college to explore more effective methods of teaching individually. Eventually, successful experiments climb to the public and private university level, where these risks are less likely to be taken initially (Van Dusen 20).

The Liberal Arts College

The liberal arts atmosphere is the perfect learning environment for many students because of smaller classes and higher faculty to student ratio. In addition, these schools prepare students for general life experience, and train students for further learning, rather than tailor students to one specific major or area of study as an undergraduate.

The most significant areas where technology has an impact on the liberal arts school are opportunities to expand student horizons and learning styles. Information technology, such as electronic mail, is very helpful in fostering interaction between the lecturer and the student. Allowing for interaction between the teacher and student rather than on the traditional lecture-learner teaching style, technology has played a vital role in allowing the teacher to involve the students in the lesson.

The Public University

Public comprehensive universities were also a result of a new public attitude towards higher education. These institutions were created in an attempt to provide opportunity for higher education to all socioeconomic classes of people. Following the Second World War, these universities resulted from the democratization of higher education (West and Daigle 52). While the research university catered more towards industrialism and expansion, the public university offered a wider variety of educational opportunities. The public university system was formed by increased federal and state spending and investment, as opposed to private funding. Public universities have been called the "malls of higher education, where learners have a wide variety of academic programs designed to prepare them for the professional and technical workplace or graduate education" (West and Daigle 51).

2.3.3 Danish School Classifications

Denmark also divides its institutions of higher learning into different classifications, based on a student's desired profession (www.sektornet.dk). The different categories include educational and business colleges, technical and engineering colleges, national universities, and specialty schools for pharmacies and media.

Differences between Universities and Engineering Colleges

The main difference between an engineering school and a university in Denmark is the greater focus by engineering colleges on workplace preparation by the student, while universities concentrate on the learning aspect in areas such as pure science, mathematics, etc. (www.sektornet.dk).

Engineering Schools

Engineering schools, while teaching higher-level mathematicsand engineering skills, focus on group and project-oriented work rather than more traditional classroom learning techniques. In addition, they focus exclusively on engineering professions, with little emphasis on pure science or graduate work. This sort of education must be pursued at a university (www.cph.ih.dk).

Universities

For pure science majors, such as mathematics, physics, or chemistry, universities, such as the University of Copenhagen fill the gap. In addition, universities generally place more emphasis on research. Specific technical skills are also taught to students to prepare them for the workplace, and much of this training is done through research (www.ku.dk).

2.3.3 Conclusions

The different categories of institutions are general categorizations of the larger European model prevalent in world higher education. The writers feel that the most effective method in combining new technologies with teaching would be to combine the resources and knowledge of a larger research university with the flexible style of the smaller community colleges. Liberal arts schools already interaction between the teachers and the students. Ideally, a successful institution of learning would continue to build on these strengths. The historical model will need to adapt to meet these new paradigms. The faculty will need to understand how and when to implement new technology, new curricula, and new methods effectively in order to make the crucial shift to a student-centered approach to learning.

2.4 Specific Curricula and Accreditation – WPI and IKT

2.4.1 Introduction

Curricula in various United States engineering colleges are very similar. This similarity is due to accrediting criteria common to all of these schools, as well as a common definition of an "engineering" academic track. WPI has a projects-based plan different from most institutions, but markedly similar to the plan espoused by IKT. The actual academic subject matter that must be covered by WPI and IKT engineers is similar to other United States and world institutions. Each specific discipline can vary somewhat within these definitions: for this analysis the MGE (Management Engineering) program at WPI will be examined. This program is the closest equivalent program to the Export Engineering program at IKT, the primary focus of our project. MGE is without the emphasis on foreign-language skills. MGE, according to the WPI course manual, "combines the best of a business degree with a technical focus" (www.wpi.edu), essentially a businessperson with a strong engineering background. IKT's export program "combines foreign language skills, a high degree of technical knowledge, and a solid command of managerial economics, international marketing, and business communication". So, the two programs are very parallel and lend themselves to comparison.

2.4.2 Engineering Curricula

Engineering curricula for the two programs are quite different. IKT export majors are inundated with a variety of engineering courses, including three mechanical and three electrical engineering courses. These courses give a very detailed overview of both of these subjects. In contrast, the WPI MGE contains less of this material. Most of the engineering that MGE majors do learn is directed toward production and industry rather than academic examination of the basic principles of electrical or mechanical engineering. Thus, for the Export engineering program, the curriculum in engineering is much more complete than it is for WPI management majors.

2.4.3 Mathematics Curricula

Mathematics is the fundamental language of engineers, and as such is a large part of both the WPI and IKT curricula, and in the general curriculum of most institutions of higher learning that have programs in engineering. WPI engineering students typically must complete at least seven mathematics courses, usually including calculus, differential equations, and probability and statistics (www.wpi.edu). Management engineers are only required to complete four mathematics courses, including calculus, probability and statistics. Specific mathematics courses suggested for the MGE discipline can be found in Appendix A. These courses tend to focus on statistics, graph theory, and system dynamics, and lack advanced calculus and differential equations. IKT mathematics classes are more detailed than mathematics courses for WPI management majors. Mathematics classes include differential equations, calculus, Fourier and Laplace transforms, and other concepts. Most WPI Management Engineering majors are not required to receive some of these concepts in class, particularly signal transforms and differential equations. Export majors take four mathematics classes totaling 17.5 ECTS (European Credit Transfer System) credits. The IKT structure for mathematics is much more rigid than WPI's: all four mathematics courses are "compulsory" for graduation. The four WPI classes are student selected, under the guidelines of distribution requirements.

2.4.4 Science Curricula

All WPI and IKT engineering students are required to have a basic understanding of scientific principles. WPI MGE majors are required to complete two basic science courses in physics, chemistry, and/or biology. These courses are often considered "general education" rather than directly major-applicable subjects. For example, mechanical physics is usually not directly applicable to electrical engineering, but is nonetheless a valuable skill for engineers (www.wpi.edu). Once again, the choice of classes is at the students' discretion: there are a variety of science courses available that be counted toward the science requirement, although most management majors elect physics or chemistry for these courses. IKT export engineering students have a much greater amount of science in their curriculum: two physics courses and two chemistry courses are included the curriculum. Of the physics classes, two of these classes are primarily mechanical physics, and the third class covers electromagnetic physics. In chemistry, the course content is about as detailed as the corresponding WPI courses, including such content as acids/bases and redox reactions. The main difference between WPI and IKT in general is that IKT specifies exactly which specific courses are to be taken, while WPI requires that physics and chemistry in general are taken, but does not specify which courses are required.

2.4.5 Writing and Presentation Curricula

A valuable skill for professional engineers is the need to effectively communicate. Both WPI and IKT make strong efforts to incorporate writing and presentation material into their engineering curriculum. Technical writing and good presentation are greatly desired skills in current industry, and requiring written reports improve this ability in university students.

2.4.6 Group Work and Projects

Currently, there is a worldwide need for engineers with social skills that are able to work in a group setting. To encourage social and group skills, both WPI and IKT have implemented their respective project systems. Three projects at WPI must be completed before the end of a student's educational experience. IKT export majors have a five-project system, including an internship and a final project.

WPI's project system requires the completion of three projects. One project, the Sufficiency, is typically an individual project and must be completed in a subject area outside a person's major. The other two projects are the IQP (Interdisciplinary Qualifying Project) and the MQP (Major Qualifying Project). The IQP and MQP projects are specifically designed for group work. In each project, the student usually works in conjunction with one or more other students and an advisor. These projects are often, but not exclusively, conducted in partnership with companies or non-profit groups.

The IQP is an out-of-major project designed to encourage social work skills and "round out" the educational experience. WPI operates an advanced global program for the IQP, adding an international experience to other skills gained. Over half of WPI juniors go off-campus for this project, and WPI has project centers in locations that include Washington DC, Thailand, Denmark, Germany, London, and Australia. The MQP is an in-major project that also encourages social skills and provides a practical application for the engineering skills that students gain in class. The MQP is a very involved technical project that could be analogous to a senior thesis to graduate WPI. Both the MQP and the IQP are worth the credit of three regular classes. The MQP also serves as the engineering design experience which is required for ABET accreditation, described later.

IKT's project system is similar. The five projects are in a variety of subjects, including economics, integrated product development, marketing, technology management, and a final project. Each project has its own focus: most include group work and collaborative activities. The final project, analogous to the WPI MQP, is designed to "give the students the opportunity to work on a task which resembles... a typical export engineering problem... and which integrates the technical, economics, marketing, and language subject components" (IKT Course Manual). The final project must be done in cooperation with a company, under the guidance of a project advisor. Like WPI, this project requires a written report (in English). This report forms the primary criteria for grading project. Unlike WPI, the final project is an individual endeavor.

Additionally, IKT includes an engineering traineeship component. In this traineeship "the student, employed by a Danish or foreign company, should have the opportunity to combine practical engineering activities with the theoretical courses at the college in an interdisciplinary context. The student should be able to gain insight into the company culture, the sales and marketing methods, and the application of business practice." (IKT Course Manual).

2.4.7 Distribution Requirements

The following are excerpted from the WPI Undergraduate Student Catalog. It details the distribution requirements for a WPI Management major. Management

Engineering (MGE here) is most likely the closest equivalent major to IKT's Export Engineering program, except without the foreign language requirement. In addition, engineering curriculum is much less emphasized at WPI than at IKT.

Requirements (MG, MGE, MIS)	**Minimum Units**
1. Management Foundation (Note 1)	11/3
2. Mathematics (Note 2)	4/3
3. Basic Science	2/3
4. Management Major (Note 3)	6/3
5. Management Electives (Note 4)	3/3
6. Computer Science	1/3
7. MQP (Note 5)	3/3
Total	10

NOTES:

1. The Management Foundation must cover the foundation knowledge in the management functional areas, including at least 1/3 unit of financial accounting, managerial accounting, financial management, organizational science, deterministic management science, operations management, marketing management, information systems management, microeconomics, macroeconomics, and business law and ethics.
2. Mathematics must include 2/3 units of calculus and 2/3 units of statistics.
3. The Management Major must comprise a department-approved integrated set of courses covering a specific area of: management, science, engineering or mathematics for MGE; computer science or information systems for MIS; management, social sciences, or humanities for MG.
4. Management electives must include at least 1/3 unit of 3000/4000 level MG courses. The remaining 2/3 units specified in the requirement may be satisfied with courses from Mathematics, Basic Science, Computer Science, Management, or Social Science, but excluding courses MG 1250, and MGIE 2850.

5. Courses may not be counted more than once in meeting the departmental distribution requirements. The total number of MG (and/or MGIE) units may not exceed 50% of the total number of units earned for the degree.

Specifically, within the MGE discipline, the distribution notes require that several possible courses are available to satisfy MGE requirements. These requirements and descriptions of the relevant courses are detailed in Appendix A, which is largely an excerpt from the WPI course catalog.

IKT's distribution requirements are very similar in content, with the exception of a greater emphasis on engineering curricula and mathematics and science. They have a rigid structure that requires that each course in the sequence to be taken. This sequence is displayed in Appendix A.

2.4.8 Course Requirements and Prerequisites

The general philosophies of both WPI and IKT are to provide a technical education for students without sacrificing personal interaction and social skills.

To accomplish these goals, WPI provides what it describes as a project-based and very student-oriented curriculum. As a general rule, there are no specific courses one must pass in order to graduate. Typically, there are alternatives to every course in the catalog, enabling students to build their own curriculum rather freely, within the constraints of degree distribution requirements. An example of the WPI distribution requirements (for majors in Management Engineering) can be found in the "Distribution" section. These guidelines form a general framework for a student's course of study. The decision of which specific courses to take, within these guidelines, is entirely within the student's purvey under the guidance of an academic advisor. WPI does not specify that a student must take a series of specific courses to graduate, just that a student must take a certain number of courses as a subset of the possible courses.

In contrast, IKT's system is more rigid and compulsory. Appendix A illustrates this fact: the Export program has a set of required classes that must be completed in a certain order or something close to it. The advantages of this system can be seen in stronger program definitions and a guarantee that program graduates will have specific skills. The disadvantage is less academic freedom for IKT students than for WPI students.

Another general philosophy of WPI's academic program is a defined lack of course prerequisites. A student may elect to take any course they desire. The course catalog either "suggests" or "recommends", but a student without the suggested or recommended background is allowed to enroll in that course.. The lack of prerequisite courses further allows for academic freedom by students, allowing the student to decide how capable they are of handling a certain course. This lack of prerequisites is atypical of United States institutions in general: such U.S. institutions as CalTech, Carnegie Mellon, the Massachusetts Institute of Technology, and Rensselaer Polytechnic Institute do enforce prerequisite courses.

IKT also enforces prerequisite courses. Advantages to this model include a guarantee that students taking a given course will have the necessary background, and more homogeneity inside each class group, ostensibly allowing the class to cover more material. Disadvantages include lesser academic freedom for students and less choice in courses. Additionally, course prerequisites prevent students from bypassing areas they feel proficient in.

2.4.9 Curriculum Accreditation

United States engineering accreditation today is performed by an organization called ABET, the Accreditation Board of Engineering Technology. ABET is a "federation of 28 professional and engineering societies" (www.abet.org). ABET, along with its international counterparts, is responsible for placing a "stamp of approval" on engineering programs that meet its criteria. ABET is recognized by the United States Department of Education for its responsibility in this area. Often, the presence or absence of ABET approval for a program determines the career options of its graduates both in industry and in further education. The process of determining adherence to these criteria is a peer-review process employing educators in applied science and engineering.

The current accreditation process by ABET is an outcomes-based approach, based less on academic elements of the educational experience and more on the demonstrated abilities of graduates from accredited programs. This change occurred recently, with changes in the academic and industrial climate indicating a dichotomy between industry-required skills and abilities possessed by college graduates.

To demonstrate outcomes, in the 2000-2001 ABET accreditation criteria, engineering programs are required to have:

> "...a meaningful, major engineering design experience that builds upon the fundamental concepts of mathematics, basic sciences, the humanities and social sciences, engineering topics, and communication skills. The scope of the design experience within a program should match

> the requirements of practice within that discipline. The major design experience should be taught in section sizes that are small enough to allow interaction between teacher and student... [though] team efforts are encouraged where appropriate." (www.abet.org).

This required project experience gives an example of the aims of the current accreditation processes: to produce engineering students that are capable of working together on project work while being capable in their chosen area of study (specific content requirements exist for specific engineering disciplines). At WPI, this project can be very interdisciplinary, with a particular Major Qualifying Project sometimes including students of various majors handling different parts of the project. On the technological side of education, ABET specifies quite clearly in its accreditation requirements that students must have a solid foundation in the use of computer technology. This requirement demonstrates the belief ABET espouses in the importance of technologically educated science and engineering majors: programs that do not provide these students with computer skills do not become accredited (www.abet.org).

Danish institutions are not accredited in the same manner as United States institutions. Because all institutions are state-funded, all curricula are considered accredited programs by the state. There is not equivalent to a private institution, and Danish students pay no tuition for attendance. State funding for institutions is granted on the basis of the number of students that pass exams at these institutions. The exams are administered by the evaluated institution, under the scrutiny of an independent observer. In Denmark, state funding, or lack thereof, forms an effective method of ensuring that institutions adhere to government education standards.

2.5 The Current Situation – Technologies and Methods

2.5.1 Introduction

This section of the report details technology and educational methodology presently utilized at WPI and in other United States institutions. This section will also describe the accepted practices of the proper application of these technologies and educational methods in United States institutions. The use of technology in science and engineering education is prevalent in these institutions, including WPI, MIT, and other universities.

Seels and Richey define the nature of instructional technology. They note that technology can be defined as the theory and practice of design, development, utilization, management, and evaluation of processes and resources for learning (Seels, Richey 9). Instructional technology is designed to "affect and effect" learning (Seels, Richey 10). In a narrower sense of the definition, this project group is concerned with the application of technology in the form of computing devices to aid in the learning process. This section will examine current trends in the United States in the area of technological education, as well as educational methods and curriculum.

2.5.2 Educational Efficiency and Academic Productivity

One of the main goals of innovation and change in the educational establishment is to increase efficiency and academic productivity. The question that institutions frequently ask is how the implementation of change and innovations in the institution will increase learning by facilitating quality learning and by decreasing the time taken to learn a concept. These changes naturally allow the academic program to cover more material.

Academic productivity, as industrial productivity, defines itself as the ratio of output knowledge obtained to the input resources required producing that knowledge (Van Dusen 7). Van Dusen also notes that prior to 1980, institutions were typically rated for quality with a kind of "scorecard" rating what he terms as the "inputs" to the equation: average SAT score of applicants, number of faculty possessing doctorate degrees, and similar criteria. However, especially with the recent shift in accreditation criteria to "outcomes assessment", the relative merit of a school has been determined by its *output*. The output is a reflection of the quality of the education, directed at what a student can do upon ending the experience instead of students' entrance credentials or specific academic components. Accreditation criteria also reflects this changing paradigm (www.abet.org).

2.5.3 Partnerships with Industry

In the United States, intense competition in the field of education and the very recent shift by the ABET (Accreditation Board of Engineering Technology) to "outcomes-based" assessments has led many institutions to innovative programs. One major component of many of these programs is partnerships with corporate interests. Educational partnerships are not a new theory, but rather an evolving idea. American business and industry are becoming increasingly involved in higher education. As companies are demanding more specific talents and skills from college graduates, they push their influence farther into the institutions of learning. Both educational institutions and corporate interests are realizing that in order for companies to receive college graduates with the desired skills, these companies must participate in the educational process. Classical teaching methods do not emphasize the focus on rapidly growing new technologies and group problem (Van Dusen 30). As a result, the responsibility on the teaching staff will also be changed dramatically. Instructors will work with companies instead of individually on students' education.

2.5.4 Current Educational Technologies

One of the first educational technologies implemented in recent history was the printing press. Gutenberg and the printing press were key factors in overcoming time and distance obstacles to learning. Through the printing press, knowledge could be recorded and easily duplicated and distributed throughout the world. An explosion of knowledge quickly followed, with universities serving as repositories for printed knowledge. The printing press was the first instance in which technology served to perpetuate the learning process, and caused a dramatic shift in how material was presented for learning.

In contemporary times, educational technology is usually electronic in nature. Seels and Richey delineate three major classes of electronic/computer systems utilized in typical educational systems of today. These categories are audio-visual technologies, computer-based technologies, and integrated technologies (Seels, Richey 38). It is important to recognize that the technology itself does not teach, but it provides a vehicle for the instruction that is set by the course curriculum (Van Dusen 41). So, it is important to use these technologies in conjunction with, not as a replacement for, standard educational techniques.

Audio-Visual Technologies

Audio-visual technologies are typically applications such as motion pictures, sounds, and imagery. These applications typically include videotapes or audiotapes, or "overhead" or visual images (Seels, Richey 38). Applications in the audio-visual category are usually linear in format, with the content and progression predetermined by the designer. The user has little interactivity with the subject matter and tends to be fairly passive. These user-passive audio-visual technologies tend to be implemented in compliance with principles of behavioral psychology in order to maximize learning (Seels, Richey 38).

Direct Computer Interactions

The second category of technological education is direct computer interaction. This category includes tutorials, games and simulations, and databases. Tutorials are useful in teaching a person how to do something in "drill and practice" (38). Games and simulations allow a user to apply previously gained knowledge to practical situations and improve critical thinking with the relevant skills. Databases, unlike either tutorials or games/simulations, are not designed to "educate" by teaching skills. Rather, databases are vast repositories of data: statistics, images, definitions, etc. User-searchable, databases are sources of raw data rather than sources of process instruction or critical thinking. Databases can be very useful when combined with the other forms of computer interaction, or with traditional research.

Integrated Systems

The third major category of technological education is the "integrated" system. Commonly referred to as "multimedia", this type of system is a hybridization of computer-directed and audio-visual learning devices. Multimedia, as the word implies, allows for the integration of text, sound, animation, video, and other diverse media into single productions (Albright, Graf 29-30). With advances in computer technology, multimedia has become a very useful educational tool. Multimedia has become more prevalent in recent years due to improved sound and video devices as well as higher processor speeds and increases in data storage efficiency and capacity (Jonassen 185). Jonassen also notes that multimedia is particularly effective in today's educational world due to the fact that it stimulates more than one sense at once: mostly through the use of audio and video. This extra stimulation is particularly useful in today's media-saturated world (Jonassen 185). Multimedia can be a very positive tool for education if utilized properly.

Specific Components of Integrated Systems

Albright and Graf detail the various components of integrated multimedia used in a college-education setting. First, the most important and relevant device is the computer. The computer, driven by ever-faster microprocessors, is the "nerve-center", recalling data. Recently, computer interfaces have improved substantially: nearly all-modern computers utilize an intuitive windowed approach to interfacing. The advantage to this method is the ease of use and ability to display several pieces of information on a screen at one time. Video is also a valuable component. With recent increases in available hard disk space and improvements in optical storage technologies (CD-ROM, DVD, etc.), digitized video can be utilized more and more in presentations. In addition, audio technology is improving. With the advent of inexpensive sound devices, sound and music can be implemented in presentations precisely and effectively. Again, improvements in static and dynamic storage technologies have fostered the growth of multimedia in the classroom; sound and video presentations can use vast amounts of storage space. Finally, the display hardware is very important. To present in an educational setting, a standard CRT monitor is often inadequate because of its small size, which makes it difficult to present to an entire classroom. To solve this problem, such technologies as LCD video projectors have been implemented. LCD projectors can project images on to walls and large screens, providing a much more visible image. These projectors have decreased significantly in price since their commercial introduction. Originally, manufacturing prices were prohibitive for the devices to be used in educational settings, or even in business settings. However, low-cost overhead and lightweight portable projectors entering the market have opened the doors to multimedia development (Jonassen 34-35).

2.6 Specific Technologies and Implementations in the U.S. and at WPI

2.6.1 Introduction

Informational technology is becoming more and more prevalent in institutions of higher education throughout the United States. With technology such as networking, the Internet, and other interactive classroom equipment decreasing in cost even as they increase in effectiveness and power, information technology is a powerful new element in education. Many technologies have been implemented or used almost exclusively in higher education since their conception. For example, for the first 25 years of the Internet's existence it was primarily used by educational institutions of higher learning (www.rand.org).

It must be kept in mind that new technologies are most effective when used in conjunction with traditional applications. Mixing new technology with some new and radical approach to educating almost always results in a complete failure of the overall program, both in educational innovations as well as the implementation of new technology. In contrast, gradual evolution of current methods under the influence of new technology tends to succeed.

2.6.2 Complementing Traditional Teaching Methods

There are numerous ways to complement a traditional teaching style or methodology with new informational technology. Prof. James C. Baird of Brown University augments his chemistry class both in and outside the classroom. His Web page for the course includes online lecture notes, lecture "overheads", and digitized audio of actual lectures. This audio can be played, rewound and replayed. The Web page also includes homework assignments and answers, updated weekly; electronic archives of past final exams and answers, and links to online resource material that relates to the course topic (www.rand.org). Students can access these resources just as they do any with any Web page: by pointing and clicking on text links.

Faculty members at WPI also routinely post course information in such a manner using traditional Web pages as well as "Course Info" pages. The next section will detail the manner in which information is made available at WPI through the Internet.

Course Information Online at WPI

Faculty members post information online in two ways at WPI: traditionally authored pages, and Course Info pages. Each system has its own benefits, and the decision is based mainly on personal preference and experience with computers and the Web. In both cases, students are able to access information relevant to their courses by simply accessing the page as they would any Web page.

Traditionally Authored Pages

Faculty members with a knowledge of Hypertext Markup Language (HTML) or web authoring programs such as Microsoft Front Page and Netscape Composer can create a page that gives students access to files and information stored on the school's main server. For example, the course page for the graduate-level CS course taught by Professor Mark Claypool at WPI was created in a standard HTML format. An index of the main page has links to the syllabus, slides used in class, homework assignments, files, and related links on the internet or school network that would prove useful to the student (www.cs.wpi.edu/~claypool/courses/502-S00/).

The advantages of traditionally authored pages are that they are universally accessible and require no additional software to create. However, a rather extensive knowledge of HTML or web-authoring programs is required to create an attractive and smoothly functioning Web page. The necessary skills often require more time or effort than most professors have available.

2.6.3 Course Info

One alternative to avoid this difficulty is to use an online education course management. For those faculty members not comfortable with file transfer protocol, HTML, and the other knowledge required in creating and displaying their own course page, the company Blackboard Inc. has created a commercial project, Course Info, that does it for them. This Windows-based application allows faculty members to create informational pages through a simple interface that requires no programming skill. Text documents, image files, and other data can all be stored and linked via this system for future access through the Internet. The instructor also has the capability to create login names and passwords so that individual students use of the page can be tracked, and the page customized for individual student use.

Course Info allows instructors to post homework solutions, relevant class information, schedules, and other information on the Internet for student access. Students can access this information from any location and can print the information if necessary. Other possible uses of the Course Info system include a forum for posting questions and answers by class members and the instructor, and chat functions in real time between students and instructors. This format allows for more interactivity between the class and the professor. Other benefits include 24-hour access to course materials, and the ability to see class grades. These advantages allow more time to be spent concentrating on individual student needs (www.blackboard.com).

Course Info is currently in use at WPI. The system is not widely utilized currently, but some instructors are beginning to take advantage of its presence. Due to the system's ease of use, instructors are being encouraged to utilize it as a viable alternative to traditionally authored pages or non-Web solutions.

2.6.4 Non-WPI Information Technology Solutions

eToolkit

eTool-Kit from eCollege is another online program, similar to Course Info. The software requires no HTML experience and is very user friendly. Like Course Info, eToolkit includes the ability to post announcements for a class along with its syllabus. Faculty and students can chat in real time using online chat software provided with the package. The software also includes an updatable course calendar and customizable grade book. As with other online educational software packages, eToolKit allows mass e-mails to be sent to entire classes, eliminating the inconvenience of dealing with extensive e-mail lists (www.eCollege.com).

eToolKit can be further enhanced with the use of eCollege's additional software packages, eCompanion and eCourse. eCompanion incorporates all the features that eToolKit does and includes new features such as document sharing for classroom discussions, a guide to Internet resources, and the ability to conduct online practice tests. eCourse encompasses both eToolKit and eCompanion into one software package that handles all aspects of online courses and online teaching. eCourse allows the teaching material to remain completely online, requiring only a 28.8 kbps connection to access course material.

Other Online Educational Software Packages

There are numerous other packages similar to Course Info and eToolKit, but varying slightly in small features and in price (Appendix D). These packages include WebCT (www.webct.com), Lotus Notes/Learning Space (www.lotus.com/home.nsf/welcome/learnspace), TopClass (www.wbtsystems.com), and WebCourse in a Box (www.wcbinfo.com).

2.6.5 Maple and mathematical simulation programs

Maple is used throughout the introductory Calculus sequence, Linear Algebra, and Differential Equations classes at WPI. This exposure to mathematical software serves a double purpose. First, using Maple allows a student to manipulate mathematical expressions to a degree beyond his or her normal capacity. This capability of the software is analogous to the added capabilities that a student gains from use of a calculator versus calculation by hand. In addition, this software allows a visualization of mathematical functions that would be otherwise impossible to graph using traditional pen and paper means, often complicated or multi-dimensional functions. Finally, the use of the Maple software package allows a student to practice the mathematical skills gained in class in a practical and problem-solving setting, allowing the student to apply his knowledge and requiring a thorough understanding of the material. It should be noted that Maple is only one of a wide range of available solutions; other programs such as MathCAD, Matlab, and Mathematica can be used equally effectively. Modeling software can be effectively applied in a range of classes such as mathematics, engineering, and science.

While Maple is introduced to students as a part of learning mathematical skills, it is also introduced to expose students to the power of computing for future use. In the courses following the introductory mathematics series, students are often required to manipulate complex mathematical calculations or solve difficult expressions. Instructors expect the student to turn to some outside source to solve problems, and having an intimate knowledge behind the workings of Maple or some equivalent mathematics software package is considered a viable option.

The Rose-Hulman Institute of Technology includes the price of a state-of-the-art laptop computer in its tuition fees so that the students can use Maple in all of their mathematics classes. The classrooms are set up in such a way that the student is directly linked via network to the instructor's machine. Data can be transmitted throughout the classroom, examples will be present on the student's screen, and Maple becomes an interactive part of the classroom experience (www.rose-hulman.edu).

One possible disadvantage in the use of Maple or similar mathematical simulation or modeling software is that it can detract from the lesson being taught. A student can become frustrated or confused with the program and miss the lesson altogether. It is therefore important that the problems asked of the students via Maple are not so complex as to create difficulty with the program. Rather, Maple or similar mathematical simulation programs should complement the skills learned in the traditional class setting while slowly introducing the new methods available in the software package. It should be noted that whatever software package is used, this package needs to be used to augment a student's ability to learn complicated concepts. Modeling software in itself is not an end in itself: it must teach course material effectively.

2.6.6 Electronic mail

Electronic mail (e-mail) is a powerful recent technology to implement. Most institutions have a centralized mail server. If centralized mail is not feasible anyone can have e-mail addresses assigned to them via any free e-mail host. Rather than wait until standard office hours to speak with a professor, a student can reach them quickly through the use of instantly delivered e-mail. Questions can be asked, information and files transferred, and contact established whenever a student or instructor needs it. The e-mail system therefore improves educational efficiency and productivity, allowing fewer resources (in this case, the professor's time) for the same result.

E-mail has grown greatly in use and has become almost a necessity in today's society, and education is no exception. Students are constantly relying on e-mail to communicate, set up meetings, ask questions, and learn course material. "The use of e-mail is now widespread within higher education and, according to Gilbert (1996), 'course-related use of e-mail is becoming the single most powerful force for integrating information technology into teaching and learning'". Of course, with every aspect of education, there are both advantages and disadvantages to using e-mail in the teaching process. Some advantages according to Huff and others are:

- Improved and asynchronous communication
- Group dynamics become more equal (Markus; Sproull & Kiesler)
- Synchronous and fast transmission of information to multiple recipients
- Facilitation of remote collaboration (Wild and Winniford)

Some disadvantages of e-mail are:

- The need for students to be willing and able to operate the software
- Most information is text-based, sometimes not allowing graphical representations such as charts and graphs.
- Loss of non-verbal communication

2.6.7 Additional Web Course Features

There are other features that can be implemented via the Internet. These include class calendars and schedules, so the student can see when homework sets are due and exams take place. In addition, "virtual" office hours would let students talk with their professor via a chat or message board during specified times when the professor is not physically at school. Also, simulations can be run from the main server or instructor's machine, but are displayed on the user's machine. Mathematical or scientific simulation programs would be of special interest in this case due to the high cost of purchase by each individual student, or by the low availability of the program.

2.6.8 Presentations

Color and graphics are very helpful in conveying information in a presentation format. Typically, such software as Microsoft PowerPoint is used to create presentations. Alessi and Trollip make the following recommendations about the usage of color and graphics in order to make effective multimedia educational presentations. Graphics should be used for important information, including primary information, graphic analogy, and cues; and should be associated with related text. Large or complex graphics should be broken down into parts, and excessive detail should be avoided. Color can be used to "liven up" a presentation, but should not be used to convey primary information that is not conveyed in other ways: colorblind viewers will have difficulty. Use of color should also be consistent with societal standards: green for "stop" and red for "go" would be confusing (82-83).

2.7 Considerations in Applications of Technology

2.7.1 Introduction

Technology can be a very positive influence on the educational processes. However, there are serious considerations that must be made before implementing major technological expansions. These considerations include possible negative effects that the introduction of technology can have on social interaction both in and out of the classroom environment. While judicious application of technology can be advantageous, to do away with traditional teaching methods in favor of excessive use of technology is detrimental to the learning process. Also, costs and monetary considerations can play a large role in deciding which technologies should be used, and to what extent.

2.7.2 Social Interaction

Along with the latest technologies must come the ability to apply them correctly and effectively. Education and learning is not solely concerned with how much information can be imparted to the student. A strong educational benefit to the student is being in the classroom environment and interacting with the other students and teachers.

"Good ideas, not necessarily good technological developments, guide the way" (Kent 51). Human interaction and social development should not be a casualty to the forward progress of technology in the classroom. "It makes no sense to sacrifice human social relations in the process... Human social interaction is too important, too fundamental, to fall to obstructionist artifacts and event fanatics" (Norman 14). Social interaction plays just as an important role in the education of a student as does the actual learning of school material.

Hewlett-Packard chairman Lewis E. Platt states "Technology has made our society a little less personal, and this trend will only increase as more and more interactions move into the electronic world and begin to dull our senses, reduce our attention spans, convert intellectual conversations into sound bites." He continues, "But as the Internet becomes more pervasive, as it becomes more commercial, it runs the risk of making our world worse, instead of better" (Holsendolph).

2.7.3 Obsolete Technology

The value of new and upcoming technologies has been touted many times in the past. However, history has demonstrated that these new technologies can be supplanted by newer technologies very quickly. Technologies from the 1980s have already been classified as obsolete and can be viewed in online museums (Kent 49).

> "Time and time again, technologies either have failed to prove their value to classroom teachers of have been replaced by newer technologies. In schools across the country, filmstrip projectors, Betamax videocassette players, reel-to-reel recorders, videodisk players, and Commodore computers are collecting dust in dark storage areas (Kent 49)."

The challenge to teachers and teacher educators is to watch trends in these technologies and to assess the value of technology implementation at different times. Outsourced consultation can be helpful in efforts to stay ahead of the technology curve.

2.7.4 Cost & Effectiveness

Another consideration in the decision of what technology to use is cost and effectiveness. Not every school or university can afford to obtain the "cutting-edge" technology. Unfortunately, cost is often the most important deciding factor or primary criteria in the choice of obtaining the new technologies. As a technology becomes more popular and widely used, high demand for that technology tends to drive the cost downward. Consequently, popular technologies have a tendency to become more accessible over time and receive higher priority in implementation. "Ultimately, decisions can be based on the cost, effectiveness, and other practical considerations of individual instructional packages" (Clark 58).

2.8 Integration of Technology into an Institution

2.8.1 Introduction

The successful integration of technology into an institution of learning requires several key steps to maximize effective technological use. Technological advances in hardware and software will not successfully advance learning: "...the appropriate use of technology by educational institutions at all levels is crucial to the reshaping of the educational process" (Busby 48).

2.8.2 Leadership

The first key aspect for successful integration lies in the leadership of the university. Without support from higher administration the plan to be implemented will not have the institutional support it needs to succeed. Along without administrative support, competent leaders with technical backgrounds are necessary to implement the technology plan with effective support. Staff and faculty should make suggestions to the technical leaders, but must realize that these technical leaders have final responsibility for project implementation. Ideally, the selected experts should make decisions on technological issues, under the advice of groups of faculty and staff. "If your institution lacks individuals with sufficient experience to develop and implement a technology plan, hire consultants" (Busby 49).

Centralized technology positions are a must when developing and implementing a technology plan in an institution or program. Positions may need to be created (such as "Director of Technology") to help centralize technology management and support.

2.8.3 Integrated Plan

In order to implement information technology, an integrated plan must be devised. Ideally, the plan should incorporate the needs of the administration, faculty and the students in an integrated environment. The plan should include the following key steps taken from Pritchard and Busby's technological integration report.

- Hardware and network acquisition and implementation
- Training
- Software acquisition and development
- End-user support
- Hardware maintenance and service
- Replacement of obsolete hardware and software
- Migration path to newer technologies

- Frequent assessment of the plan (Busby 49)

When purchasing hardware, careful consideration should be given to the overall plan. Although purchasing through multiple vendors is common in today's market, staying with a select group of vendors may eliminate many compatibility problems, saving money and resources in the long run.

Implementing the devised technology plan in discrete phases can be advantageous. The entire university can be divided into groups, and the technology can be implemented fully group by group, instead of a gradual phase-in for the entire university. Technologically immersing certain groups of people or a particular department encourages those users to become masters of the software and to aid the next group of users during the next implementation phase. "Diluting a system by spreading limited hardware over the entire institution may excite all recipients in the beginning, but will soon frustrate them when they discover that the dilution of hardware also dilutes the functionality of the integration plan" (Busby 49).

At the St. Petersburg Junior College (SPJC) in St. Petersburg, Florida, the technology plan in effect calls for a desktop computer to be on the desk of every administrator, staff member, and faculty member. In addition, a "teaching bunker" is present in every classroom, containing a computer, laser-disc player, CD-ROM drive, overhead video projector, large screen monitor and a link to the campus network. The presence of technological hardware in every classroom in this model eliminates the need for a "cart" system. In such a system, commonly employed, a computer, overhead projector, etc., is on a cart and must be reserved, wheeled from class to class, and set up.

Although the use of carts can save money, this plan minimizes the technology use because the inconvenience the faculty must bear to obtain the cart (reservations, etc.) makes the cart unappealing and therefore used much less often. Eliminating this cart system allows the teacher to become more familiar with the technology and rely more on the technology to effectively demonstrate classroom material.

2.8.4 Software Development and Selection

Software development must begin early. Inclusion of the faculty in this implementation phase is important. Some will be very eager to help in this stage and will possess strong skills in computer software. Additionally, inclusion of the faculty in the software development allows them to become experts in the software, and more likely to use it effectively in the classroom. In the experience of the SJPC in Florida, it was noted that the faculty that were most excited and creative in the use of technology were not the ones usually associated with computers.

2.8.5 Support Staff

A very important part of the information technology system is support faculty and staff experts. It is important to identify persons who are excited about the project or technology and involve them early and often. Involving and supporting these faculty and staff gains support for the technology plan and gives the plan more power throughout the institution. As for technical support, there are many ways to support and train the faculty and staff in the necessary areas. Guidance on how to incorporate the new technology into the curriculum is vital to the success of its integration. Guidance in this area can come from either outsourced consultation or internal talent. When supporting experts early in the development phase, lending out hardware and/or software may not be the best approach. Rather than lending software or hardware out to faculty, allowing them to keep the new equipment or software gives the faculty the ability to continuously explore their new items and become a more effective teacher.

2.8.6 Rewards

Another positive step towards successful integration of technology into an institution is providing meaningful rewards. Certain staff or faculty members are interested and use the technology because they see an inherent benefit in its use. Others may not have this affinity for technology. "These individuals might need an *extrinsic* reward for taking what they see as a risk and for the added time involved" (Busby 50). Pritchard and Busby suggest several ways to reward interested individuals:

- Receipt of equipment at the start of implementation
- Outside recognition (e.g., publication of software or article, award nomination, article in a local newspaper, or TV appearance)
- Internal recognition (e.g., demonstrations for other faculty, article in an internal newsletter or alumni publication)
- Enhancement units or in-service credit
- Credit towards tenure or re-certification

Normally, individuals who support the integration of new technology go beyond their normal duties to work on projects involving the technology. The recognition and reward of that effort often produces a more enthusiastic staff and more valuable technological advances with the new hardware and software.

2.8.7 Technology Placement

An important aspect of a successful integration of technology is putting the right tools or material in the right places. For the new technology to have an impact, it must be accessible to users. Accessibility may be an issue due to resources constraints. "You may not be able to provide networked computers for every faculty member, student and administrator" (Busby 50). Publicly accessible labs are an excellent way to provide the new technology to a group of users. The traditional approach to the lab model is a single centralized large lab at a particular site. A less typical approach is the construction of several, decentralized labs throughout a campus or site, each to support a different discipline or major. Also, the creation of faculty-specific technology centers is important. These centers, containing high-performance equipment, provide an environment where faculty are free to experiment and to make mistakes while learning the new hardware and software.

2.8.8 Partnerships

Creating partnerships with vendors of hardware and software often an effective strategy. With the support of local businesses and technological companies, it is easier to defer costs because the vendors are willing to showcase their hardware and software. "Thus, partnerships are critical for providing the resources necessary to ensure the success of large projects" (Busby 51). In addition, software and hardware vendors, like other companies, are always looking to decrease their cost of training. By aiding institutions with technology, the students will be able to enter their work force already trained in relevant skills.

Partnerships can also be formed with other schools or institutions in the area. Night classes can be offered, training in the software use and other computer skills. Offering other schools the ability to teach technology in an institution will provide visibility for that institution, and it will allow sharing of information and resources between institutions.

2.8.9 Assessment

While the integration of technology and curriculum progresses, assessment of the progress being made toward an institution's strategic goal is important. Outsourcing this evaluation process can be a valuable tool: the criticism will be objective and professional. "Once the assessment is complete, make every attempt to address each recommendation of your evaluator" (Busby 52).

2.8.10 Relevancy

To ensure the success of new technology, it is imperative that the relevancy of the technology be demonstrated to the people involved in the project. "Placing technology in people's hands does not ensure that it will be used" (Busby 52). When new technology is displayed to users, it be shown how this technology will enhance learning, not just all the "neat" things that the new technology can do. Different groups of people:

administrators, researchers and professors, have different uses for the technology, so it is important to consider these different uses in the implementation phase.

2.8.11 Change

Lastly, it is important that an organization be prepared for change. "One constant you can always count on with technology is that there are no constants" (Busby 54). Anticipation of what effects new technology will have is difficult. Changes must be made dynamically, by analysis of individual situations. Any project with such an impact will inevitably have political implications as well as technical. Implementation of technology forces people to change methods. It is important to tailor the plan to the needs of the people involved: their support is imperative to the success and future shaping of educational technology in an institution.

2.9 The Future of Technology and Learning

2.9.1 Introduction

Throughout the history of modern education, educators have tried to improve the quality of education by implementing new ideas. Such ideas include the use of computers and other multimedia technologies. Also, new teaching ideas such as collaborative learning have been used to heighten the classroom learning experience. However, the students will only benefit by correct application of these new technologies.

2.9.2 Virtual Education

For higher education, Perelman suggests eliminating the classic campus known today and become completely "virtual". The term "virtual" is indicative of having no real physical classrooms, but rather refers to the use the Internet and online courses to educate. Perelman states that virtual education provides "know-how." Instead of learning specific skills, the student learns problem solving and how to continue learning through work experience. The students learn independently and utilize the latest technologies in conjunction with the Internet for distance learning.

2.9.3 Hypertext and the World Wide Web

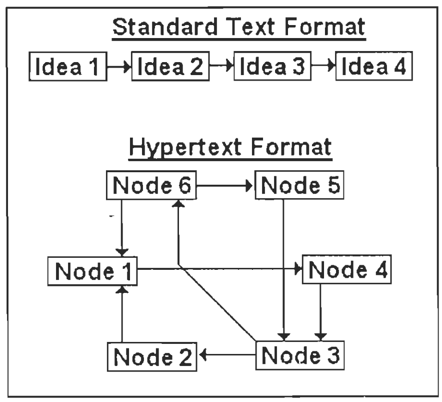

Figure 1: Standard Text vs. Hypertext

One very prevalent technology utilized by most American technological institutions is the technology of hypertext, implemented in a system called the "World Wide Web". Hypertext is an organizational technique, typically implemented in computer applications, by which a group of related "nodes" cross-reference each other so that a user is able to traverse these cross-references ("links") in exploration of the subject matter. Hypertext is a useful way to organize data because it is not locked into the linearity of more traditional forms of paper text. The user can decide in what order he or she can access various pieces of information. A hypertext document could be compared to an encyclopedia with each entry cross-referenced to others in the book (Jonassen 188-189). In paper media, this approach is usually impractical due to physical limitations of books; cross-references between different books result in the reader having to track down each individual volume for every cross-reference for which the reader has an interest. In electronic media, all the associated information is right at the user's fingertips; usually a mouse click is enough to move the user from node to node. This nonlinear approach allows the user access a great deal of related information on any subject that he or she chooses. Jonassen also notes the disadvantages of a hypertext structure, notably the easy confusion of the reader or the difficulty of assimilating a structured system of hyperlinks into a user's own knowledge base (190).

As previously mentioned, the invention of hypertext has provided for an innovation that permeates American technological education: the World Wide Web. "The Web" is an enormous set of inter-linked documents written by millions of authors on any subject. American higher education in technology has seized this tool and made great use of it as well. Many mathematics, science, and engineering courses have an associated course Web page, allowing course documents to be disseminated online, saving paper and improving accessibility. In addition, these Web pages typically have links to other Web pages containing material relevant to the material at hand.

With increases in available bandwidth and improvements in video and sound capabilities, the World Wide Web has been further enhanced by the addition of multimedia components ("hypermedia"), allowing the Web to serve as a purveyor of integrated educational technologies. Multimedia educational content on the Web is typically not implemented in a classroom-education setting, however, possibly due to the complexity of designing such an interface (Albright, Graf 30).

The World Wide Web will undoubtedly have a great impact on the shape education takes in the future. The Web, is a virtually limitless source of information available instantaneously. Since its inception in the 1980s, the Web has exponentially grown to be the largest source of free information in the world. Using the Web, students are able to research and perform experiments with ease.

> "But the greatest gain in the Web is in terms of link-ability of materials. Such links capitalize on access-ability and store-ability. Lists of links, embedded links, image maps and computed links are the forte of the Web, HTML, and scripting languages. Starting from one topic the interested student can delve deeper into the material, jump to related material, or shift ideas altogether following links in the WWW jumping within information on the same server or from server to server around the world" (Norman 15).

2.9.4 Distance Learning

In the past, people could be educated and take courses through the mail, while completing the required work at home. Now, and in the near future, this idea can be extended by the use of the Internet. People are beginning to enroll in courses and earn degrees over the Internet, completing assignments and communicating to professors through electronic mail.

> "A new generation of distance education emerged. Complementary to the other models, Internet-facilitated instruction allows for the implementation of synchronous and asynchronous interaction and opens a new series of learning opportunities for education. Increases in bandwidth technologies and worldwide access to interconnected networks enable the Internet and

the World Wide Web to develop into a viable delivery system for distance education" (Passerinni et al. 2).

In the future, earning degrees and distance learning will become much more common. With Web use continuing to grow, distance learning will become more popular, especially to those who are unable to leave their homes.

2.9.5 Further Upcoming Technologies

There are a variety of new technologies that will be emerging in the near future. These technologies are very diverse and difficult to forecast. An example of a new future technology is being developed at the Massachusetts Institute of Technology in Cambridge, Massachusetts. They are working on a new development called e-ink, essentially an electronic book containing a grid of microscopic spheres, that, depending on the text can be black or white to represent a page of words. A computer contained in the binding of the book will contain libraries of information and will allow the reader to select the material they want to read. The book will have the feel and look of a traditional book but will have the capability to display thousands of literary sources. A prototype book of a few pages is scheduled to be ready in two to three years.

2.10 Studies

2.10.1 Introduction to Studies

Studies are an effective way to examine past attempts to implement new technology or teaching methods. The following studies were considered to be successful within the United States in many areas of technology implementation, including curriculum change, software use and hardware integration.

2.10.2 Campus Computing Project Study

Each year a national survey is taken to determine the condition of technology in the United States' secondary schools. The report, The Campus Computing Project, is published with valuable information pertaining to the integration of the latest technologies into education curriculums. Some of the highlights of Green's 1999 report titled *The Continuing Challenge of Instructional Integration and User Support* are:

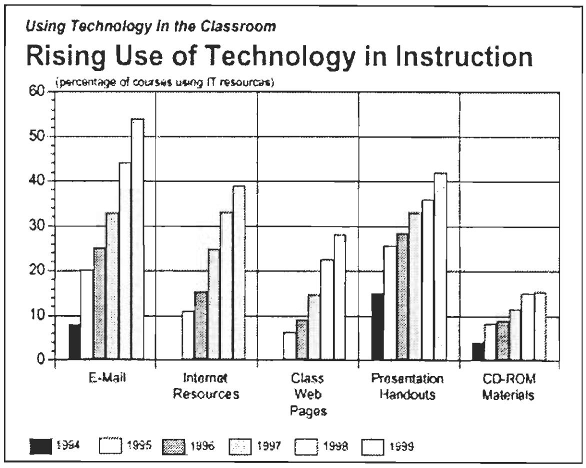

Figure 2: Use of Technology in Instruction (Green)

- Forty percent of the institutions involved say instruction integration is the greatest IT (information technology) challenge.
- Second to instruction integration, providing adequate user support is another IT challenge faced by higher learning institutions.
- Web use has greatly increased for use of course supplementation.

- The greatest increase in technology use has been e-mail, up to 55% from 42% in 1998.
- E-commerce is a new information technology universities are starting to use.
- Most colleges and universities are developing strategic information technology plans.

2.10.3 Smith Case Study

In a recent study by Smith et al., two courses were taught, one called "Psychology and IT" which was taught completely by e-mail and the other "Cognitive Psychology" which had portions taught by e-mail and portions taught by traditional lecture. For each of the courses, tutors, who were also responsible for providing some of the course material, were available to the students and then questioned about the usefulness of e-mail while teaching the course. The tutors suggested many advantages: (Smith, et al.)

- There could be fewer or no scheduled help sessions.
- Delivery and 'reading' of e-mailed course material was recorded ('reading' means only that the recipient had opened the e-mail message).
- Submission of coursework could be direct to the tutor with delivery and reading would be recorded.
- Coursework need to involve little or no paper.
- Once prepared, course material could be delivered in seconds and reused in subsequent years – amended as necessary.

(Smith, et al.)

Similar to the tutors, the students involved in the two courses offered opinions on the e-mail based learning and offered these few advantages:

- There was no attendance requirement.
- Students could work in their own time and at their own pace.
- Course material was received well in advance of its scheduled use.
- All course material could be stored for future use.
- Access to the tutor could be gained via e-mail.
- Delivery (and non-delivery) and 'reading' of coursework was recorded.
- Rapid, secure feedback could be given by e-mail.

Obviously there are many good things to be said about learning through e-mail and working at the students' own pace. However, as enticing as learning completely online sōunded to the students, "none wanted it to be delivered entirely via computers" (Smith et al. 17).

2.10.4 Lessenger Middle School Study

At the Lessenger Middle School in Detroit, Michigan, students utilized a software package, called Model-It, to enhance their science education. This software package uses highly complicated differential equations to model non-steady-state systems, such as pollutant levels in lakes. The students at the middle school, using the software, worked directly with the nearby polluted River Rogue to model different levels of contamination and life. Working with the software, the students gain exposure to real life situations, such as the environmental care of a river, and learned concepts such as differential modeling, without knowing the complicated calculus behind it. “In this case, technology is making the lessons possible” (Manzo 1).

After building a simulation model for the river, the students created graphs and charts to monitor levels of dissolved oxygen, nitrates and other chemical and biological material. "Once they build [the model], they can simulate the different causes and effects" (Manzo 1). This software is a powerful learning tool for education. Instead of learning concepts that the students are unable to apply, they get to see these concepts in action using the modeling software and it is interesting because they are doing hands on work. "Before, I didn't know how different pollutants have different effects on the river," says 7th grader Chantell Bellanfant. "Now, I know that the river is not just polluted because there is trash in it, but that the trash causes changes in the water."

2.10.5 Classroom of the Future

The classroom of the future, according to Farley, is a place where “learning holds no bounds”. The students will have limitless access to resources around the world using the Internet. Desks will be replaced by worktables that have laptop computers and telephones. The students’ education, for the most part, will be self-governed with the teacher monitoring progress. The common textbooks will be replaced by CD-ROMs and laser discs. In this “Classroom of the Future”. Students will direct when and where they learn. Community members, parents and online education mentors will be available resources and the world will become the classroom.

A prototypical “Classroom of the Future” is currently being implemented in California. At the charter school Horizon Instructional Systems, learning has become completely individualized. Each student, along with his or her parents, is assigned to an education specialist. Working with the specialist, the student discusses his or her goals and objectives and then develops a curriculum. Each specialist is assigned to 37 students and everyone is connected using computer technology. Each student has free Internet access while being provided with online material from the school. Occasionally, students will learn together using "whiteboard" technologies via the Internet and local networks with a teacher monitoring. Essentially, each student is never required to leave the house and can receive a full education using only a computer and a connection to the school and Internet. The cost of this program is $3300 per student, currently subsidized through a grant received by the school (Kent 53).

2.11 Literature Review Summary

As technology continues to increase, it will take the effort of the educators of the country to decide how to apply those technologies effectively. "Believing students can shape their own learning productivity simply because they have access to a digital network is equivalent to turning students loose in a library and expecting them to benefit spontaneously from the vast resources on the shelves" (Kent 59). Technology in the classroom does not guarantee an educational benefit. With new upcoming technologies such as e-ink and the "Classroom of the Future", teachers must learn to apply them in an effective manner in order to shape the education of the students. Technology will not shape the future of education, but implementation of that technology will. "As with every other technology that has emerged on the educational landscape, ultimately the teacher will establish the value of the computer in learning" (Kent 59).

3.0 Methodology

3.1 Introduction

The purpose of this project was to assist IKT in adopting beneficial technology and non-traditional teaching methods in the curriculum and in the classroom environment. We used several strategies to accomplish this plan.

The first action we took, after initial meetings and consultations with our project advisor was to draft a literature review. This review was important for our group to gain the necessary background to address information technology and methodology issues in an educated manner. This review of literature outlined the history of higher education and the effect of educational technology on education, the present-day uses of educational technology practice, and some future possibilities of adopting educational technology and its benefits. Using this information, we then conducted surveys based on this background research with students and interviews with faculty members at WPI to gather data about American information technology, specifically that in use at WPI and the United States.

The surveys and interviews undertaken at WPI were mirrored at IKT, utilizing questions tailored to each institution. The information gathered at WPI was valuable to use as a standard to compare the results of the same surveys from IKT against. The student surveys, conducted first, gave us further direction in which to take our project. Responses to these surveys allowed us to adjust our final recommendations to the student perspective as we analyzed student attitudes toward information technology.

We also examined different class web-sites at WPI in order to see which information was most commonly included in a course web-site. This examination was performed by creating a checklist of several aspects that we expected to find on a web-site, and then choosing several web-sites from different departments at WPI. Each site was compared with the checklist to see how it matched with our "model" Web page. In addition, we compared the traditionally authored web-sites with Course Info sites.

After surveying web-sites, we created a mock Web page using the Course Info software via the Internet. We then demonstrated the course management software capabilities to the interested faculty members at IKT using this Web page. This demonstration not only allowed them to see the advantages to posting course information on the Internet, but also the advantages of using course management software such as Course Info.

Finally, we attended several classes in order to compare WPI's classroom methodology with that of IKT. We did this to determine how students could benefit from an increased use of technology in the classroom, or possibly a use of technology to alter teaching styles or methods. Teaching styles, student/teacher interaction, and use of class time were all noted in our observations during class sessions.

All these different elements of our research were analyzed and meshed together to form our final recommendations, which represent a synthesis of all our research.

3.2 Literature Review

The bulk of our literature review research was accomplished by searching for books, journal articles, and web-sites that contained information related to the use of educational technologies in the classroom and the positive or negative effects of these implementations. The review outlined a general history of higher education, present-day educational technologies and methods, and future possibilities for educational information technology and methods. Also, case studies of previous uses of technology in higher education were reviewed, and the benefits and disadvantages of each approach were noted.

The information that we gained in this literature review was used in formulating questions for the interviews and surveys that we conducted. The remainder of the information was background information for our use to provide a background context for our research in this area.

3.2.1 Curriculum

In order to provide a basis of comparison for IKT's curriculum, the curriculum at WPI was investigated. Because our project sponsors asked us to concentrate more exclusively on information technology and the Export Engineering program, we first compared academic majors at WPI to the Export program to find the most similar. The Management Engineering program at WPI was the best match, mixing production engineering and mathematical skills with business and management classes. The course requirements for this major were studied and recorded in the review along with excerpts from the WPI course catalog. Because our sponsors asked us to concentrate more on information technology and methodology than curriculum, our treatment of curriculum subject matter was more limited than that of other subjects. However, some implementations of information technology may require alterations to the existing curriculum, though we did not make any specific recommendations in this area.

3.2.2 Case Studies

When researching relevant case studies, our goal was to find studies involving new and innovative teaching methods as well as studies that describe the successful integration of technology into a curriculum. The Smith case study, discussed in 2.10.3 was examined because of the method the psychology classes were conducted. They used the integration of e-mail as part of the curriculum, relying on e-mail to assist in the distribution of tests and homework. The study demonstrated a possible future step towards technologically enhancing educational curricula.

The Lessenger Middle School, discussed in 2.10.4 was chosen because of the concept behind the study. This study was technology implementation on the most basic level: the use of software to aid in learning material. It demonstrated that software programs can be successfully integrated into a curriculum, even at the middle school level, and be effective learning tools with practical applications.

The College Computer Report, discussed in 2.10.2 was chosen because of its information relating to the use of technology in college-level education. It was used primarily to document the use of information technologies in the classroom such as e-mail, Internet resources, class Web pages, presentation handouts and CD-ROM materials. This study allowed us to make some technological recommendations based on activities in other areas when reporting to IKT.

The Classroom of the Future study, discussed in 2.10.5, was chosen because of its radically new method of teaching. The study involved no classrooms at all and relied solely on Internet and Web-based software to distribute information and assignments. It was chosen because of its success in advancing the technological use in distance learning, a new educational method that is becoming more popular and widely used. While it was deemed by our group highly unlikely that we would recommend such a radical approach, this study was useful in examining how these approaches functioned in extreme settings.

3.3.3 Information Technology

Once our initial project presentation had taken place at IKT, the literature review was revised to include more information on educational technologies. Because our sponsors had expressed interest in programs such as "Course Info" and other Internet course-management programs, different software packages were investigated and referenced for IKT's use in choosing a specific package in the event of a decision to implement course-management technology. In addition, methods for creating Web pages with more traditional methods, such as direct HTML-authoring, were reviewed and discussed.

Also, more generic uses of information technology such as audio-visual technology, e-mail, and the World Wide Web were researched and included in the review. Different technologies were discussed, and their projected impacts on the educational process at IKT were examined. These projections were considered when writing up the final results and recommendations for IKT's use of technology.

3.3 Specific Technologies

We investigated three specific technologies used at WPI: Maple and other mathematical simulation software, Course Info, and e-mail. The general benefits and disadvantages of each were analyzed (as is discussed throughout this section), and these were taken into account when the initial and final recommendations were made to IKT.

3.3.1 Courses on the Internet

We investigated two different methods of posting course information on the Internet. First were traditionally authored Web pages, typically authored by the professor. The second method was the use of a commercial product known as Course Info, by Blackboard, Inc. We also set up a mock course Web page to provide as a demonstration of the use of this software to IKT faculty members.

Traditionally Authored Web Postings

The first step was to survey different course Web pages posted by professors at WPI. Classes were chosen off of the course page at WPI. We searched several departments, to find if there were similarities and differences by department and level of class – graduate or undergraduate. A short checklist of information expected to be on a typical course Web page was constructed, and we checked each page against this list (Figure 1).

Course #	BE1001	CE1030	CS502	CS562	EE2014	PH1140	PH1120	ME1520
1. Contact Information								
2. Course Schedule								
3. Course Syllabus								
4. Homework Sets								
5. Homework Solutions								
6. Past exams w/solutions								
7. Links to related material								
8. Listed on Course page								

Figure 3: Course Web page Checklist

The most common information on each page typically included contact information such as phone and e-mail address, a syllabus for the class, homework sets, solutions, and past exams with solution sets.

The contact information was checked to determine if it was linked. For example, the e-mail address could automatically open electronic mail software when clicked on with the mouse. A course syllabus and/or schedule was also included on the checklist of necessary information. This method allowed students to check the expectations of the professor, grading methods, and the information that would be covered in class each day so that a student would have a way to follow along or review material. In addition, links to other resources on the Internet or in the school's department were a sign that the professor had included information helpful to the student's individual education.

For homework and old exams with solutions, there were two options. The professor had the option of using equation editors to demonstrate how to calculate the answers. Most often, however, the work was performed on paper and then scanned into the computer. The images of the scanned solutions were viewable as graphic files directly on the page or as Adobe PDF documents. The drawback to Adobe files is that a special viewer needs to be downloaded in order to see the documents (Adobe Acrobat PDF Viewer).

Courses that were examined can be accessed at http://www.wpi.edu/Academics/Depts/courses.html. All checklist results were compiled to determine the information that was most commonly included in course Web pages. These results were then used to suggest information that should be included in a typical course web-site. In addition, the department that each Web page was associated with was taken into account due to certain requirements on the department or the level of technology the professors were comfortable using. For example, while computer science professors may be comfortable creating a complex Web page with many options, a civil engineering or management faculty member may not share that technical prowess. Therefore, some discrimination was used when reviewing course pages.

Course Info

Professors uncomfortable with HTML or traditional authoring, or looking for a more convenient way to post information, opted to use Course Info. Course Info is an easier tool, though it requires the school to purchase licenses for the software and a technician familiar with the software to serve as technical support. Once the software is up and running, the professor needs to spend time learning the software, making up the class e-mail list for login purposes, and performing other administrative tasks. However, once these tasks are completed, files can be easily inserted and opened without requiring the user to use special software. The documents can be opened within the Course Info system. Files can be edited, announcements made, and mass e-mails are easy and routine with functions built into the software. Courses on the Web that utilize this software at WPI include Quantum Mechanics II, Civil Engineering, General Physics I, Intermediate Physics Laboratory, Discrete Mathematics, and other courses that can be found and accessed from http://courses.wpi.edu.

As a test of the software, we set up a mock page for this project using Course Info. As 'instructors', we worked through Blackboard's test page and edited the course description, files that could be viewed through the page, and the login information. We set up passwords and login names for several hypothetical users, and added various documents to the site. These hypothetical students, using only a standard Web browser, could view all of these items. This page was used to demonstrate ease of use and benefits in posting course information to the professors at IKT. While we included this software in our final project as such an example, we were careful not to promote Course Info over another similar product. Course Info was the easiest for us to use due to the demonstration system set up through the company's Web page.

Specific questions that were addressed by the project sponsor included information on these topics (cited from www.blackboard.com). Again, most course software provides these capabilities, but description of Course Info allows for a generalized description of this type of software.

Asynchronous Communication

Students have greater opportunity to exchange ideas and ask questions or give responses using threaded discussions.

Synchronous Communication

Group projects can be easier to coordinate for students by including real-time chat and whiteboards on the site.

Assessment Tools and Gradebook

Automated tests, quizzes and surveys. Students receive immediate feedback, and instructors save time grading. The grade book can be exported, so transferring student records to the registrar is easy.

Collaborative Work Groups

Online work groups can be created specific to the needs of a class, allowing access to only those individuals in the group. This keeps students' work secure and allows instructors to follow groups' progress.

Content Creation

A professor can post goals and objectives, course descriptions, syllabi, reading list and assignments online and provide students perpetual access to the materials they need. Audio, video and still images can also be integrated into the site.

Messaging System

Students communicate on a regular basis with individual students without them having to come to an office.

Online File Exchange

Student-written assignments can be collected online. Students may place their work in a drop box for you to pick up at your convenience. You can even grade their work online.

Online Assistance

An instructor can receive printed development and technical information from within your site and communicate with other educators online through discussion groups.

User Tracking

The professor can see how often each student accesses the course site, and what he or she is doing at the site.

Price listings for Course Info and other software were also investigated. A professor can both set up and teach an entire course entirely through the Blackboard.com web-site, or one can purchase the software (alternatively, the school can license the software for campus-wide use). If a professor uses the site for free, the services can be used for free providing that the professor does not charge the student for the class and accesses the site at least once every 30 days. For a $100 (US) registration fee, he or she can register the class and solicit students, charge them for the course, and receive unlimited use of the site for one year.

3.3.2 Mathematical Simulation Software

Mathematical software was investigated for the literature review, specifically Maple because it used extensively at WPI. Upon arriving at IKT, we noted that they used some software such as MathCAD or MatLab, but that use was limited to higher-level mathematics classes specific to certain majors. Without drastically changing the curriculum, there was no real way to integrate this technology further into the classes at IKT, especially into entry-level mathematics courses. Since the faculty at IKT has specifically shown an interest in information technology rather than curricular changes, the use of mathematical software was concluded to be already acceptable and no further work was undertaken in this area.

3.3.3 E-mail

Most WPI professors have e-mail lists for the class set up ahead of time so that information, corrections to mistakes, and general announcements can be made at any time and not just in class. We studied the use of e-mail at IKT through student surveys to determine the level of use. We also included questions in faculty interviews to determine what they used e-mail to accomplish and how they felt about increasing its use. The answers from these questions were included in the final recommendation process.

3.4 Faculty Interviews

3.4.1 Method

Interviews were scheduled with several faculty members at WPI and at IKT (Appendix B). At WPI, these faculty members were Professors Steve Pierson of the physics department, Thomas Keil, head of the WPI physics department, Denise Nicoletti and Richard Vaz of the Electrical Engineering Department, David Dibiasio and W.M. Clark from the Chemical Engineering Department, and Art Heinricher from the Mathematics department. Professor Judith Miller of the department of Biology and Biotechnology was also interviewed, due to her experience in educational innovations and reform. She also is the head of the Center for Educational Development at WPI (CED). These interviews were scheduled at our convenience and the convenience of the interviewees through the first part of the year 2000. Our goal in the selection of the WPI interviewees was to have a broad sampling of professors from several departments, as we decided that the different departments at WPI likely had different viewpoints on information technology.

At IKT, the interview situation was intentionally kept very similar to the procedures at WPI. The faculty we interviewed were Professors Vagn Køhler, Lise Valeur-Jacques, Claus Petersen, Ian Bridgwood, Ole Schultz, and Bent Jørgenson. The professors we interviewed were selected on advice from our project sponsor, who informed us that these professors at IKT would be knowledgeable in the area of information technology and methodology. Additionally, we attempted to interview a broad spectrum of IKT's faculty, as was done at WPI.

Interviewees were posed similar sets of questions. These questions were worded in such a manner as to allow for open interpretation, and so we received a variety of valuable responses. A copy of the questions asked and the transcribed responses can be found in Appendix B. These were recorded for later analysis. In addition, any other valuable information, names, or sources of information that came up during the interviews (WPI or IKT) were noted and further investigated.

3.4.2 Interview Analysis

There were two purposes behind conducting interviews with faculty at WPI. First of all, the faculty members' answers are a good foundation of information. Much of our later research was performed in the context of this research. We used the information and attitudes towards innovational teaching methods at WPI (through the use of technology and otherwise) as a basis for comparison when the same questions are asked to faculty at IKT. This method allowed us to isolate areas where the faculty might be especially in favor of or resistant to change in teaching methods at IKT. Additionally, we wanted to ensure that we did not exclude crucial points that needed to be addressed. By asking the faculty broad questions, we hoped to eliminate this possibility.

These questions were developed in an attempt to determine the attitude of faculty members on change and technological innovation in their workplace. We needed questions that allowed the faculty to express their feelings on educational change and the structure of the present educational system. The questions focused on two main points: "What do you feel technology has helped to accomplish?" and "How else do you feel technology can benefit education at the college level?" Additionally, we asked further questions about methodology in the areas of group work and similar education. While the results of the interviews conducted at WPI were in line with what we expected, they served as a good base of comparison for the results of faculty interviews at IKT.

In the process of our analysis, we first determined general trends in the responses to the faculty questions. We examined IKT and WPI's professor responses to the questions posed and looked for similarities in answers to specific questions and general themes to the answers of the questions. Secondly, we examined unique responses regarding specific aspects of their teaching methods or the structure of education at their respective institution. This analysis allowed us to tailor our final recommendations to the specific needs of IKT as opposed to broad generalized recommendations.

3.5 Surveys

3.5.1 Methods

Surveys were distributed to approximately 90 students, representing a wide variety of ages and majors on the WPI campus. The list of questions distributed can be found in Appendix C. These surveys were distributed via hard copies and e-mail. They were mainly distributed to students known to members of our project team in an attempt to raise the response rates and reduce the number of hastily completed, and therefore less valid, surveys. These surveys were intended to gain a better understanding of how students at WPI view educational technology and to what extent they use this technology. In addition, questions regarding course structure and leveling were asked to see how students felt about their overall education at WPI. The surveys consisted of five open-ended questions, again allowing for a diverse range of responses. Again, we felt that allowing a freedom of response gave the respondents more ability to communicate their views rather than simply confirming or refuting our views.

Surveys were also distributed to approximately 50 IKT students. At IKT, we took a more direct method to the surveys, by actually sitting down with the students, explaining the purpose of this project to them, and then verbally administering the survey. This interviewing procedure was utilized so that the students could be more serious about the survey. Also, it allowed us to gain more information, so we could continue to expand the survey questions if necessary. However, this procedure limited the number of surveys we could do because of the greater time involved with each student. This is the reason for only 50 surveys being conducted at IKT as opposed to the 90 at WPI. We discovered that several topics were brought up in the course of the surveying that were not included in our original set of questions. We could therefore address these topics in later surveys, allowing us to tailor our questions further.

Although the surveys provided ample information on technology use at both WPI and IKT, there were limitations. The surveys at WPI were distributed to a wide variety of people and were not distributed in a random fashion. At IKT, the surveys were distributed more randomly but as with WPI, were not mass distributed. The pie charts created were based on a limited population and not the entire student body. However, the results obtained were assumed to represent the thoughts and ideas of the student body at both WPI and IKT.

3.5.2 Analysis

The student surveys were an excellent source of information because the students are the people most affected by changes in technology use and curriculum, and will be the beneficiaries of new implementations in information technology. The results of these surveys played an important role in how the recommendations to IKT were formulated. Once all the WPI student surveys were collected, they were analyzed for useful information. The WPI student surveys were analyzed one by one, and commonalties were found from question to question. After the responses from both WPI and IKT were compiled, pie charts were created that displayed the major student responses in an organized fashion. Based on this analysis, general conclusions were formed about how students felt about each topic examined. Using this information, recommendations were made on technology use and curriculum changes for the review of IKT.

3.6 Conclusion to Methodology

Using the literature review, we were able to design the survey and interview questions needed to evaluate the educational process at IKT. Once we had completed the interviews and surveys, we were able to analyze the results and decide what changes could be implemented. We were then able to tailor specific recommendations based on the results of the analysis.

All of the separate tasks that we accomplished were then analyzed with the plans detailed above. Once this was accomplished, we reviewed the results of each step and put them together into our Results section. These results were then reviewed again, compiled into groups based on topic and feasibility, and from these groups we formed our final recommendations for IKT.

4.0 Results

4.1 Introduction

The purpose of conducting the research and data collection was to formulate recommendations for IKT in adopting new information technologies in the classroom and in general education. In this section, the results of the background research and data collection analysis are presented.

Section 4.2 covers the results of the student survey analysis that was conducted on the surveys from WPI and IKT. Section 4.3 details results from faculty interview analysis of WPI and IKT faculty interviews. Section 4.4 describes the results of the analysis conducted on various course Web pages in use at WPI.

4.2 Survey Analysis

The following is a detailed analysis that examines each survey question used in the student surveys at both institutions. The survey responses found were then used in creating our recommendations to IKT. Questions posed to both sets of students are listed near each other, for comparison. Unique questions are analyzed at the end of the section.

4.2.1 Survey Analysis Results

1. How do you feel technology plays a role in your education at WPI?

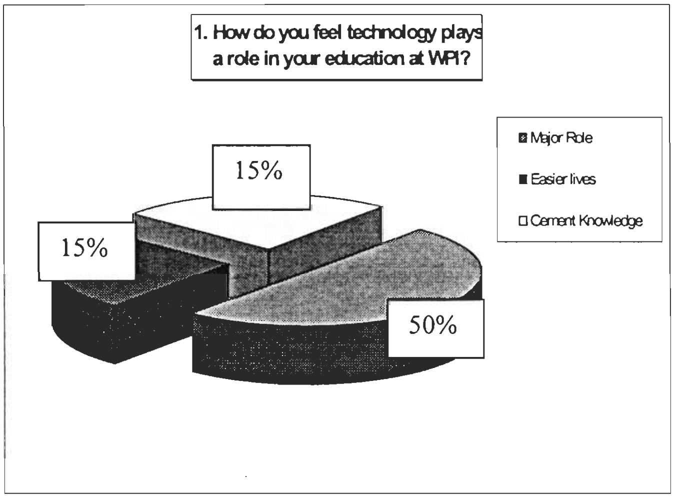

Figure 4: Student Question 1 (WPI)

In general, the student population surveyed at WPI felt that technology played a major role in their education (~50%). Responses mentioned that technology made students' lives easier because of, among other reasons, a student's ability to do tasks faster and more effectively with computers. Also, technology has helped cement knowledge learned in the classroom, by allowing students to learn material at their own pace through educational software programs. An example is Maple in the mathematics classes, or Pspice in the electrical engineering classes.

How do you feel technology plays a role in your education at IKT (how much do you rely on certain technologies such as computers, e-mail, etc)?

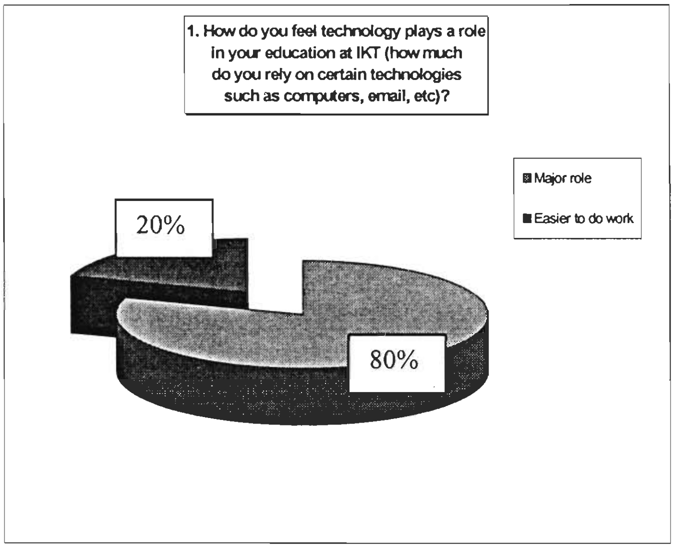

Figure 5: Student Question 1 (IKT)

Students tended to respond that technology plays a large role in their education at IKT. Students mentioned use of the Internet as a key aspect along with the general use of computers to help with classes, homework and projects.

2. What aspects of technology do you feel that you benefit from the most (WPI)?

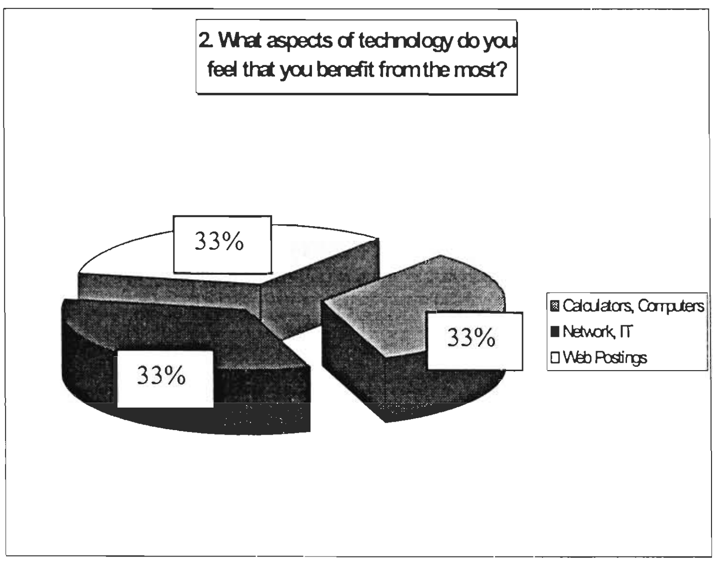

Figure 6: Student Question 2 (WPI)

Most of the students mentioned e-mail as being most beneficial along with computers in general and calculators. Other benefits were programs and software used in classes as well as the high-speed network on campus at WPI. Others responded by saying information technology in general was beneficial to their education. Also, students endorsed the availability of homework solutions and Web courses through the Internet.

What aspects of technology do you feel that you benefit from the most (IKT)?

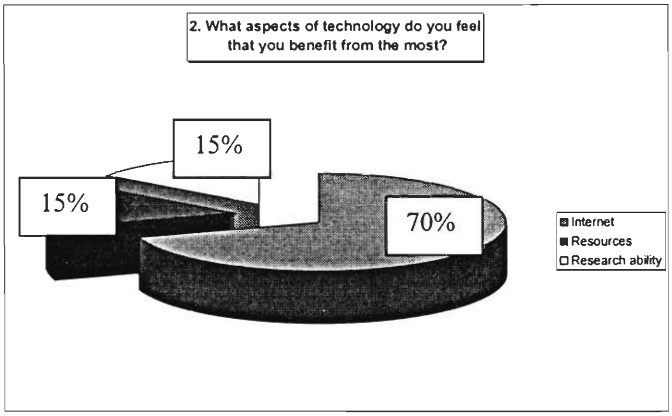

Figure 7: Student Question 2 (IKT)

Almost all of the students mentioned that the greatest benefit is the Internet. Using the Internet for general resources and course research was generally felt to be the largest benefit.

3. Which aspects of technology do you feel you could do without or are detrimental to your education? If any, why (WPI)?

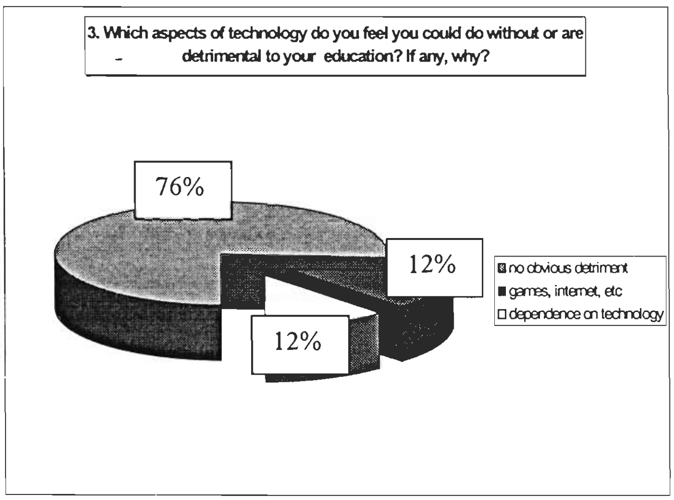

Figure 8: Student Question 3 (WPI)

Most responses to this question indicated no obvious negative attributes of informational technology. Minority responses indicated that technology could become detrimental if the technology is emphasized excessively, creating dependence on the technology rather than on the students' own mental abilities. A few surveys also mentioned that games and other recreational technologies could be distracting, although these technologies are usually not implemented in an academic environment.

Which aspects of technology do you feel you could do without or are detrimental to your education? If any, why (IKT)?

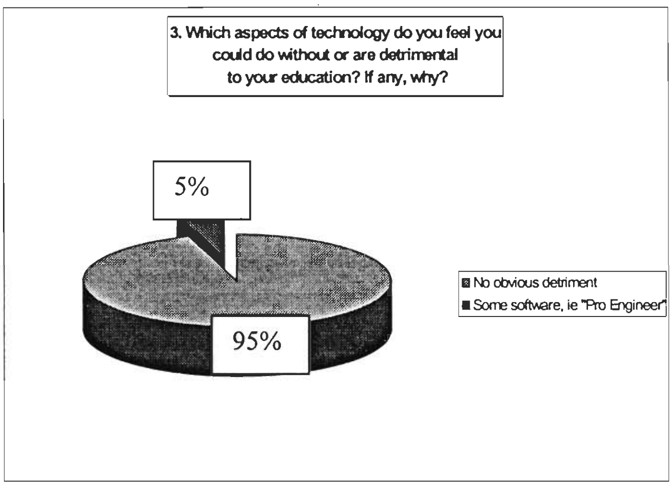

Figure 9: Student Question 3 (IKT)

The students felt there there were no obvious detrimental technologies currently in use. However, some students mentioned the software package "Pro Engineer" as a program that is not widely accepted by the students at IKT.

4. Do you feel that group-oriented work heightens your educational experience (WPI)?

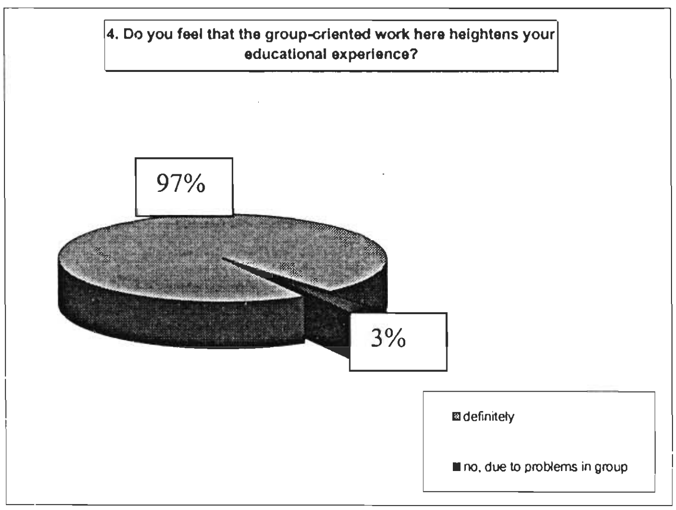

Figure 10: Student Question 4 (WPI)

Most of the students surveyed at WPI believe firmly that group work has heightened their educational experience and proves beneficial. Some students also noted that practice working in groups will be invaluable when entering the work force.

Have you had any experience working in groups? If so, do you feel that the group-oriented work here heightens your educational experience (IKT)?

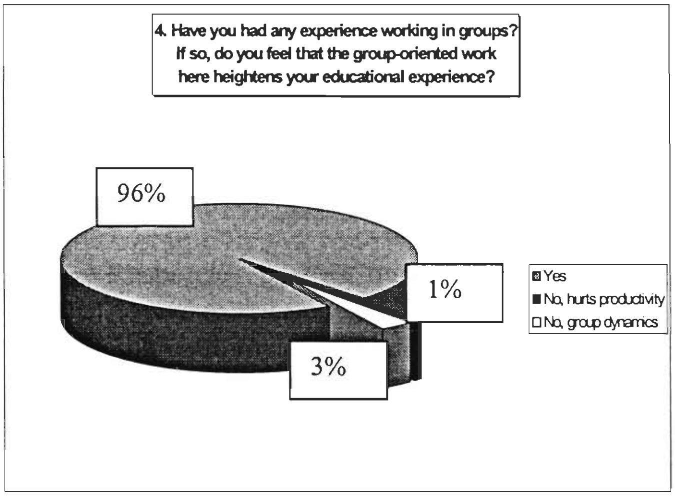

Figure 11: Student Question 4 (IKT)

Approximately 90% of the students expressed approval of group work in the IKT curriculum. These students thought that group work was very beneficial to their education, and they felt that the experience will prove to be helpful when entering the work force. A few students thought that group work could be detrimental due to group dynamics and that sometimes coordinating group work wastes time and decreases individual productivity.

5. Do you think that it would be advantageous for WPI to offer classes teaching the same material at different levels of difficulty?

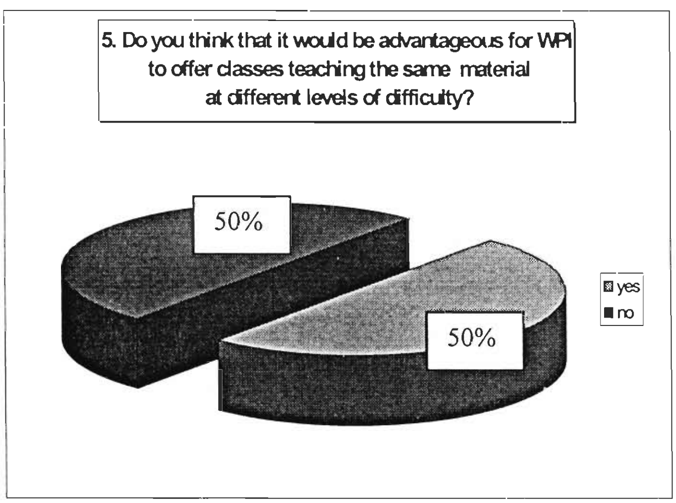

Figure 12: Student Question 5 (WPI)

The student population answering this question was split in opinion. Half thought that splitting courses by difficulty would be beneficial, allowing the more gifted student in a particular subject to take more difficult classes. Conversely, the other half of the students felt that splitting the courses by difficulty would be detrimental because it would separate the student body.

Do you wish that you had access to certain technology that you do not have currently (IKT)?

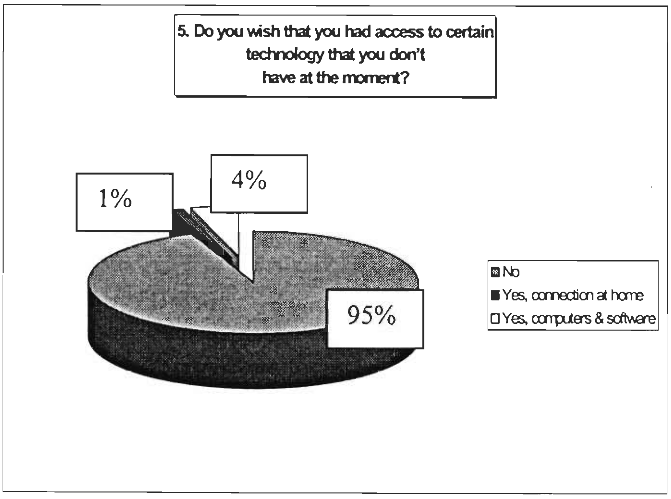

Figure 13: Student Question 5 (IKT)

The answers to this question ranged widely. Some students had no response. Others mentioned that more exposure to computers and new course related software would be beneficial. Also, students expressed a desire for an Internet connection at home as well as at school.

Would you like to see your courses offer information on the Internet such as homework solutions, old examination problems, etc (IKT)?

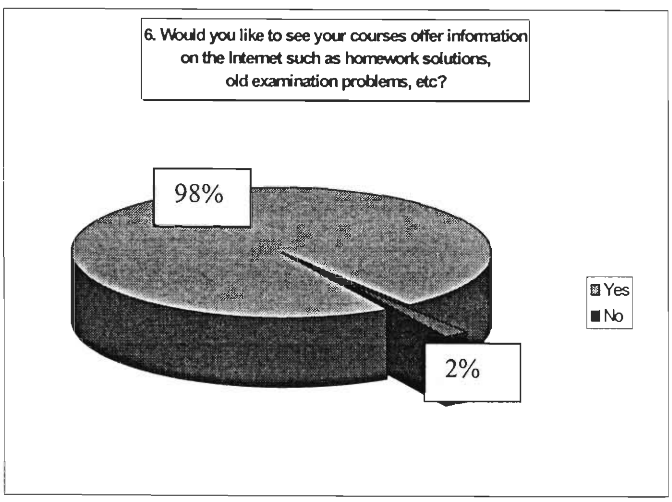

Figure 14: Student Question 6 (IKT)

About 97% of the students surveyed reported that they would like to see more course-related material posted on the Web. Only a handful of students thought that web postings of homework or other course related information would not be beneficial.

4.2.2 Other Topics

While conducting the student surveys, other topics arose that were not specifically questioned in the survey. One of these topics was electronic mail. Most of the students at IKT use e-mail, but not extensively. For the most part, the students think that e-mail is useful and would use to communicate with professors and other students if given the opportunity. Also, many of the students mentioned that further training in the use of certain software would be helpful. Some products that were specifically mentioned were Microsoft products such as Word and especially Excel. Some students reported that, at times, the most difficult part of a project was learning to use the associated software. A training course, similar to that of Denmark's PC License program, was suggested by some students as an effective method for training students in this way.

4.3 Interview Analysis

4.3.1 Results

What aspects of your teaching style do you consider unique?

Answers to this question varied quite a bit, by the very nature of the question. WPI's and IKT's responses to this question were similar. Some professors noted that they had students use specific software packages to augment their teaching. Others noted a penchant for interacting with students personally instead of students being only "a number" in their class, or a tendency to teach broad course objectives instead of only specific course material. This concept includes "bridging" between various courses (e.g. physics and electrical engineering).

How do you believe advancements in technology have aided or improved college-level education?

Answers to this question varied as well. Most of the WPI professors we interviewed believed that technological innovation in education has had a positive impact on college-level education in some way. A minority did not see a significant improvement to the inclusion of technology. Several pro-technology WPI professors responded that more difficult problems and projects could be attempted with the aid of simulation and visualization software. One professor noted that this software should be learned on the students' own, as studying the fundamental concepts of the class is much more important than learning an often soon-to-be obsolete software package. Two of the professors agreed when to the statement that a student must "learn how to learn" software packages: this will be a valuable skill in industry. A few professors mentioned that e-mail and course information on the Web has been helpful in communication between students and class staff. One professor noted, interestingly, that a student reluctant to contact class instructors personally is more likely to do so via e-mail.

IKT professors tended to feel similarly, although the responses tended to vary a bit more. Several noted that computers have allowed students to educate themselves at their own pace and have given them easy access to a large amount of data via the Internet. Another professor expressed pleasure with the greater ability to handle paperwork and administrative tasks of a class, freeing up resources for more productive tasks. Other IKT professors agreed with WPI professors in their attitudes toward software packages: they can be very helpful for visualization and simulation, and learning the software can be very helpful to the students in industry later on. One professor indicated a need for caution in this area because these packages can decrease students' ability to think analytically and understand basic concepts, as there is a tendency to allow the computer to "do the work for them".

Please name some educational technologies or curriculum aspects you believe to be unique to WPI/IKT (Question was occasionally separated into two).

Responses to this question were fairly specific. The computer network and multimedia equipment (projectors, etc.) were cited as unique, as was WPI's utilization of Blackboard's Course Info system and Web-based course material. Several noted that the project system was a unique innovation at WPI, specifically the IQP. One professor noted that several institutions have a project similar to the MQP, but the IQP is a singularly unique interdisciplinary project. Ease of student access to professors was also cited as relatively unique at WPI.

Responses were very similar among the IKT staff. Many cited IKT's project system, which is analogous to WPI's system in some ways, but with more academic stress on projects: IKT students spend nearly half their time doing project work. Professors also noted that IKT has a small class size and smaller lecture halls. IKT professors cited their use of software packages such as Pspice and others, and members of the electronic engineering department noted their departments increased reliance on laptop computers.

Do you feel the group work is advantageous? Why or why not?

WPI professors were in favor of group work, if properly integrated into the curriculum. They cited an allowance by group work for active student participant with peers in learning course material. However, if used excessively or improperly, group work can reduce the effectiveness of the educational experience. A few professors noted that many people do not learn effectively with a lecture approach, and group work can do well to augment a lecture approach. Additionally teaching group skills specifically is important so that students are not 'taught to swim by being thrown in the river', as one professor put it.

IKT professors also felt that there was a great deal of benefit in utilizing group work due to the reliance on group work in today's industry. In many cases, IKT's curriculum is as much as two-thirds project work and only one-third standard academic work. Additionally, group work can be important because teachers can often forget what specific material students can find difficult to learn after years of teaching the material. According to IKT professors, group work tends to minimize the problems associated with this.

What technologies or educational innovations would you like to see implemented at IKT? (Only answered by IKT professors).

Several professors indicated an interest in course material to be put on the Web, and an increased presence of relevant software packages. One professor suggested that permanent television and video functionality in most or all classrooms would be a major benefit. Others believed that personal computers need to be available in the classroom, communicating via a computer network. Increased use of the Web and e-mail was also seen as helpful. One professor expressed a need to train students in such software as Microsoft Word and Excel.

4.4 Web page Analysis

4.4.1 Web Postings via Traditional Methods

Once a short checklist of different information had been created, eight different course Web pages on WPI's *Courses on the Web* directory were chosen to compare against the checklist (www.wpi.edu). The results of these comparisons can be seen in the chart below.

Course #	**BE1001**	**CE1030**	**CS502**	**CS562**	**EE2014**	**PH1140**	**PH1120**	**ME1520**
1. Contact Information	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2.Course Schedule	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
.Course Syllabus	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4.Homework Sets	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5.Homework Solutions	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6.Past exams w/solutions	No	No	No	N/A	No	Yes	Yes	No
7.Links to related material	Yes	Yes	Yes	Yes	No	No	No	Yes
8.Listed on Course page	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Figure 15: Course Web page Checklist

Using this checklist, we could easily discern which information was included most often in WPI Web pages. By examining the results of our checklist, we determined that from WPI's perspective it was important to include all of the topics that we had in our checklist, with the exception of past examinations. The research suggests that past examinations are not strictly necessary, although they can be a valuable tool for students to study. Often, professors re-use tests or drastically change their examination methods, lessening the effectiveness of this method. Therefore, we feel that tests and solutions should be utilized at the professor's discretion. Homework solutions are important, as well. Students need to see the correct methods for solving problems in order to prepare for future material and exams. Because class time does not always permit a professor to go through each solution as thoroughly as may be necessary, solutions available to students via the Internet are extremely helpful to students, according to our research.

In addition, other information such as the professor's contact information is necessary to allow students to contact professors with any questions regarding class or Web page content. Contact information usually includes e-mail addresses, office numbers, and telephone numbers. Our checklist analysis concluded that a good course page contains most or all of the information on the list.

5.0 Recommendations

5.1 Introduction

The following section is details the recommendations made to IKT. These recommendations are all products of the data analysis results and background studies that were detailed in Section 4. Each recommendation is suggested by the results of our research, and methods for successful implementation into the educational structure at IKT are illustrated.

The recommendations include the use of web postings for course and other material, course management software, increased use of e-mail among students and faculty, introductory software lessons, and others. Section 5.3 is an overall conclusion to the recommendation section. It compiles recommendations that resulted from the different analysis results. It also summarizes the major changes that we suggest should be adopted and the reasons these changes are justified.

5.2 Recommendation Statements

The following is a list of recommendations grouped by subject. Group A deals with instituting software training for new students at IKT. Group B details the need for Web-based course information. Group C recommends the adoption of course management software at IKT. Group D recommends the further use of group work in the classes. Group E discusses e-mail, and Group F recommends that IKT anticipate further equipment needs to implement the other recommendations. Each recommendation statement is supported and described by research results and other details immediately following the statement.

Recommendation A: S*oftware training should be introduced to teach students software necessary for classes at IKT.*

When interviewing IKT students about their experience with technology in education, some students reported difficulty in using some common software packages. If a training program were to be set up training students with specific software such as Microsoft Excel and Word, students would be able to use this software much more effectively. More complicated tasks could be performed and more difficult problems solved within projects or course work. Efficiency in completion of assignments and projects would rise concurrently. Not only would this introductory training prepare students for their academic work at IKT, it will also prepare them to use this software in careers in industry or other applications. Professor interviews and background research support the contribution of this type of program to industry preparation. There are several methods for implementing software training. A course could be set up resembling or supplementing the PC License training course in Denmark, allowing students to verify competency using a personal computer and associated software. An after-hours class where students would learn relevant software could meet once or twice per week. Depending on demand and other factors, one of these programs could be implemented as a mandatory or (more likely) non-mandatory addition to the curriculum.

Recommendation B1: *All or most courses offered at IKT should have associated Web pages on the Internet.*

From analyzing the WPI student interviews, it was concluded that such innovations as the Web, online courses, e-mail, and Internet access have had a significant impact on the education of WPI students. Many IKT students expressed a desire to see course-related material such as homework solutions, example tests and assignments posted on the Web for convenient access. In order to create a culture of web access for classes and a general acceptance of the Web as a medium for distributing information, Web access should be implemented for as many classes as possible.

Recommendation B2: *Online courses should be implemented via one of two methods: traditional web authoring software or a course management program.*

The use of an online course management program such as Course Info by Blackboard, Inc. would greatly improve the quality of communication and ease of managing courses at IKT. After implementation of this software, students will be able to access general information on their class. This information should include grade information, individual and group assignments, and professor information, such as office hours and contact information. Additionally, previous tests and solutions can be included optionally. There are many software packages similar to Course Info. The differences in features and price between these packages are included in Appendix D.

If course management software is not a viable option, IKT has the option of posting standard pages provided by the professors using authoring tools such as Front Page by Microsoft or Netscape Composer. These programs take somewhat more knowledge of Web design and associated technical knowledge. If this option were selected, an information technology specialist on-site at IKT would likely be necessary to aid professors in posting their information on the Web. The need for this extra staff, as well as the likely high degree of difficulty and frustration among faculty, will likely mitigate the cost-effectiveness of this approach. Consequently, this approach is not recommended as a general solution.

Recommendation B3: *Course Web pages should contain the following material and properties:*

a) The page must be easy to locate and access.

A main page should be implemented on the IKT server that lists all web courses, and the specific courses should be linked from that directory. Also, announcing the presence and location of the course page in the classroom is important, so as to emphasize its existence and encourage use.

b) Each course Web page must include certain specific information.

The necessary information includes contact information for the professor teaching the class, teaching assistants, support staff, or related personnel. Additionally, course schedules and syllabi are necessary. Homework sets for the term and homework solutions after the sets are due are strongly recommended. Old tests, with or without solutions, and links to related course material are optional. Scanned images are recommended for homework sets and old tests.

c) Scanned images must be manageable and clear in order to be effective.

Image files are not always clear or easily accessible: although GIF or BMP images of homework solutions are clear and readable, they can occasionally become large. Additionally, pagination can be difficult with image files, as large images do not lend themselves easily to printing on multiple pages. An alternative to GIF or bitmapped images is the use of Adobe's PDF format, requiring the students to have Adobe Acrobat Reader software on their computer. This requirement must be noted and announced to the students, although any computer that can handle Web browsing can also run the Acrobat Reader. Adobe Acrobat Reader is freely available via the World Wide Web, and solves pagination and presentation issues.

d) A course page should be easily navigable.

To ensure navigability, one may use frames or links at the top of the page to each specific section of the course page. These links will allow the student to quickly and easily navigate to each section with a minimum of confusion.

e) Students must be aware of the existence of the course page and be notified that much of the course information will be included and distributed through it.

Students should be encouraged to view this page as a helpful tool. A professor, in order to encourage access to the page, might place some or all course materials solely on the Web page. This strategy can be very effective in encouraging page access. Homework sets and solutions should be updated regularly, and instructions and information on the page should be clear and understandable.

Recommendation C1*: IKT should utilize course management software.*

Course management software is an effective alternative to traditional Web page authoring. Course management software requires more resources to set up and introduce to faculty members than requiring them to create traditional Web pages. In the long run, though, these difficulties are overcome by the positive benefits of utilizing this software.

Course management software sets a standard for distribution of course information, such that students are familiar with one format for these pages. Additionally, use of this software will save a great deal of professors' time and reduce the need for staff to support the Web effort.

Recommendation C2: *A central course management server should be implemented.*

The first step in setting up a course management package such as Course Info is to purchase the software and have it configured on the central academic server. The software at this point is available to all faculty members. Professors can also teach a class for free through the Blackboard.com web site, but we do not recommend this approach, except as a method of evaluating course management software for potential future use. A full comparison of six different course management programs, done by Wichita State University in 1999 (http://company.blackboard.com/CourseInfo/productreviews.html#), is performed in Appendix D. This comparison illustrates different features associated with each product and gives estimated price quotes and contact information from each vendor.

Recommendation C2: *Instructors should be introduced to course management software as a whole in a seminar or series of instructional lessons.*

Once the software package is available, the teachers should be introduced to it as a group and all at once, possibly in a seminar-style lecture. This introduction will provide the faculty a certain level of comfort with the software. Additionally, introduction of the software to all faculty members at once will encourage the faculty to use it.

Recommendation C3: *A system head should be appointed to oversee course management software operation.*

A system head should be appointed that is familiar with the technical aspects of the course software and with its properties and capabilities. This implementation will allow for in-house troubleshooting and technical support that faculty members can access easily. Proper support will also encourage use of the software, because the faculty will have technical and instructional support available as necessary. On-site help will alleviate many apprehensions in the faculty about Web implementation.

Recommendation D: *IKT faculty should continue to use group work in the classroom and for projects.*

At IKT, students are involved in extensive group work. As demonstrated from interviewing both students and faculty at WPI and IKT, group work is very effective and useful. It teaches students social skills in working together and prepares them for work once leaving the school environment. The only recommendation here is to continue to support the use of group work in course and project work. However, it was mentioned several times that once in a while a student is in a group where not all the members are contributing equally. In such a case, a good idea would be to have instructors assist in resolving differences in the group and perhaps change groups if necessary. Additionally, specific instruction in group dynamics to students would be beneficial early in students' academic careers in order to prepare them to work effectively in groups.

Recommendation E: *Electronic mail should be more widely utilized among the IKT community.*

During the WPI and IKT surveys, there were many mentions of e-mail from both schools. Many students, mostly from WPI, mentioned that e-mail plays a very significant role in their education. However, e-mail is not utilized as widely at IKT, according to student and professor questioning. There are many benefits from the extended use of e-mail. There was a general agreement between WPI and IKT faculty about the value of electronic communication tools between students and faculty. WPI professors were enthusiastic about positive effects that e-mail and web access for their classes had on the educational process. Instantaneous communication is a very useful device, and students and professors can communicate much more easily with each other, especially with the establishment of class electronic mail lists.

One major difficulty with the current European communication infrastructure is the inconvenience of home Internet access. However, it is important that electronic mail be externally accessible to IKT users, both students and professors. IKT should investigate methods of increasing the accessibility of its e-mail systems from outside the system. This accessibility can be implemented by running a mailer program (such as Pine or Elm) on a Unix server externally accessible via Telnet or a similar communication protocol. Additionally, 'POP' post-office software can be installed on a main academic server configured to provide mail capability to IKT users that are not directly on IKT's system. In both these cases, authentication is important, probably via a username and password combination both to send and receive mail. These requirements will ensure that only authorized users may check their own mail, and limits system susceptibility to relay-hijacking for sending unauthorized electronic mail.

With the implementation of other recommendations, such as course management software and web postings of homework and solutions, there will be a natural increase in use of e-mail. Web and Internet-based technologies will gradually encourage students and faculty to use e-mail more extensively.

Recommendation F: *IKT should anticipate increased equipment needs.*

Some IKT professors expressed a need for more computer and multimedia equipment, in classrooms and elsewhere. IKT computer labs, particularly in the Export department, are already reaching capacity in computer usage levels. If Web-based course information and other technological educational methods are adopted, there will be a corresponding increase in use of computers in the labs. Alternatively, a program encouraging personal computer ownership by students could be beneficial, as well, as is the case in IKT's electronic engineering department. Additionally, placing tests and homework solutions on the Web will likely require extra scanners, and computers to operate them, because of the number of professors (and students) that will be scanning these documents.

5.3 Conclusion to Results and Recommendations

Based on the research results, several recommendations were made based on analysis of IKT. We then determined which recommendations were feasible and recommended by our sources: surveys, faculty interviews, Web page analysis, and background research.

All three major sources of data recommended an implementation of course information through the Internet. As stated previously in this project, this implementation can be done in two ways: generation of traditionally authored Web pages or utilization of course management software. We recommend the latter, and have detailed several different software vendors, referenced their contact information, and cited comparative data between them. While our project focuses most heavily on Course Info, this should not be construed as an endorsement of a specific software package.

The student surveys performed at IKT showed student interest in a training class for basic software packages, either as part of the regular curriculum or as a night course. Interest in this training class was supported by faculty interviews. This course could include applications such as Microsoft Office, generic Internet tools, and other relevant software that would be used in future classes. We feel that this course will allow the students to undertake projects and schoolwork more efficiently and confidently. Because students will already be capable of using this software effectively, they will be able to engage in productive class work instead of learning the software during class time.

Our final recommendation is an increased use of e-mail, a highly effective means of communication if properly used. This increase in e-mail can be brought about in conjunction with some of the other recommendations. An increase in faculty use of electronic mail in classes would assist the process. Additionally, course information on the Internet will help to encourage students to utilize electronic mail to contact faculty and staff. Professors must stress to students that they can easily and quickly contact faculty members through e-mail, and faculty must do their best to communicate through this medium.

Appendix A –Distribution Requirements: WPI and IKT

The following material is directly excerpted from both the WPI Undergraduate Catalog and the IKT Course Manual. The material has been edited to provide clear and concise information on the MGE program and the IKT Export program.

WPI: MANAGEMENT ENGINEERING (MGE)

Management Engineering at WPI combines the best of a business degree with a technical focus. MGE majors develop a broad understanding of business through what we refer to as Foundation Courses. These include such courses as Financial and Managerial Accounting, Marketing Management, and Operations Management. On top of the Foundation Courses, each student can select six courses in which they can focus their advanced work. These courses must be approved by the Department's Undergraduate Committee and usually come from electives in the Department or from areas such as Engineering, Mathematics, or Science. Career opportunities for Management Engineering majors are quite varied. While many become engineers in the focus area (Industrial Engineering, for example), many join management training programs or accept sales positions with technological firms.

Curriculum Guidelines for MG, MGE, MIS
Specific course recommendations for complying with the distribution requirements are given below. These guidelines are intended to offer flexibility while meeting minimal standards in preparing for careers in MG, MGE, or MIS.
MATHEMATICS-minimum of 4/3 units is required, with 2/3 units in calculus and 2/3 units in statistics. For most students, MA 1021, MA 1022, MA 2611, and MA 2612 will be appropriate.
BASIC SCIENCE-minimum of 2/3 unit is required, where all courses with the prefix PH, CH, BB, and GE 2341 and GE 3050 qualify.
COMPUTER SCIENCE-minimum of 1/3 unit is required where all courses with the prefix CS qualify (except CS 3043). CS 1005 is recommended for students concentrating in MIS and MGE.

MAJOR-minimum of 2 units of integrated course work is required for students majoring in Management, MIS, or Management Engineering. Often students focus their major courses on particular areas such as those noted below. Other focus areas are possible, but must be approved by the student's academic advisor and the Department's Undergraduate Committee early in the student's program.

MGE
Operations Management
MG/IE 3351, MG/IE 3400, MG/IE 3401, MG/IE 3410, MG/IE 3420, MG/IE 3440, MG/IE 3501, MG 3651, MG/IE 3760, MG/IE 4720, MG 4151, MG 4365, MA 3619, EE 3601, ME 1800,ME 2820, ME 3820, ME 4815.
Operations Research*
MG/IE 3400, MG/IE 3401, MG/IE 3501, MG/IE 3760, MG/IE 4720, MA 3271,MA 3273, MA 3431, MA 3613, MA 3619, MA 3625, MA 4231, MA 4233, MA 4235, MA 4237, MA 4631, MA 4632.

Management

SCIENCE -- MANAGEMENT OF CHANGE.
Cat. I
This second course in organizational science provides experience in analyzing and applying the theories of leadership, motivation, conflict management and the management of planned change. The thrust of the course is the examination of managerial theories to determine appropriate approaches to their use. The course is conducted as a seminar and workshop and concentrates on the problems experienced in the workplace.
Recommended background is MG/IE 2300 or agreement of the professor.

MG/IE 3400. PRODUCTION SYSTEM DESIGN.
Cat. I
An introduction to the planning, analysis and design of production systems. Designed for students in engineering or management who may wish to assume responsibilities in the production of goods or services.
Topics to be covered will include: microscopic and macroscopic analysis of the production process, facilities location and arrangement, resource allocation and optimization of the use of facilities, work measurement and economic evaluation of alternatives.
A knowledge of differential and integral calculus is assumed. More importantly, knowledge of basic statistics and the ability to think quantitatively are desirable. Intended primarily for third- and fourth-year students. Students in engineering curricula are encouraged to enroll.

MG/IE 3401. PRODUCTION PLANNING AND CONTROL.
Cat. I
An introduction to the planning and control of production systems. This course complements MG 3400 and may precede or follow it.
Topics include: forecasting, scheduling, and production and inventory control maintenance, and quality control.
A knowledge of differential and integral calculus is assumed. Some knowledge of probability and statistics is helpful but not mandatory.

MG/IE 3405. WORK SYSTEMS AND FACILITIES PLANNING.
Cat. I
This course covers the fundamentals of developing efficient layouts for production and service facilities, as well as analysis of location and distribution configurations. Methods analysis, work measurement, material handling and material flow analysis are also covered. Mathematical models and computer tools are used to assist decision-making.

Recommended background: MG/IE 2500 and MG/IE 3400.

MG/IE 3410. CASE STUDIES IN INDUSTRIAL ENGINEERING.
Cat. I
A number of in-depth case studies in Industrial Engineering and Operations Research are analyzed. The cases will cover both manufacturing and service systems ranging from production system design to operations planning and control. Specific topics may include: technology selection and replacement, facilities planning, production planning and control, quality control.
Familiarity with basic material from the methods courses MG/IE 3400, MG/IE 3401, MG/IE 2500 and MG/IE 3501 is assumed.

MG/IE 3420. QUALITY PLANNING, DESIGN AND CONTROL.
Cat. I
This course focuses on the quality aspects of product design and manufacturing. Topics include: Total Quality Management, Poka-yoke systems, Statistical Process Control, Capability Studies, Quality Loss Function, and Design of Experiments (Taguchi Methods).
This course is intended for both industrial and systems engineering (MGE) and product engineering (MFE, EE, ME, CE) students. A knowledge of differential and integral calculus is assumed. More importantly, the ability to think quantitatively is strongly desirable.
Recommended background: MG/IE 3400 and MA 2612 or consent of the instructor.

MG/IE 3450. HUMAN FACTORS ENGINEERING.
Cat. I
This course examines the human-machine interface in the workplace, concentrating on how workplace design can influence effectiveness and enhance health, safety, and satisfaction. Human sensory, motor, and decision systems are studied, as well as principles for designing visual and auditory displays, control devices and tools, and work spaces. Problems with repetitive and high physical effort tasks, illumination, noise, and atmospheric conditions, along with relevant governmental regulations, are also considered.
Recommended background: none.

MG/IE 3501. MANAGEMENT SCIENCE II: RISK ANALYSIS.
Cat. I
This course provides coverage in decision analysis. Decision analysis is a technology that assists decision makers in quantifying consideration of complexity and uncertainty in problems of choice. The course applies decision analysis to problems in risk assessment and risk evaluation. Decision making in risk analysis is examined across a wide set of management engineering problems including case studies in environmental risk, product liability, facilities design, and R and D management. The course is intended to be highly integrative with respect to risk analysis including issues such as business ethics and risk communication.
While the course is self contained, a knowledge of calculus and introductory probability and statistics is preferred.

MG 3600. MARKETING MANAGEMENT.
Cat. I
Designed to give the student a broad appreciation of the fundamentals of marketing management, this course is taught primarily by the case method with several lectures based on behavioral science concepts included for the studentÕs general background. An analysis and discussion of cases and problems are used to study demand advertising, personal selling, channels of distribution, marketing research, pricing, new products policy and the marketing-mix.
This course assumes a knowledge of the material in SS 1110, SS 1120; MG 1100, MG/IE 2200.

MG 3640. MANAGEMENT OF PROCESS AND PRODUCT INNOVATION.
Cat. II
This course is based on the hypothesis that high performance firms depend on a sustainable patter of new and innovative processes and products. Sucessful companies are examined in regard to their strategies for innovation and technology transfer. Technology alliances among industry, universities, and government are

considered in order to increase the leverage of the individual firm. International benchmarking and international commercialization from research to actualization is discussed through cases and examples.
Recommended background: MG/IE 2200 or MG/IE 2850.
This course will be offered in 2000-01 and in alternating years thereafter.
Students may not receive credit for both MG/IE 3440 and MG 3640.

MG 3651. INDUSTRIAL MARKETING.

Cat. II

Provides an understanding of the industrial marketing process and practices. It presents the latest concepts, tools and techniques for marketing complex products and services to industrial and institutional users. Topics include: product innovation strategies; purchasing management and buyer behavior; major intelligence; pricing strategies and tactics; developing markets for new industrial products; bid proposals; industrial distribution; managing the industrial sales force; marketing controls.
This course will be offered in 1999-2000 and in alternate years thereafter.

MG 3700. INFORMATION SYSTEMS MANAGEMENT.

Cat. I

This course introduces students to the management of information technology within complex organizations. It covers the range of information technologies employed by business organizations and the manner in which they are deployed. The course places special emphasis on the management of information resources from a user and manager point of view and will help students understand how particular technological arrangements can facilitate achievement of organizational goals. The impact of information technology on management control, organizational structure, individual workers, relationships between organizations, and business transformational will be discussed. Students may not receive credit for both MG 2700 and MG 3700.
Recommended background: MG 2101 and MG 2300 or equivalent business background.

MG/IE 3720. BUSINESS DATA MANAGEMENT.

Cat. I

This course introduces students to the theory and practice of database management and the application of database software to implement business inofrmation systems which support managerial and operational decision making. Special topics covered include relational and hierarchical datamodels, query languages, normalization, locking, concurrency control and recovery. The course covers data administration and the design of data tables for computerized databases. Students will use a commercial database package to design and implement a small business database application. Students may not receive credit for both MG 4700 and MG 3720.
Recommended background: MG 2720 or equivalent knowledge.

MG 3740. ORGANIZATIONAL APPLICATIONS OF TELECOMMUNICATIONS.

Cat. II

Students taking this course will develop an understanding of how organizations can effectively use telecommunications technology to enhance business functionality. Students will analyze the devlopment of organizational communications infrastructures and their use for the development of "virtual" organizational structures and to support globally-distributed organizations. The course will begin with a survey of the concepts and technologies which form the basis of a business telecommunications system and which allow the merging of voice, data and video in an integrated multimedia communications structures. Students may not receive credit for both MG 4701 and MG 3740.
Recommended background: MG 2710 and MG 3700.
This course will be offered in 2000-01 and in alternating years thereafter.
Students may not receive credit for both MG/IE 3740 and MG 3740.

MG/IE 3760. SIMULATION MODELING AND ANALYSIS.

Cat. I

This course covers the application of simulation to a variety of managerial problems with examples from operations management, industrial engineering and manufacturing engineering. It introduces the student to the concepts of computer simulation, with an emphasis on the design of a simulation experiment and statistical interpretation of its results. It will discuss simulation of queueing models, inventory and

industrial dynamics, and gaming situations. The role and use of computers for the execution of simulations will also be highlighted.
A commercial simulation language such as SIMAN will be used to solve problems from the manufacturing and service industries. Recommended background: computer programming and statistics (as in MA 2612 or MA 3619).

MG 3800/SS 3111. MANAGERIAL ECONOMICS.
Cat. I
An application of economic theory to the problems of the firm with special emphasis on decision-making. A study of how the firm manipulates such variables as output, price, advertising and product quality so as to achieve its goals; and of how its pricing and selling strategy choices are affected by consideration of the reactions of rival firms.
Also covered are demand forecasting and cost analysis using regression and other techniques. A knowledge of the expected future distribution of demand for individual goods and services and their costs of production is vital in establishing national economic policies and priorities. In demand and cost analysis, there is an interface between economics and technology. Consequently, this area provides a source of interactive projects that will enable students of engineering or science to draw on knowledge of their own discipline as well as economics in analyzing important social problems.
Students taking this course should be familiar with the material covered in SS 1110, Introductory Microeconomics.

MG 3960. SMALL BUSINESS MANAGEMENT.
Cat. I
This course addresses itself to the practical problems of starting and managing a small business for profit. It focuses on the planning required to buy an existing business or to start a small business from the ground up and develop it into a profitable on-going concern. The course uses the case method giving the student an opportunity to apply and integrate the knowledge previously acquired in such areas as accounting, finance, marketing, production, engineering and business management.

MG 4151. COST ACCOUNTING.
Cat. II
This course is designed to give basic understanding and skill in the area of cost accumulation to anyone concerned with recording the expenses associated with a given activity or project.
Cost accounting provides data for three major purposes: 1) planning and controlling routine operations, 2) making non-routine decisions, and 3) inventory valuation and income determination. All three are important, but the course stresses the first two as they relate to project activity.
The goal of the course is to put cost accounting in focus as a highly useful technique in any decision-making situation where expense levels are important. While some attention is directed toward accounting systems and procedures for data accumulation, stress is given to the theme that cost accounting is a vital and dynamic tool for problem-solving.
Because of the technical nature of the subject, students should have mastered the material of MG 1100, Financial Accounting, in order to be able to comprehend the concepts and techniques of cost accounting procedures.
This course will be offered in 1999-2000 and in alternate years thereafter.

MG 4364. HUMAN RESOURCE MANAGEMENT.
Cat. II
This undergraduate/graduate course in applied organizational sciences introduces concepts and techniques of human resource management. It provides experience in the solution of a variety of human resource problems through classroom exercises and organizational cases, introducing and building upon the basic concepts and techniques of industrial and organizational psychology. The course focuses on changing labor markets, employee recruitment and selection, performance appraisal and compensation, job evaluation, training and development, job design, labor relations, diversity and gender issues in the workplace, government involvement in human resource issues, job satisfaction, and motivation to work.
Recommended background: MG/IE 2300 (or agreement of the professor).
This course will be offered in 1999-2000 and in alternating years thereafter.

MG 4365. LEADERSHIP IN GROUPS AND ORGANIZATIONS.
Cat. II
This undergraduate/graduate course considers the essence of leadership in groups and organizations. Specifically, it examines the personal, interpersonal, group, and contextual factors which affect formal and emergent leadership in groups and organizations. It also examines the effectiveness of various leadership approaches and styles under various conditions. Using case studies, simulations, group projects, and selected readings on leadership in groups and organizations, this course will give students an opportunity to assess and develop their own leadership talents. Recommended background: MG/IE 2300 (or agreement of the professor).
This course will be offered in 1999-2000 and in alternate years thereafter.

MG/IE 4460. GLOBAL PLANNING AND LOGISTICS.
Cat. II
This case-based course will examine methods and strategies for managing and controlling material movement, with particular emphasis on international operations, from the purchase of production materials to the control of work in process to the distribution of the finished product. Strategies that will be discussed include the design of international distribution networks, the use of third-party logistics providers, and the creation of links between logistic systems and marketing to create competitive advantage. The course will also explore tactical issues that must be managed to pursue a logistics strategy successfully, including choices regarding means of transportation, packaging, and inventory policies. Underlying themes of the course will be the use of information technologies (such as electronic data interchange and bar coding) and mathematical models to support logistics decision-making.
Recommended background: MG/IE 3400, MG/IE 2200 or MG/IE 2850.
This course will be offered in 1999-2000 and in alternating years thereafter.

MG/IE 4720. SYSTEMS ANALYSIS AND DESIGN.
Cat. I
This course integrates students' bakcground in MIS in a one-term project focusing on development of breative solutions to open-ended business and manufacturing problems. The project will utilize systems analysis and design tools such as systems development life cycle, feasibility study, cost-benefit analysis, structured analysis and design. Students will aquire the skills necessary to analyze, develop, implement, and document real-life information systems. Students must be able to organize themselves and the project to complete their work within a seven week term. It is recommended that MIS majors take this course in preparation for their MQP. Students may not receive credit for both MG 3750 and MG 4720.
Recommended background: MG 3720.

MG 4750. MANAGEMENT OF THE IS FUNCTION.
Cat. II
This course integrates students' background in management policy and business analysis and addresses the practical problems of developing and running an IS organization. It focuses on the planning and management required to assure systems performance and monitoring, systems reliability and quality change management, backup and recovery, security, new technology assessment and implementation, staffing and staff development. Through case studies and mini-projects students will analyze existing structures in industry IS organizations.
Recommended background: MG 3700.
This course will be offered in 1999-2000 and in alternating years thereafter.

MG 4900. POLICY.
Cat. I
The purpose of this course is to provide a capstone or final integration of the various functions of management. The course focuses on the strategic allocation of scarce resources: human, financial and physical. The topics include: the functions of strategy, setting objectives, planning systems, corporate strategy and organizational structure, identification of opportunities and risks. The course is mainly case oriented to permit the student to integrate the material from various parts of the management program

including marketing, production/operations management, finance, accounting and economics. Student presentation of written and oral solutions to case problems is highly stressed.

Mathematics

MA 1021. CALCULUS I.
Cat. I

This course provides an introduction to differentiation and its applications.
Topics covered include: functions and their graphs, limits, continuity, differentiation, linear approximation, chain rule, min/max problems, and applications of derivatives.
Recommended background: Algebra, trigonometry and analytic geometry.
Although the course will make use of computers, no programming experience is assumed.

MA 1022. CALCULUS II.
Cat. I

This course provides an introduction to integration and its applications.
Topics covered include: inverse trigonometric functions, Riemann sums, fundamental theorem of calculus, basic techniques of integration, volumes of revolution, arc length, exponential and logarithmic functions, and applications.
Recommended background: MA 1021. Although the course will make use of computers, no programming experience is assumed.

MA 1023. CALCULUS III.
Cat. I

This course provides an introduction to series, parametric curves and vector algebra.
Topics covered include: numerical methods, indeterminate forms, improper integrals, sequences, Taylor's theorem with remainder, convergence of series and power series, polar coordinates, parametric curves and vector algebra.
Recommended background: MA 1022. Although the course will make use of computers, no programming experience is assumed.

MA 1024. CALCULUS IV.
Cat. I

This course provides an introduction to multivariable calculus.
Topics covered include: vector functions, partial derivatives and gradient, multivariable optimization, double and triple integrals, polar coordinates, other coordinate systems and applications.
Recommended background: MA 1023. Although the course will make use of computers, no programming experience is assumed.

MA 2051. ORDINARY DIFFERENTIAL EQUATIONS.
Cat. I

This course develops techniques for solving ordinary differential equations. Topics covered include: introduction to modeling using first-order differential equations, solution methods for linear higher-order equations, qualitative behavior of nonlinear first-order equations, oscillatory phenomena including spring-mass system and RLC-circuits and Laplace transform. Additional topics may be chosen from power series method, methods for solving systems of equations and numerical methods for solving ordinary differential equations.
Recommended background: MA 1024.

MA 3271. GRAPH THEORY.
Cat. II

This course introduces the concepts and techniques of graph theory -- a part of mathematics finding increasing application to diverse areas such as management, computer science and electrical engineering. Topics covered include: graphs and digraphs, paths and circuits, graph and digraph algorithms, trees, cliques, planarity, duality and colorability.
Recommended background: MA 2071.
This course will be offered in 2000-01 and in alternate years thereafter.

MA 3273. COMBINATORICS.
Cat. II

This course introduces the concepts and techniques of combinatorics -- a part of mathematics with applications in computer science and in the social, biological, and physical sciences. Emphasis will be given to problem solving.
Topics will be selected from: basic counting methods, inclusion-exclusion principle, generating functions, recurrence relations, systems of distinct representatives, combinatorial designs, combinatorial algorithms and applications of combinatorics.
Recommended background: MA 2071.
This course will be offered in 1999-2000 and in alternate years thereafter.

MA 3431. MATHEMATICAL MODELING WITH ORDINARY DIFFERENTIAL EQUATIONS.
Cat. I

This course is primarily concerned with the study of physical and biological models leading to systems of nonlinear ordinary differential equations. Examples are taken from electrical and mechanical oscillations, ecological models and reaction kinetics. Students will learn how to turn a real-life physical or biological problem into a mathematical one and to interpret the mathematical results. The following mathematical topics will also be covered in this course: solving systems of ordinary differential equations using the matrix method, linear stability theory, phase-plane analysis and limit cycles.
Recommended background: MA 1024, MA 2051 and MA 2071.

MA 3613. PROBABILITY I.
Cat. I

This course is designed to introduce the student to probability.
Topics to be covered are: basic probability theory including Bayes theorem; discrete and continuous random variables; special distributions including the Bernoulli, Binomial, Geometric, Poisson, Uniform, Normal, Exponential, Chi-square, Gamma, Weibull, and Beta distributions; multivariate distributions; conditional and marginal distributions; independence; expectation; transformations of univariate random variables.
Recommended background: MA 1024.

MA 3619. INTERMEDIATE REGRESSION, ANALYSIS OF VARIANCE AND EXPERIMENTAL DESIGN.
Cat. II

This course extends the student's knowledge of multiple regression, ANOVA and experimental design beyond the levelof MA 2612. The matrix formulation of the general linear model and its applications to multiple regression will be discussed. Other topics include diagnostics and remedial measures, regression model building methods, blocking in experimental design, nested designs, repeated measures, split plot, Latin square designs, and crossover designs. Special emphasis will be given to fitting models to real data sets using statistical software.
Recommended background: MA 2071 and MA 2612.
This course will be offered in 2000-01 and in alternate years thereafter.

MA 3625. TOPICS IN STATISTICS AND PROBABILITY.
Cat. II

This course covers one or more selected topics from such subjects as time series analysis, nonparametric and robust methods, decision theory, Bayesian inference, survival analysis, categorical data analysis, modern data analysis, and statistical computing and simulation.
Statistical software will be used wherever appropriate.
Recommended background: MA 2612.
This course will be offered in 1999-2000 and in alternate years thereafter.

MA 4231. LINEAR PROGRAMMING.
Cat. I

This course considers the formulation of real-world optimization problems as linear programs, the most important algorithms for their solution, and techniques for their analysis.
Topics covered include: the primal and dual simplex algorithms, duality theory, parametric analysis, network flow models and, as time permits, bounded variable linear programs or interior methods.
Recommended background: MA 2071.

MA 4233. DISCRETE OPTIMIZATION.
Cat. II

This course develops specialized techniques to solve linear programs having integer constraints and considers the application of these techniques to problems in areas such as capital budgeting, scheduling, project management, or routing decisions.
Topics covered include: branch and bound, out-of-kilter, network flow, greedy, and dynamic programming algorithms. The complexity of the algorithms will also be treated.
Recommended background: MA 4231.
This course will be offered in 2000-01 and in alternate years thereafter.

MA 4235. NONLINEAR PROGRAMMING.
Cat. II

This course explores theoretical conditions for the existence of solutions and effective computational procedures to find these solutions for optimization problems involving nonlinear functions.
Topics covered include: classical optimization techniques, Lagrange multipliers and Kuhn-Tucker theory, duality in nonlinear programming, and algorithms for constrained and unconstrained problems.
Recommended background: Vector calculus at the level of MA 3251.
This course will be offered in 1999-2000 and in alternate years thereafter.

MA 4237. PROBABILISTIC METHODS IN OPERATIONS RESEARCH.
Cat. II

This course develops probabilistic methods useful to planners and decision makers in such areas as strategic planning, service facilities design, and failure of complex systems.
Topics covered include: decisions theory, inventory theory, queuing theory, reliability theory, and simulation.
Recommended background: Probability theory at the level of MA 3613.
This course will be offered in 1999-2000 and in alternate years thereafter.

MA 4631. PROBABILITY AND MATHEMATICAL STATISTICS I.
Cat. I (14 week course)

Intended for advanced undergraduates and beginning graduate students in the mathematical sciences and for others intending to pursue the mathematical study of probability and statistics, this course begins by covering the material of MA 3613 at a more advanced level. Additional topics covered are: one-to-one and many-to-one transformations of random variables; sampling distributions; order statistics, limit theorems. Recommended background: MA 3613, MA 3831 - MA 3832.

MA 4632. PROBABILITY AND MATHEMATICAL STATISTICS II.
Cat. I (14 week course)

This course is designed to complement MA 4631 and provide background in principles of statistics. Topics covered include: point and interval estimation; sufficiency, completeness, efficiency, consistency; the Rao-Blackwell theorem and the Cramer-Rao bound; minimum variance unbiased estimators, maximum likelihood estimators and Bayes estimators; tests of hypothesis including uniformly most powerful, likelihood ratio, minimax and bayesian tests.
Recommended background: MA 4631.

Mechanical Engineering

ME1800. MATERIALS SELECTION AND MANUFACTURING PROCESSES.
Cat. I
This course is designed to introduce the student to the engineering fundamentals of the most commonly encountered manufacturing processes. A thorough treatment of sketching, casting, welding, machining, and material properties are developed through a combination of class work and machine shop experience. Each student is required to sketch and fabricate his/her own prototype part. Experience is also provided in the area of automated process parameter selection through the use of microcomputers.
This course is recommended for all majors, for students who plan to utilize the machine shop facilities as part of their MQP work, or for those students who wish a fundamental background in materials processing.

ME 2820. MATERIALS PROCESSING.
Cat. I
An introduction to material processing in manufacturing. This course provides important background for anyone interested in manufacturing, design engineering design, sales, or management.
Processing of polymers, ceramics, metals and composites is discussed. Processes covered include: rolling, injection molding, forging, powder metallurgy, joining and machining. The relationships between materials, processes, processing parameters and the properties of manufactured parts are developed. During the course the students should develop the ability to choose materials, processes, and processing parameters for designing manufacturing procedures to take a prototype part to production.

ME 3820. COMPUTER-AIDED MANUFACTURING.
Cat. I
This introductory course in modern control systems will give students an understanding of the basic techniques, and the range of equipment used in most computer controlled manufacturing operations. The class work is reinforced by hands-on laboratories in the Robotics/CAM lab.
Class topics include: Manufacturing Automation, Microcomputers for Process Monitoring and Control, Computer Numerical Control, Switching Theory and Ladder Logic, Transducers and Signal Conditioning, and Closed Loop Digital Control. The laboratories allow students to program and implement several types of the controllers, and will provide an introduction to the topic of industrial robotics.

ME 4815. INDUSTRIAL ROBOTICS.
Cat. I
This course introduces the student to the field of industrial automation. Topics include: kinematics, dynamics, mechanics, sensors, end effectors and parts presentation devices. Programming languages, system design and safety issues are also covered. This course is a combination of lecture, laboratory and project work, and utilizes industrial robots. Theory and application of robotic systems will be emphasized.

IKT: EXPORT ENGINEERING SEQUENCE AND REQUIREMENTS (XP)

ECTS point	2½	5	7½	10	12½	15	17½	20	22½	25	27½	30
1st sem.	Mathematics-1				E.Sc.& Chem.		Multimedia		Macro Eco.-1		E-1a	2S-1
					TRAFFIC, ENVIRONMENT & ECONOMICS (PROJECT)							
2nd sem.	Math.-2		Physics-1		E.Sc.-2		Chemistry-2		Economics-1		E-1b	2S-2
					PROJECT							
3rd sem.	Mathematics-3				Physics-2				Eco.-2	Marketing Eco.-1	2S-3	
sem. ++	Physics-3		Mechanical Engineering-1						Markt. Eco.-2		KOME	2S-4
			INTEGRATED PRODUCT DEVELOPMENT (PROJECT)									
5th sem.	Math.-4		Electronics-1						International Marketing-1		E-2	2S-5
			ELECTRONICS (PROJECT)									
6th sem.	Mech. Engineering-2				Electronics-2				Int. Marktg.-2		E-3	2S-6
	INTERNATIONAL MARKETING OF B2B-PRODUCTS (PROJECT)											
7th sem.	ENGINEERING TRAINEE PERIOD											
8th sem.	Mech.Engineering-3				Electronics-3				Int. Marketing-3			2S-7
	INFORMATION TECHNOLOGY MANAGEMENT (PROJECT)											
9th sem.	FINAL YEAR PROJECT											

Abbreviations:

E.Sc. & Chem.: Environmental Science & Chemistry

E: English

2S: 2nd Foreign Language (i.e. German, French or Spanish)

+: Introduction to Mechanical Engineering (workshop, 60 hours)

++: Introduction to Electronics (workshop, 60 hours)

KOME: Communication/English

B2B: Business-to-Business

Appendix B – Interview Transcripts

1) What aspects of your teaching style do you consider unique?
2) How do you believe advancements in technology have aided or improved college-level education?
3) Please name some educational technologies, if any you believe to be unique to IKT/WPI.
4) Do you believe that improvements in technology will continue to help higher education in the future? Why or why not?
5) In your opinion, how integrated is technology in Danish/American science/mathematical/engineering education?
6) Are there any aspects in the IKT/Export Engineering/WPI curriculum that are unique to IKT/WPI? If so, how successful are these methods?
7) Do you feel that group work in education is advantageous? Why or why not?
8) What technologies or educational innovations would you like to see implemented at IKT/WPI?

(Answers to these interview questions are paraphrased)

WPI Interviews

Professor Clark – Chemical Engineering Department

What aspects of your teaching style do you consider unique?

I like to encourage the use of computers in class and out of class to aid in the learning of the material. I like to have the students use MathCAD and Excel to involve more computer use when solving difficult problems. Also, when doing projects I think that it is unique when I have the background information relevant to the project be on the computer, so the student is required to use the CD-ROM or software to learn the material to then, in turn, do the project. Therefore, during class time, the student can ask questions regarding their progress with the software based material or ask questions regarding the on going project, so there would be no lecture.

How do you believe advancements in technology have aided or improved college-level education?

I think it's easier to do more difficult problems by using software. Students can use a certain program and input a number of different situations and see the results of those right away. However, not all students learn by using the computer. Some learn better by reading the book, some by attending lecture. The computers, though, allow hands on work, which is an active style of learning and for the most part, is how students learn the best.

Please name some educational technologies you believe to be unique to WPI.

I think the network here at WPI in really good allowing many programs to be accessible all around the campus. This really isn't unique to WPI though. WPI also has the ability to have computer classrooms with projectors and other multimedia devices. It's not like every professor uses the computer classroom though, but we do have the capability.

Are there any educational methods that are unique to WPI? If so, how successful

are these methods?

I guess the emphasis on active learning and the projects are pretty unique to WPI. Also, the peer learning assistant (PLA) program was started at WPI which seems to be successful. They help coordinate between the professor and the student to help the student understand the material better and even how to work better in groups.

Which is more advantageous: leveling by ability or not leveling by ability? Why?

I don't feel that I have too much experience in this so I don't really know which side would be better. You could try to make a course where there is a certain amount of material that everyone needs to learn and then have there is extra material for those that feel they need to be challenged. I guess it would be trying to appeal to both sides in one particular class.

Do you feel that group work in education is advantageous? Why or why not?

Yeah I think so. It has a lot of merits. There have been studies that have shown that the lecture is the least effective ways to have students retain information. The more active students are the better they are to learn the material and be able to use that in the future. It's not to hard to find support in the area of group work. I don't think it needs to be done all the time though. Some situations call for more traditional educational methods and some would be better by learning in groups. It might not be practical but offering two different versions of a class, one more group oriented than the other. However, a student might learn better one way but chose the other because it is more enjoyable.

Professor Dibiasio – Chemical Engineering Department

What aspects of your teaching style do you consider unique?

I like interacting with the students. I would much rather present some material, give them something to do and then go around and see how they are doing, answering questions and stuff.

How do you believe advancements in technology have aided or improved college-level education?

I'm not sure they have yet. Being able to communicate through e-mail for the most part, but that's more low level technology. I don't know of any situation, for me, where the computer in the classroom would significantly increase the quality of teaching. It's not really what I do. For me right now, it's a pencil and paper and students interacting while learning the material. In my view, the people interaction is the most important.

Please name some educational technologies you believe to be unique to WPI.

I think that the IQP is pretty unique to WPI. There are many schools that do something like the MQP, but not really the IQP. Its multi disciplinary and its much more than doing work, it's more of a learning experience. I don't think it exists in any other engineering school, maybe in some liberal arts schools.

Are there any educational methods that are unique to WPI? If so, how successful are these methods?

I think that the IQP is pretty unique to WPI. There are many schools that do something like the MQP, but not really the IQP. It's multi disciplinary and it's much more than doing work, it's more of a learning experience. I don't think it exists in any other engineering school, maybe in some liberal arts schools.

Do you feel that group work in education is advantageous? Why or why not?

I think it's very advantageous but it has to be done right and structured properly. People learn more when they are involved. Most people do not learn as well when they sit and listen, when being passive. But it has to be managed better. Telling people 'Go work in groups to do your homework' will not necessarily make the learning experience any better. The projects we assigned weren't do able by just one person, they required a team effort to complete.

Professor Vaz – Electrical Engineering Department

What aspects of your teaching style do you consider unique?

The important thing about a course is teaching to broad education objectives as opposed to specific course objectives. The subject matter of the course is important, but students should be able to read, write, and solve problems in general.

How do you believe advancements in technology have aided or improved college-level education?

Technology aids and improves education only in a certain way. When used to augment a course, technology can be very beneficial. When it is used to supplant part of the course material, it can definitely be detrimental. Students must learn about the technology (software, etc) on their own, because classroom time studying fundamental material is much more valuable than tools that may become obsolete in a short time. It is important that students "learn how to learn" a software package.

Please name some educational technologies you believe to be unique to WPI.

Online information repositories such as Blackboard and Course Info are helpful in that they provide an extra means of communication between faculty and students. E-mail is also extremely helpful. Sometimes, students otherwise reluctant to communicate with professors will use e-mail or similar means of communication when they would not have communicated at all before.

Do you believe that improvements in technology will continue to help American education in the future? Why or why not?

Yes, advances will continue to assist American education, depending on how they are used. Good educators will know how to make use of new technologies.

Do you feel that group work in education is advantageous? Why or why not?

Yes. Learning to function as a group is essential to function in life. Development of social and group skills are crucial components of education.

What do you feel are skills that an engineer needs to have? (Not a set question)

Engineers should have cognitive skills: "problem solving and knowing how to learn". They should also have social skills, oral and written communication skills and the ability to work with people from different professions and cultures. Engineers should also, obviously, have an understanding of the fundamental concepts of the particular area of engineering that the student studied.

Professor Heinricher – Mathematics Department

What aspects of your teaching style do you consider unique?

Very few aspects of my style are unique. Most of it is bits and pieces of education borrowed from others. I am fairly good at large lectures and keeping people awake.

How do you believe advancements in technology have aided or improved college-level education?

In math, more realistic and large problems can be analyzed with easy access to technology – e.g. graphing. The emphasis has been shifted from solution techniques to modeling and analysis.

Please name some educational technologies you believe to be unique to WPI.

WPI is actually somewhat behind in educational technologies. For example, in some universities, every classroom has computer projection available. WPI has few.

Do you believe that improvements in technology will continue to help American education in the future? Why or why not?

Further technological improvements will aid American education. Now, people are teaching with technological tools that they did not use to initially learn the material. In the future, teachers will teach the material with tools that they themselves used to learn material. This will be a very positive thing. In terms of classroom management, things are going to change as well. Electronic submission of homework assignments and similar changes to class procedures will be seen in the future.

Which is more advantageous: leveling by ability or not leveling by ability? Why?

Advantages can be found in either approach. Dividing people by ability levels can sometimes impact the self-confidence of some of the students. However, advantages are that students with similar ability levels can learn better with students of their own level. It may be more advantageous to group students by area-of-interest rather than by ability level.

Do you feel that group work in education is advantageous? Why or why not?

Group work is advantageous, although many students are "taught to swim by being thrown in the river". Students that are not used to working in groups are quickly introduced to it without much of an introduction. It is important and valuable for group work to be used, but many educators in the higher-education area are not trained in the pedagogy of teaching, and it can take work for them to perfect their technique.

<u>Professor Denise Nicoletti – Electrical Engineering Department</u>

How do you believe advancements in technology have aided or improved college-

level education?

Educational and informational technology have been very helpful to technological education. One way these technologies have been helpful is that students will definitely use these tools in industry, and the use of this technology gives good preparation for this. Additionally, projects that are more "interesting and relevant" can be done in the course of class work. From an educational standpoint, education has been improved only in that the audience has changed: students that have grown up with technology are also exposed to it in the course of their education. This allows for a better match between the students and the education they are receiving.

Do you believe that improvements in technology will continue to help American education in the future? Why or why not?

A small amount of improvement will allow the bugs to be ironed out of existing technology solutions. It is also very important that the human side of education be demonstrated as well: education is not all about computers and technology, but includes elements of personal interaction.

How integrated is technology in American science/mathematics/engineering curricula?

Many professors use technology to great gain in their classes. Informational and educational technology is such a "high-tax" activity, requiring a great deal of investment of time and energy, that people that do not know how to utilize it effectively will not do so.

Are there any educational methods unique to WPI? If so, how successful are these methods?

Unique to WPI is emphasis on projects and grading, which implies a respect and appreciation for the human side of the students and faculty. WPI also has a high regard for undergraduate education. The project system succeeds very well, and in that regard WPI is under-appreciated. The grading system (A, B, C, or NR) and the subsequent lack of any form of grade-point average, is a "subtle but important" development to WPI's system.

Do you feel that group work in education is advantageous? Why or why not?

Group-work is important from a resource point of view: it can be very resource-consuming to have to review material presented by all the members of a class individually instead of in pairs or groups. Students learn well as a team, and higher demands can be placed on teamed students. The drawback to group work is, of course, the issue of equal effort. It is difficult to be sure that students are going to put equal effort into projects.

Professor Thomas Keil – Physics Department

What aspects of your teaching style do you consider unique?

I like to make the introductory classes a little more interactive. It's hard to do this, most of the time it has to be a lecture style class with a little more discussion in the conference sections. With the higher level classes, I try to make them very interactive and allow the students to explore more.

How do you believe advancements in technology have aided or improved college-level education?

They have made it very easy for students to gain access to professors, as well as for information to be offered for easy access via the Web pages. They also allow students to be able to take a more interested active role in learning through certain specific software applications or demonstrations.

Please name some educational technologies, if any you believe to be unique to WPI.

There are really none unique to WPI, many other universities use the same sort of things. I would say that we are somewhat in the middle when it comes to technology use and traditional teaching styles.

Do you believe that improvements in technology will continue to help higher education in the future? Why or why not?

I believe that it will help students to be able to learn at their own pace even more than now. The human aspect can't be forgotten though, one thing that some of the transfer or cross-town students say that they enjoy about WPI is the ease that the faculty members can be reached. The professors always seem to be willing to help students, and they are easy to find between classes.

In your opinion, how integrated is technology in American science, mathematical, and engineering education?

This varies. Some schools are much more integrated than WPI, some much less. Like I said, WPI is middle of the road when it comes to this. Some classes, in large lecture halls, while they use projectors or overheads are still taught with a lecture, and there isn't a lot that you can do to get away from this.

We are involved in a study that Harvard is doing to measure the amount of technology used, and like I said, from the results that we get periodically we are pretty average here at WPI.

Are there any aspects in the WPI curriculum that are unique to WPI? If so, how successful are these methods?

Obviously there are projects that a lot of other schools are trying to emulate. These have been very successful because they really help people learn problem solving skills that you need in the workplace. Some other departments have been trying different methods, but it's still pretty early to see how effective they are.

Do you feel that group work in education is advantageous? Why or why not?

Yes, group work is advantageous for some of the reasons I have already mentioned.

What technologies or educational innovations would you like to see implemented at WPI?

I think that e-mail and Web pages are going to continue, along with programs such as CourseInfo. There aren't any really dramatic new technologies being implemented here every day, but these are slowly being used more and more. I think that it will continue to grow, but in which manner is almost impossible to say.

Professor Steve Pierson – Physics Department

What aspects of your teaching style do you consider unique?

For my intro courses, like PH1140 I try to involve a lot of group work into the curriculum. It gets the students ready for larger projects later on. Also, I have recently tried to make the "bridging" element take part in my classes. For 1140 I divide the EEs into groups, and the mechanical engineers into groups, and the physics majors into groups as well. That, and the reading summaries I assign help the students get more out of the class.

How do you believe advancements in technology have aided or improved college-level education?

Through things like courses on the Web, and e-mail, communication has been greatly increased between students and professors.

Please name some educational technologies, if any you believe to be unique to WPI.

I don't know about technologies, but for things like projects, obviously there are some very new and different ideas here.

Do you believe that improvements in technology will continue to help higher education in the future? Why or why not?

It will help, but it's not totally necessary. In the physics department there aren't that many applications of technology in the classroom other than the occasional computer presentation.

Are there any aspects in the WPI curriculum that are unique to WPI? If so, how successful are these methods?

Again, the projects are a big thing. Many schools are trying to emulate or project program, and I think that they are the best educational tool that we have implemented here.

Do you feel that group work in education is advantageous? Why or why not?

Yes, group work is advantageous for some of the reasons I have already mentioned.

What technologies or educational innovations would you like to see implemented at WPI?

None really, but some group technologies like videoconferencing and computer chat could help. Also, some of the grad courses and the distance learning they do is pretty low tech. All they do is tape the lecture and send them to the students. Something more could be done there.

IKT Interviews

<u>Professor Vagn Køhler – Electrical Engineering</u>

What aspects of your teaching style do you consider unique?

I haven't taught classes for several years, I have been mainly administrative. For example, right now I am the Chief of Staff/Students. However, in terms of all the professors at IKT; any changes or teaching styles we adopt are measured up against the "5 Pillars of Education" which include things like motivating the students, and using the Socratic method. This is something that is what we all try and aim for, and what all future additions to the education program here will have to meet.

How do you believe advancements in technology have aided or improved college-level education?

Computers, of course have played a huge role in improving education by allowing students to educate themselves and at their own pace. Students can learn so much more in that regard. I think that that is the main improvement or advancement made in respect to education and technology.

Please name some educational technologies, if any you believe to be unique to IKT.

Project work isn't educational, but it is in use. It's not unique to IKT, the other two or three major engineering schools in Denmark use this as well. I would say that IKT isn't lagging behind anyone in technology, but it also isn't a frontrunner.

Do you believe that improvements in technology will continue to help higher education in the future? Why or why not?

Yes. A good example of this is that next semester, every student coming into the Computer and Electrical program has his or her own laptop computer with network capabilities. Each classroom will be wired into the main network. I don't think that the other departments will be willing or able to do this, and I know that they are not planning on it. But this will change teacher roles very much in the fact that they will cease to be lecturers and become moderators or counselors.

Are there any aspects in the IKT curriculum that are unique to IKT? If so, how successful are these methods?

Export is very management-oriented, a combination degree. This degree itself is unique, though the curriculum really is not.

Do you feel that group work in education is advantageous? Why or why not?

Yes, this is the way that engineers will work after schooling. Groups are crucial in engineering, so we are teaching them skills and information at the same time doing this. In fact, some semesters are almost 2/3 group and project work, with very little individual work.

What technologies or educational innovations would you like to see implemented at IKT?

Just what we are trying to implement already. Once students have computers, courses will be put on the net, and there will be a course first semester on how to use technology.

In your opinion, how integrated is technology in Danish science/math/engineering education at the higher levels?

Starting to be more and more integrated, but it is fairly well integrated now. Only in these fields of study though, and in engineering it depends on which branch you are talking about. In universities as well, there is a good deal of integration.

Professor Lise Valeur-Jacques – English Department

How do you believe advancements in technology have aided or improved college education?

Advances in technology have aided education by reducing the amount of paperwork that needs to be done by hand. With classes of more than one hundred students, a teacher must check and track a great deal of material. In addition, the use of word processing software for quick edits of content is very helpful in keeping class material up-to-date without having to rewrite all the material. However, the negative aspects of the ease of dealing with paperwork are that since generation of paperwork is easy, more paperwork can be created, adding unnecessary levels of complexity to the educational process.

Do you believe that improvements in technology will continue to help higher education in the future? Why or why not?

Yes. When paperwork becomes less of a chore, more time can be devoted to other academic matters. By using a VCR, I can quickly tape material from television channels to use in class. Then, quickly, I can make up a list of English vocabulary words. These improvements will continue to occur.

Do you feel that group work in education is advantageous? Why or why not?

Yes, group work is very advantageous. Since students are going to need to work in groups effectively when they leave school, it is good that they get the experience now.

What technologies or educational innovations would you like to see implemented at IKT?

Permanent television and video functionality in every classroom would be a positive influence on the school.

<u>Professor Ian Bridgwood – Electronic Engineering Department</u>

How do you believe advancements in technology have aided or improved college-level education?

One aspect that has significantly advanced college-level education is the presence of new software packages. For example, in the mathematical sciences, computers have allowed better visualization of mathematical functions, such as pole/zero and three-dimensional functions. These benefits will improve as computing power continues to improve. Disadvantages to this scenario are a decrease in student ability to think analytically, allowing the computer to do the computational work for them, and sometimes missing basic concepts as a result. Another powerful tool has been the Internet. Material can be obtained from many locations, and both students and instructors can do research with ease, unrestricted to textbooks or other traditional media.

Please name some educational technologies, if any, you believe to be unique to IKT.

The IKT academic system is very project-oriented. Half of the students' time is spent on course work, and the other half is spent implementing this material in project work. The purpose to this is to mirror the engineering world and provide students with more practical engineering experience. Additionally, IKT uses standard technology and design tools: Pspice, Matlab,and other tools are common.

Do you believe that improvements in technology will continue to help higher education in the future? Why or why not?

Improvements in technology will continue to help. In electrical engineering, design is becoming more integrated, and more of a case of wiring up a string of 'black boxes' than knowing what is inside the black boxes. This is tremendously helpful, but also encourages students to forget what is inside the 'black boxes' or how they work.

Improvements in technology will also allow for an expanded ability of students to experiment, designing a system and adjusting the parameters for that system.

In your opinion, how integrated is technology in Danish science, mathematical, and engineering education?

Technology is very integrated in this education. Students frequently do projects with Matlab and similar software packages. Personal computers have become part of everyday teaching, as well. For the electrical engineering department, digital signal processing, of necessity done by calculation before, can now be done with DSP boards. In addition, there has been an increase in communication over the Net and e-mail.

Do you feel that group work in education is advantageous? Why or why not?

Group work is advantageous. It reflects real-life engineering situations, and students acquire difficult-to-teach working and social skills by being required to work in groups. In addition, students can help each other and discuss course material: students are on the same level and teachers can sometimes forget what students find difficult. Disadvantages include group members do not contributing equally to the group effort.

What technologies or educational innovations would you like to see implemented at IKT?

Personal computers need to be in the classroom, with faculty and students communicating (partially) via a computer network. Each student would have a PC in front of him or her. Increased Web use would be good as well, and an increased use of e-mail.

Ole Shultz – Electrical Engineering

What aspects of your teaching style do you consider unique?

Well, I like using just the plain blackboard and chalk. I try to use simple examples on the board when teaching the material. I don't really like using overheads or PowerPoint because I think that when teachers use that the students just fall asleep. I guess I would consider my style old-fashioned but it is effective. I try not use the entire 4 hours to lecture. I like to lecture some and then give some problems for the students to do.

How do you believe advancements in technology have aided or improved college-level education?

I think with new advancements in technology, students are able to understand how systems, such as electric circuits, behave. Also, students are able to design and understand systems better.

Please name some educational technologies, if any you believe to be unique to IKT.

I like that at IKT there is a small class size. We don't really have the large lecture halls where all the students for one subject gather to be taught be a teacher. I am not sure if it's unique, but we use software programs to help show simulations of systems which allows us to do many things and get results quickly.

Do you believe that improvements in technology will continue to help higher education in the future? Why or why not?

Yes, but for larger, more general educational uses. I think for the more specific problem solving things, solving with pencil and paper is still good. Also, in the High Schools there is more computer use so it will definitely grow in use when those students reach the higher education schools. It's definitely good when aiding regular course material such as basic electronics or math. However, using the computer takes out the middle steps of calculations. You type in an equation and it spits out an answer and the student doesn't learn how to get to that answer.

In your opinion, how integrated is technology in Danish science/mathematical/engineering education?

We use a book called DSB First Book which includes a CD-Rom disc with it. I think using the book with some computer software is good and we will probably see more of that in the future and being more connected to the Web.

Are there any aspects in the IKT/Export Engineering curriculum that are unique to IKT? If so, how successful are these methods?

Well, we do the projects for the most part throughout the students' career at IKT. Mostly, the projects are closed problems and they work in groups to gain real world experience.

Do you feel that group work in education is advantageous? Why or why not?

Yes, I definitely think that group work is advantageous because of the social experience and how they learn how to deal with different types of people. However, sometimes group work doesn't work out that good because of the group dynamics. For example, there could be a case where one student doesn't do any work or where one student does all the work.

What technologies or educational innovations would you like to see implemented at IKT?

Well, I think in the next 2 to 5 years, there will be a network connection in every room. Hopefully, there will be more Internet use and all the students would have their own computer, or laptop. I would like to see a project where students from different disciplines work together to solve a large problem or project. Training on how to use Word and Excel would also be good as well as more e-mail use and maybe have things posted on the Web for the students and faculty.

Professor Bent Jørgenson

What aspects of your teaching style do you consider unique?

I think that it is very important, first of all, that I am very close to the students, almost more as a friend and another student than a teacher. This allows me to easily communicate with them and help them learn more effectively. It's more of a top-down approach to teaching.

How do you believe advancements in technology have aided or improved college-

level education?

Well, MatLab and Pspice are both programs that we utilize, and it allows the students to go more into depth with a certain topic. Also, we can bridge subjects now...people in mathematics classes are solving digital signal problems with these programs and they are learning applications and material at the same time. I don't think that any more than a short introduction is necessary to teach these programs and software, the students can explore this on their own.

Please name some educational technologies, if any you believe to be unique to IKT.

Well, there are different approaches in different departments, so it is hard for me to speak about the school as a whole. Electrical engineering here is very project-oriented. In addition, laptop use is emerging more and more every year. I think that that will help us make great strides in using educational technologies.

Do you feel that group work in education is advantageous? Why or why not?

Yes. You learn many other skills rather than just the course material teaching through group work. However, it is not all positive. Some students get lost in the group, they lack the social skills required to become an integral part of the project. This is quite hard for the teacher to fix...the student has to learn the confidence and skills on his or her own.

What technologies or educational innovations would you like to see implemented at IKT?

I think a broad perspective that includes more society and economical focus would be good in the curriculum. Engineers need to have a good grasp on these things. Also, a shift towards more student responsibility would be good, though that's what we are trying to accomplish with laptops.

In your opinion, how integrated is technology in Danish science/math/engineering education at the higher levels?

Some teachers like to integrate it more than others. It's slowly becoming more common. In addition, like I mentioned, starting to bridge more courses together is a result of this. However, many course are still very traditionally taught, and will continue to be. There is a gap between the old and the younger professors here, and that will remain for some time.

Claus Petersson – Mathematics and Physics

What aspects of your teaching style do you consider unique?

I'd say that I demystify the mysterious. I don't like to use any intense mathematics theory, more practical problems to allow the students see the purpose behined learning the math. I also like to integrate other topics from classes to form examples using the math. Again, it allows the student to see more of the purpose behind the math.

How do you believe advancements in technology have aided or improved college-level education?

I think the pocket calculator has come a long way and definitely aided at the college level of education. Also, new modeling software for things like differential equations have been good in helping students understand the material better.

Please name some educational technologies, if any you believe to be unique to IKT.

I think the fact that we have small class sizes is unique compared to the universities that have the big lecture halls. It allows us to be more personal with the students and have more one on one time with them. Mostly, the classes here, on the introductory level, are 50% lecture and then 50% homework / exercise work. This allows us to teach the material and then walk around the class and help the students through problems and homework sets. However, there isn't much computer use in the mathematics introductory classes, such as Maple, but there is a little more use in physics with some modeling programs.

Do you believe that improvements in technology will continue to help higher education in the future? Why or why not?

Yes, future advancements can always help. It is up to the teacher, however, to properly use those tools to effectively teach material with them. Some of the teachers here at IKT are a little too conservative to use new technologies but I think it is the way things will turn out in the future. The Internet will continue to be helpful for students and probably the extended use of modeling and simulation software will become more common.

Do you feel that group work in education is advantageous? Why or why not?

Yes, I definitely feel that group work is adventagous. There are plusses and minusses to it but I think there are more plusses. Group work allows many social benefits such as working with teams which will be helpful in the workplace. Some group work, though, may not work out due to group dynamics though, so it all depends on who is in the group.

What technologies or educational innovations would you like to see implemented at IKT?

I guess one technology I would like to see is maybe to tape the classes. I do basically the same lecture every semester and it would be neat if the lectures could be videotaped and then have the students view them in a computer based format. The videos could cover the main topics in the course and if something minor is mentioned that the student doesn't understand, then he/she could click on a link and see a video on that specific topic. I don't know how feasible a system like this would be but I think it would be very useful. Also, it would allow me to spend more time with the students, helping them with problems and things like that.

More use of e-mail would be good too. Even in writing an e-mail, the student would probably learn some by just the act of typing it out. Also, putting homework solutions and such on the Web would be useful, I think, for the students.

Appendix C – Survey Questions

These questions were very similar between WPI and IKT students. These are the questions posed to the IKT students. The WPI students were posed functionally similar questions, although occasionally with slightly different wording.

1) How do you feel technology plays a role in your education at IKT/WPI (how much do you rely on certain technologies such as computers, e-mail, etc)?

2) What aspects of technology do you feel that you benefit from the most?

3) Which aspects of technology do you feel you could do without or are detrimental to your education? If any, why?

4) Have you had any experience working in groups? If so, do you feel that the group-oriented work here heightens your educational experience?

5) Do you wish that you had access to certain technology that you don't have currently?

6) Would you like to see your courses offer information on the Internet such as homework solutions, old examination problems, etc?

Appendix D – Course Management Software

The following are the Web sites associated with each package of course management software that was examined. This research group does not advocate any one product over any other, but has attempted to provide the reader with all necessary information.

Course Info - http:// www.blackboard.com

TopClass - http://www.wbtsystems.com/

eToolkit – http://www.ecollege.com

Lotus Notes/Learning Space - http://www.lotus.com/home.nsf/welcome/learnspace

Web Course in a Box - http://www.wcbinfo.com/

WebCT – http://www.webct.com

The following is an independent examination of various course management software packages. This chart is linked from Blackboard's Web site, and is the results of an independent study by Wichita State University. The Web location is http://www.mrc.twsu.edu/mrc/im2/websystems.htm. (Used with permission of Wichita State University).

Independent Study conducted by Wichita State University Comparison of Features, Tools, Specifications, Support, & Pricing Updated 1/26/00					
Our Recommendation					
	Web Course in a Box	WebCT	Bb Courseinfo	TopClass	Lotus LearningSpace

Version reviewed in this matrix	2.0/ Portions of 3.0/4.0	1.2/ Portions of 2.0	4.0	2.03 (Mac) 3.0 (Unix/NT)	3.0
Version currently under review	4.0	2.0	-	-	-
Top 3 things that influenced our decision... (our opinion only)	**WCB**	**WebCT**	**Bb CourseInfo**	**TopClass**	**LearningSpace**
Advantages	1. Easy to use. 2. Good set of tools, many unique features. 3. Inexpensive.	1. Strong toolset. 2. Large user base 3. Textbook partnerships.	1. Very easy to use. 2. Supports SQL for NT - good system architecture. 3. Growing rapidly - leaders in IMS standards initiative --offer Enterprise version.	1. Some features are very robust, such as quizzing. 2. Been in market for some time. 3. Textbook partnerships.	1. "Groupware" concept. 2. Good toolset. 3. Strong development - integration with 3rd party apps.
Disadvantages	1. Proprietary database. 2. Encountered numerous administrative issues. 3. Dwindling user base	1. Clumsy interface. 2. Requires considerable training to support and master. 3. Difficult to administer on certain systems.	1. Not the strongest toolset. 2. Lacked key textbook partnerships, although that has recently changed. 3. More expensive than WebCT or WCB.	1. Very expensive. 2. Comparatively small user base. 3. Some administrative issues.	1. Relatively expensive. 2. Requires Lotus Notes to use properly. 3. Some speed issues and concerns - should be used in conjunction with Domino server for best results.
General Features	**WCB**	**WebCT**	**Bb CourseInfo**	**TopClass**	**LearningSpace**
Client Platform	N 3.0 > IE 4.0 >	N 3.0> IE 3.0>	N 3.0 > IE 3.0 >	N 2.0 > IE 2.0 >	Lotus Notes client and Java-enabled browser
HTML knowledge required to develop course material	No	No	No	No	No
Password and username security	Yes - also supports security for some subsections	Yes	Yes - also supports security for specific subsections	Yes	Yes
Desktop-based file management for uploading to server	Yes	Yes	Yes	No	Yes

Desktop-based file management for viewing files on server	No	Yes	Yes	Limited	Yes
Directory upload capability	No	Yes- Through built-in Zip utility	Yes- Through built-in Zip utility - Supports MacZip, PKZiP, WinZip	UNK	UNK
Automated glossary tool/Automatic link to course content	No/No	Yes/Yes	No/No	No/Yes	No/Yes
Automated indexing tool	No	Yes	No	No	No
Search tool for course material	No	Yes	Yes	Yes	Yes
Student can make private annotations of course material	No	Yes	No	Yes	Yes
Student presentation area	No	Yes	Through student/group homepage tool	Yes	Yes
Student homepage tool	Yes	Yes	Yes	UNK	Yes
Instructor can create groups of students	No	Yes	Yes	Yes	Yes
Instructors can assign specific course material to individual or group of students	No	Yes	Yes, through built-in drop box.	Yes	Yes
Custom graphics upload (icons, buttons)	Yes	Yes	Banners and logos.	Yes - Extensive	Yes- Limited
Course can be downloaded to desktop for backup	No	Yes	Yes	Yes	Yes
Courses can easily be moved from one server to another	No	Yes	Yes	Yes	Yes
Built-in hit counter	No	Yes	Yes - Supports advanced site visitation statistics	Supports Third-party	Yes
Customized "look and feel" (colors, icons, logos, etc.).	Yes - supports custom icon upload	Yes	Courses can have custom buttons. Other changes affect all users on system.	Yes - also supports customizable toolbar and utilities page.	Yes - Limited
Student can change password.	Yes	Yes	Yes	Yes	No
Searchable image archive.	No	Yes	No	No	UNK
Descriptive/Quick Link Menu	UNK	Yes	Yes	UNK	UNK

Calendar/ Scheduling tool	Yes	Yes	Yes	Supports Third-party	Yes - Can view in a variety of formats (D/M/Y)
Grade book	No	Yes - exportable to Excel or Access	Yes - exportable to Excel	Yes - exportable in text format	Yes
Course Task Manager	UNK	UNK	Yes	UNK	UNK
Course "Welcome" page - viewable by non-course members.	No	Yes	Yes	Yes	Yes
Frames support. Static toolbar and Table of Contents	No	Yes	Yes	Yes	Yes
Multi-language support	No	Yes	UNK	Yes	Yes
Class announcements	Yes	Yes	Yes	Yes	Yes
Automatic URL "hot-linking" capability	Yes	Yes	Limited. Supports "Smart Text" auto html coding	Yes	Yes
Multi-instructor support	No	Limited	Yes	Yes	Yes
Student file upload capability/instructor comments	As an e-mail attachment	Yes	Yes	As an e-mail attachment	Yes
Group File Upload	No	Yes	Yes	No	Yes
Automatic conversion of existing word processing documents	Copy & Paste from word processor	Yes	Copy & Paste from word processor	Yes	Yes
Support for open enrollment, as well as fixed-date courses	UNK	UNK	Yes	Yes	Yes, schedules can be customized for each student
Search tool for course material	No	Yes	Yes	Yes	Yes, using Lotus Domino server's search function
View content offline (CD-ROM support)	No	No	Yes	In development	Yes, using Lotus Notes client
Support for online enrollment	No, student accounts must be created by instructor	No, student accounts must be created by instructor	Yes	Yes, with options for each class to allow previews, enrollment limits, controlled start/stop dates, and e-mail confirmation of registration	Yes

Quiz/Survey Features	**WCB**	**WebCT**	**Bb CourseInfo**	**TopClass**	**LearningSpace**

HTML knowledge required to develop quiz material.	No	No	No	No	No
Multiple choice self-test tutorial questions (auto marking).	Yes	Yes	Yes	Yes	Yes
Multiple image choice questions.	No	Yes	Yes	Yes	UNK
List matching questions.	No	Yes	Yes	Yes	Yes
Essay questions.	No	Yes	Yes	Yes	Yes
Fill in-the-blank self test tutorial questions (auto-marking).	No	Yes	Yes	Yes	Yes
Short-answer self-test tutorial questions (auto-marking).	Yes	No - but supports multiple-choice self-test tutorial	Yes	UNK	Yes
Multiple correct answer questions.	No	Yes	Yes	Yes	Yes
One question at-a-time testing capability.	No	Yes	No	Yes	No
Imagemap questions (click on the correct part of the image).	No	No	No	Yes	Yes
Question file upload capability.	No	Yes	Yes - using proprietary Question Pool Import feature	Yes	No
Customized feedback to tutorial questions.	No	Yes	Yes	Yes	Yes
Redirect path of tutorial, depending on question answers.	No	Yes	No	Yes	Yes
Timed quizzes. (Graded with permanent mark retention. Delivered on-line on a predetermined time and day.)	No	Yes	No	Yes	Yes
Timed test submission, completion, and results recovery.	No	Yes	Timed test submission only	Yes	Yes
Batch test question creation.	No	No	Limited - using Question Pool feature	Yes	Yes
On-line marking and grading management of	No	Yes	Yes	Yes	Yes

timed quizzes.					
Supports graphics files adjacent to quiz questions.	Limited	Yes	Yes	Yes	Yes
Can create quiz with mixture of question types.	No	Yes	Yes	Yes	Yes
Scores can be e-mailed to instructor.	Yes	Yes	No	Yes	Yes
Grades can be stored on server.	No	Yes	Yes	Yes	Yes
Assign point values to questions.	No	Yes	Yes	Yes	Yes
Creates survey questions - non graded.	No	Yes	Yes	UNK	Yes
Displayed statistical results of surveys	No	Yes	Yes	Yes	No
Password Protected Assessments	Yes	Yes	Yes	Yes	Yes
Calculated Questions - Program generates random values for variables, thus giving different questions to different students.	No	Yes	No	UNK	Yes
Randomized Questions	UNK	Yes	Yes	UNK	UNK
Question Banking	UNK	Yes	Yes	UNK	UNK
IP Security Masking	UNK	Yes	No	UNK	UNK
Weighted Grade Book Capability	UNK	Yes	No	UNK	UNK
Student Grading	**WCB**	**WebCT**	**Blackboard**	**TopClass**	**LearningSpace**
Student access and progress data available.	No	Yes	Yes	Yes	Yes
Ability to add offline grades	No	Yes	Yes	Yes	Yes
Grade statistics and histogram.	No/No	Yes/No	Yes/No	Yes/	No/
Instructor comments available with grade.	No	Yes	Limited	Yes	Yes

Class Management	WCB	WebCT	Blackboard	TopClass	LearningSpace
Class list can be entered one student at a time, or uploaded as a file.	Yes	Yes	Yes - supports multi-delimitation options	Yes	Yes
Class lists can be presented, saved, and print in a variety of ways	Yes (limited)	Yes	Yes	Yes - limited	Yes - Limited
Students can create their own temporary accounts in a class	No	Yes	Yes	No	No
Online Student manual/Help	Yes	Yes	Yes	"How to" page	Yes - includes orientation
Online Instructor manual	Yes	Yes	Yes	Yes	Yes

Communication	WCB	WebCT	Blackboard	TopClass	LearningSpace
One-to-one course e-mail	Yes	Yes	Yes	Yes	Yes
One-to-many course e-mail	Yes	Yes	Yes	Yes	Yes
E-mail to teaching assistants	UNK	UNK	Yes	Yes	Yes
Threaded Discussion Board/Searchable	Yes/No	Yes/Yes	Yes/Yes	Yes/No	Yes/
Group e-mail capability	No	Yes	Yes	Yes	Yes
Multiple forum capability for course	Yes	Yes	Yes	No	Yes
Course chat facility/logged	3rd party/No	Yes/Yes	Yes/Yes	No/No	Yes/No
Virtual field trips within chat	n/a	No	Yes	No	Yes
Shared whiteboard	No	Yes	Yes - also supports Web pages	3rd party	Yes
Newsgroup facility	No	No	On certain platforms	3rd party	No

Additional Features	WCB	Web CT	Blackboard	TopClass	LearningSpace

Aggregated course enrollment, course announcements, grades, and course content	UNK	Yes, using "My WebCT" utility	Yes, using "My Blackboard" utility	UNK	UNK
Campus Community Support Links	UNK	UNK	Yes	UNK	UNK
Campus Community Discussion Board	UNK	UNK	Yes	UNK	UNK
Personal Tools Editor (Tasks, Calendar, Contacts, etc.)	UNK	UNK	Yes	UNK	UNK
Course Cataloging	Yes	Yes	Yes	UNK	UNK
Text-Only Version Available	UNK	UNK	Yes	UNK	UNK
Guest Access Available	Yes	Yes	Yes	UNK	UNK
Provides Externally Supported Web Resources	UNK	Upcoming in January 2000	Upcoming in March 2000	UNK	UNK
Textbook Partnerships - Course Cartridges	UNK	Pearson - Prentice-Hall/Irwin	Houghton Mifflin/ Sixth Floor Media Pearson - Prentice-Hall/Irwin McGraw-Hill	Pearson - Prentice-Hall/Irwin	UNK

Pricing/Support	WCB	WebCT	Blackboard	TopClass	LearningSpace
Trial period	Earlier versions are free for dowload and use	Initial download is free - cost apply when courses are hosted	30-Day evaluation license.	Download four-user, 120-day trial for free	$250 (academic), plus cost of Domino software
Price per year	$3,000	$3,000	$4,500	$37,500 - negotiable fee, depending on several factors	$5.00 per course per student
Licensing	Licensed per computer system	Licensed per course/per user		Licensed per concurrent user	Licensed per course/per user
Technical support	Included	Included	$500/Basic $1,500/Premium $5,500/Elite	Included	Available, depending upon contract
Number of users	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited

Compliancy	WCB	WebCT	Blackboard	TopClass	LearningSpace
IMS Standards Compliancy	UNK	Under Development	Under Development	UNK	UNK

Server/OS	WCB	WebCT	Blackboard	TopClass	LearningSpace
Platform(s)	UNIX, NT, Macintosh	UNIX, NT	UNIX, NT (supports Microsoft SQL Server 7 for NT)	UNIX, NT, Macintosh	Domino 4.6x, 5.0 running on: NT, AIX, Solaris, NT Alpha, IBM 350, AS/400, HP-UX

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