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Research Report

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Rapport de recherche

DEVELOPMENT OF MARKET-ORIENTED DESIGN

A Course in Invention, Innovation and Entrepreneurship for the Technically Able

by

Robert D. de Pencier

Queen's University

1985

#98

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The views and opinions expressed in this report are those of the author and are not necessarily endorsed by the Department of Regional Industrial Expansion.

DEVELOPMENT OF MARKET-ORIENTED DESIGN

A Course in Invention, Innovation and Entrepreneurship

for the Technically Able

"What is honoured in a Country is cultivated there."

PLATO

by

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1985

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INTRODUCTION

Since 1969, I have offered a course called "Market-Oriented Design" as a 4th year option in the Department of Mechanical Engineering at Queen's University, Kingston, Ontario, Canada. Students from other Departments and faculties have been welcomed although only several from this group have taken it to date. The course aims to encourage and enhance in interested students qualities related to invention, innovation, and entrepreneurship.

Class size has varied from a minimum of two to a maximum of twenty. During this period a great variety of approaches have been taken with respect to all aspects of the course, and this has been done under varying levels of student interest and support from departmental and university administrations.

For the 1983-84 academic year, through the Office of Industrial Innovation at the federal department of Industry, Trade, & Commerce, I received a grant applicable to this effort. For the first time it was possible to provide a reasonable budget for the work of the students and to provide other forms of backup in the form of travel and office expenses, information materials, and other features to complement the course.

As a result of these efforts and input from students involved, I feel in a position to make some recommendations in case other universities contemplate efforts in this area. Although I feel a course like this should be reviewed and perhaps redesigned each year by students and staff involved, some of my observations and recommendations may be of use.

The course description is set out in the Faculty of Applied Science Calendar as follows:

> Mech-492
> Market-Oriented Design I and II
>
> Mech-493
> For those students with appropriate interests and aptitudes, the course aims at further development of inventive, innovative and entrepreneurial skills, with particular reference to product design and manufacture.
>
> Most aspects of the process of converting a product idea into a product and company to manufacture it will either be accomplished or dealt with by means of class projects, seminars, outside speakers, and student presentations.
>
> It is suggested that students discuss specific course requirements with the instructor prior to registration in it.

The "vehicle" around which the course is structured, by means of which these goals are to be approached, is that of student design, development, and construction of new products, plans for introduction of these to the market, and design of business approaches by which these plans could be profitably realized.

In this context "Design" is defined in the Total sense as set out by Mayall[1], "Entrepreneur" as described by Gilder[2], "Product" and "Marketing" as employed by Levitt[3], "Profits" as understood by the Japanese, and the traditional, persisting Canadian approach to all of these as documented by J.J. Brown[4].

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[1]Mayall, W.H. - Principles in Design - Van Nostrand Reinhold - 1979.

[2]Gilder, G. - The Spirit of Enterprise - Simon & Schuster - 1984.

[3]Levitt - The Marketing Imagination - Free Press, MacMillan - 1983.

[4]Brown, J.J. - Ideas in Exile - McLelland & Stewart - 1967.

Of the many reasons that can be offered to support the development of these skills among Canadian engineering students, I will mention only a few.

Most efforts in our schools of engineering are directed at developing "leading edge", "advanced", "knowledge intensive", mathematically oriented, quantitative skills. If graduating Canadian engineers wish to use their "leading edge" skills in Canada, they usually must gravitate to large companies which are frequently controlled elsewhere.

If they wish to work for smaller, Canadian-owned companies, they frequently find themselves in a situation in which their skills are underutilized or irrelevant.

This course aims at presenting approaches by which an engineer can direct his engineering skills at the problems of Canadian society rather than simply solving "engineering problems" presented and stated by others, often through a hierarchy which does not have its apex in Canada.

Inherent also in this course are consideration of qualitative aspects of complex situations and qualities of perception and judgement, in contrast to the quantitative approach to engineering problems which can substitute for judgement and decision.

1. FACTORS INFLUENCING THE FORM & CONTENT OF THE COURSE

1.1 The Canadian Attitude

There is an historical and political context for the course, expressed most aptly in J.J. Brown's, Ideas in Exile:

> Most institutions handle innovation very badly. In thinking about an institution's role in society, we should not be misled by theory. In theory the universities, for example, should be hotbeds of innovation. But they are not. It is a curious fact in the history of inventions that the great breakthroughs have come not from the famous institutional research laboratories but from obscure and relatively unsubsidized individuals. There is, then, a difference between theory and practice. Universities should, by definition, be working out on the frontiers of knowledge, but in practice the great ideas -- particularly in technology -- have not come from engineering schools. In theory, the NRC is the focus of Canadian inventive genius; but in practice, the bulk of our really great ideas come from somewhere else.
>
> .....
>
> Our abundant raw materials -- wood, minerals, coal, petroleum -- have made us lazy, timid, conservative to the point of idiocy. Our competitors have not had such natural advantages, hence have had to work for a living. We would have been much better off as a nation if we had been like Switzerland with no natural resources at all. Then we would have been forced to use our brains.

1.2 The Canadian Environment

We are surrounded in Canada by a most peculiar environment. Manufactured objects have generally been provided for us by others, by almost anyone else but Canadians. We take for granted that what we use is neither designed nor made in Canada. Few of us, including engineers, have participated in the product design or development process, or know anyone who has.

The engineer should be exposed to the practical aspects of design -- how to finance his venture, how to deal with suppliers, how to make out a tax form, some of the impediments to action.

1.3 The University Environment

As pointed out above, universities themselves offer impediments, such as difficulty in carrying out appropriate research in established areas, or finding useful design books in the library.

At this time of reduced finances, one of the "coldest climates" for industrial innovation can be within an Engineering Department. A university town of modest size, with little indigenous industry or technological entrepreneurship, and remote from industrial centres does not offer the external resources needed, nor the variety of entrepreneurial examples which might encourage budding entrepreneurs. Although evidence of increased support is appearing on many campuses, much of this takes the form of pouring the new wine of innovation -- imagination and risk -- into the secure old bottles of knowledge, tenure, and expertise.

The problem is to create an atmosphere at a University in which innovation will be encouraged with as little bureaucratic delay as possible.

1.4 The Course Philosophy

The course encourages the student to "start with a blank sheet of paper and convert it into a new product and an enterprise based on that product."

This course espouses the idea that the Canadian nation would be better served if a technologically trained person (a graduate

of this course) pulls together the means to meet the needs of Canadians (the need for employment in industries located in Canada) and of potential customers. The course provides the training for creation of business entities, their survival and growth (in the form of "profit"), against the background of a knowledge of technology, objects, and physical laws provided by conventional engineering education. It provides technically able persons with the skills to operate in the inventive, innovative, entrepreneurial, and qualitative modes, by channelling engineering skills into a business organization.

Engineer-entrepreneurs could solve Canada's unemployment problem if they will accept that "solving unemployment" is a problem which they are equipped to address.

This course evolved from experiments in product design and the teaching of Engineering Design, and from the recognition that such skills are of little use to the possessor or a country unless applied to marketable products through indigenous business.

Many of the skills and attitudes appropriate for solution of engineering design problems are transferable and applicable to entrepreneurial problems, and this is a philosophy on which this course was founded and has persisted.

The basic idea in this course is that students seek and find an "opportunity idea" or an "opportunity situation" to be embraced, which can create advantages for them and for others -- a real opportunity, a potential "win-win" change that could be economically realized, providing profit for themselves and others. These are opportunities which one could fill in the form of products.

Usually we said "look for a product, look for a need which you can design a product to fill or a situation in which you can create positive change by design of a product." And then -- "look for or design an enterprise, a way you can make use of the product which you have designed so that the product will exist not only on paper, or as a single prototype, but will actually be produced in multiples and disseminated throughout the community."

The entrepreneurial role, the enterprising role, would be to initiate, to advance and to aggrandize an actual enterprise to get a real product out in multiples to people who would use it. And that is where the concept of marketing came in. This idea has been expanded somewhat recently, influenced by the "supply makes demand" theory of Gilder, because people do not know in advance what they want, and are influenced by the inherent experimental aspect of product and enterprise introduction.

Early efforts in the development of the course were guided by three main beliefs:

(a) That the type of thinking/activity which was our concept of "design" also embraces those generalizable aspects or skills of invention and entrepreneurship which can be conceived of apart from specific "knowledge" with which they deal or to which they are applied. Thus the fundamental human skills and attitudes involved in activities described as "design" include many of the skills implied by these other two although specific deficiencies in attitudes and knowledge might still exist for a given individual.

(b) That even as the concept of "synergy" is closely related to design in principle, it is applicable not only to the activities of the inventor, designer and entrepreneur but also to an approach to learning related to these activities. In principle the individual who was conversant in the three areas mentioned and could allow considerations from each to interact with the others, could produce better results than if he could consider these only separately. Thus we could aspire to a "synergy in the mind".

(c) That the story of Canada and her people seems to persist as one of "potential." With the knowledge and skills gained in the engineering program, our graduates have great potential for success. With the skills and attitudes developed by this course, some individuals might be able to break through the "lost potential" barrier to "make things happen" in Canada. These students would be encouraged to think it was not unreasonable to aspire to such productive roles.

1.5 Approach of the Course

The course is one where the student is expected to design and build a new product prototype and design a new business to make the product a reality in the market. This could be regarded as analogous to the "problems assigned" in more theoretical courses. It reveals areas of difficulty to the student and an appreciation of the nature of the activity. Concerns arising out of discussions and projects are handled in seminar labs, and through cross-action

between several groups working on different problems. In addition, outside speakers and visitors provide knowledge and examples of attitudes and skills related to their own projects, as well as critical input directly to the student projects. Information sources related to current and future projects are also relied upon.

2. THE COURSE OF 1983-84

2.1 The Course Proposed for 1983-84

The course planned for 1983-84 was to correspond roughly to that included as Figure 1* (Fall Term) and Figure 2 (Winter Term). In the first term, the product was emphasized; in the second, the business plan.

The emphasis was on "constrained realism" i.e. -- realism within our budget, resources and time. The timing of the topics and speakers was based on a reasonable sequence of steps beginning with the decision to look for a need for which a new product could be supplied and carrying through to the establishment of a working enterprise. These stages were reinforced weekly in at least 4 ways:

1. Examples from a complete case history.
2. Lectures and notes (1 hour per week).
3. Outside speaker, student presentation, discussion (1 hour per week).

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*See Appendix IV for Figures.

4. Work of student on his/her own project (individual or group). This project was intended to cover all of the steps from a decision to seek a need through the product design and formation of an enterprise to produce and distribute the product. Particular attention was given any Canadian factors that would affect these steps.

It should be noted that although the schedule was spread over two terms, the students were encouraged to try to include in their thinking as many considerations as possible at a given time. Thus, it was not suggested that an "optimum" product be designed in first term, and then an "optimal" business approach be designed around it in the second, in an "optimum" fashion. Rather, insofar as possible, the first term would include also consideration of foreseeable business factors to be dealt with more fully in the second.

2.2 The Actual Course (1983-84)

In the fall term of 1983-84, 9 students (out of about 85 in fourth year mechanical engineering) registered for this course.

Several had decided in advance that they would not take the second term course but expressed great interest in the business aspects scheduled for the second term.

2.2.1 Course Schedule. As a result, the first term content was compressed somewhat to include business aspects in Term I (Figure 3). The formal meetings, of which there were two a week, around a circular table, generally followed this schedule. Where available outsiders such as inventors, entrepreneurs, and businessmen, ran or assisted in running the seminars. Members of the business

school and a professor of law made presentations. In two cases, students from other faculties who had entrepreneurial and small business experience ran discussions with the class.

Throughout this period, the students were working as a group on the development of their own products and business plans. Thus the students, as a result of their involvement in a project, always had specific questions to ask of seminar visitors.

2.2.2 Physical Arrangements. The course was assigned its own room (to which each student was issued a key), its own small library of reference books, several drafting boards, a telephone, and a budget of $2500 which students could spend on projects at their discretion, subject to production of receipts at end of course.

2.3 Product Development

2.3.1 Selection of a General area. In the first week it was decided first, that the product would be in the area of exercise equipment, and second, that it would be aimed at displacement of existing machines, and at "import displacement" in this area. It was determined also that the product would be a rowing machine. This latter decision was easy as no Canadian manufacturers of such machines were found. The observations and factors that contributed to these decisions included the following:

Home and office fitness equipment seemed to be an expanding area. The variety of equipment available and firms in the business suggested that no "final solution" had been provided or recognized. Rowing machines were recognized as particularly useful as they exercise all main muscle groups in a balanced fashion and also provide aerobic

exercise. It also seemed that the high ratio of exercise bicycles to rowing machines sold and used might be reversed if a rowing machine was designed to incorporate more advantages vis-a-vis the bicycle devices than appeared to exist at that time. It was thought, for example, that the existing sales ratio had little to do with their relative potential comparative advantages.

2.3.2 Formation of Subgroups. At early stages, part of the group worked on rowing machines for gyms, rowing clubs, while another faction specifically addressed the problem of providing an improved product for the home and office market, and at increasing the size of that market.

2.3.3 Commitment to Single Product, and Group "Structuring". It was subsequently decided to focus the entire group's efforts on the home and office market. The group was then restructured. One individual was made responsible for the product, and one for the business aspects. Although the others were loosely grouped rather equally around these two poles, it was accepted that the area in which an individual would work during a given week would depend mainly on which group needed him. This would be determined at one or more meetings at which the group heads and instructor would plot the direction for the next phase.

2.3.4 Market Research -- and Learning from Competitors. One of the first moves was to canvas stores, both locally and in other centres, for products which would be competitors. Two of these products were purchased and examined carefully and critically.

Students tried to discern ways to improve each detail, to improve the overall concepts employed, to improve their

understanding of the "problem" illustrated by this competitive solution. They even spent considerable effort to establish useful ways to assess their ideas as "better" in the context.

2.3.5 "Methodology" and Philosophy. There was constant emphasis on the need to accept the possibility of false starts, "errors", "misses", "imperfect ideas", even waste, in these activities.

2.3.6 Product concepts and manufacturing methods. Various approaches were taken to the problem, to the overall concepts that could be employed in the product, to the quantity and types of manufacture and to the production and design of each subassembly and detail.

2.3.7 Patent searches and intellectual property considerations. This area was explored at the patent office in Hull in the form of a "field trip" directed at making a preliminary search and at understanding the general concept of intellectual property and some functions and uses of the patent office in efforts of this kind.

2.3.8 Concept tests and prototypes. Several prototypes and test rigs to represent possible subassemblies or concepts for the final device were prepared.

2.3.9 Sketching, drawing, drafting, modelling. Considerable drawing and sketching was required. Drawings and a full-sized model of the production prototype were prepared just prior to completion of fall term in November.

2.3.10 Use of computers. Some "back-of-the-envelope" calculations were later confirmed by computer.

2.3.11 Term II. In Term II the students formed two groups again. One group concentrated on refining the design and building the device, while the other concentrated on revised business plans including industrial design registration and patent considerations.

2.4 The Business Aspects

2.4.1 Business Plan. During this period, the business aspects individuals prepared a business plan, based on considerations which included direct consultation with buyers from large chain stores and local sport shops. Assistance and guidance was obtained from professors and students in the Business School, as well as from readily available documents describing preferred and standard approaches in this area.

2.4.2 Cost estimates. Cost estimates were prepared based on several volume estimates, manufacturing approaches and price comparisons of similarly manufactured parts.

2.4.3 Industrial design. An industrial design registration was applied for.

2.4.4 Patent Consideration. The leader of the business group conducted a search and drafted a patent application on the device, developing skills which he later used to apply for a patent on a device he had invented prior to the course.

3. RESULTS OF COURSE

3.1 Term I - Results

Most aspects appropriate to a successful effort of this type were covered by the group, with varying degrees of success.

The students considered the course of great "benefit," a "real eyeopener", etc. It was suggested that the course be continued in the second term. A student proposed that the device be prepared for entry in the OEDC (Ontario Engineering Design Competition) within the terms of reference of the course. The four students who seemed most interested during Term I formed the class of Term II. The others did not take the course in Term II.

3.2 Term II - Results

In effect, the students repeated the work of Term I from the vantage point of several month's experience in Term I, and achieved a much better product and business plan.

The product won prizes at the OEDC and later at the 1984 EIC competition in Halifax. The OEDC prizes included an award from the Ontario Innovation Centre to be used toward commercialization of the device. The four students were extremely pleased with the results, and rated the course very highly in all aspects.

4. SUGGESTIONS FOR "FIELDING" SUCH COURSES

4.1 Overall Considerations

This course is intended to be run in engineering schools, by those who share the values of Entrepreneurs, Inventors, Innovators, preferably by those who have experience related to actual design and development of products and machines produced in large quantities. It leans heavily on skills and attitudes appropriate to design in the total sense as opposed to post-concept numerical "sizing" or "optimization."

4.2 Staff

If an individual is to operate the course, I believe he/she should espouse the values and attitudes of healthy competition. He/she should be a student of these areas, as there is much to be done and learned. There should be a devotion to excellence of product. Teaching this course is somewhat like athletic coaching ability to bail out students who have reached an impasse. The instructor should not be a novice. The person will have significant experience in product design and in starting and running a product based business. Some ability as an organizer or administrator is desirable.

4.3 Students

Students should be technically able -- but they will not necessarily have taken specific courses in manufacturing, "design" etc., as these courses don't influence or predict performance particularly well. It will be more rewarding for students with prior practical background, in machine shops, for example.

It will be more interesting for students who are capable of initiative and self-discipline. Students who can combine a relentless quest for perfection with an acceptance of failure will be more successful.

The course should be optional, but a "learn-about" course related to these areas should be in curricula.

The course could be of interest and be run effectively with a variety of students in terms of courses taken and levels of achievement. Indeed, it might be interesting if the "common thread" was the entrepreneurship/inventive/product interest rather than the "technically able" qualification.

4.4 Class Organization

The number of students involved influences the quality of the course. The most success will be achieved with approximate sizes of about:

4.4.1 Total Class Size -- 15 or 20: as larger classes impede one-to-one relationship and "hands on" involvement.

4.4.2 Seminar Size -- for speakers/visitors and instructor -- 15-20 (maximum) -- 4-5 (minimum) to encourage free discussion.

4.4.3 Idea/Product Discussion Session -- 6-8 for significant interaction with others.

4.5 Project

4.5.1 Project Group Size. Given the limits of time, and of students, groups of two to four seem about right. This allows for complementary skills, and experience, but reduces organizational problems. It also generally assures some success, whereas with individual projects results have been disappointing.

One aspect of organization that has been relatively successful with larger groups requires that only selected individuals have fixed responsibilities -- e.g. -- the "product design" -- the "business plan" and the others serve as a "talent pool" working in various areas according to the demands of the effort at a given time. In this way every individual in the class may be involved in, and learning from, several projects at once.

4.5.2 Project Selection. It is essential that a project be selected very early in the course. A simple "10-3-1" or "3-1"

approach has generally yielded quite interesting and satisfactory projects. A group might "list ten" "present three" to class and "choose one."

Areas in which there are already products and technology where improvement is desirable, possible, and likely, and where it is not necessary to provide a new device are very fruitful. All of the aspects of the exercise could be covered by reference to existing devices. (This is, of course, not the ultimate goal.) Most aspects of innovation are more demanding, and thus more educationallly enriching if one is working in areas of "well-farmed" problems and technologies. This is because the simple changes, and ideas, such as those based on some new problem or some new "technology" have already been recognized and probably applied. The course aims to develop innovative approaches not just familiarity with some "latest and greatest" or "highest" "technology." One learns not only from one's own efforts, but from those of the competition as well. So it is best to work in areas where there are competitive products. These are the primary types of projects at which the course is aimed.

"Maxi-projects" or "Mega-Projects" in which giant problems facing humanity and this country, which have not previously been posed as "engineering" problems and not regarded as "product-related", could be dealt with in the course using "product-design" skills. "Canadian Unemployment" is an example.

4.5.3 Methods Of Approach. In the presence of facilities and resources, students can perform with relatively little "coaching". The aim is to improve self-directed performance rather than to suggest that a mystery, heretofore obscured in all aspects, is to be revealed

during the course of the term.

It is better to approach the course and the projects according to the "ol' one-two" approach. This consists of urging students, to prepare a "final submission" for the course within 12 weeks. Those who are more interested will build on this earlier effort in the companion subsequent course, do-it-again, starting to design the product again from scratch, or choosing a new area for the second "go-round."

4.6 Support Staff

Such a course could probably be run with a number of assistants and complex equipment. But if there is one quality that typifies entrepreneurs and the situations they find themselves in, it is their ability to wear many hats and to be self-reliant. Rapid adequate appropriate results with minimal means is what is usually sought by entrepreneurs in action.

However, students require backup and support from machine shop staff particularly, while they improve their own skills in this area. Machine shop training has been de-emphasized in engineering curricula along with drafting boards, visual and drawing skills, with the result that many students emerge from Engineering School without these practical skills.

4.7 Speakers and Visitors

Irrespective of the instructor's abilities, a very significant contribution is made to a course of this type by visitors. There are certain aspects which can best be introduced by visitors. The great opportunity for students is to meet them, to benefit from

their attitudes, opinions, and experience.

Preferred visitors are entrepreneurs, inventors, innovators, and operators of small businesses. The skills, attitudes, and perceptions of those actually working in the system are of greatest interest, particularly those persons whose work directly relates to student projects. The rules for obtaining a bank loan could best be dealt with by factual literature, for example, but a bank representative could spell out the way financial decisions are made.

When university professors are visitors, I think it is preferable that information on their field is not readily available by reading; that they are acquainted with and honour the values represented by the course; and that they have actually operated in the areas they describe.

Although subjects such as patent law, import-export regulations, accounting, etc. could be studied superficially in the course, it is sufficient to convey how an entrepreneur, inventor, etc. deals with these. It is probably more valuable to hear from inventors and entrepreneurs on their experiences with banks, government programs, etc. than from bankers, program directors, etc.

4.8 Location and Physical Facilities

To develop a sense of cohesion, and to allow projects to remain undisturbed, the course should be permanently located in a room or rooms close to or including, drafting room, workshop, library, and a catalog library. Included should be adequate space for discussions, a blackboard, and permanent projectors. Additionally, it should include:

- Large variety of hand tools
- Telephone available for long distance calls
- Canadian and U.S. telephone books
- Fraser's Guide & Thomas Registers
- Special reading materials and books for the ready use of course members
- Magazines (Forbes, Fortune, Canadian Business, etc.)

For each group an "office" or a separate location for storing project and materials, should be provided.

Some drafting boards, paper and other supplies and such tools as cameras and tape recorders, typewriters, computer could usefully be included.

4.9 Scheduled Activities

Possibilities which have been reasonably successful are:

4.9.1 Visitors. Visitors can be extremely helpful even if they serve only to answer questions, rather than to make a presentation to the students.

4.9.2 Brief student seminars. Students prepare dittoed write-ups (e.g. -- "Brainstorming and Other Idea-generating Methods") which they circulate and discuss.

4.9.3 Discussion/criticism. Larger student groups focus on the area and on the product of individual or small groups.

4.9.4 Lab periods. Attempts to schedule long periods of extended work in a drafting-room atmosphere generally have failed. Brief discussion/criticism by the instructor has generally been most productive. Using a drawing board, either for design or drafting

is generally avoided by students except in private unscheduled hours.

Figures 1, 2, and 3 show schedules which were drafted for overall lecture, seminar, lab approaches. Although they were not consistently followed, they represent a reasonable approach to a schedule for either a 2-term or a 1-term course. It requires considerable effort to adhere to them and a great deal is not lost if most of what is covered is done in an unscheduled, as-and-if-necessary fashion, as long as it is dealt with reasonably well.

4.9.5 Final presentation of projects. This is seen as beneficial to students in the course, to others in the school, and to the university as a whole.

4.9.6 Final submission requirements from students. Attached as Appendix III is a copy of a Final Submission which is to be used for grading, and to "wrap up" the effort.

Students emphatically request that it be given near the start so that they are clear about the requirements of the course because it has been different from other engineering courses.

4.10 Administrative Aspects and Financing

The group should manage its own financial resources, use its own judgement, conduct its own purchasing arrangements. Preferably, it should operate within the university on a separate "grant number" with authority resting in the instructor. The students should be given a cash budget at the start over which they have complete control. These aspects have been possible here recently as a result of a grant received from I.T.C. Even a modest amount

of financing makes a great difference. For example, this year there are five groups taking the course. A budget of only $300 each has allowed them to purchase competitors' products, and to procure materials and normal purchased items to enable preparation of prototypes of professional quality.

4.11 Field Trips

Although other beneficial field trips could be considered for the class, one to the patent office in Hull has proved of special interest and benefit. All associated with this facility have been helpful over the years providing literature and presentations on operation of the system, and guidance to the students in performing a search.

4.12 Industrial and Trade Assistance

Students have been encouraged to make requests of suppliers, salesmen, etc. as they would if actually "in business" as if they were entrepreneurs in fact. Those they have contacted in industry, in Canada and the U.S., by mail and telephone, have been most helpful and interested. Locally, such firms as Alcan, DuPont, MacPhersons and Mason Boats have this year been helpful.

There have also been several genuine offers of investment money to one group producing a particularly interesting product this year.

4.13 Course Content

The "medium" here is indeed the "message." However, a lot of "message" in the form of "content" is provided.

Some topics that could be considered as relevant to the course as run from 1969-1977 are recorded in Figure 4. Attention of the students should be drawn to this list. I have regularly pointed out various of these topics at the stage in the work when it is likely to be most useful.

Another arrangement of "Content" is offered in Figure 5 -- Content grouped by Product Design & "OUIJA"* and Figure 6 -- Content grouped by Business Plan and Production.

Additional content of the course is furnished as a bound set of complementary reading materials. Approximately half of this 500-page volume is devoted to "The Product" and half to "The Enterprise." The index to the materials is included as Appendix I.

Additionally, a number of books and articles were acquired and located in the location established for the course. About $1500-$2000 worth of books is located there, and the students have appreciated this as ready reference and as a source of interesting reading. Some of these, such as the CCH Volume, the students find of outstanding interest and help.

These books are also included in a larger list known as the "Industrial Innovation Collection." The list was compiled by student employees and myself and the books are to be purchased by special university library funds. Appendix II includes the general headings describing the collection.

A significant extra source of content is provided by a number of magazines subscribed to for the course. Most useful here are such popular magazines as Forbes, Fortune, Inc., and Canadian Business.

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*Acronym for Observation, Understanding, Invention, Judgement, Action

CONCLUSION

The course makes students aware of values, knowledge, skills, attitudes, content, and difficulties involved in the activities of invention, innovation, and entrepreneurship.

The course recognizes that these activities are performed in unique complex situations usually in competition with others where the degree of success or failure is determined quite swiftly by the subsequent evaluation of a third participant, the consumer.

The course aims to help the student improve his/her understanding of innovation and to provide skills for high performance in these areas. It aims to provide the knowledge, skills, and attitudes by which they will more easily continue such development into the future.

It aims to free the "spirit of enterprise" in some, and to provide a better understanding of it in others.

I have described here what I consider to be the most significant aspects of my efforts to fulfill these aims.

Appendix I

TABLE OF CONTENTS TO:

"COURSE MATERIALS"

MARKET-ORIENTED DESIGN - 1984

PART A - TABLE OF CONTENTS

4. CREATIVITY AND PROBLEM SOLUTIONS

4.1 On the Limits of Creativity -- from **THE COURAGE TO CREATE**, Rollo May, Norton.

5. AESTHETICS

5.1 Introduction to: **A SENSE OF BEAUTY**, George Santayana, Dover.

5.2 Form -- from: **A SENSE OF BEAUTY**, George Santayana, Dover, ("How Form Affects our Perception").

6. THE DESIGN PROCESS

6.1 Finding Out What is Really Wanted, ("Designers Win by Meeting User Needs"), Syd Love.

6.2 Structure of the Design Process -- from: **THE PRINCIPLES OF ENGINEERING DESIGN**, Hubka, Butterworth Books.

6.3 Case Study: A Welding Positioner -- from **THE PRINCIPLES OF DESIGN**, Hubka, Butterworth Books.

6.4 Condensed Method, Hubka, **IBID.**

6.5 Brainstorming -- from **DESIGN ENGINEERING**, R.J. Dixon, McGraw Hill.

6.6 Inventiveness Case Studies -- from **DESIGN ENGINEERING**, ("A Walk Through of a Creative Process), R.J. Dixon, McGraw Hill.

6.7 The Design Method

6.7.1 From Overall Concept to Concept for Details -- (a hypothetical approach) -- R.D. de Pencier.

6.7.2 **OUIJA** (a pragmatic approach) -- R.D. de Pencier.

7. DESIGN PLANNING

7.1 Managing Innovations in Design, ("Why is Engineering Management Different?"), Syd Love.

7.2 Scheduling Innovation -- from **CREATIVE SYNTHESIS IN DESIGN**, Alger/Hays, Prentice Hall.

7.3 Defining What is to be Achieved, ("The Principle of Setting Objectives"), Syd Love.

7.4 Contents to **DESIGN PLANNING AND DEVELOPMENT METHODOLOGY**, ("All of the Things that Need to be Thought About"), Benjamine Ostrofsky, Prentice Hall.

8. FEASIBILITY

8.1 The Feasibility Study.

8.2 How to Screen Out the Unsuitables, ("It's a Good Idea, But ....."), Syd Love.

9. HUMAN FACTORS

9.1 Excerpts from -- **"BLAMING TECHNOLOGY"**, Samuel C. Florman, St. Martins.

9.2 The New Phoenicians, Walter F. Light Convocation Address, Queen's University, 1981.

9.3 Excerpts from -- **'GOOD WORK'**, E.F. Schumacher, Harper.

10. RELIABILITY

10.1 Reliability -- **DESIGN ENGINEERING**, ("What is Quality"), R. Dixon, McGraw Hill.

10.2 Non-Design for Ease of Maintenance -- **DESIGN FOR PEOPLE**, Design Council of Canada.

10.3 Success by Doing it Over Again, ("A Perfect Design is A Myth"), Syd Love.

10.4 How to Make Sure It Works, ("Criteria Measure Achievement of Objectives"), Syd Love.

11. OPTIMIZATION

11.1 Optimization, **DESIGN ENGINEERING**, R. Dixon, McGraw Hill.

11.2 How to get Good Ideas -- ("There is Always Room for Improvement"), Syd Love.

12. THINKING

12.1 Introduction to -- **'MEGATRENDS'**, Naisbitt, Warner.

12.2 The Secret of Strategic Vision -- from **THE MIND OF THE STRATEGIST**, K. Ohmae, Penguin.

13. EXAMPLES

13.1 The Story of Alex Issigonis -- from **AUTOMOBILE DESIGN**, Ronald Barker, d & c.

("To bring motor car travel within the reach of millions is surely to have contributed in the highest degree to human happiness, human sociability and human broadening of the mind and spirit in the last half of our century.")

14. DESIGN AND SKILL IN DRAWING

14.1 Comments on Drawing --from **MACHINE DESIGN**, Albert Leyer.

INFORMATION SOURCES

MECH 492 Information Sources, ("Market Oriented Design Information Sources"), C. Randle.

RECOMMENDED READING - Part A

PART B - TABLE OF CONTENTS

18. MARKETING & PRODUCT EVALUATION

18.1 "The Marketing Dimensions of Technical Entrepreneurship", Lawrence M. Lamont, Business Quarterly, Vol. 37, #2, pp.70-75.

18.2 **PROJECT NEWPROD. WHAT MAKES A NEW PRODUCT A WINNER,** Robert G. Cooper, Quebec Industrial Innovation Centre, (with list of variables measured for success).

18.3 Design of Research for Marketing -- from ("More on New Product Evaluation and Success Estimates"),R. Cooper, Project Newprod.

19. CORPORATE ORGANIZATION FOR INNOVATION

19.1 "What is the Value of Industrial R&D?", Edwin Mansfield.

19.2 "Organizing for Product Innovation", Jay W. Lorsch and Paul R. Lawrence. Harvard Business Review.

19.3 "Putting Innovation on Tap", Bernard M. Gordon, Machine Design Magazine.

20. DESIGN PROTECTION

20.1 "Patents - Another Engineering Tool", Gordon Asher, the Engineering Journal, Jan. 1963, EIC-63-MGMT-1.

20.2 "Patents and the Public Servant", Gordon Asher.

20.3 **PATENTS AND THE SALE OR EXCHANGE OF SCIENTIFIC AND TECHNICAL INFORMATION,** Science Council of Canada.

20.4 Original Idea Disclosure or Design Record,(Do's and Don'ts for Recording Ideas).

20.5 "It's Patently Clear -- Strain on Inventors Brains": David Quinter, Toronto Star, Oct. 3/75.

21. SOME MORE EXAMPLES

21.1 Assorted Examples.

21.2 Autonomy and Entrepreneurship, 3M Example -- from **IN SEARCH OF EXCELLENCE,** Peters/Waterman, Harper & Row.

21.3 Excerpts -- from **CANADIAN BUSINESS**, Archer, McGraw Hill:

a) "Zenair's Chris Heintz Turns a Hobby Into Business with Wings."

b) "It's Easy to Get Burned Jumping from the Fireplace Into the Market Place."

c) "Love for Sale."

d) "There's Money in Boats."

21.4 Introduction to -- **IN SEARCH OF EXCELLENCE**, Peters/Waterman, Harper & Row.

21.5 Examples of Successful Products:

- A.T.V.'s

- Versatile Constant Power 4WD Tractor.

RECOMMENDED READING PART B

Appendix II

SUBJECT HEADINGS FOR

THE 'INDUSTRIAL INNOVATION COLLECTION'™

100 ECONOMY

- 110 Economic History
- 120 Economic Theory
- 130 Economic Development
- 135 Economics of Engineering
- 140 Economic Forecasting
- 145 Future Economy
- 150 Business and the Economy
- 160 Entrepreneurs and the Economy
- 170 Finance
- 180 Industry and the Economy
- 185 Computer Economy
- 190 World Economy

200 SCIENCE, TECHNOLOGY AND R & D

- 210 History
- 220 Economics
- 225 Foreign Ownership
- 227 Change and World Politics
- 230 Industrial Research
- 240 Public Research
- 250 The Government and Technological Development
- 260 The Universities and Technological Development
- 270 The Universities and Industry
- 275 Engineering Education
- 280 Research Management
- 285 Technology Transfer
- 290 Ethics & Responsibility

300 INNOVATION AND INVENTION

- 310 Creativity, the Psychology
- 315 Creativity and Innovation
- 320 Creative Problem Solving
- 325 Creative Thinking
- 330 Technical Innovation
- 340 Managing Innovation
- 350 Innovators
- 355 Works of R. Buckminster Fuller
- 360 Inventing
- 365 History of Invention/Innovation
- 370 Inventors
- 375 Inventions
- 380 Evaluation
- 390 Commercialization
- 395 Commercial Trends

400 DESIGN

410 Philosophy
415 Historic Designs
420 Architectural
422 Textile
424 Furniture
426 Decorative
430 Engineering
435 General Hints
440 Industrial
450 Human
460 Aesthetics
470 Modelling
480 Drawing
490 Value Analysis

500 PRODUCT DESIGN

510 Patents
515 Product Designs
520 Trademarks
530 Copyrights
540 Registration
550 Materials
560 Purchasing
570 Production Plans
580 Manufacturing
585 Project to Production
590 Distribution

600 ENTREPRENEURSHIP

610 Theories
615 Entrepreneurs - The People
620 Starting a Business, Small Businesses
630 Economic Feasibility
640 Market Survey
650 Technical Feasibility
660 Financing/Financial Assistance
670 Legal Form of Business
680 Opportunities
690 Samples

700 MANAGEMENT

700	General
710	The Small Business
711	The Innovative Firm
715	Planning Technological Forecasting
720	Accounting
730	Financial Management
740	Marketing
750	Taxation
760	(Gov't) Regulations
770	Employee Selection
780	Export/Import
790	Consulting/Internal & External

800 OPERATIONS

Starting a Small Business in Ontario. Ministry of Industry & Trade, Ontario. Toronto.

How to Run a Small Business, J.K. Lasser, McGraw-Hill Book Company, 1963

How to Organize and Operate a Small Business, Kelley, Lawyer, Baumback, Prentice-Hall, 1968.

900 DOCUMENTS

Project New Prod., ("What makes a new product a winner"), Robert G. Cooper, Centre Quebecois d'Innovation Industrielle, 1980.

Assistance to Business in Canada. Board of Economic Development Ministers. Ministry of Supply & Services, Canada.

Appendix III

FINAL SUBMISSION REQUIREMENT

FOR COURSE COMPLETION

MECH 492 - Market Oriented Design

Requirements for Completion of Course

Group Report (Typewritten)

Part I - The Product

This is to be a description of the product intended for production, and as a minimum will include:

(1) Assembly Drawing of Prototype.

(2) Assembly Drawing of Proposed Final Production Product.

(These Drawings, accompanied by others if desired or necessary, will represent all details of the designs they represent.)

(3) Black & white photograph (8" x 10") of finished working prototype.

(4) Approximation of a Patent Drawing and description of product features and function - to be suitable for patent attorney to use to prepare a patent disclosure. This drawing to be on a sheet no larger than required by patent office -- (Drawings can be reduced on "PMT's" at Visual Aids -- if supplied in ink or heavy pencil, and with adequate time).

(5) Brochure design (based on approaches and information supplied on competitive brochures) (at least to preliminary stage).

(6) Package design - (at least to preliminary stage).

(7) Description of important features of product from point of view of purchaser/user -- and with respect to alternatives available.

(8) Estimated selling price to consumer.

Part II - The Business Plan

This plan is to be based on the assumption that your group intends to set up in business to "make the product happen." This is to be based at the least on consideration of the aspects outlined in the guide furnished to you from the School of Business (by Moore) and on the CCH document distributed. (Reasons should be given where certain aspects of these are ignored or dismissed.)

Provisions for survival "if things don't go quite as planned" will be of particular interest.

Part III - The Process

This is to include Discussion of Design Development from initial stages and thinking, to final design -- also to include some discussion of alternatives considered.

This will include for reference at least four of the "Evolution" Drawings -- (i.e. - the drawings that were prepared for each Monday review for the last four weeks of the course -- or equivalent).

This may also include discussion and photos related to experiments, competitors, construction of prototypes.

Part IV - Intellectual Property Considerations

This will include a proposed:

-- Company name proposed

-- Company and/or product logo

Some discussion of Trademarks, Industrial Design, Copyright, and Patent Protection related to the business plan and product.

If possible, identify features which you consider to be patentable or at least worth considering with respect to patentability.

Part V - Futures

What would you consider as reasonable next steps in the Product evolution? -- What about future directions with respect to the Business, with respect to this -- and possibly other products?

(Note: It is expected that the author of each portion of the report will be clearly identified in the report.)

(b) Individual Submission - This is to take the form of a "portfolio" of the work performed for course by the individual involved. Copies of rough work, drawings, notebooks, should be packaged along with a brief description of effort, results, and time spent on the course.

An "estimated" or "justified grade" is to be submitted with this also.

A brief individual interview will also be arranged prior to the end of term.

(c) Prototype - A working prototype of professional quality is to be submitted along with (a) & (b).

-- Date of Submission - (Due Date) - _____

Appendix IV

COURSE PLAN - 1983-1984

(Repeat of Figures 1, 2, 3)

MARKET-ORIENTED DESIGN -- 56-492 - 1980-81 - Fall-Term Plan (12 weeks) - Instructor - R.D. de Pencier

	LECTURES - INSTRUCTOR		SEMINARS - VISITORS TOPIC	VISITOR		LAB PROJECTS - INSTRUCTOR
1	Change - Ethics & Theories Course Introduction	1	Creativity - Theories Idea generation	Psychology Department	1	Problems, Needs, Situations.
2	Invention, Innovation & Entrepreneurship Modes & Models	2	Successful Products, Enterprises & Entrepreneurs	Entrepreneur (Products)	2	Product Concepts, Spec's, Restraints, Alternatives
3	Choosing Problems & Products	3	Inventing & Selecting Products for Profit	Inventor	3	Reducing Alternatives -- Information gathering.
4	Critical Review of Alternatives	4	Information gathering & Use	Librarian TIS	4	Patent Office Visit --
5	Invention: by request and by accident	5	Industrial Design Considerations	Industrial Designer	5	Alternative Conceptual Designs. (Review, Revise & Recycle from 2).
6	Design, Philosophy & Process	6	Patents, Trademarks, Design Registration, etc.	Patent Attorney/Agent	6	The Concept Described * Presentation of Drawings & Report
7	Optimum & Improved Designs: Natural & Man-made - (Objects, Processes, Strategies)	7	Observing & Criticizing Existing Products	Product Designer	7	Calculations, Analysis, Preliminary Drawings
8	Treatment of Physical Laws & Effects	8	Development of a new Product	Product "Champion"	8	Components & Alternatives. Simplification.
9	Treatment of Unknowns	9	Purchasing New Products	Purchasing Agent	9	Drawings & Engineering Spec's. * Submission Due.
10	Observation and Existing Situations	10	High-Technology Products	Project Engineer	10	Construction. Tests.
11	Making Presentations: Written, Oral, etc.	11	New Process Development	Developer & Manufacturer	11	Redesign.
12	Summation	12	Designing for Production	Detail Designer	12	Drawings, Models & Report. * Presentation

* - To be evaluated for grades.

Figure 1. Course Plan - Fall Term

MARKET-ORIENTED DESIGN -- 56-493 - 1980-81 - Winter Term Plan (12 weeks) - Instructor - R.D. de Pencier

	LECTURES - INSTRUCTOR		SEMINARS - VISITORS TOPIC	VISITOR		LAB PROJECT THE ENTERPRISE	THE PRODUCT
1	BUSINESS APPROACHES START UP ENTREPRENEURSHIP	1	Incorporation & Other Forms	Lawyer, Accountant	1		
2	CANADIAN CLIMATE & OPPORTUNITIES	2	Starting a Business in Canada		2	(Continuing Design of Enterprise & approach -	- Continuing tests - Redefine
3	EVALUATION, JUDGEMENT & RISK	3	Choosing a Business to Start	Venture Capitalist	3	to include final report on at least all aspects	- Redesign - Prototype
4	CASE STUDIES	4	Canadian Business Cases	Business School Professor	4	covered in seminars)	- Field Test Model - Field
5	FINANCING	5	Financing your Business	FBDB & Local Banker	5		- Final Production Design
6	MARKETING & DISTRIBUTION	6	Selling your Products	Manufacturers Agent, Salesman	6	**	** (Includes production, methods
7	BUSINESS PLAN	7	Planning your Business	Business School Professor	7		costing & pricing)
8	FINANCIAL MANAGEMENT & FOOTWORK	8	Managing your small Business Finances	Accountant	8		
9	GOVERNMENT PROGRAMS	9	Obtaining Government Assistance	Government Representative	9		
10	EMPLOYEES	10	Dealing with Employees and Records	Bookkeeper	10		
11	TAX ASPECTS	11	Tax Aspects	Law School Professor	11		
12	SUMMATION	12	Summation		12	* Enterprise Design & Strategy Presentation	Prototype & Final Report * Presentation

* To be evaluated for grades

** Mid-term Reports due at the end of Week 6

Figure 2. Course Plan - Winter Term

Schedule for MECH 492 - September 1983-84

Week	The Product Tuesday, (12:30 - 1:30)		The Business Plan Thursday (11:30 - 12:30)	
1	Sept. 20	Introduction & Product Search	Sept. 22	Starting & Operating Product Based New Business
2	Sept. 26	Selection of Product	Sept. 29	Preparing a Business Plan (Marketing/Retailing)
3	Oct. 4	Understanding & Improving Design	Oct. 6	Getting Information
4	Oct. 11	General Design Approaches	Oct. 13	Developing a Marketing Plan
5	Oct. 17	Creativity & Invention	Oct. 20	Production, Costing, Pricing
6	Oct. 24	Patents, T.M. & Licensing	Oct. 27	Sources of New Venture Funding (Presenting Your Financial Requirements)
7	Nov. 1	Industrial Design & Graphics	Nov. 3	Entrepreneurship in Action
8	Nov. 8	Preparation of Ads & Brochures	Nov. 10	Form of Business Association
9	Nov. 15	The Business of Invention	Nov. 17	General Small Business Management
10	Nov. 22	Developing Products in Industrial Environment	Nov. 24	Accounting, Bookkeeping & Tax
11	Nov. 29	Histories of Successful Products	Dec. 1	Business Plan Assessment
12	Dec. 6	Lessons	Dec. 8	Lessons

R.D. de Pencier, Sept. '83

Figure 3. Schedule for Actual Course Approach - Fall Term (1983-84)

A. The Product

1. Design Philosophy
2. Design Process
3. Design Process Applications
4. Organization for Design
5. Planning & Scheduling
6. Information Sources & Uses
7. Creativity & Problem Solving
8. Invention & Innovation
9. Physical Laws & Effects in Design
10. Entrepreneurship
11. Designs in Nature
12. Modelling & Representation
13. Modern "Design Methods"
14. Mathematics in Design
15. Aesthetics
16. Optimization
17. Reliability
18. Patents, Trademarks, Copyrights
19. Design Registrations
20. Quotations & Advice
21. Checklists
22. Value Engineering
23. Human Factors
24. Presentations
25. Writing, Reports, Proposals

B. The Enterprise

1. Marketing & Distribution
2. Government Assistance
3. Trade Organizations
4. Financing & Taxation
5. Business Structure & Start-up
6. Costing, Pricing, Estimating
7. Purchasing
8. Employee details - e.g. hiring, insurance, tax, etc.
9. Bookkeeping, Billing, Financial Statements
10. Advertising
11. Equipment Rental & Purchase
12. Profits from a Design
13. Making Models & Prototypes
14. Plant Layout
15. Doing Business in Canada

Figure 4 - Some "Content" Discussed (1969-1977)

THE SITUATION

Observation and Understanding

↓

Information Sources
Physical Laws & Effects
Designs in Nature
Competitive Designs
Aesthetics
Mathematics in Design
Economics
Manufacturing Methods
Patents
Trademarks
Copyrights
Design Registration
Existing Components
Human Factors
Physical Properties
Materials
Forms
Structures
Drawing
Modelling (Math, Physical & Abstract)
Needs, Problems, Opportunities

↓

Invention

Imagining, Change
Creativity
Generating Alternatives
Generating Concepts for Machine
Concepts for Product

↓

Judgement -- feasibility

Concept of "Good Design"
Refining & Improving
Selection of "Best"
Acceptance of Concept
Optimization
Reducing Alternatives
Costs

↓

Action

Describe for Others
Prototype
Motivate Others
Testing
Implementation
Entrepreneurship

↓

The Product Design

Figure 5 - "Content" from Situation to Product Design

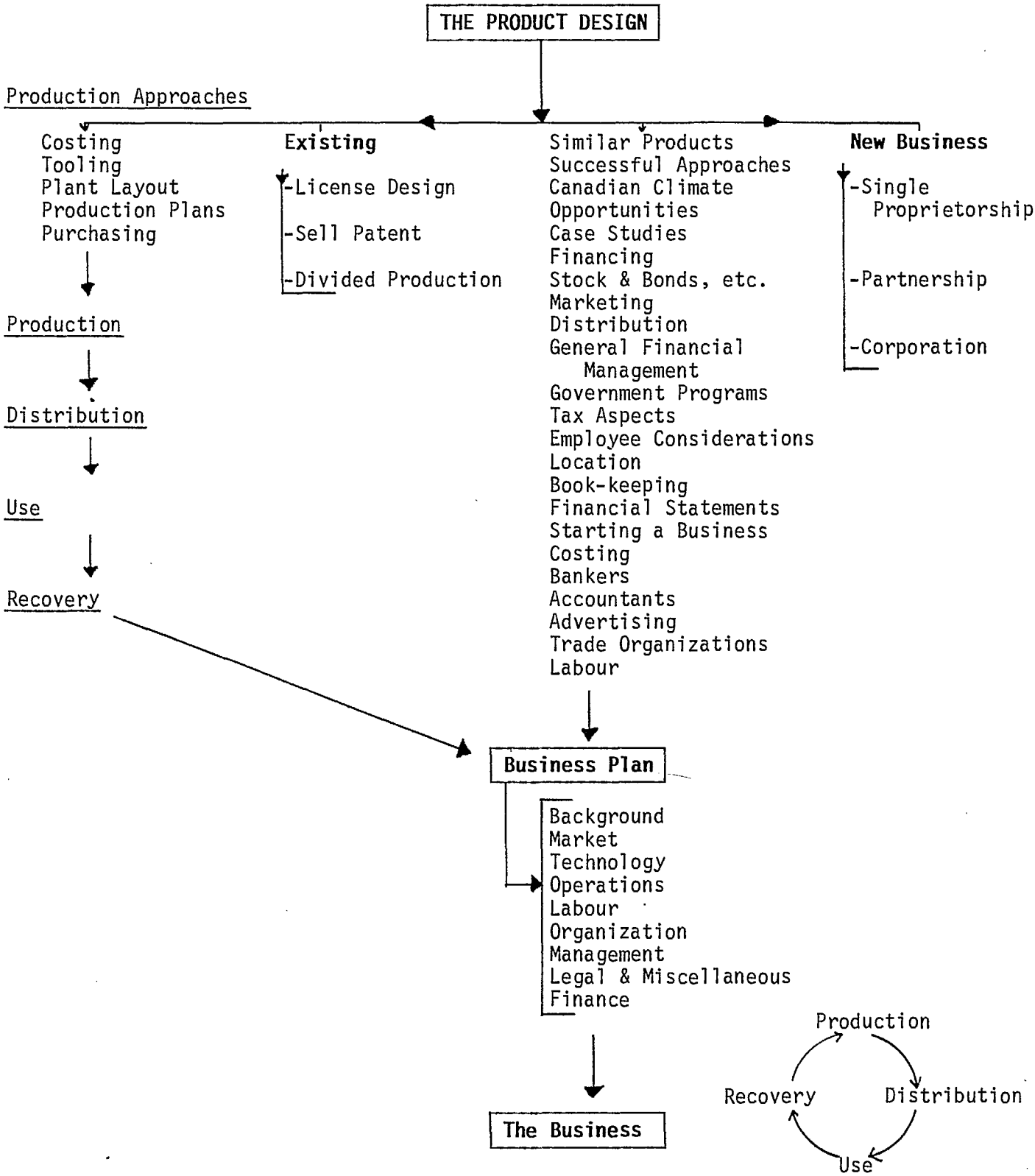

Figure 6 - "Content" - from Product Design to Production Cycle

DUE DATE			
SEPT 16	1987		
	201-6503		Printed in USA