

**2006-751: DEVELOPMENT AND PRESENTATION OF THE
INTERDISCIPLINARY COURSE PETROLEUM PROJECT EVALUATION:
INTEGRATING ENTREPRENEURIAL AND BUSINESS CONCEPTS INTO A
PETROLEUM ENGINEERING CURRICULUM.**

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Development and presentation of the interdisciplinary course *Petroleum Project Evaluation: integrating entrepreneurial and business concepts into a petroleum engineering curriculum.*

Abstract

The interdisciplinary course, PET 4460 – *Petroleum Project Evaluation*, offered at Montana Tech, was a direct result of the changing landscape in the petroleum engineering field. The course combined engineering concepts that students learned in other courses with entrepreneurship and other business concepts that entry-level petroleum engineers must possess in order to be successful. Faculty from the Business and Petroleum Engineering departments developed the course over a two-year time span with input/feedback from the Petroleum Engineering Department’s industrial advisory board as well as input from upper-level management from many of the businesses operating in the petroleum arena. The subjects covered in the class were designed to cover topics from “beginning to end” in petroleum project evaluation. The course begins with an overview of project management principles and then continues with coverage of subjects such as entrepreneurial startup financing and capital formation, land ownership, oil and gas contracts, cash flow analysis, financial statement analysis, and the use of futures contracts to hedge risk, to name a few. The course culminated with a hands-on project using the lessons provided in the course combined with commonly used industry software to “tie everything together.”

The paper examines the development of the course, the need for interdisciplinary cooperation, the delivery of the course, and assessment of the course effectiveness.

Introduction and Background

Today’s outstanding engineer must have the knowledge of many sciences and disciplines. Interdisciplinary skills help an engineer to cope with the changing social, economic, and political conditions that influence technology and its development¹. Engineering is a profession that serves many functions of design and problem solving. These engineering functions support the goals of business and entrepreneurship, and in turn engineering is supported by entrepreneurship. The ideas and designs created by engineers are only useful if they fill a need and have a market, such as creating machines for improving industry or solving troublesome problems. As Thomas L. Magnanti, dean of engineering at the Massachusetts Institute of Technology has stated, “We in engineering don’t study entrepreneurship per se; we do entrepreneurship. We create products and processes that people use. Bringing together management and engineering provides an ideal combination².”

This basic relationship is not often demonstrated in the delivery of college engineering courses. The lectures and labs for engineering courses tend to focus on the scientific method and the application of principles and tools to solve problems. For engineering training to be complete it must also emphasize that successful engineering takes place within the framework of business and entrepreneurship. Engineers are [an] excellent source of high growth potential

entrepreneurial and technology commercialization ventures, with their creative product and technology ideas³. However, a recent study of executives in design and construction found that 65% of the executives had an engineering background and their analytical skills were not focused on the traditional business focus of finance, accounting, organizational behavior, law, marketing, and human resources⁴. Engineering and technology students are increasingly more interested in creating their own companies, but do not traditionally have the [entrepreneurial] skill sets necessary to evaluate opportunities and create successful businesses. The rate of success in bringing undergraduate, graduate, and professional engineered products to market has been hindered by a lack of business expertise⁵. The PET 4460 class developed at the Montana Tech of the University of Montana was designed to emphasize this crucial relationship of engineering and entrepreneurship.

Webster's dictionary defines an *entrepreneur* as "one who organizes, manages, and assumes the risk of a business or enterprise." Traditional engineering curricula are typically weak in entrepreneurship studies. Instruction in engineering theory and practice is present in all engineering classes, but too often the links between engineering methods and business and entrepreneurial needs are not addressed. Although few students go to work, immediately after graduation, for a small company (or start one themselves) [any entrepreneurial] skills that they learn are valuable in large companies as well, such as IBM, which is organized into units where entrepreneurship is encouraged⁶. Gifford Pinchot coined the term *intrapreneur* in 1985 to describe this new paradigm of releasing the entrepreneurial spirit within an established corporation. Whether the objective is to develop individual entrepreneurs or to inculcate intrapreneurship in a company there is clearly a need for courses such as Montana Tech's PET 4460.

One of the objectives of Montana Tech's interdisciplinary course, PET 4460, Petroleum Project Evaluation, is to introduce senior-level petroleum engineering students to the concept of entrepreneurship by exposing the students to the "big picture" of how their engineering decisions tie into their company's profitability. More specifically, the constantly changing landscape of the worldwide petroleum industry (i.e. - reengineering, mergers, and downsizing) has created an environment in which young engineers will be expected to demonstrate intrapreneurship and leadership, by dealing with business issues and implementing policies that will contribute to the company's success and bottom-line.

Genesis of Pet 4460 - Petroleum Project Evaluation

When he became department head in 2003, one of the first endeavors that Professor John Evans participated in was to travel to the board rooms and offices of the companies that hire Montana Tech petroleum engineering graduates. These companies ranged from major petroleum firms (Chevron/Texaco, Shell, Exxon/Mobil), to larger independents (Burlington, Anadarko) as well as service companies (Schlumberger, Halliburton). Evans wanted to discern what Montana Tech could do to make its petroleum engineering graduates a "better product." The overwhelming number of responses from company representatives fell into three areas: new engineers need to be more proficient in business/economic analysis, petroleum engineering curricula needs to be more oriented towards the "business" of oil and gas and engineering students need to improve their communication skills. Evans took this information to his faculty members as well as faculty from Tech's Business department and the first iteration of the class was developed and presented to the departmental Industrial Advisory Board

(IAB) in 2004. The course was enthusiastically endorsed by the IAB, and, with further development, was first taught during the Spring Semester of 2005.

The notion of creating a course that would make engineers more aware of the business and entrepreneurial environment and creating more value for an entry-level engineer was one of the driving forces behind the development of the course. "This class is an attempt to prepare our petroleum engineering graduates for employment with a growing number of companies that require their employees to fulfill more than one job. It is our job as educators to give engineers a broader context to the foundation of engineering and exposing students to the entrepreneurial side of things is a major piece of the puzzle," says Evans. "Historically, Montana Tech graduates were quite adept at the technical side of things, but they needed a broader background in the ability to synthesize engineering data from a business perspective," continued Evans.

History of Entrepreneurship Education at Montana Tech

Entrepreneurial education at Montana Tech came about with the start of a movement by the school to diversify into programs that reflected the technologically based role and scope of the institution. The school has long enjoyed a heritage deeply rooted in engineering and particularly engineering in the extractive industries. Currently the school would be classified as a small comprehensive college with just fewer than 2,000 students. The engineering side represents about 50 percent of the student majors while the non-engineering students are able to select from a number of degree options including business, math, sciences, nursing, computer science, and others.

The business offerings have seen some significant changes over the past two decades. Montana Tech offered students a fairly traditional business administration until the late 1980s when the Board of Regents required the campus to phase out the degree. For a number of reasons, including the state-funding model, Tech decided to pursue other business related degrees. Starting in 1990, the Department of Business and Information Technology (BIT) developed a bachelor's degree program titled "Technology and Business Development," which the framers purposely designed as entrepreneurial type program that matched the role and scope of the university as well as a program that did not directly compete with the business administration programs offered at the neighboring state funded campuses. The business department wasn't particularly fond of the name of the new business program and in the late 1990's the opportunity presented itself to change the business offerings at the school and Montana Tech started the new century by offering a bachelors program in Business and Information Technology with three options including Business Information Systems, Management, and Entrepreneurship.

Historically, the entrepreneurship program at Montana Tech has been led by an individual professor, which appears to be the case in many entrepreneurship programs⁷. Looking into the future, Solomon, et al. described a changing pedagogy based on the broadening market interest in entrepreneurial education, which partially explains this current interdisciplinary course offered by the petroleum engineering and BIT departments⁸. This class appears to have the potential for growth as the engineering programs at Montana Tech are currently making changes based on the recommendations of the Accreditation Board for Engineering and Technology (ABET) for additional management and entrepreneurship coursework in the curriculum.

The Course – Pet 4460

An array of pertinent petroleum engineering and business topics were included in PET 4460, Petroleum Project Evaluation. The topics ranged from land ownership and reservoir estimation to methods of financing, financial statement interpretation and cost accounting. The subject matter was selected to provide practical information needed by entry-level petroleum engineers, based on the previously discussed input from the petroleum industry and from discussion/planning sessions by a representative group from the Business and Petroleum Engineering Departments. Table 1, PET 4460 – Petroleum Project Evaluation Course, contains a list of the major topics and subtopics, along with the department responsible for delivering the subject matter.

A complete project evaluation was an integral part of this course. The class project utilized PEEP®, a widely used industry software package for economic evaluations. PEEP® software is industry specific software that generates production and economic information for decision making purposes for oil and gas companies. Not only did it contribute to a substantial part of the student's grade, but also it tied many of the different subject areas together. It helped demonstrate to the students how the engineering and business aspects were related and often dependent on the other (e.g., information regarding financing or costs was needed in order to make engineering decisions). The students were required to work in teams, as is common in industry. The experience of allocating work and being responsible for completing tasks on schedule and reporting back to the group was invaluable to the students.

The evaluation project consisted of information regarding possible investments in five oil and/or gas fields, each a different field type and each with different levels of associated risk. The groups were to assume they were a small independent oil producer and were given a fixed cash reserve. They then calculated expected cash flow amounts for various field developments. In addition, they were allowed to seek financing through bank loans or equity partners. The groups' charge was to determine the "best" methods of development for the five fields that would yield the maximum total return on investment.

Table 1. PET 4460 – Petroleum Project Evaluation Course list of topics and subtopics.

	Topic	Responsible Dept.
1	Intro/Project Management – overview of how it all fits together	Petroleum
2	Land Ownership <ul style="list-style-type: none"> • Oil & Gas leases (rights & obligations) • Working interests • Royalty and Override interests • Net Revenue interests • Government concessions & licenses 	Petroleum
3	O&G Contracts <ul style="list-style-type: none"> • Joint Operating Agreement - w/attachments (AFE, Ops cost & OH) • Unit Agreement • Farmout Agreement - payout provisions, non-consents • Legal rights and obligations of Operator and Non-Operator 	Petroleum & Business

4	Regulations	Petroleum/Speaker
	<ul style="list-style-type: none"> Well Spacing Permitting Reporting Environmental protection OSHA Safety Other 	
5	Oil & Gas Reserves	Petroleum
	<ul style="list-style-type: none"> Estimation methods (volumetric, material balance, simulation models) Reserve Categories (proved, probable, possible) Reserve reporting (SEC, financial lenders, partners) Engineering ethics and responsibility 	
6	Production Performance	Petroleum
	<ul style="list-style-type: none"> O&G production estimating methods (PEEP) Correlation with reserves Economic limit determination 	
7	Timing	Petroleum
	<ul style="list-style-type: none"> Capital investment timing Start of production timing Impact of timing changes 	
8	Financing	Business
	<ul style="list-style-type: none"> Internal financing Bank financing Venture capital Partnerships 	
9	Price Forecasting – read journals, look up prices	Petroleum & Business
	<ul style="list-style-type: none"> Commodity pricing – spot markets Forecast sources Pricing contracts 	
10	Costs	Petroleum & Business
	<ul style="list-style-type: none"> Capital costs (tangible & intangible) Expense costs Accounting methods Severance taxes Ad Valorum taxes 	
11	Capital Recovery	Business
	<ul style="list-style-type: none"> Depletion Depreciation Amortization 	
12	Financial Statements – income, cash flow, balance sheet	Business
	<ul style="list-style-type: none"> Income statement Cash Flow statement Balance Sheet Data sources for investment evaluation 	
13	Cash Flow Analysis (PEEP software from Schlumberger)	Petroleum & Business
	<ul style="list-style-type: none"> Spreadsheet setup Common features 	

	<ul style="list-style-type: none"> • Industry software • State & Federal income tax 	
14	Time Value of Money <ul style="list-style-type: none"> • Net Present Value 	Business
15	Economic Indicators <ul style="list-style-type: none"> • NPV • IRR • ROI • Payout 	Business
16	Risk <ul style="list-style-type: none"> • Analysis methods • Decision Trees • Monte Carlo simulation • Available S/W 	Business
17	Sensitivity <ul style="list-style-type: none"> • Analysis methods • Tornado charts 	Petroleum & Business
18	Project Management <ul style="list-style-type: none"> • Planning • Budgeting • Scheduling • Implementing • Operating • Follow-up 	Petroleum

Assessment

This section of the paper looks at the course requirements used to assess the students as well as provides a summary of the overall assessment of the course by the students and the instructors. The student assessment focused on the students' perceptions of the value of the course, as well as the role of the course in promoting general business and entrepreneurial thinking.

Assessment of the Students

The grades assigned to the students were based upon various small homework assignments, three exams, and the presentation of a major group project that employed industry related software. The homework was generally problem-based examples that emphasized discussion points from the lecture. The professor who assigned the homework was responsible for grading the work and for assigning an appropriate point value for the assignment.

The first two exams were oral exams based on a series of questions that were distributed a week prior to the exam. The faculty determined oral exams to be excellent real world experiences that will prepare the students for the near-term challenges of job interviews, field internships, as well as on the job briefings or presentations to colleagues and/or management. The students were required to think on their feet and approach this assessment like they would a formal job interview or management presentation.

To prepare for the oral examinations, the students were assigned to a specific group and it was the responsibility of that group to develop answers to each of the questions. The same exam questions were given to each group. During the oral examination, each individual randomly drew a question and was required to develop and present an answer without the aid of her or his group. The professor who assigned the question was allowed to ask follow up questions related to the material in order to make a judgment as to how well the individual student understood the material. Again it was required that the individual answer the question without the aid of the other group members.

For the oral examinations, the students were rated by the professors on each of the following criteria: 1) knowledge of the topic (did they understand the topic), clarity of communication (did they sufficiently answer the question, was the answer clear and concise), and appearance and delivery (did they stay within the time limit, did they use proper speech, appropriate gestures, appropriate dress).

The third exam, completed during the final week of the semester, was a written take-home exam and it contained questions similar to the previous oral exams. Each of the professors graded the questions they assigned.

The required presentation by the students communicated their results from a project using PEEP® software. The students were given two training sessions, led by a company representative, in the use of the software toward the middle of the course and were required to make their presentation at the end of the coursework. This presentation to two members of the faculty included the engineering and entrepreneurial elements discussed in the course. One business faculty member and the head of the Petroleum Engineering department evaluated the presentations for their thought, creativity, application of learning, and their ability to convince a hypothetical management team of their project plan.

Student Assessment of the Course

The students were given two opportunities to assess the course. The first assessment was part of the usual course evaluation process required by the college wherein the students were given a series of open-ended questions related to the course and topics within the course. The second assessment occurred six months after the completion of the course and was designed to address the material from the course after the student had gained experience in the petroleum industry either after taking permanent employment or working over the summer in an internship program.

The first assessment allowed the students to address specific items about the course related to topics covered, the use of multiple faculty members, and suggestions related to improving the content of the course. In the initial student assessment, a clear majority of the students stated that the PEEP® software, and the related project, was the most valuable course topic. The students were also asked about the least valuable topics and a clear majority of the students stated that the business content were the least valuable. Items not considered as valuable to the students included such topics as business basics, cost and curve analysis, and financial statements. The students also questioned the worth of specific business topics such as

depreciation, project management, options, and price forecasting. A minority of students questioned the value of the lectures related to starting businesses, and equity markets, stating these items will not apply immediately after entering the work force.

The students generally gave a favorable review to the use of multiple faculty members in the first assessment. A majority of the comments generally stated that it was beneficial because it kept the class interesting. More specifically a majority of the students agreed that it was helpful to have a faculty member presenting topics from her or his area of specialization. The single negative comment, regarding multiple faculty members, addressed the need for increased collaboration among the professors in order to a smoother transition between topics.

Finally, the initial evaluation asked the students to list specific changes that would improve the course. The two prevailing items mentioned addressed the timing of topics and the equity of the oral examinations. A number of students stated that it would be beneficial to present the business related lectures at the beginning of the semester, as their required curriculum only allows them a minimal exposure to these topics. Additionally, a few students suggested that the PEEP® software project also be introduced at the beginning of the semester. A majority of the students opined that the oral exams were not fair, but it is interesting to note that only one student recommended doing away with the oral exams. The majority of the evaluations addressed the need for an improved oral exam process.

The second student assessment regarding the course was in the form of a focus group between willing students and four instructors. The students comprising the focus group included seven individuals still on campus that were able to meet with the instructors and participate in an in-depth group discussion about the course and one graduate currently employed in the petroleum industry in the State of Texas, who was able to provide an individual view of the same questions. The focus group occurred six months after the initial course evaluation and was designed to specifically address the business topics in the course and whether the student's perceptions of the overall course had changed over time. All but one of the students had been subject to some employment experience in the industry either through permanent employment or an industry-related summer internship.

The students in the focus group who had worked in industry were unanimous in stating that the class had benefits that they did not otherwise receive in their curriculum. A number of the student interns had been given actual projects to manage. Only one of the student interns had been on a job that did not require some degree of business or economic analysis. The students stated that the type of education provided in this course was necessary for them to effectively communicate between the office and the field. The students were quick to agree that the business concepts from the course were easily carried over to their jobs, which allowed them to get off to a running start. Also of note, one student mentioned that this course provided an understanding of business terminology that allowed this individual to possess additional confidence during job interviews as well as a differentiation of their Petroleum Engineering degrees from other schools offering similar programs.

The focus group was asked about the amount of overlap between the business component of this course and the business education received in other areas of their curriculum. The students that

confirmed the existence of an overlap were the students that are pursuing a business minor; historically about 10 percent of the petroleum students complete the business minor. However, these students did recognize the benefit of the material to the other petroleum engineering students.

The students in the focus group were then asked questions about the managerial and entrepreneurial aspects of the course and whether it had changed their thoughts regarding career possibilities. Six of the eight (75%) students envisioned a career in some sort of management function and again cited this course as adding value regarding the business and management side of the industry. Two of the students suggested that this course removed the fear of the unknown as to what is necessary to operate a business and it even instilled a sense of confidence as to possibly starting a new venture. While six of the eight aspired to a career in management, all eight basically understood the role of the entrepreneur and two of the students stated that they saw themselves taking the role of an entrepreneur within seven to ten years and that this class helped motivate them to explore business opportunities and understand the importance of developing business related networks within the industry.

Finally, the focus group was asked to assess the value of the course by rating its content on a scale of one to five with five being of highest value. The students were asked to provide a rating based upon their perspective at the completion of the course six months ago as well as their current perception after gaining work experience in the industry. A summary is presented in table 2.

Table 2: Students’ Rating of the Course (5 = highest value, 1 = lowest value)

Historical Perspective (after completion of the course)	Current Perspective (after work experience)
4	4
3	3
4	5
3	5
3	5
2	4
3	4
4	5

The result of this assessment indicates that all but the first two students relate an increase in the perceived value of this course after they have gained some work experience in the industry. Additionally, it appears that most of the students see value in the course as seven of the eight students provided a rating of five or four.

Assessment of the Course by the Instructors

The instructors scheduled a formal meeting to discuss potential changes for the course. Seven of the instructors met to discuss their thoughts as well as address the comments made by the

students in the initial evaluation. The instructors agreed that for the most part the information presented in the course was valuable to the students but agreed to some changes in course content and student assessment, generally based on the comments provided by the students. In addition, the instructors discussed whether the other engineering disciplines on the campus of Montana Tech would benefit from adding such a course to their curriculum. It was the consensus of the instructors that that this would be the case.

Lessons Learned and Conclusions

In summarizing the value of this course to the students and the faculty, there are numerous highlights. The faculty was successful at reaching a need of our graduates through a deliberate and focused interdisciplinary program built from the bottom up. Interestingly, administration had not asked for this course. The faculty had listened to the voices of industry and reacted to their needs. Don't wait for an administrative directive or for the curriculum review committee to act - - just do it!

As we reflect on the effect of this course from the perspective of the student, good things have been reported. In short, the student perspective can be summed up well with this quote from one of the first graduates of this program. Darren Gollehon (Montana Tech 2005) says, "in the business world you can be the best engineer that ever lived, but it doesn't mean anything if your projects are not economical."

Of special note was the student assessment of the value of the course. The view of the students regarding the value of the course changed quite dramatically over the six months from first assessment to the focus group. In the first assessment the students felt that studying anything outside of their narrow discipline was irrelevant while just a short six months later a significant majority felt the course content had a direct and positive impact on their immediate and long-term careers. This finding suggests that further research needs to be conducted into the perspective of the student. Understanding and interpreting student evaluation of coursework as well as overall program and curriculum review could be enhanced with this research.

Clearly, much more attention must be paid to presenting entrepreneurship and management topics as future engineers are developed and sent into the working world. Creativity and initiative, as accomplished by the PET 4460 course, on the campus of Montana Tech, is just one of the ways to make this happen. Engineering curriculums across the country need to be examined for their inclusion of courses designed to educate our future engineers in engineering entrepreneurship.

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