2006-1903: INTERDISCIPLINARITY, FINANCIAL SOFTWARE PRODUCT DEVELOPMENT, AND ENTREPRENEURSHIP IN AN URBAN UNIVERSITY

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Interdisciplinarity, Financial Software Product Development, and Entrepreneurship in an Urban University[†]

Abstract

Because interdisciplinary learning can be challenging to students, it is important for teachers to maintain high expectations of students, promote student centeredness, and develop students into self-aware learners if students are to comfortably think across disciplinary boundaries. The recent surge in demand for college graduates with an entrepreneurial mindset is motivated, in part, by the changing nature of the global economy and competitive nature of today's businesses. A dominant raw material in the global economy is innovation. This makes the teaching of creativity, innovation, and entrepreneurship in computing and engineering sciences programs very important. Additionally, the dynamism in finance created by its challenging problems and the availability of sophisticated algorithms and cheap computing power has attracted professionals from computer science, engineering, physics, and mathematics resulting in the growth of many vibrant interdisciplinary fields involving finance. In spring 2005, we developed an entrepreneurial financial computing course with the objective that individual student teams would design and develop a commercially viable financial software product to satisfy a market need. Five purposefully and two adhocly designed E-teams were formed with students majoring in computer science, finance, mathematics, and management science. Each E-team worked on a different project. The course was supported by a finance and a computer science professor who team taught the course and nine mentors/advisors who assisted the E-teams in identifying financial problems in need of improved solutions, formulating problems to enable efficient software solution, identifying markets for their completed software product, determining the level of software product user friendliness, and counseling and advising E-team members in the development of a successful business plan. On the basis of the midterm exam and the project, the evaluation of the course showed that each of the five purposefully designed E-teams completed their financial software product by the end of the semester. Two showed promise of being commercially viable with slight improvements. This was determined by percentage error tests and the two professors' joint assessment of the E-teams' software products. We considered the course a qualified success. However, issues such as differential experience in teamwork along disciplinary lines, and the need for more business communication skills will need to be more fully addressed in future course offerings.

Background

Multidisciplinary and interdisciplinary concepts of teaching and learning have appeared in research literature since the early part of the 20th century[10]. Many college students have become accustomed to taking a minor with their major or taking a double major. More recently, students have been increasing the number of majors and/or minors they take. Many employers are questioning students' wisdom in their multidisciplinary choices. They believe that there is a limit to the number of disciplines a student can concurrently study without loosing the depth of

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foundational knowledge necessary to function adequately in a disciplinary or interdisciplinary workplace environment. This may be partly caused by the lack of an attempt by both teachers and students to connect disciplines that are simultaneously studied[4]. A solution to this multidisciplinary learning problem is carefully crafted interdisciplinary learning that satisfies the need of the student, industry, and society[1]. Interdisciplinary learning is a vehicle that can enable students to become intentional learners[8,9,10] who are able to transfer their learning across multiple contexts and domains including disciplinary domains[5]. Interdisciplinary learning can sometimes be more challenging to students because of the multiplicity of different concepts coming from philosophically and culturally different disciplines, acculturation in single discipline thinking, and the inability to synthesize at disciplinary boundaries and across disciplines[4]. This suggests that if these courses are to be successful teachers of interdisciplinary courses should maintain high expectations of their students; promote student centered learning through collaboration, inquiry, discovery, frequent feedback, and facilitation[2,3,6,7,13]; and students should become partners and metacognitive active participants in the learning process[14]. Moreover, teachers should employ learning styles, monitoring and supporting collaborative learning, research, diversity and cultural sensitivity in their teaching techniques, and develop students' written and oral communication skills. Courses that include monitoring and supporting students' academic activities help to improve their performance and achieve higher retention rates[6].

Entrepreneurial education is a growing trend that is strongly supported by private foundations such as the Lemelson Foundation and the Kauffman Foundation. Within the last 20 years, the number of colleges and universities offering training in entrepreneurship grew from a few to over 1500. Entrepreneurship education comes in a myriad of forms ranging from simply one entrepreneurship course to many including interdisciplinary courses. Some interdisciplinary variations include entrepreneurial finance, entrepreneurial engineering, and entrepreneurship and technology-based new ventures. One of the reasons for the increasing rise in entrepreneurship education is student demand. This education provides students with an entrepreneurial mindset that enables them to manage a career and/or a business. It provides students with the tools needed to pursue opportunities in a changing economy without regard for the current controls on available resources. In addition, it empowers and enables students to not be daunted by failure but to grow from its lessons and use it to achieve success.

The global information-driven economy has put pressure on the engineering, physical sciences, and computing disciplines in terms of employment opportunities for new graduates. Polcznski and Jaskolski[15] made the case for entrepreneurial engineering education at Marquette University's College of Engineering; they saw such a program as "providing some useful insights into the changing nature of engineering and engineering education." Their case is equally applicable to the computing and information sciences:

> Many businesses are striving to grow sales and profits while simultaneously reducing tangible assets, including high-cost, high-maintenance engineering staffs. Coupled with the continuing development of strong and highly accessible technical capabilities in so-called low cost countries (LCCs) … increasing automation of common traditional engineering tasks, this situation significantly impacts the engineering profession as currently performed in non-LCCs … Globalization has given rise to design-produce-service engines with electronically linked elements located across the globe. These virtual entities provide the capacity to produce a wide range of products and services at high quality levels and low costs, but rely heavily on a high volume and steady flow of innovative new concepts to feed the front end of these engines ... innovation in product and service offerings becomes a key differentiator and critical success factor.

Since innovation is becoming the most important raw material in the current global economy -- the fuel for the “design-produce-service engine” -- it is very important that creativity, innovation, and entrepreneurship training be integrated into computing and engineering sciences programs.

Finance is perhaps the fastest growing area in business. Its institutions sustain metropolitan areas such as New York City. Finance is the art and science of managing money. It is a dynamic field that includes corporate finance, financial services, insurance, and real estate. There are chief executive officers that believe that formal education in finance is an enabler for new graduates to find their first job and for advancement within a corporation. The dynamic nature of finance and the challenging problems inherent within it have attracted many including computer scientists, engineers, physicists, and mathematicians. The attraction of these professionals to modern finance has resulted in the growth of many vibrant interdisciplinary fields that involve finance. Some of these fields include financial computing, financial engineering, econophysics, computational finance, and mathematical finance.

Course Overview

In spring 2005, we offered a National Collegiate Inventors and Innovators Alliance (NCIIA) funded course: Entrepreneurial Financial Computing. The course consisted of five purposefully and two adhocly designed diverse interdisciplinary E-teams formed from 28 students including five females and two auditing students. Five of the E-teams consisted of four students, one E-team had three students, and one E-team was comprised of five students. Each E-team consisted of students who shared the same dominant learning styles. The students majored in four disciplines: computer science, finance, mathematics, and management science. Many had minors. The course had an entrepreneurial component that was experiential. Entrepreneurs and corporate executives who served in the role of mentors/advisors facilitated this component of the course. Some of the E-teams worked on projects belonging to the mentors/advisors. An E-team was viewed as an entrepreneurial small company or consulting firm depending on the source of its project. Three E-teams were viewed as entrepreneurial consulting firms. Each E-team was allowed to decide on realistic roles for its members. Four of the seven E-teams decided on member roles from the list of chief executive officer (CEO), chief financial officer (CFO), chief operating officer (COO), president, and treasurer.

The course objective was for each E-team to design and develop a commercially viable financial software product that would satisfy a need in the market. The course’s academic foci were the application of financial models including the capital asset pricing model and Black-Scholes option pricing formulas; computing methodologies including programming in such languages as visual Basic for applications (VBA), Java, Perl, and Matlab; data retrieval and its manipulation from such websites as Yahoo and Bloomberg; and experiential entrepreneurship with emphasis on small business creation, operation, and management along with niche marketing and creation of successful business plans. The E-teams researched the market for potential consumer-driven financial problems for projects and worked with mentors/advisors and the professors to identify possible products that would solve the financial problems. Four of the projects were selected from a list generated by the finance professor. Each E-team chose a project by unanimous decision of its members. The computer science professor advised the E-teams to work closely with their assigned mentors/advisors in the process of innovating and creating their products. He encouraged and frequently reminded the E-team members to regularly collaborate and share resources with each other. In fact, the E-teams were provided with the resources to facilitate discovery learning in the development of good problem solving skills, innovative thinking, experiential entrepreneurial skills, and team building skills. The out-of-class work on the financial software product development was facilitated by at least one E-team member having a laptop computer. All E-team members had easy access to desktop computers.

The five purposefully designed E-teams completed their financial software product by the end of the semester. Two showed promise of being commercially viable with slight improvements. The evaluation of the course included the two professors' ratings of the E-teams' products, feedback from mentors/advisors, oral and written exams, and interviews as well as student journals, surveys, and questionnaires. The course was considered to be successful from the point-of-view of the project and midterm exam as evidenced by a percentage error test. However, it had some problems. These included course duration, minimal cross-disciplinary knowledge, difficulty in knowledge transfer, differential course expectations along disciplinary lines, and a need for more business communication skills.

Course Design

The course, Entrepreneurial Financial Computing, was offered in the spring 2005 semester. It was a 3-credit course in the Department of Finance and a 4-credit course in the Department of Computer Science. Two professors team taught the course: one from finance and the other from computer science. They used a combination of teaching techniques including lecture-discussion, collaborative learning, inquiry, problem-based learning, and discovery learning. All students in the course met in the same classroom to receive the same finance, teamwork, entrepreneurship, and project management instruction once per week. Moreover, computer science students received introductory instruction in finance and project management in their additional class hour. The teaching was supported by nine mentors/advisors from computer-related and finance industries that facilitated the entrepreneurial component of the course. These mentors/advisors sometimes served as guest lecturers. The 28 students (twenty-six were registered) in the course were grouped into seven E-teams labeled E-team #'s 1-7. Five of the E-teams (E-team #'s 1-5) were deliberately designed by the professors within the first two weeks of the semester using student information obtained from a professor designed questionnaire and a multiple intelligences inventory. These E-teams' formation parameters were learning style, ethnicity, gender, major/minor, course prerequisites, business and computer-related work experience, time expected to devote to course study, students' preferences for team membership and project assignment, total number of students in the class, number of students per E-team, and employment status. Learning style, which was characterized as multiple intelligences, was held relatively constant while E-team parameters such as major/minor, gender, and ethnicity were intentionally varied and the few known student preferences for E-team membership were honored. These E-teams were designed to maximize students' collaboration and achievement. Two E-teams (E-team #'s 6 and 7) were adhocly formed from late registrants and students who were previously undecided about E-team participation.

Design Objectives

To achieve the course objective and to facilitate the course's entrepreneurial component with efficient use of mentors, each E-team was viewed as a project-oriented small entrepreneurial company that builds financial software products for a market niche. The seven projects for software product creation were the following: Capital Budgeting, Exchange Rates, Allocation of Portfolio of Securities Based on Target Return, Derivatives Calculation and Shell, Inventory Management System and Merchandizing, Portfolio Management, and Capital Asset Pricing Model Applied to Renewable Energy Needs. Each E-team was advised to name itself, decide upon its leadership structure, and to consciously plan for effective E-team functioning. Each E-team was further advised to identify and record individual team members' strengths, determine three specific activities the E-team would perform to achieve a potentially high quality marketable financial software product, and to document the operational goals and procedures of the team. In addition, E-team members were to evaluate each other's performance.

Mentor Roles

Three of the E-teams (E-team #'s 1, 5, and 7) were entrepreneurial consulting companies. These E-teams had mentors/advisors that were the source of their projects. In addition, two of these E-teams (E-team #'s 5 and 7) had projects that resulted from their research and were consistent with their visions and desires. Overall, there were nine mentors/advisors that assisted the E-teams in identifying financial problems in need of improved solutions, formulating problems to enable efficient software solution, identifying markets for their completed software product, determining the level of software product user friendliness, and counseling and advising E-team members in the development of a successful business plan. Two E-teams (E-team #'s 1 and 5) had two mentors and the remainder had one each. The meeting arrangements between E-teams and mentors/advisors were generally flexible. Most mentors/advisors made themselves available to meet their respective E-team on campus if the E-team could not come to their work/job site. All of the mentors/advisors invited their E-teams to visit their work/job site and to call or email them with questions about the projects. The computer science professor closely monitored the E-team – mentor/advisor meetings and arranged some of the meetings between E-teams and mentors/advisors. The mentors/advisors worked closely with both professors. They provided the professors with frequent feedback on the E-teams' progress, performance, and attendance at scheduled meetings.

Grading Policies and Statistical Tools

The grading policy for finance students was different from that of computer science students. Finance students midterm and final exam scores summed to 70% of the total course grade with the sum of their project and midterm exam scores being 65% of the course grade. The computer science students' project score was 55% of the total course grade. They had a 15% midterm exam with no final exam. The project score consisted of the grade students received for the software product, product documentation, technical report, and presentation. Therefore, for the finance and computer science students the midterm exam and the project were viewed differently -- along disciplinary lines. The computer science students were also graded on teamwork performance for an additional 10% of their course grade.

The unit of analysis for this study was the E-team. The midterm exam and project grade averages for each E-team were computed. The standard deviations and the percentage errors were evaluated across the E-teams. The percentage error formula used was the following:

$$\text{percentage error} = \left(\frac{\text{(experimental value)-(true value)}}{\text{true value}} \right) \times 100\%,$$

where true value was defined as the average of the E-teams' midterm exam averages multiplied by the average of the E-teams' project averages divided by the average of the midterm exam averages plus the average of the project averages. The experimental value was each E-team's midterm exam or project average. From the class perspective, the inter-team performance for an E-team was deemed acceptable if its percentage error value met the following criteria:

1. Not less than -10%
2. Be within 15 points of each of the other E-teams' percentage error value
3. Be within ± 10 points of the E-teams' average percentage error value.

Demographics and Characteristics

The 26 registered students in the course had the following distribution of majors: 14 finance, 8 computer science, 1 computer science and business, 1 finance and management, 1 management science, and 1 mathematics. Their minors were two in business, five in economics, one in economics and mathematics, one in finance, two in information systems, three in mathematics, one in mathematics and psychology, and one in management science. Six students registered late: two of whom majored in computer science with minors in information systems. Four majored in finance: two had minors in economics. One of the computer science students registered two weeks late while the other registered four weeks late but started class attendance in the seventh week. The four finance students registered two weeks late. Five of the 26 registered students were females. Two of the females were computer science majors with one having minors in economics and mathematics and the other having minors in mathematics and psychology. One of these two students was African. Of the three females who majored in finance, one was Hispanic. None of the other females and none of the males who majored in business or mathematics met the criteria of belonging to an underrepresented minority group. One of the males who registered in computer science was of mixed Caribbean heritage: African-East Indian. The students were mainly seniors. Their employment status was the following: 27% worked full time, 46% worked part time, and 27% did not work. Seventy-two percent of the students reported that they were registered for an average of 15.1 credits and 73.1% of the students said that their grade point average was above 3.0. Almost all of the students (96.2%) were commuters. Two finance students dropped the class after the midterm – one was male.

Results

The results of the Entrepreneurial Financial Computing course ranged from satisfactory to excellent in one sense but were mixed in another. The leadership structure among E-teams varied from one to another. Three E-teams simply had leaders or coordinators while one had a role of president and two others had the role of chief executive officer. One E-team (E-team #7) had two chief executive officers and no role for the third member. Moreover, two E-teams had assigned roles for each member. Each E-team's software product was jointly judged by the two professors on the basis of relevance to market research; problem definition; financial, computing technology, and entrepreneurial processes; and technical soundness. Two E-teams (E-team #'s 2 and 4) produced high quality financial software products that with only slight improvements are potentially marketable: E-team #2's software product's main task was exchange rate computations while E-team #4's product dealt with derivatives hedging and arbitrage. E-team #2 named itself HedgePotential.com and E-team #4 named itself ABIA Company. Three other E-teams completed their financial software products. Two of these E-teams (E-team #'s 3 and 5) developed products that were good but needed general improvements in user-friendliness, range of application within product description, and/or relative sophistication of the packages while the other E-team's (E-team #1) software product failed to function as specified on demonstration – it seemingly had a glitch. E-team #3 named itself Fibonacci and E-team #5 named itself MRY Consulting. The two adhocly formed E-teams did not complete their software products. However, some of their members individually completed scaled down versions of the teams' projects. Moreover, all the E-teams had problems writing an effective business plan.

When the course was also evaluated on the basis of each E-team's midterm and project averages, it was found that their midterm exam averages were correlated to their project averages with 65% of the variability about the mean of the project averages attributable to the variability about the mean of the midterm averages. Neither the midterm exam averages nor the project averages were normally distributed. The midterm exam averages had a skewness of -0.3 and a kurtosis of -2.6 while the project averages had a skewness of -1.2 and a kurtosis of 1. The midterm exam and the project averages had standard deviations of 8.8 and 26.6 respectively. Fifty-seven percent of the E-teams' midterm exam averages fell within one standard deviation of the overall mean while 85.7% of the projects' averages fell within one standard deviation (See Table I). E-team #6's averages fell outside of one standard deviation for both the midterm exam and the project. For both midterm exam and project, all of the E-teams' averages fell within two standard deviations of their respective means. Furthermore, the percentage error test (See Table II) on the midterm exam averages showed that all of the E-teams met the performance criterion of *not less than -10%*, the performance of E-team #'s 1-4 and E-team #'s 5-7 formed two clusters in meeting the criterion of *be within 15 points of each of the other E-teams' percentage error value*, the performance of E-team #'s 2 and 4 exceeded the +10 points of the *be within ±10 points of the average percentage error value*, and none of the E-teams simultaneously met all three criteria of acceptable class performance. For the project averages, five E-teams met the performance criterion of *not less than -10%*, three E-teams (E-team #'s 1, 3, and 5) met the performance criteria of *not less than -10%* and *be within 15 points of each of the other E-teams' percentage error value*, and E-team #'s 2 and 4 met the performance criterion of *be within 15 points of each of the other E-teams' percentage error value* but they exceeded the upper limit of *be within ±10 points of the average percentage error value*.

Discussion

The two professors collaborated on all aspects of the course. They used division of labor to expedite the execution of the course: the finance professor was mainly responsible for the pedagogical content while the computer science professor was mainly responsible for project management and development and facilitation of the experiential entrepreneurial component of the course. They were both present throughout each of the 14 sessions of the course; communicated weekly with each other on the course development, execution, and progress; and coordinated their communications with the E-teams, so as to speak to them with one voice. This collaboration between professors provided the E-teams with a model of teamwork.

From the evaluation of the E-team project and the statistical analyses of the midterm exam and project averages, two E-teams – E-team #'s 2 and 4 -- out-performed the others. They produced financial software products that had merit in satisfying the goal of commercial viability with a focus towards a market niche. These E-teams successfully completed all the components of the course including product development, product documentation, technical report, product demonstration and oral presentation as well as business plan, student journal, and peer evaluations. These E-teams communicated frequently with the professors and their mentors/advisors to resolve problems they had been experiencing and provided and received feedback on their progress. Three E-teams – E-team #'s 1, 3, and 5 -- produced relatively acceptable software products. Moreover, they each did not submit all of the required documentation that supported their project. The above five E-teams were the ones that were purposefully designed. These five E-teams met relatively regularly with their mentors/advisors for guidance on the entrepreneurial and business aspects of the course. The two adhoc E-teams failed to meet regularly with each other and to complete the class project. These E-teams infrequently communicated with their mentors. This was due in part to an inability to make timely progress on product design and development, late registration of some team members, hesitancy of some team members to participate in teamwork, and the computer science team members' relatively weak programming skills for their respective tasks; as well as the absences and tardiness of the late registrant computer science team member in E-team #7 and the unofficial withdrawal of the other computer science team member from E-team #6 in week 12 of the semester. In general, all of the E-teams and the students lacked sound knowledge in business communication skills and their slowness to incorporate the suggestions of the mentor/advisors into their business plans resulted in business plans that needed specificity.

The mentors/advisors expressed their joy of participating in the course and their willingness to participate in the next course offering. The general beliefs among them were that students had the capability, desire, and motivation to execute the requirements of the course and to meet the course's main objective. The respective mentors/advisors of the five functional E-teams felt that their E-team performed good to excellent under the constraints of out-of-class responsibilities including work and travel. One mentor/advisor reported that the team "was serious-minded in pursuing the course assignments. They clearly understood the financial and software components of the project." The students individually and as E-teams benefited from working on real financial problems in an attempt to find creative solutions while under the guidance of entrepreneurs/mentors and professors. Most students felt that the course was challenging and rewarding and taught them skills they would not have otherwise received. This was echoed in the following statement by a computer science student: "The class is full with great experience that students need to learn about businesses and learning how to start building one's own business." A finance student commented that the project was invaluable.

Many typical urban university characteristics created constraints on some E-teams'/students' ability to meet the course objectives. The fact that 73% of the students worked either part time or full time and 96.2% commuted placed additional constraints on the available time each E-team had to complete a high quality software product with commercial viability. The constraints of work and travel limited team members' face-to-face interaction, meetings with mentors/advisors, writing of effective business plans, and the quality of teamwork in some E-teams. Sometimes, it was logistically difficult to get all E-team members to meet for a particular session. Most E-teams' members communicated electronically.

The percentage error test was more effective in identifying the high and low performing E-teams than measures of variability around the mean as defined by the standard deviation. E-teams #2 and #4 were the highest functioning teams on both midterm and project averages. Their performances were relatively close to each. E-teams #6 and #7 were the lowest functioning teams with E-team #7 having the lowest performance of all E-teams on the project. This result is consistent with the fact that E-team #7's programmer unofficially withdrew from the class during the 12th week of the 14-week semester. This was the time in the semester that E-teams were putting the most effort into the project as well as seeking and finding solutions to critical financial and programming problems that arose in the project. Moreover, the percentage error values seem to show a pattern in rank order of the midterm averages and project averages. This observation was confirmed by an $R^2 = 0.65$, which indicates a strong linear relationship between the two variables. Furthermore, the nonzero values of the skewness and kurtosis for the midterm and project averages provided evidence that neither the midterm averages nor the project averages were normally distributed.

When considering the feedback from the mentors/advisors and E-team members as well as the project evaluation and the percentage error test of the midterm exam and project averages, the course was assessed to be a qualified success: successful for the five purposefully designed E-teams. However, there were problems. These included the 14 week semester which proved to be too short for some of the E-teams to produce the niche-based commercially viable financial software product they had desired in order to meet the course objective. Most E-teams had insufficient computing and programming skills as echoed by one computer science student: "It was hard for me as a single computer science student in the group to understand and develop [the] project technically by myself." The computer science and the finance students were members of different disciplinary cultures. The grading policies were different for these two sets of students. Exams constituted 70% of the finance students' grade and only 15% of the computer science students' grade. The computer science students saw the course to be more project and team oriented. One computer science student commented that "the Finance majors did not take the project as seriously as we did. They wanted to focus on their upcoming midterm exam due to the difference in the distribution of points amongst the various tests and the project." A finance student suggested the following course improvements "[computer science (CS)] students have more finance experience before taking [the course]. Same grading system should be used for all the students in the course. More time should be spent on the CS part of the course." Although many of the computer science and the finance students were trained in multidisciplinary learning they seemed to be unable to communicate this learning across disciplinary lines. One student commented that "It was difficult to understand what they were saying because we speak different languages (finance and computers)." In general, the computer science students had more teamwork experience. At least eight of them had previous experience working in student teams.

Moreover, most of the mentors/advisors reported that all the students needed more time to develop their business communication skills.

Conclusion

The entrepreneurial financial computing course revealed that goal-focused collaborative learning courses produce better results when the teams are purposefully designed and the teams are sufficiently motivated to identify themselves with a name that describes their functions, passion, and uniqueness. A general consensus among finance and computer science students was that the grading policy should be the same for all students. This would have probably motivated a larger number of both sets of students to become equally dedicated to the project. Both the computer science and finance students seemed to have difficulty communicating previously acquired knowledge across their disciplinary boundaries. The computer science students' lack of prior knowledge in the basic concepts of finance further contributed to problems in cross disciplinary transfer of knowledge. While the course was considered a qualified success, the issues of disciplinary culture, cross-disciplinary knowledge and learning transfer, differential experience in teamwork along disciplinary lines, and the need for more business communication skills should be addressed in future offerings of the course.

"Crossing [disciplinary] boundaries [are] a hallmark of innovation." Some of the world's most famous scientists got the inspiration for their renowned scientific contribution from nonscientific fields including the arts[13]. Whether one is trained in a single discipline or multiple disciplines, the application of this training to human problems requires an interdisciplinary approach. Many problems including simple ones in modern finance are unsolved. Many talented computer scientists, mathematicians, physicists, engineers, and economists have been attracted to the financial industry to tackle these quantitative problems within the last two to three decades. This suggests that students from the physical, social, computational, and engineering sciences stand to gain important insights in current and emerging financial problems as well as good cross cultural working relationships within the financial industry. Moreover, when students' projects involve "real world" problems, they come to realize the open-ended nature of these problems – the type of problems they are likely to encounter in the workplace. Furthermore, it is in the setting of interdisciplinarity that students are most likely to encounter higher level learning[4,5,8,9,10,20].

Table I

Measures of Variability

E-Team#	Midterm Exam Within 1 Std Dev	Midterm Exam Within 2 Std Dev	Project Within 1 Std Dev	Project Within 2 Std Dev
1	yes	yes	yes	yes
2	no	yes	yes	yes
3	yes	yes	yes	yes
4	yes	yes	yes	yes
5	no	yes	yes	yes
6	no	yes	no	yes
7	yes	yes	yes	yes
Percentage	57.1	100.0	85.7	100

Table II

Percentage Error

E-Team #	Midterm Exam	Project
1	18.7	5.2
2	25.2	32.6
3	19.2	6.9
4	24.3	29.7
5	-5.7	-4.4
6	-4.5	-89.0
7	-3.0	-42.1
Average	10.6	-8.7

References

1. S. Appold, "Competing to improve? A difficult terrain," *Proceedings of the 1st International Conference Teaching and Learning in Higher Education*, Singapore (December 1-3, 2004), 264-269, 2004.
2. D. Bardin, "Discovery Learning," http://coe.sdsu.edu/eet/articles/discoverylearn/start.html.

3. R. Barr and J. Tagg, "From Teaching to Learning: A New Paradigm for Undergraduate Education," *Change*, pp. 13-25, Nov./Dec. 1995.
4. J. Bradbeer, "Barriers to Interdisciplinarity: Disciplinary Discourses and Student Learning," *Journal of Geography in Higher Education*, vol. 23, no. 3, pp. 381-396, 1999.
5. J. Bransford, A. Brown, and R. Cocking (Editors.), *How People Learn: Brain, Mind, Experience, and School*, Washington, D.C.: National Academies Press, 1999, http:/books.nap.edu/html/howpeople1.
6. D. Ebert, "Learning Communities and Collaborative Teaching: An Interdisciplinary Approach for Increasing Student Success and Retention," *International Journal of Innovative Higher Education: The Official Journal of the University Without Walls International Council*, vol. 13, pp. 22-26, fall 1999.
7. J. Green, "'There's Gotta be a Better Way:' In Search of a New Pedagogical Paradigm for Teaching the Humanities," *Interdisciplinary Humanities: Dedicated to the Teaching of Integrated Studies Among the Humanities, Arts, and Related Fields in Schools, Colleges, and Cultural Institutions*, vol. 15, no. 1, pp. 77-90, spring 1998.
8. L. Ivanitskaya, D. Clark, G. Montegomery, and R. Primeau, "Interdisciplinary Process and Outcomes," *Innovative Higher Education,* vol. 27, no. 2, pp. 95-111, winter 2002.
9. V. Mansilla, "Assessing Student Work at Disciplinary Crossroads," *Change*, pp. 14-21, Jan./Feb. 2005.
10. S. Mathison and M. Freeman, *The Logic of Interdisciplinary Studies*, Paper presented at the Annual Meeting of the American Educational Research Association (Chicago, IL), March 24-28, 1997, http://www.eric.edu.gov/ (ERIC Document Reproduction Service No. ED418434).
11. J. McClave and T. Sincich, *A First Course in Statistics*, 9th ed., Upper Saddle River: Pearson Prentice Hall, 2006.
12. K. McKeage, D. Skinner, R. Seymour, D. Donahue, and T. Christensen, "Implementing an Interdisciplinary Marketing/Engineering Course: Project Format, Preliminary Evaluation, and Critical factor Review*," Journal of Marketing Education*, vol. 1, no. 3, pp. 217-231, Dec. 1999.
13. C. Myers and C. Haynes, "Transforming Undergraduate Science Through Interdisciplinary Inquiry," in *Innovations in Interdisciplinary Teaching*, Ed. C. Haynes, Westport: Oryx Press, pp. 179-197, 2002.
14. National Commission on Accountability in Higher Education, *Accountability for Better Results: A National Imperative for Higher Education*, State Higher Education Executive Officers (SHEEO), March 2005, http://www.sheeo.org/account/accountability.pdf.
15. M. Polcznski and S. Jaskolski, Entrepreneurial Engineering Education. *Proceedings of the National Collegiate Inventors and Innovators Alliance (NCIIA) 9th Annual Meeting,* San Diego, CA. (March 17-19, 2005). pp. 93-101, 2005.
16. J. Wentworth and J. Davis, "Enhancing Interdisciplinarity Through Team Teaching," in *Innovations in Interdisciplinary Teaching*, Ed. C. Haynes, Westport: Oryx Press, pp. 16-37, 2002.
17. T. Zimmerer and N. Scarborough, *Essentials of entrepreneurship and small business management*, 3rd edition, Upper Saddle River: Prentice Hall, 2001.
18. The Joint Task Force for Computing Curricula 2005, *Computing Curricula 2005: The Overview Report Including the Guide to Undergraduate Degree Programs in Computing For Undergraduate Degree programs in Computer Engineering, Computer Science, Information Systems, and Software Engineering*, The Association for Computing (ACM), The Association for Information Systems (AIS), and The Computer Society (IEEE-CS), Sept. 2005, http://www/ac.org/education/curri_vols/CC2005_Final_Report2.pdf
19. "Blooms Taxonomy," http://www.officeport.com/edu/blooms.htm.