Title: Integrating Engineering Management Best Practices into the Undergraduate Engineering Design Curriculum: A Business Plan

Course: EMGT 506/606
Term: Fall
Year: 1997
Author(s): J. Goulding

Report No: P97071

Abstract: This work argue that undergraduate engineering students were not graduating with an understanding and appreciation for Engineering Management education value, which include knowledge of the PRP(Product Realization Process), management-oriented communication skills, and basic project scheduling and control. This paper suggests a "self-contained learned experience" case study is the best mechanism to effectively teach undergraduate engineering students design methods and PRP.

Integrating Engineering Management Best Practices into the Undergraduate Engineering Design Curriculum: A Business Plan

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Integrating Engineering Management *Best Practices* into the Undergraduate Engineering Design Curriculum: A Business Plan

by

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for

Dr. Dundar Kocaoglu

There is a collection of ideas but they are not synergistically linked together

An Engineering Management 506 project report submitted in partial fulfillment of the requirements for the degree of Master of Science in Engineering Management.

December 10, 1997

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ABSTRACT

During the second year of study in Portland State University's Engineering Management (EMGT) Program, this author realized that undergraduate engineering students were not graduating with an understanding of and appreciation for EMGT best practices. These best practices include knowledge of the Product Realization Process (PRP), management-oriented communication skills (i.e., the language of time, cost, and performance), and basic project scheduling and control.

An opportunity exists to provide engineering design educators with teaching materials that more effectively integrate engineering design and PRP into their curricula to graduate engineers who better meet the needs of industry. The outcome of this study suggests a "self-contained learning experience" case study is the best mechanism to effectively teach undergraduate engineering students design methods and PRP.

Since educational institutions cannot compete with business and industry in providing work experience, the case study simulates "real world" design project experience. By supplying the students with everything they need to experience a design project in a structured environment, a guided learning process is developed whereby successive learning and reinforcing activities (homework, team-based exercises, and class presentations) give students an understanding and appreciation for design methodology and best practices.

The outcome of this work, multimedia lecture materials and case studies, suggest that the partnership of a small business and universities have the potential to secure grant-based funding.

FORWARD

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ACKNOWLEDGEMENT

Special recognition is due to Dr. Herman J. Migliore and the mechanical and electrical engineering students of Portland State University (PSU) who have taken the Design Methods class over the past six years. Ten years ago, Dr. Migliore described the Design Methods course offered at PSU to this author who was then a Junior-level engineering student. Dr. Migliore's course required students to find a project with local industry, act as "Engineers" responsible to faculty and industry advisors, work in teams of 3 to 5, and give numerous oral presentations and written reports. At the time, only a handful of universities required a similar level of project content, commitment, and responsibility from industry, faculty, and students.

As a graduate-level student, this author visited with Dr. Migliore and casually recommended that he could improve his course by teaching *Best Practices* from the Engineering Management curriculum. A Teaching Assistantship for the Design Methods course was awarded the following year. This author sincerely appreciates the freedom, latitude, and encouragement given him to try different lecture topics, case studies, and presentation methods over the past sixty-four lectures. The results of this study are directly due to the support, feedback, and enthusiasm given by Dr. Migliore.

It is the hope of this author that the results of this work will contribute in some meaningful way to the quality of the Engineering Design profession.

Further, the long-term outcome has the potential to generate advertising and product sales revenue.

The mission of this endeavor is to create a forum for documentation, communication, collaboration, and management of technology projects and to create useful content for business and personal Intranets to improve the quality of product development. Useful content is technical documentation of engineering technology relating to products and practices used in design.

The overall business orientation is characterized as a "rapid growth, low-cost provider of high quality design methods and industry-accepted best practices." The marketing focus is to provide needed educational services that universities and the private sector cannot develop on their own.

INTRODUCTION

During the second year of study in Portland State University's Engineering Management (EMGT) Program, this author realized that undergraduate engineering students were not graduating with an understanding of and appreciation for EMGT best practices. These best practices include knowledge of the Product Realization Process (PRP), management-oriented communication skills (i.e., the language of time, cost, and performance), and basic project scheduling and control. Industry would spend less time and effort training such well-educated, entry-level engineers, and the ideals of PRP, team synergy, empowerment, and concurrent engineering would be more quickly realized.

This document reports on a five-year study of *Integrating Engineering Management Best Practices into the Undergraduate Engineering Curriculum* at Portland State University. The initial educational context was to write a textbook. The ultimate goal of continuing this topic as a Ph.D. dissertation remains unchanged; however, an entrepreneurial opportunity has presented itself.

Three requirements changed the context outcome during the course of study. The three requirements are: 1) define the market for the proposed textbook and identify areas of competitive advantage; 2) observe the student's reaction to and interest in the EMGT fundamentals and modify the lecture material to best teach EMGT fundamentals; and 3) seek ways of making money from the endeavor. The outcome of this study is a business plan written in preparation for writing future grant proposals.

Opportunity Identification

Successful manufacturing companies exhibit the ability to develop new products and processes quickly, cost-effectively, and with a high degree of customer or end-user satisfaction. In high-technology markets characterized by volatile product life cycles and low per-unit profit, determining key product features that yield the "best bang for the development dollar" is crucial to successful technology programs.

Surveys of industry show that new engineering graduates and entry-level engineers are considered only marginally prepared for new product design [1]. Is it enough to teach engineering students only analysis? In the past, companies have been willing to invest several years into entry-level engineer training. Decreasing product life cycles, increasing demands to maximize customer satisfaction per development dollar, and products combining mechanical, electrical, and software components are motivating companies to expect some design project experience from new engineering hires.

Companies tell the Accreditation Board for Engineering and Technology (ABET) that they desire new engineering graduates who have a demonstrated ability to solve complex technology problems using industry's best practices [2]. Companies seek new engineering graduates who can solve ill-defined problems, work effectively in cross-disciplinary organizations, and communicate both orally and in written form using management's language of time, cost, and performance.

Since the mid 1970s, improving engineering design through the PRP has been recognized as the single most essential step to increasing global competitiveness of U.S. manufacturing companies [2]. Because an organization is ultimately dependent on the quality of its employees,

improving an individual's design skills and PRP knowledge is key to increasing the competitiveness of manufacturing companies.

Generally speaking, undergraduate engineering design courses seek to provide students with a "real world" design experience and in doing so teach design methods and PRP. Teaching is, however, an individual effort, and the quality of engineering graduates varies from school to school. Typical engineering curricula focus on only a few conventional design procedures rather than on the entire PRP. Industry's efforts to teach engineering design tend to be fragmented, at best. ABET guidelines and the relatively small number of quality textbooks ensures only minimum standards.

To this end, an opportunity exists to provide engineering design educators with teaching materials that more effectively integrate engineering design and PRP into their curricula to graduate engineers who better meet the needs of industry. The outcome of this study suggests a "self-contained learning experience" case study is the best mechanism to effectively teach undergraduate engineering students design methods and PRP. Prototype lecture materials for engineering educators have been developed to effectively teach PRP and are included as an intranet-based "appendix."

Product Realization Process

The Product Realization Process is best conceptualized as a logical sequence of "best practices" used to design products and processes. Because entry-level engineers must work closely with experienced engineers and managers, PRP also encompasses good oral and written communication and teamwork skills. Because not every design problem requires the same solution, PRP is not a "one problem solving strategy fits all" design methodology. PRP should

be construed to mean the set of practices that is best for a particular company. It should also be noted that best practices are evolving continuously.

The PRP education philosophy is to expose students to design's best practices through an actual design project. Through the process of solving a design problem, students learn design, divergent-convergent thinking, decision making, teamwork, and communication skills to name but a few. The best practices taken from the Engineering Management curricula and presented as best practice lecture material to senior-level undergraduate mechanical and electrical engineering students are:

- Communications in organizations
- Decision making techniques
- Marketing strategies
- Motivational techniques and leadership principles
- Product/Project life cycle
- Project management concepts (time, cost, and performance goals)
- Scheduling practices (GANTT and CPM)
- Systems analysis

Business Plan

In 1985, Congress passed several legislative acts designed to "adopt and apply performance-improving technologies as needed to meet intensifying domestic and global competition in manufacturing" [3]. The outcome of this work, multimedia lecture materials and case studies, suggest that the partnership of a small business and universities have the potential to

secure such funding. Further, the long-term outcome has the potential to generate advertising and product sales revenue.

Rather than merely presenting the best practices used in this study, this report is written as a business plan and is divided in to five major sections. The first section, entitled "Design Methods Background," discusses the technical context of design methodology, PRP, and the underlying entrepreneurial motivation. The following three sections, entitled "Venture Activity Analysis," "Market Environment Analysis," and "Business System Plan," establish the business case, propose products and services, and outline a general plan of action to further develop the outcome of this study.

BACKGROUND

Entry-level engineers are often assigned projects which, to them, incorporate new or vaguely familiar design skills and practices. So where does this leave the engineer? First, design handbooks must be consulted for basic design theory, best practices, and rules of thumb. After gaining the necessary how-to experience, trade journals (magazines) and sales literature is studied for off-the-shelf solutions and to generate design alternatives. Once confident of a solvable conceptual design, the product is diligently developed.

Some experienced industry managers and supervisors argue that product background and design expertise can be learned only through years of practice [4]. Generally, senior design engineers can design complex parts in less time, with lower cost, and greater customer or end-user satisfaction than entry-level engineers can. The senior engineer's broader knowledge and familiarity with the Product Realization Process allows them to recognize similarities in known and proven sub-solutions of the overall design.

If this design paradigm is so, the entry-level engineer must spend less time physically producing the *best* design and more time investigating the possible design alternatives. The conventional approach is to automate the operations of analysis, drafting, simulation, and planning using CAD/CAM/CAPP software. While this approach reduces the time it takes to produce the final design, it does not ensure that the

senior design engineer may have a better design solution. Consequently, the conventional approach often exhibits large re-design cycles that lengthen the development schedule.

More can be done to ensure that the entry-level engineer's first design is also the *best* design solution. General knowledge of the Product Realization Process must be learned to function effectively in concurrent and simultaneous engineering environments. Management-oriented communication skills, i.e., the language of time, cost, and performance, must be learned to gain appropriate feedback throughout the project life cycle. Basic project scheduling and control must be learned to understand work assignments and responsibility in organizations.

Macroenvironment Considerations

According to a 1991 report by the National Research Council, many of the 381,000 manufacturing companies employing 500 or fewer workers are not using modern design methodologies and best practices [5]. The report cited difficulty in obtaining budgets, lack of in-house expertise, difficulty in finding unbiased advice, lack of awareness of changing technology and production techniques, isolation, and other constraints, as barriers to learning about and adopting modernization techniques. Perhaps more important, the rate of U.S. productivity increase is lower than that of industries in many other competing nations [6].

Global competition has caused the need for improved delivery time, reduced cost, shorter product lifecycles, increased organizational efficiency, and better quality products that satisfy customer wants and needs [2], [7], and [8]. Many experts correlate product

quality with market share and total life cycle cost [9], and [10]. However, it should be noted that successful firms utilize design methods tailored to their products and manufacturing strategy [11]. R. E. Gomory, a senior vice-president at IBM, states that foreign competition has been "educated on the relevant technologies, on the competition's products, and on what is going on in the world" [12, p. 11].

For all the above reasons, it is naive to believe that small manufacturing companies will spend the time and effort necessary to educate their design workforce on modern design methodologies and best practices. How will small manufacturing companies modernize? One modernization mechanism available to all companies is to hire new employees skilled in such modernization methods. Education is thus crucial to the U.S. manufacturer's global success.

Technical Context

Statistically, "more than 75% of American engineers and scientists eventually hold technical management positions," reports Bruce Baird [13, p. 4]. Robert Shannon adds, "such positions require new knowledge and skills that their previous professional training has not provided" [14, p. vii]. The graduate-level Engineering Management program is rich in modern design methodologies and best practices. Needless to say, companies who hire Engineering Management graduates will gain needed modernization methods.

The undergraduate-level Engineering program, however, lacks the focus and quality of coursework found in the Engineering Management program. Considering that far more undergraduate engineers enter the workforce than do graduate engineers,

undergraduate engineering education – particularly engineering design – is crucial to manufacturing modernization [15]. When all members of a design project work and communicate with a common language – the system developer's language of time, cost, and performance – and follow a common unifying set of best practices, the overall enterprise would function far superior to present practices.

Improving engineering design education is the key technical issue facing our profession [15] and [16]. The Accreditation Board for Engineering and Technology was established in the post world war II era to "strongly influence" undergraduate engineering content by establishing minimum standards. However, more can be done to improve the quality of undergraduate engineering design to best meet the needs of manufacturing companies. Specifically, the following engineering management concepts can be taught:

- Attention to marketing and sales [17]
- Certainty, risk, and uncertainty concepts. [18]
- Collaboration throughout organizations and teams [19] and [20]
- Communication skills [17] and [21]
- Competitive advantage [22] and [23]
- Competitor strategies and reactions [24]
- Concurrent and simultaneous engineering practices [25]
- Contingency viewpoint – what works best in what situation [26]
- Customer feedback regarding product performance [24]
- Customer wants and needs versus product design requirement [25] and [27]
- Decision making under when faced with incomplete and conflicting information [18]
- Distribution of the acquired information to the right people [28]

- Emphasis on marketing orientation [29]
- Emphasis on satisfying user-needs [21]
- Functions of management (planning, organizing, staffing, motivating, communicating, measuring, and correcting) [30, p. 15]
- Functional decomposition into smaller more manageable sub-problems [26]
- Issues of complexity, change, uncertainty, and unpredictability [26]
- Managing conflict [26]
- Market knowledge and strategy [17]
- Matrix methods and probability trees [18]
- Motivation of technological entrepreneurs [31]
- Organizational Behavior [26]
- Organizational goals (mission statements) [30]
- Organizational roles, structures, and practices [32]
- Organization theory (specializing activity, simplifying the tasks of management, grouping employees for the purpose of direction and control, providing formal channels of communication and coordination, encouraging the interaction of employees) [30, p. 67]
- Pairwise comparison methods [33]
- Planning and scheduling using GANTT and CPM charts [25]
- Process oriented [34]
- Product fit with internal functional strength [35]
- Project control concepts (cost, manpower, time, and need) [26] and [30, p. 29]

- Projects: people; attitude; organization; market [36]
- Product development cycle (planning, scheduling, budgeting, control, organization, communication, negotiation, documentation, resource acquisition and allocation, and distribution, support, maintenance, recycling, and disposal) [26, p. 94-5]
- Project management (planning, organizing, leadership, control, and change) [26, p. 21-2]
- Project planning (clarification of purpose, achievement of better communications, proper allocation of resources, establishment of a basis of control, advance recognition of problems, establishment of a basis for diagnosis, and avoidance of wasted or duplicated effort) [30, p. 36]
- Project roles, responsibility, and authority (integrator, communicator, decision maker, motivator, evangelist, entrepreneur, and change agent) [26, p. 172]
- Responsibility Interface matrix [37]
- Risk management [18]
- Strategic and technology planning [38]
- Strong external orientation [34]
- Strong interfaces with customers and suppliers [39]
- Strong market orientation [21]
- Systems approach to problem solving [26]
- Systems development cycle [26]
- Team approach [34]

- Team coordination (prioritize, share expectations, clarify purpose and objectives, and formulating operating guidelines) [26, p. 208]
- Test marketing results [24]
- Time as the equivalent of money, productivity, quality, and even innovation [40] and [41]
- Types of organizational structure [30]
- Understanding of user needs [17]
- Work Breakdown to simplify and define engineering tasks [42] and [43]

Product Realization Process

The Product Realization Process (PRP) – as proposed by Polya [44] and [45] – has been defined by Cooper as "*a formal blueprint, road map, template or thought process*" to be used by engineering educators to provide guidance about the thought process, as opposed to technical analysis, of design [46, p. 1]. It was the recommendation of the ASME Council on Education that engineering educators should understand and teach the PRP [1].

Many of the "Best Practices" require interdisciplinary efforts between engineering departments. Fifty-six different "Best Practices" were identified and classified into 5 broad categories [1, p. iv]: 1) Knowledge of the Product Realization Process, 2) PRP Team Skills, 3) Design Skills, 4) Analysis and Testing Skills, and 5) Manufacturing Skills. The PRP is outlined in the following list [1, p.4]. Industry's top 20 and academe's top 16 "Best Practices" for new graduates are italicized [1, p. iv and v]. The author has bolded the "Best Practices" presented in the Design Methods class.

Knowledge of Product Realization Process

- **Benchmarking**
- ***Concurrent Engineering***
- **Corporate Vision and Product Fit**
- **Business Functions (Marketing, Legal, etc.)**
- Industrial Design

PRP Team Skills

- **Project Management Skills**
- Budgeting
- **Project Risk Analysis**
- ***Design Reviews***
- Information Processing
- ***Communication***
- *Sketching/Drawing*
- **Leadership**
- **Conflict Management**
- ***Professional Ethics***
- ***Teams/Teamwork***

Design Skills

- **Competitive Analysis**
- ***Creative Thinking***
- **Tools for "Customer Centered" Design**
- Solid Modeling and Rapid Prototyping Systems
- ***Systems Perspective***
- ***Design for Assembly***
- **Design for Commonality-Platform**
- ***Design for Cost***
- **Design for Disassembly**
- **Design for Environment**
- **Design for Ergonomics (Human Factors)**
- ***Design for Manufacture***
- ***Design for Performance***
- ***Design for Reliability***
- ***Design for Safety***
- **Design for Service/Repair**
- *CAD Systems*
- *Geometric Tolerancing*

Analysis & Testing Skills

- Finite Element Analysis

- Design of Experiments
- ***Value Engineering***
- Mechatronics (Mechanisms and Controls)
- **Process Improvement Tools**
- Statistical Process Control
- Design Standards (e.g. UL, ASME)
- Testing Standards (e.g. ISO 9000)
- Product Testing
- Physical Testing
- Test Equipment
- *Application of Statistics*
- *Reliability*

Manufacturing Skills

- Materials Planning-Inventory
- **Total Quality Management**
- *Manufacturing Processes*
- Manufacturing Floor/Workcell Layout
- Robotics & Automated Assembly
- Computer Integrated Manufacturing
- Electro-mechanical Packaging

Observations and Recommendations

The aforementioned Engineering Management and PRP concepts were presented to senior-level undergraduate mechanical and electrical engineering students at Portland State University over a 5-year period. Several surveys were conducted at the end of each year, and the results were used to modify the content and presentation format of succeeding year's lectures. The 6th year lecture notes are presented in Appendix A, the prototype Cordless Screwdriver case study is presented in Appendix B, and class surveys are presented in Appendix C.

In general, only a small fraction of the students were receptive to "high-level" engineering management best practices such as team motivational techniques, organization theory, project roles, responsibility, and authority, risk management, and the like. At the undergraduate level, students are most interested in and anxious to work on a design project. So, the best method of presenting best practices was found (by trial and error) to be a hypertext/hyperlink-based case study implemented on the Internet.

The Cordless Screwdriver case study was developed to teach fundamental problem solving methods. (See Appendix B.) As the students follow the case study, they formally learn best practices from lecture and informally understand best practices as they work through the case study homework assignments. Because the case study is presented in electronic web browser format, best practices are accessed in multiple ways. That is, the same instructional material is accessible through the lecture notes, case study, problem solving flowchart, bibliography, search engine, and so on.

To the author's knowledge, this method of learning – using multiple hypertext/hyperlink accesses to design methodology and best practices – is unique and

original to industry and academia. However, recognition of the need to provide students with access to design resources dates back to the mid 1960s [47]. Recent studies by David Ullman of practicing mechanical and electrical engineers suggest that "design resources such as handbooks, textbooks, catalogs, trade journals, research journals, and company guidelines are generally useful only if close at hand (some say 'within reach') and if they deal specifically with the designer's current problem" [48, p. 173].

Engineering students and entry-level engineers, on the other hand, desire autonomy and resent "hand holding" during the design process. Design feedback and guidance must be a non-threatening resource available to the entry-level engineer. In this fashion, the student will use the resource as much as possible during the learning process.

The case study is only as effective as its supporting design materials. It has been observed that ill-defined and poorly supported cases studies cause the student to learn more about the technology used in the case (e.g., batteries, motors, gearboxes, etc.) than the best practices. The solution to this dilemma is to provide the student with a "self-contained learning experience" case study that provides all the necessary background materials. When the student does not have to "work," e.g., researching trade magazines, talking with experts, and so on, to solve the homework assignment, the student is more likely to recognize how best practices are applied to engineering design.

In summary, educational institutions cannot compete with business and industry in providing work experience. Therefore, this author recommends that an effective approach to teaching undergraduate engineering students design methodology and best practices is through an internet-based case study which simulates "real world" experiences. By supplying the students with everything they need to experience a design

project in a structured environment, a guided learning process is developed whereby successive learning and reinforcing activities (homework, team-based exercises, and class presentations) give students an understanding and appreciation for design methodology and best practices.

The following sections develop an Intranet product that allows educators to effectively teach design methodology and best practices. Furthermore, the results should also be a useful reference for practicing engineers and engineering managers.

VENTURE ACTIVITY ANALYSIS

The focus of this work is producing web content for technically oriented people working on new product or process design and development projects in a business environment. Such a product provides an information service to the design community presenting product and process modernization techniques, management and professional practices, and insight into the use of many other cross disciplinary best practices in the form of product-based case studies.

The goal of this work is to develop an internet-based tool for the Design Methods course taught at Portland State University. Various government and private grants for distribution and study at other educational institutions can support the work. However, the end result of this endeavor is a product that can be marketed and sold to the design community. This section develops the guiding product and venture context necessary to develop the product.

Products and Services

By focusing on developing "self-contained learning experience" case study materials for the Design Methods course, the student engineer works through a realistic case study, and in doing so learns about design methodologies and best practices. The case study comprises a combination of lectures, case studies, laboratory sessions, and small design projects to prepare students for undertaking comprehensive, open-ended

design projects. Primary emphasis is placed on design efforts that broaden the student's concept of engineering problem solving and technology project management.

Examples of systems, products, and processes are required to simulate a realistic new product and process design environment. Such examples teach students and entry-level engineers about new systems and technology, draw analogies from previously designed products and processes, and get inspiration for creating new designs. Entry-level engineers use this experiential knowledge when they solve unfamiliar problems. Experiential knowledge, according to Schank's theory of cognition, is an integrated problem solving method based on past situations or cases [48].

An entry-level engineer may design a new electronic circuit, for example, by synthesizing together several previously designed circuits that solve parts of the overall problem. This is referred to as case-based reasoning. Many commercial electronic components are specifically designed and marketed as building blocks for more complex circuits and devices. All engineering disciplines, including management and industrial design, use case-based reasoning during problem solving.

Because everybody thinks and reasons differently, presentation of experiential knowledge in case studies must be generic in form. The goal of presenting a case study is to enlighten the entry-level engineer about a particular solution or general solution method for a specific problem. A well developed case study also decomposes the problem through various functional levels of abstraction (methodology, system, part, component, and so oil) to discuss whatever questions tile Junior engineer wishes to explore during the design experience.

Case studies in Design Methods should focus on teaching design methodology rather than developing solvable engineering problems. If the class lesson involves scheduling, the case study should present scheduling concepts used in realistic engineering contexts. If the class lesson involves creativity, the case study should present realistic creative exercises. If the class lesson involves identifying the customer, the case study should present the tools that engineers use to identify customers.

Most important, the traditional case study used in Design Methods should not be "simplified" to teach design methodology. Rather, the case study should be made as realistic as possible. To provide the students with a realistic design experience, excerpts from handbooks, textbooks, catalogs, product advertisements, trade journals, research journals, company guidelines, and interviews with experts are collected and presented using a multimedia CD-ROM and web browser interface. Products used in the Cordless Screwdriver case study include:

- Battery
- Electrical Connectors
- Speed Control (mechanical switch, electronics, sensors, etc.)
- Electric Motor
- Speed Reducer (gears, gearbox, lubricants, etc.)
- Bearings
- Production Equipment (electrical test, mechanical test, assembly tools, etc.)

The following list summarizes the resources available to practicing engineers, and the materials necessary to provide a realistic case study:

- Collaborative filtering to capture conventional wisdom [49]

- Company Guidelines
- Creativity Exercises
- Design Engineering Methodology
- Design Equations & Rules-of-Thumb
- Engineering Thesaurus (with Pictures)
- Handbooks
- Hands-on Multimedia Lectures
- Industry's Best Practices
- Interviews with Experts (Videos)
- Journals and Trade Magazines
- Product Advertisements
- Product Catalogs
- Professional Topics and Personal Growth
- Textbooks

The following list summarizes potential sources for the above mentioned materials:

- Company Product Catalogs and Advertisements
- Consultants
- Educators
- Expert Engineers and Managers
- Magazines and Trade Journals
- News Media and Publishers

- Societies and Other Non-Profit Organizations

Revenue Generation

Several sources of revenue are available to continue this work. The primary source of education-directed funding is through government and institutional grants [50]. Few educational projects lend themselves to corporate advertising as a source of revenue. Product advertising is a major component of an engineer's environment, and this work seeks to provide a "realistic" design experience. Thus a potential and perhaps major source of revenue is product advertisement in support of the case study topic (outlined above).

It is expected that companies will not see the immediate benefits of advertising their products and services to engineering students. (Perhaps, engineering educators will not see the benefits either?) So, the initial developmental source of revenue should be grant based. The following list outlines all possible sources of revenue over the development period of the product life cycle:

Grants (years 1 through 4)

- Developmental
- Collaboration Profiles

Personal Intranet (years 2 through 4)

- Internet "Bounce" Royalty Payments
- Product Advertisement

- Unit Sales from Multimedia CD-ROM

Subscription Internet Site (years 3 through 4)

- Electronic-Mail Reply Royalty Payments
- Individual and Corporate Subscription Fees
- Product Advertisement
- Secure Chat Rooms, Newsgroups, and Peer Groups

Fee-for-Service (year 4)

- Design Experts and Consultants
- Lectures
- Profiling-Based Suggestions
- Technical Searches
- White Papers
- Workshops

The case study product will utilize several broad classes of ways to make money: advertising, fees, transactions, and grants. By combining multiple sources of income in a flexible business model, the project is less likely to suffer from lack of funding during periods of development and competition. Advertisers provide a stable source of income.

Fees may be charged to provide content and consumable services to attract and keep core subscribers. Consulting-Based transactions have the potential to generate considerable revenue.

Since the underlying goal of this service is to educate the engineering community, grant funding is an appropriate method to build resources and "critical mass" to attract advertising sources and customers.

Advertising Sources

Product-Based "how-to" case studies reference company products. Advertising includes passive push-based content, active "click-throughs," directly embedded products in case studies and indirect forms such as e-mail. Although content is "free," users are profiled to learn about discipline-specific interests. Such information is sold back to advertisers or used in (fee-based) "group-think" profiling services to assist, improve creativity, and shorten the design cycle time.

Attracting long-term users and consequently long-term advertisers requires a substantial base of case study material. Fortunately, staple products found in motion control, mechanical drives, electrical and electronic systems, and hydraulic and pneumatic power systems provide plenty of available start-up material.

Syndication

Add syndicated content to license content for a flat fee or split the advertising space and page views. Content aggregators, such as trade magazine like Cahners Publishing and Penton Publishing, must be considered as another vehicle for distributing the case study product.

Fee Structures

Fees are generated through subscriptions to one or all of the following: advanced case studies, in-depth system profiles, engineering and technical management information, new idea resources, news, white papers, lectures, workshops, e-mail, searches, entertainment and creativity games, secure discipline-based peer groups and chat rooms, and personal growth and professional issues. Alternative methods of generating revenue include supplemental reading materials such as periodicals and books, and intranet-based sites.

Perhaps a lucrative market exists for customizing information services to corporate clients. Customized subscription services to corporate users for appropriate "look and feel," control of content, and employee time tracking. Certainly, some corporate users would desire to keep in-house information confidential; thus, a fee would be charged for the service of developing case studies.

Transaction Services

Aside from educating via case studies, direct consulting provides cross-disciplinary expertise to individuals and companies. In-house experts who develop case-study material answer general "bulletin-board" problems. Contract engineers tackle longer-term problems in-depth. Many engineers, this author included, feel that "information" should be free. However, these same engineers believe it fair to pay for another engineer's expertise in answering a specific question.

Government Funding (Large-Scale Collaboration)

Finally, obtaining funding through partnership and interaction among industries, universities, and government is possible. For example, a 21-month DARPA (Defense Advanced Research Projects Agency) funded joint project among two companies, a research institute, and multiple universities to develop a multimedia processor over the Internet.

National Institute of Science and Technology (NIST) Grants and Awards Programs include the Advanced Technology Program (ATP), the Small Business Innovation Research program (SBIR), and other Grant programs. ATP provides multi-year, co-funding for high-risk, high-payoff civilian technology development by individual companies. The SBIR programs provide funding for research and development efforts that fall within areas recommended by the US Department of Commerce. Appendix D contains several applicable SBIR funding topics that one or more grant proposals the can be applied for. Possible funding sources include:

- Technology Reinvestment Program (TRP)
- National Science Foundation (NSF)
- Small Business Initiatives for Research (SBIR)
- National Institute of Standards (NIST)
- Department of Defense's Advanced Research Projects Agency (DARPA)
- Department of Energy (DOE)
- Department of Commerce (DOC)

Promotion and Distribution

For this work, Product promotion during the development phase will be achieved through participation "awards" in grant-based research and free distribution of CD-ROMs to students. Getting engineering educators to buy-in to new teaching methods is typically difficult; therefore, monetary incentive is crucial to initial adoption. Once some engineering educators formally adopt the products to their courses, direct advertising (personal selling) will be required to motivate all 412 universities to use the product. Finally, given the relatively large number of new engineers that graduates nationally each year, only word-of-mouth referral and a strong Internet presence is necessary to generate over-the-counter product sales.

The most effective distribution platform to support a multimedia-based case study is through the publishing tools and browsers available for the Internet. Internet or world-wide-web technology is mature from the standpoint of content development and management, publishing tools, and structuring group collaboration and communications. Several methods exist to deliver content using computer technology: CD-ROM disks, Internet, Extranet, and Intranet. Detailed survey information is presented in Appendix E.

CD-ROM Delivery

Internet content may be delivered using CD-ROM media, thus allowing unit sales revenue. This practice is called Intranet web browsing. Intranets, using CD-ROM technology as opposed to the world-wide-web, ensure that users have reliable and speedy access (T-1 like connection speed) on their desktop. This characteristic is important to the usability of multimedia-based content. Further, Intranet delivery is key to product

personalization (discussed in the following section). In general, there is no difference between CD-ROM content and Internet content.

Internet Delivery

The Internet, also called the world-wide web (www), has found its way into the homes, offices, and educational facilities of millions of potential users. In addition, the www promotes on-line commerce, electronic banking, trading securities, selling products and services, and customer surveys. The www is an ideal medium to deliver the following:

- Entertainment
- How-To
- New Ideas
- News
- Product Advertisement
- Product Support
- Purchasing & Inventory Tracking
- Systems
- Technical Information
- White Papers

The www is also bringing engineers and scientists together through common open forums and powerful search engines that contain URL addresses of millions of points of presence. Such mechanisms allow for organize and structure of information to enable the technical professional to work in ways that were never before possible.

However, it's often difficult to find meaningful data on the internet. Using a search engine can yield several hundred possible URL addresses that match the query. The www is a smattering of all sorts of information. Some information is useful. Some information is not useful. Some information is marketing propaganda – manufacturers often discuss only technology the manufacturer has to sell and do not present thorough unbiased viewpoints. How does the engineer obtain unbiased design advice? As a matter of course, the engineer must review many sites to obtain solutions. This is a time consuming and expensive process.

The savvy engineer uses a web-bot or other intelligent search engine to find specific content. Unfortunately, a web-bot is a background tool and does not produce results for several minutes and even hours. Thus, the quality of the search is dependent on the quality of the search parameters. Using a web-bot can result in long itterative sessions.

Internet bandwidth issues are a temporary problem because technology exists to send data at terra-bit per second rates. The biggest problem is packaging content – how to personalize content so it attracts the appropriate users. The Content Definition Format (CDF) is one method to index web content for different users. The CDF separates web site structure from presentation and content form.

Extranet

The Extranet acts as bridge for online business relationships. Company-to-companies communication is facilitated through an organized network that allows for

communication and data exchange over a secure network. The Extranet gives specific customers access to confidential information such as shipments and inventory holdings.

Intranet

The definition of an Intranet is a private Internet – an organization-wide web. The business Intranet can connect every person, every document, and every application in an organization. The Intranet has dramatically change the way companies internally communicate. Intranets give every employee complete access to mission-critical information. Many businesses make their best practices available to give employees answers and help them do their jobs better.

Because the business Intranet often contains trade secrets and other mission sensitive information, many companies elect to use only Intranet technology and deny users access to the Internet. Such companies copy, called web theft, thousands of megabytes of content to their Intranet. The danger in developing an Intranet is that the developers can loose site of the ultimate goal – to be profitable.

Because the majority of Internet content is generated by private individuals and businesses as opposed to libraries and permanent government institutions, many engineers are worried that mission-critical content is temporary and will someday "disappear." Out of fear, many individuals and often businesses web theft entire sites to their local hard disk. Other reasons for web theft include the need to comment on, called personalization, an article or other information they've found on the Internet.

Finally, the Intranet extends the design team via network based collaboration. Intranet based design, like concurrent and simultaneous engineering, promises to slash

time to market, increase product quality, and reduce costs. Using the standardized HTML browser - allowing access regardless of hardware platform or software - teams can transfer technical specifications, design images, project-management, and financial data to extended team members.

MARKET ENVIRONMENT ANALYSIS

Small and medium-sized manufacturing companies account for more than 98% of U.S. manufacturers, employ approximately 12 million people, and contribute 20% of the nation's Gross Domestic Product [5] and [6]. Such manufacturers also comprise much of the supplier base for larger manufacturers. In general, manufacturing accounts for one-fifth of the U.S. gross national product over the past 40 years [5].

In previous sections, a case was made to present engineering students and to a lesser extent entry-level engineers with an adequate learning environment. This section analyses the market for the case study product

Markets

One of the biggest hardware and software growth areas in the secondary computer market is the business Intranet. An Intranet is basically a Private Internet available only to those within an organization. An Intranet can be as simple as a single computer using a CD-ROM collection. The typical Intranet is a networking together of at least 2 computers to share database files, printers, fax/modems, Internet access, and other common resources.

Unlike the Internet, an Intranet is a private collection of resources for use solely by the owner. The greatest difference is that Intranets offer a higher level of security through firewalls and passwords. While an Intranet may be connected to the Internet,

outsiders are prohibited access by means of a software firewall. Firewall products to prevent intellectual piracy will constitute a large segment of Intranet software growth.

Businesses large and small, universities, and even some home offices are starting to build intranet-based databases. The common tool enabling this repository of knowledge is the web browser. Means that anyone using a popular desktop computer can access internal information quickly and easily using the same familiar tools as the Internet. Learning curves are minimized and effectiveness is maximized. The benefits of owning an Intranet are:

- Ability to change and append content
- Cost effective
- Efficient information delivery
- Easy to manage
- Easy to set up
- Easily updated
- Great for company email
- Instant access to databases
- Integrates multimedia
- Make research interactive
- Minimal security issues
- Platform independent
- Publish confidential matter
- Publish trade secrets
- Set up and maintain calendars

- 24 hour access to information
- Unlimited exposure potential
- Users develop content
- Update information quickly

When employees document and share their knowledge and skills, collaboration increases, functional boundaries fall, product development time decreases and interdisciplinary and cross-company collaboration increases. Even small companies who have frequent hallway meetings can communicate and collaborate more effectively if their ideas are documented. The Intranet provides the tools and information needed to make smarter design decisions, enhance expertise and build state-of-the-art designs.

Why adopt the Intranet strategy?

Principally, let technology drive strategy. Bandwidth issues limit productivity on the Internet. Finding useful information on the Internet is difficult. Security and administration issues slow the adoption of "open" Internet environments. It is difficult to compete with the Giants such as Microsoft and Netscape to produce comparable software products. A talent shortfall causes information technology or it departments to hold off implement in Internet infrastructure or presence.

Intranets are an ideal mechanism to add value in a unique way: interactive advertisements are placed into the product. Advertisements differentiate the case study product from all other educational materials in the market today. Such a product is intentionally sold with ads and links to commercial web sites. In particular, the

interstitial ad – the advertising message that appears after a page of information is requested and before the page arrives – is a lucrative method of generating revenue.

The Approach

The best approach to Intranet development is finding a project where people have to work sequentially and have trouble making meetings. In such a situation, they start with existing content and model their efforts on what they see. Especially target small companies and individuals that can not afford the time and resources to build an Internet infrastructure or presence. Employees of small companies are also more specialized and thus companies have a higher liability that critical information will leave.

The customer wants the proven system. Doesn't want the R&D project that may or may not deliver. On target time, cost, performance. Development equals time and money. Utilize the Intranet to decrease development time and maintain project control through implementation of best practices.

Intranets Need Customization Capability

Best practice information can come from a variety of sources. But if it can not then be easily modified or customized, it is of little use to companies who strive for the "learning organization." Further, engineers need buy-in or market share of a product to motivate them to use it. Customization using Intranet technology is one such motivational mechanism for the case study product.

Competitive Advantage

The business Intranet represents a very common, low risk-of-ownership, rapid growth market segment. In the next 4 years, the Intranet market will gain millions of potential end users. By using existing technology developed for Internet applications, significant development advantage is leveraged. It is advantageous to develop the case study product as an Intranet-based multimedia CD-ROM to facilitate adoption.

The case study product, a CD-ROM and Intranet site, contains images, applications, movies, animation, interstitial advertisements, and so on with text content and coordination information coming from web site that constantly changes. The case study product will thus not face competition from traditional textbooks used in educational environments. Key product attributes or features that customers desire and thus define market segments are:

- Cross-Disciplinary Design Best Practices – communication, design methodology, functional decomposition, technology projects, systems approach, specification development, quality function deployment, conceptual design & evaluation, creativity, DFX, product realization, design integration, project life cycle, and general answers and rules-of-thumb to common design questions
- Examples of Case Studies
- Guide to Technology – electrical, mechanical, fluids, etc.
- Indexes
- Multiple Ways to Enter Content
- Pictorial Thesaurus
- Search Engines

- Simple Entry Methods
- Source of Design Ideas

Gap Analysis

Four general areas exist to compete in or deliver the product through. These areas are hardware, software, service, and content. Both hardware and software markets are dominated by large, well-funded corporations. Hence, is not feasible to propose to enter such markets. The service market is less defined and open to new ventures. The current saying is: "Content is king." The market for content is undefined and very open to both small and large ventures. This subsection discusses the market arenas for viable entry paths to produce content.

Why would potential advertisers and individuals pay to support the product if it is available for free on the Internet? This obvious question is answered through a Gap Analysis of seventeen general types of service and content providers exist for web applications, outlined as follows. The following subsection summarizes compelling reasons to support the continuation of this endeavor. Detailed survey information is presented in Appendix E.

1. Pre-Packaged Intranet Applications
2. CD-ROM Delivered Products
3. Collaboration Software
4. Internet Subscription Services
5. Groupware
6. Site Management Tools

7. Installed Intranet Interfaces

8. Managed Sites

9. Government Sites

10. For-Profit Sites

11. Non-Profit Sites

12. Educational Sites

13. Home Sites

14. List Servers

15. Manufacturers Distributors

16. Information Publishing Server

17.Web Content Theft

Pre-Packaged Intranet Applications and Site Management Tools

"Instant Intranet Kits" contain sample databases, technical support, HTML development books, on-line catalog, internet database, and web site toolkits. Toolkits supply web development drivers, server software, JAVA developers kit, IE, CGI libraries, and support utilities. Intranet kits run in about an hour and are one of the most affordable business networking solutions available.

Such intranet kits and management tools purchase web content and re-package it for their own purpose. Hence, a well-developed case study product could be sold. At present, there is no threat of competition.

CD-ROM Delivered Products

Software tool that generates new concepts and recommendations for resolving engineering problems are rare but do exist. Most products allow browsers to view and search for almost any document without standardizing on one platform. Other products work as:

- Application notes
- Data storage and management
- Data retrieval
- Data Acquisition
- Design white papers.
- Demonstration programs
- Online catalog
- Product data sheets
- Product selection tables and programs
- Publishing tools
- Reference Manual
- Technical support reference
- User solutions

Potentially, engineering educators could build a realistic case study using several CD-ROM products from other vendors. The drawback to this approach is the volume of physical CD-ROMs needed to service every student. Without doubt, several for-profit intermediary businesses would start-up to facilitate this service. Thus, this venture should seek to capture this market.

Collaboration Software and Groupware

The Intranet represents the next big arena of collaborative computing. The goals of such collaboration include the following:

- Evaluate products on a pre-release basis
- Give industry a "heads up" on trends and problems
- Help to select hot products
- Share knowledge and experience, best practices, standards, recommendations, and lessons learned
- Share vision of how the Internet could be used to enhance design methodology
- Tell others about the type of design performed
- Tell others what tools are being investigated

The danger of collaboration is shared content and loss of unit sales. The target market should be students and entry-level engineers who are not in an environment that necessitates collaboration.

Internet Subscription Services

Push content and advertisements to employees through e-mail messages and GUIs. Many engineers consider this practice "annoying," however. Thus, such a service should be optional and based on user requests. This approach negates the threat of similar competitive products, represents a well-targeted user base, and would demand considerable advertisement revenue.

Installed Intranet Interfaces

Interface sites come with an GUI that replaces your browser but allows customization to see only content such as news, new products, and so on, which meet pre-defined filters. The interface also accesses a CD-ROM containing a supplier's directory with product data sheets and application notes. Many interface sites contain magazine-like content:

- Associations
- Buyer's Guide
- Community Forums
- Feature Articles
- Industry Surveys
- Job Information
- Latest News
- Market Intelligence
- New Products
- Roundtables with Industry Experts
- Search Tools
- Tradeshow

For example, EE Times www magazine is a "one-stop" source for:

- Advertisement:
- App Notes
- Case Histories
- Columns, Techwire, EE Times, Online, EBN Online, Asia-Pacific News, PR Channel

- "Cool Stuff"
- Demos
- Design Solutions: Application Notes, Best Practices, Standards Watch, Vendor Tools, Shareware, Directories, Information Partners
- Data Sheets
- Direct Links
- Directories
- Newsletters
- Event Calendar
- Evaluation Kits
- Forums
- New Products: IC Selector ($)
- News: Daily Web Updates
- News Briefs
- Patches
- Press Releases
- Shareware
- Solutions
- Sponsors
- Standards Watch
- Support Tools
- Tools
- Tutorials

- Utilities
- Web Site Updates
- Yellow Pages

The greatest threat to the case study product is the ready availability of design materials available for free over the Internet. Many sites, such as EE-Times, do a very good job of providing significant and well-structured content. It would be very costly to compete directly with such publishing giants. Thus, niche applications are warranted. On the other hand, such Internet sites often purchase web content and re-package it for their own purpose. Hence, a well-developed case study product could be sold.

One principal advantage of the case study product is that it entails considerable detailed study into a specific technical topic such as the Cordless Screwdriver. The mission of the Internet providers is "To be the best one stop information source." So, focusing efforts on technical detail and completeness should be paramount to bar entry from large competitors and to secure use from engineering educators who need to maximize their students study time.

Managed Sites

Managed sites comprise personal and businesses endeavors into the Internet. Such sites offer electronic commerce, products, tools, training, and support, general product and technology information, reviews and evaluation guides, service packs, training materials, feature articles, and drivers and patches. In general, there are hundreds of managed sites containing competitive content. Engineering educators, however, avoid requiring students to "surf the web" as a course requirement due to the

time required locating appropriate content. Opportunity exists to capture the market in indexing managed site context for case study products. No market entrants are known at this time.

Government Sites

The Manufacturing Extension Partnership, for example, contains a compilation of success stories about center projects. Sites such as the National Science Foundation (NSF) and the National Research Council (NRC) are candidates for hosting case study products. The need to include advertisements to provide a realistic design experience in the case study product precludes entry of competitive government sites. Such sites are not a potential market threat.

For-Profit Sites

Many companies now advertise and sell products directly form the web. Publishers, for example, put portions of books (teasers) on the web to sell books. The number of new for-profit entrants grows every year. This is a for-profit venture. Hence, direct competition after establishing a viable product should be expected. Competitive advantage must be gained through early adoption and placing emphasis on the amount of work involved to produce the case study product.

Non-Profit Sites

Many non-profit sites contain hundreds of annotated links to other sites. Other sites are established as forums of communication to help engineers find answers to

technical questions. Many non-profit organizations, such as the American Society of Mechanical Engineers (ASME), have and are presently developing case studies. The need to include advertisements to provide a realistic design experience in the case study product precludes entry of competitive government sites. Such sites are not a potential market threat.

Educational Sites

Many universities and institutions are publishing course information on the web. Direct competition from engineering educators should be expected. Competitive advantage must be gained through early adoption and placing emphasis on the amount of work involved to produce the case study product.

Home Sites

Many people publish their personal views on the Internet. Such content is generally avoided because of lack of credibility. There exists no direct competition from home sites.

List Servers

Many companies find that list servers are a good and inexpensive way to start sharing information across functional groups. List servers facilitate access to existing content. Implementing a list service as an "Internet bounce" from a CD-ROM initiated inquirer is a very accountable mechanism of generating revenue. An added benefit is that CD-ROM users do not have to maintain URL addresses that often change. There is no

direct threat form list servers. The case study product should incorporate a list server site.

Manufacturers Distributors

Electronic catalogs from IC Master, Digikey, PetroConnect, Wiznet, Industry-Net, and so on are available, but generally do not replace the "physical" distributor. Rather, globally based Manufacturers Distributors should be counted as a potential source of revenue.

Information Publishing Server

Publishing services allows users to organize their business Intranet. Such services often purchase web content and re-package it for their own purpose. Hence, a well-developed case study product could be sold. At present, there is no threat of competition.

Macroenvironment

When developing a case study product, one can get lost in the production and multimedia tools. The real measure of success is in how well it impacts the education of entry-level engineers and in a general way corporate culture.

In the boundaryless workplace – especially important in new product development where products are developed by functional groups often separated by physical or cultural distances – cross-company collaboration is impeded by fear of giving away competitive secrets. Often, business groups compete against themselves and no one trusts each other. Releasing the product as an Intranet (modified by the user) does not

not resolve collaboration fears. However, the product should contain literature espousing the benefits of collaboration.

Collaborative filtering maintains statistical data about how users access the information they desire. The statistical data is then used to assist other engineers in locating and suggest information they need. Research into collaboration and collaborative filtering has the potential to create spin-off projects and alternative sources of funding.

Finally, the entire project is subject to web theft. Because the product is delivered electronically, unlike a book, is it very easy to copy. If a user copies some or all of the content to the Internet, revenue from unit sales will be lost. Fortunately, images may be "watermarked" with copyright signatures and intelligent agents and robots, known as web-bots and web crawlers, spiders, and worms can actively search through every page on the Internet for unauthorized content. Such tools automate the task of copyright enforcement.

BUSINESS SYSTEM PLAN

The mission of the Product Design Intranet is to create a forum for documentation, communication, collaboration, and management of technology projects and to create useful content for business and personal Intranets to improve the quality of product development through multimedia-based communication. Useful content is technical documentation of engineering technology relating to products and practices used in the design methods. The mission is satisfied through the context of the following statement and is developed as a business plan in this section.

Mission Statement

1. Generate Income To Make A Profit – Facilitate product development through advertising of relevant technology, studies of product use to improve content delivery, and technology transfer through direct sales of the product.
2. Inform and Educate Consumers About Technology and Best Practices – Provide a forum and useful content for business, education, and personal users as a marketable product (to satisfy the first objective).
3. Provide A Collaboration Mechanism For Personal or Intranet Use – Allow users to add, append, and change content using pre-defined, structured forms and content scripts, and provide an automatic mechanism to disseminate such content across teams and

organizations (to satisfy the second objective) using common tools based on Internet technology.

Strategic Orientation

The overall business orientation is characterized as a "rapid growth, low-cost provider of high quality design methods and industry-accepted best practices." In general, focus on needed educational services that universities and the private sector cannot develop on their own. As a business entity, forge constructive working relationships with universities, private consultants, federal laboratories, and other non-profit institutions to develop the case study product.

MOGSA Hierarchy

In addition to the mission statement, a plan of action is outlined to develop the case study product. This plan is conceptualized using the MOGSA hierarchy of organizational purpose. The MOGSA hierarchy for this venture is functionally broken into three independent topics comprising the mission statement. Figures 1 through 3 visualize the MOGSA hierarchy described below. MOGSA entails the following:

- Mission – What business are we in? Who is the customer? What roles do they play?
- Objective – Directions to follow to fulfill mission requirements
- Goals – Targets and benchmarks established to reach goals
- Strategies – Pathways developed to reach goals
- Actions – How and where do we allocate resources to support strategies

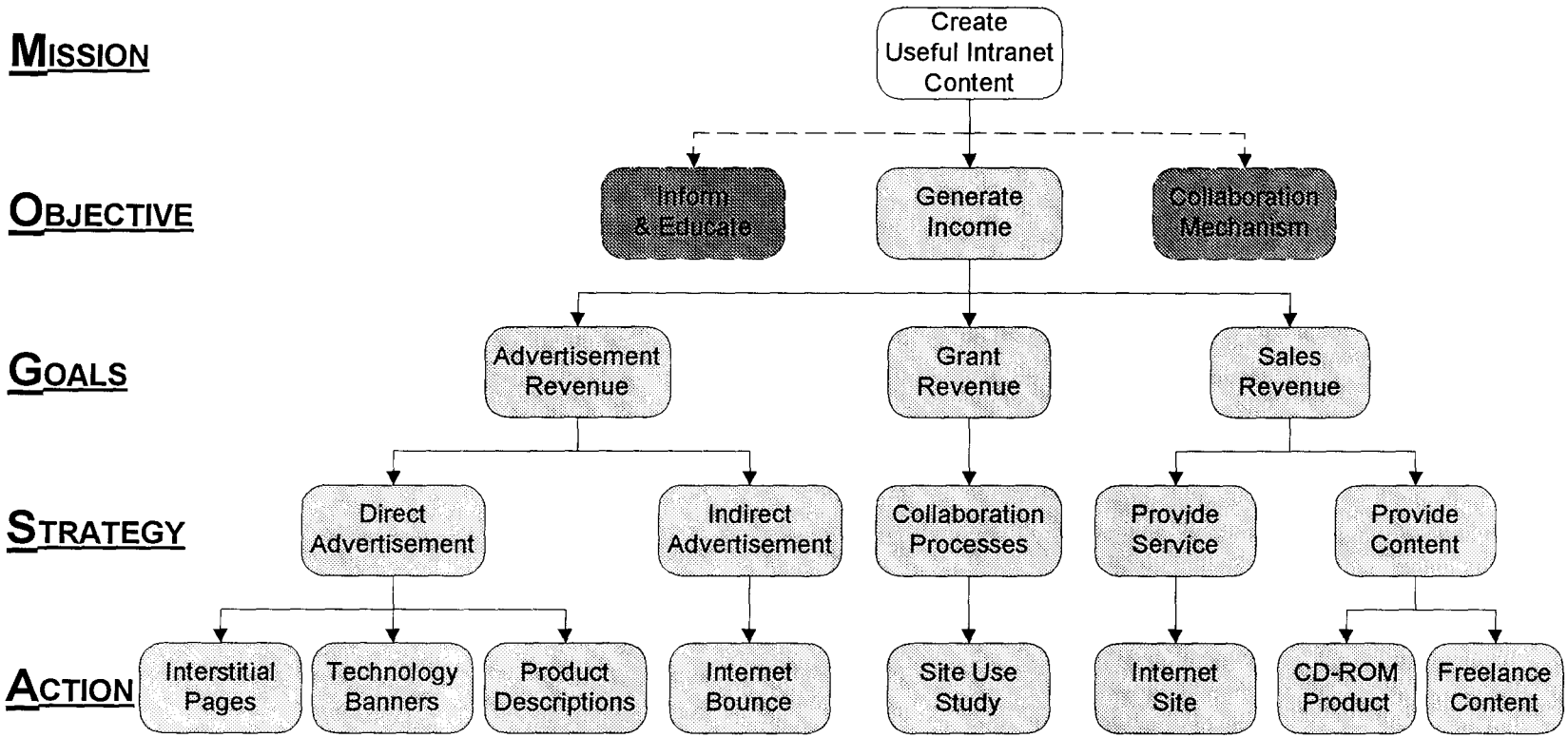

Figure 1. MOGSA Hierarchy for Income Generation Objective.

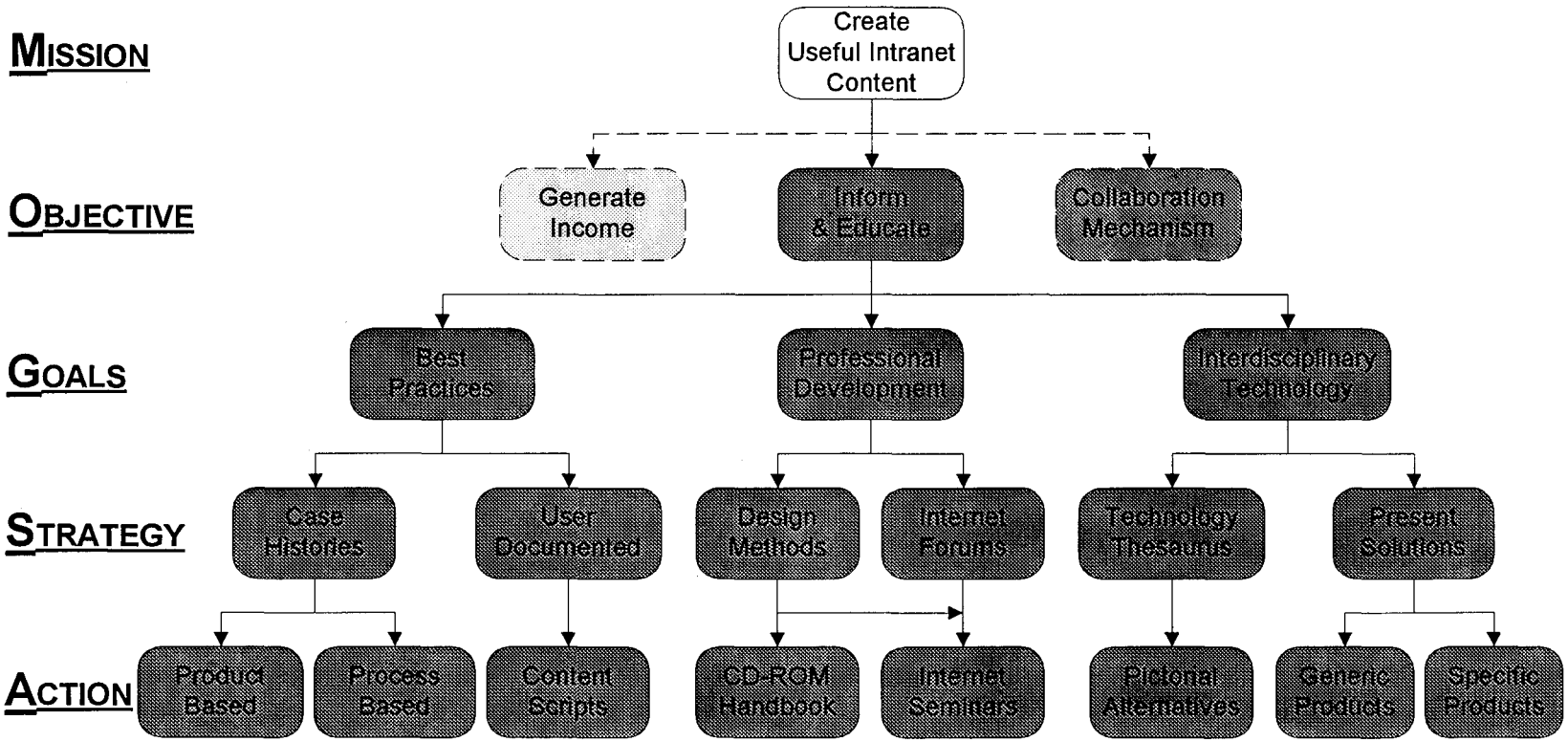

Figure 2. MOGSA Hierarchy for Inform & Educate Objective.

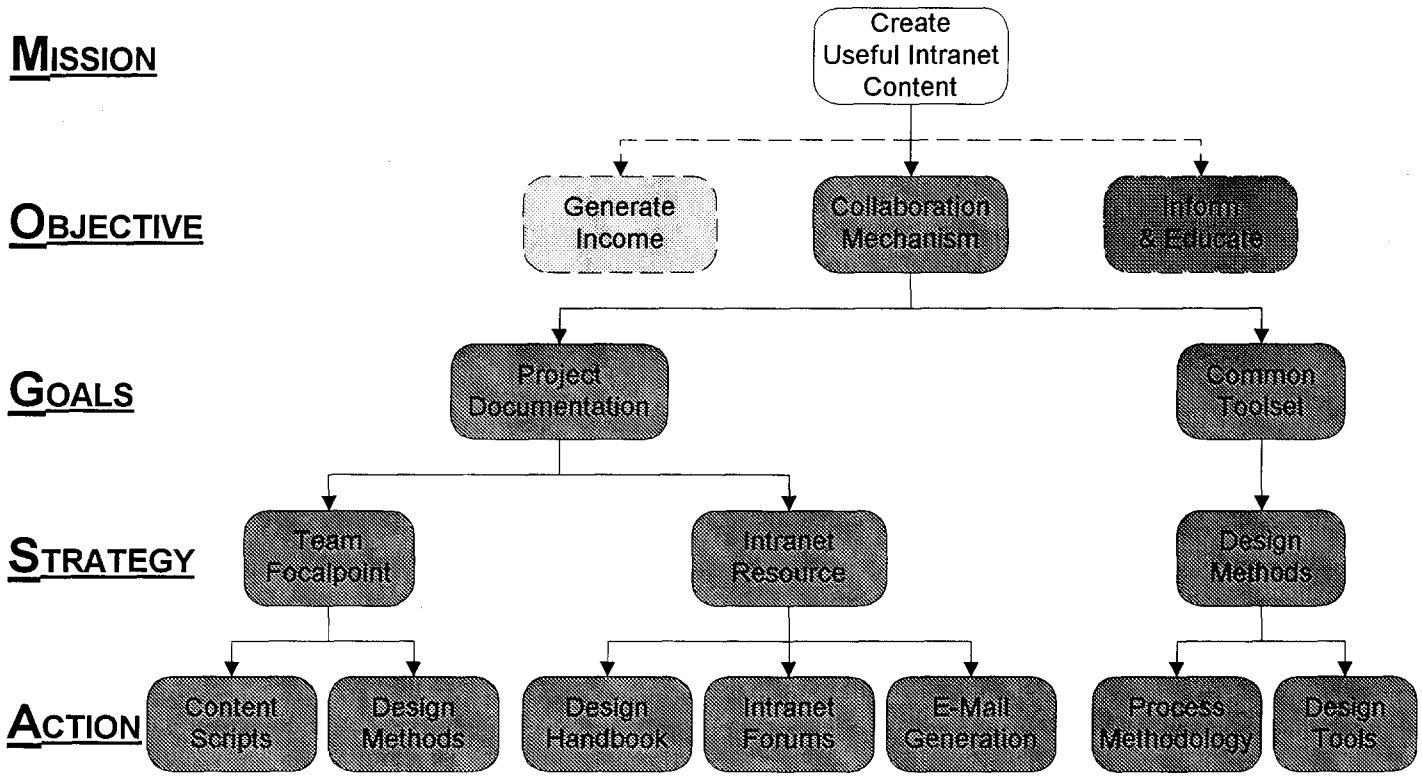

Figure 3. MOGSA Hierarchy for Collaboration Mechanism Objective.

Generation of Income

Three potential sources of income were outlined in the preceding sections as advertisement revenue, grant revenue, and sales revenue. Several strategies must be put forth to achieve these goals. First, obtain direct advertisement revenue in the form of interstitial ads, technology barriers, and product descriptions. Indirect advertisement revenue is generated from Internet bounce presence. Grant revenue is obtained by writing small business, university, and industry collaborative proposals that study the impact of the case study project on engineering graduates. Finally, sales revenue is obtained through the over-the-counter sales of CD-ROM products, developed content, and subscriptions to Internet site services.

Inform & Educate

Three general goals for content development were outlined in the preceding sections as design methodology and best practices, professional development issues, and the use of interdisciplinary technology. Several strategies must be put forth to achieve these goals. First, product and process-based case histories as well as appropriate user documentation must be developed to support design methodology and best practices. Content must be put in web-ready form and discussion materials (homework) must be well-developed to allow students and entry-level engineers a means of learning (professional development). Finally, methods of multiple access to content, such as a pictorial thesaurus and generic and specific product component solutions, must be developed to facilitate learning of interdisciplinary technology.

Collaboration Mechanisms

Two general goals for collaboration mechanisms were outlined in the preceding sections as personal and business customization of content (project documentation) and providing a common set of design methods and best practices (toolset) used to design products and processes. Several strategies must be put forth to achieve these goals. First, active JAVA scripts must be developed and embedded into content pages to provide a focalpoint for customization and project documentation. Resources such as design handbooks must be written or purchased. Internet forums and e-mail "newsletters" must be devised and refined. Finally, the PRP, design methodology, and best practices must be developed into applicable web pages – the content.

Action Items (Schedule)

The following chronology of action items, developed from the MOGSA hierarchy, satisfy the mission statement. Action item #1, a quarterly newsletter to communicate experiences that engineering programs have had in developing and conducting design courses, is already in progress.

Year 1

Action Item #1: Publish a quarterly newsletter.

Action Item #2: Apply for several grants.

Action Item #3: Develop the case study Intranet multimedia CD-ROM.

Action Item #4: Obtain no-cost advertising from manufacturers and distributors.

Action Item #5: Use the CD-ROM in the '98-'99 school year at PSU.

Action Item #6: Hire outside consultants to add content.

Action Item #7: Hire support staff (secretary)

Action Item #8: Establish Internet web presence and infrastructure

Year 2

Action Item #1: Request proposals from university partners to use multimedia CD-ROM.

Action Item #2: Select, train, and fund participants.

Action Item #3: Develop the case study Intranet multimedia CD-ROM.

Action Item #4: Obtain no-cost advertising from manufacturers and distributors.

Action Item #5: Hire outside consultants to add content.

Action Item #6: Use the CD-ROM in the '99-'00 school year at several universities.

Action Item #7: Hire support and development staff

Action Item #8: Develop Internet web site

Year 3

Action Item #1: Review use of the case study by university partners.

Action Item #2: Obtain advertising revenue from manufacturers and distributors.

Action Item #3: Develop Internet web site

Action Item #4: Develop the case study Intranet multimedia CD-ROM.

Action Item #5: Hire outside consultants to add content.

Action Item #6: Use the CD-ROM in the '99-'00 school year at several universities.

Action Item #7: Sell CD-ROM to general public.

Action Item #8: Hire support, development, and sales staff

Year 4

Action Item #1: Deliver case study Intranet CD-ROM to 412 universities.

Action Item #2: Assess interest in developed content (IPO, acquisition, or liquidation)

Action Item #3: Sell CD-ROM to general public.

Action Item #4: Obtain advertising revenue from manufacturers and distributors.

Action Item #5: Develop Internet web site

Action Item #6: Develop the case study Intranet multimedia CD-ROM.

Action Item #7: Hire outside consultants to add content.

Action Item #8: Hire support, development, sales, and marketing staff

Organization

Implementing the above chronology of action items requires establishing a small business. The business will rely on private consultants, industry experts, and university instructors to generate much of the case study content. So, the business need only have a small staff during its first year. A small 5-person team comprising a President, Comptroller/CPA, Secretary, Web Administrator, and Development Supervisor would be most efficient. Successive development years would see the addition of Marketing, Sales, and additional support staff. In general, heavy reliance on outsourcing to develop content will keep the business lean and relatively flat.

Financial Section

The operating budget is presented in this subsection. It was developed to support a one-year grant proposal. Because a grant is basically a "window of opportunity," pro forma sales and income projections, statements of cash flow, and balance sheets must be determined at the time of application and directed towards the specific outcome/purpose of the grant. The goal of this subsection is to identify and outline operating expenses, development expenses, and general administrative expenses and establish targets and goals for discussion.

Operating Expenses

- Promotion (PR) – $1,500
- Travel – $10,000
- Remote Conferences – $5,000

Development Expenses

- Consulting (2 man years) – $150,000
- 35 Partner Grants – $350,000
- Hardware & Software (Expensed) – $25,000
- Internet Site (Expensed) – $6,000
- Travel – $10,000
- Legal/Copyright – $2,500

General & Administrative Expenses

- Consultants – $50,000
- Employee Compensation and Taxes – $200,000
- Insurance – $10,000
- Legal Fees – $25,000
- Office Expenses – $15,000
- Office Rental – $50,000
- B&O Tax – $7,500
- Telephone – $2,000
- Internet – $2,500
- Travel – $10,000
- Utilities – $750
- Consortium Fees – $5,000
- Miscellaneous – $6,400

Future Directions

As the final subsection to this report, a discussion of future directions upon successful implementation of the business plan is warranted. To this point, the business plan has described only the developmental phase of the business life cycle. There are nine basic ways to grow an established business. The following list outlines some of the advantages and disadvantages of each direction. It should not be the business strategy at this time to follow any of the directions; they are presented for general reference.

1. Slow growth over time – The principal disadvantage is missing the market opportunity

2. IPO or Bond issue – The disadvantage is in entering the market and being subject to its rules (e.g., quarterly reports) and volatility. The advantage is potentially raising significant capital.

3. Venture Capital – The disadvantage of using "loan sharks" is that they do not have a vested interest in your business and often sell their interest to less amenable parties.

4. Merge With Another Company – Often advantageous; however, acquiring company typically uses different organizational structures.

5. Get Bought Out – Typically large companies buy smaller ones to (sometimes) "terminate the competition."

6. Start a new company spin-off – It is often advantageous to begin a new company to improve a product's image or acceptance.

7. Government or other grants – The potential for further funding must always be considered.

8. Work for Somebody Else – Quitting should always be considered.

9. Self-Funded – When company employees invest their own money to form a partnership, the business often benefits because of "buy-in" motivation.

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