Handbook for IQP Advisors and Students
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Chapter 1: Introduction

The IQP and the WPI Plan

An Interactive Qualifying Project (IQP) at WPI is a project which deals with the relationship between technology and society. The IQP is a central feature of the WPI Plan, a new approach to engineering undergraduate education introduced at WPI in the early 1970s. The goals of the Plan are to promote learning by doing through project work, maximize student choice in designing their own educational programs, and ensure that students had not only passed courses but were in fact competent as professionals, literate in the humanities and understood the societal implications of their professional work. The IQP contributes importantly to the first two of these WPI Plan goals as well as, of course, the last.

Importance of the IQP

It has been frequently observed that the IQP is the only unique element of the WPI Plan. What is less commonly recognized is that the IQP is of critical and growing importance to WPI's entire undergraduate educational program and our ability to attract students. This importance is due to its uniqueness and distinctiveness and the following major factors:

- The IQP is vital to WPI's claim to have a project-oriented program. Many colleges, including liberal arts colleges, require senior year theses in a student's major discipline. The presence of the IQP doubles our program's commitment to project work relative even to those programs that do involve project work in the senior year. Recent surveys have shown that our emphasis on projects is clearly the most attractive aspect of the WPI plan for prospective students.

- The IQP is the means which WPI has chosen to make science and engineering students aware of the role of their professions in society. The importance of such an understanding has been reinforced by the proposed ABET Engineering Criteria 2000, which requires that engineering programs demonstrate that their graduates have "the broad education necessary to understand the impact of engineering solutions in a global societal context." The IQP is also a very effective means of meeting or helping to meet a number of other Criteria 2000 outcome requirements such as "an ability to function on multi-disciplinary teams", "an understanding of professional and ethical responsibility", and "an ability to communicate effectively".

- The IQP is by design interdisciplinary. Despite the fact that virtually all real-world problems of broad scope are interdisciplinary, technical education has found no good way to provide students with interdisciplinary experiences. Through their IQP's students obtain practice in dealing with unstructured, open-ended, interdisciplinary problems, opportunities to work independently with peers and extensive experience in writing about previously unfamiliar concepts utilizing new terminology.
The IQP is the major element of another important pillar of the WPI educational philosophy, that is the freedom of students to make their own educational choices. However, course selections must satisfy distribution requirements and Major Qualifying Projects (MQPs) are frequently utilized to meet the design requirements of engineering accredited programs. Fortunately, in choosing their IQPs, students can truly be guided by their own interests. The ability of students to pursue their own interests is clearly another major selling point of our educational program.

The IQP is essential for our off-campus programs. It would be very difficult to arrange to have students from a wide variety of disciplines, and concentrations within those disciplines, working together on their disciplinary projects (MQPs) at off-campus sites on a continuing basis. Therefore, we are not likely to be able to build up the level of our off-campus MQP activity to anything more than a fraction of what the IQP permits us to do. Many of the environmental concerns and other issues involving societal/technological interactions that are natural subjects for IQPs are inherently international in character and scope. Consequently, there is a natural synergy between the IQP and Global Programs. Though MQP numbers off campus are growing, it is no accident that almost all of the projects conducted abroad to date have been IQPs.

Perception of IQP Quality
The IQP is obviously very important for our undergraduate program and consequently, its quality has to be an issue of major concern. Unfortunately, we do not marshal all of our possible resources to prepare students for the IQP. For example, there is no specific set of courses or activities required as preparation for the IQP (except to a very limited extent for off-campus IQPs), and there is typically no correlation between students’ social science and humanities coursework and choice of IQP topic. Most observers would assume that the social sciences and humanities have relevant analyses to contribute to an understanding of the relationship between technology and society and human values. However, it is clear from our program that we are not requiring our students to acquaint themselves with any of that background as preparation for their IQPs. Moreover, we know from our many past reviews of IQPs that even the best projects very frequently fail to apply clearly relevant methods of analysis or knowledge drawn from the social sciences, humanities, mathematics, and other disciplines. Methods of survey research, case studies, content analysis, comparative analysis, historical analysis, cost benefit analysis, statistics, interviewing and modeling techniques, among others, are not being used where appropriate or are being used incorrectly.

We also know that common methods of scientific inquiry (hypothesis formulation and testing) are frequently not brought to bear in IQP’s and that, in the past, a great many IQPs, particularly those done on-campus, fell far short of reasonable intellectual standards for college level work. The issue of IQP quality has assumed added urgency recently as a result of our decision to be reviewed for the ABET reaccreditation under their new outcomes-based criteria.

Objectives of the Handbook
The primary purpose of this handbook is to provide faculty with information that will help them do a more effective job of advising IQPs and avoid the quality problems common in the past. The handbook describes the objectives of the IQP; expectations for IQP outcomes; grading standards; issues to be considered in selecting the topic and designing the project, including key
problems in project design to be avoided. It provides advice on how to write project proposals, conduct literature reviews, form and manage project teams, schedule project activity; run project meetings, review drafts, conduct assessments, and organize and structure the reports. It defines, describes and illustrates the application of several commonly used methodologies in the social sciences, humanities, management and mathematics that are applicable to IQPs. It is intended to be useful to both faculty and students. Most chapters are clearly aimed principally at the faculty. For others the reverse is true. However, student familiarity with the content of this handbook, particularly the chapters directed at them, will facilitate the advising process.
Chapter 2: Objectives of the IQP

The 1972 Zwiebel Report

In 1972, a group of seven faculty under the leadership of Imre Zwiebel, Head of the Chemical Engineering Department from 1976 to 1980, formed a committee to define the requirements to be met by the Interactive Qualifying Project. They proposed, and the faculty subsequently approved, that this project must deal with interactions among technology, society and human needs. They supported their recommendation with the following rationale:

"The engineering curricula of the past were primarily concerned with the conveyance of technological skills and scientific concepts. Their primary purpose was to train the personnel needed to design and operate the machinery of a rapidly evolving technological era. Graduates often emerged ill-equipped to assist society in evaluating the overall effects of technology on the quality of life. At this point in the technological revolution, however, it has become increasingly evident that the institutions and value systems of society are strongly related to its rapidly changing technological base. Significant educational reform is urgently needed. That is why the architects of the WPI Plan have established the concept of the Interactive Qualifying Project as a degree requirement. This degree requirement is intended to effect a broader and more integrative education for engineers and scientists."

The Zwiebel Committee expected that "as a result of completing the Interactive Qualifying Project students [would] be

- sensitive to general social problems
- able to question, criticize or reinforce prevailing ethics and value concepts
- aware of societal-humanistic-technological interactions
- able to analyze these interactions
- able to make better judgments and policy recommendations on issues that affect society."

"In the future a graduate will be prepared to stand back, momentarily detach himself from the details of the everyday activities, and observe and assess the ways in which technology and society impact upon each other. It is hoped that he will also develop a sense of balance and self-confidence, so that he can view the course of events in a context of controllable change and not solely as a threatening, inevitable, and irreversible phenomenon. By understanding the nature of social needs and human interactions he will be able to apply his efforts and energies to effect changes of benefit to mankind. (Zwiebel Report, pp. 5-6)"

Original Objectives of the Interactive Qualifying Project
In their 1972 report the Zwiebel Committee defined the specific educational objectives of the IQP as follows:

1. To create an awareness of socially related technological interactions
2. To enable the identification of socio-technological systems, subsystems, and the linkages between them
3. To cultivate the habit of questioning social values and structures
4. To develop and integrate the skills of evaluation and analysis in the societal, humanistic, and technological disciplines
5. To provide methods for assessing the impact of technology on society and human welfare, and the impact of social systems on technological developments
6. To encourage the recommendation of policy.

The Committee noted that "it is unlikely that every Interactive Qualifying Project will meet all of these objectives.... Working toward these objectives, however, will aid the student in gaining a more mature understanding of himself as a professional whose decisions have human and social consequences. Engineers are being held increasingly accountable for these consequences of their decisions. The Interactive Qualifying Project is the vehicle by which WPI seeks to prepare its graduates to meet this challenge. (Zwiebel Report, pp. 8-9)"

Relevance of the Original IQP Objectives Today
These original objectives have withstood the test of time. If anything, they are even more relevant and appropriate today than when they were originally set out in 1972. The new proposed ABET Engineering Criteria 2000 at last explicitly recognize the importance of the relationship between technology and society, and the need for a global outlook. In Criterion 3, Program Outcomes and Assessment, requirement (h) calls, as noted above, for "the broad education necessary to understand the impact of engineering solutions in a global/societal context." It is certainly the case, as ABET clearly recognizes, that the issues surrounding the relationship between society and technology transcend international boundaries and are typically very international in character. Consequently, the IQP provides a logical vehicle for globalizing undergraduate engineering education.
To ensure that the objectives of the IQP are achieved it is essential that advisors and students share a common set of expectations for the outcome of the project. Ultimate responsibility for establishing appropriate expectations with respect to the level and scope of work done on IQPs rests with the faculty advisors and should, of course, be communicated clearly to students at the beginning of project work. The following discussion is intended to stimulate thought on this subject and help advisors form their own judgments.

As an IQP is intended to be equivalent to three courses, it would seem that there should be little disagreement that the scope of the work expected from each student should bear some equivalence to what would be expected in three courses, and that the level of difficulty and complexity would be comparable to upper class college level courses and would reflect a similar commitment of time, i.e., 15 hours per week. Our experience has shown that to realize these expectations in practice it is helpful if the objectives of IQPs are multifaceted. There may be one overriding objective but it will be possible to identify, at a minimum, sub goals that can be accomplished at different stages of the project or allocated to different individuals. Failing that, the procedures required to achieve the objectives should be multifaceted in the sense of involving numerous steps, and possibly alternative approaches, so that the efforts of the entire project team will be required to accomplish them. Obviously, if adequate expectations have been fulfilled, the advisor will be able to look at the project group's output and say honestly that, yes, that output could not have been achieved with one or more fewer students.

Experience has also shown the importance of good literature reviews. A topic of substance that is suitable for a college project degree requirement is likely to be one which has attracted the attention of prior investigators. It is very important for students to become familiar with the relevant literature in order to immerse themselves in the topic and to ensure that their work will benefit from knowledge of what has already been accomplished. The literature review should demonstrate that the students have been able to interpret the published prior work for themselves and that they understand its implications. The literature reviews of our best projects are thorough, and suggest that the students have in fact acquired significant mastery of an identifiable field of inquiry.

The project report should have a structure that is appropriate to the topic. The structure employed at many of our off-campus project centers provides a useful framework that can be of benefit, particularly in helping to organize the research and in suggesting aspects that should be included. That structure includes the following sections:

- an abstract and executive summary
a background section outlining the general nature of the subject under investigation;
a statement of the specific objectives of the project;
a literature review as discussed above;
a methodology section outlining how the project's objectives were achieved;
a section presenting the results of the research, which would describe any data, survey results or experimental results that have been obtained;
analysis of the results, and conclusions drawn from that analysis;
and finally a set of recommendations for policy actions or further research based on the conclusions.

In a given project, some of these sections may be much more important than others, and some may not be appropriate at all. The final report structure will reflect that relative importance.

The writing should be at a professional level: clear, well organized and free of spelling and grammatical errors and awkward expressions.

The methods of analysis utilized in the project should be appropriate to the topic and reflect the practices of other researchers who have conducted similar investigations. Where a given type of analysis is clearly feasible and appropriate, it should be conducted, and conducted correctly whether it involves statistical analysis, cost/benefit analysis, life cycle costing, survey research or any other technique.

It is, of course, important to remember that IQPs must be interactive in the sense that WPI has defined i.e. they should examine "how science or technology interacts with societal structures and values". More specifically IQPs should meet one or more of the educational objectives, originally identified by the Zwiebel Committee in 1972 and presented above in Chapter 2.

Finally, there is the issue of the length and size of the project report. It is axiomatic to say that the number of pages of a report is not the primary determinant of its quality. Moreover, we wish to encourage students to write succinctly, as well as clearly, and certainly wish to discourage them from padding reports, particularly with material copied from other sources. However, if students are to do a thorough job of surveying the literature and describing the multiple steps that they have followed to achieve an objective of some complexity, the result is quite likely to be a report of significant length, far longer than a term paper for a single course, closer to the thirty or so pages per student average achieved by our best projects than the dozen or fewer pages common in the past for the shortest and weakest project reports. It would seem that the appropriate model for IQPs would be that of a thesis or a professional report to a lay audience that is unfamiliar with the literature. Such an audience could not only benefit from a thorough description of that literature, but will require a detailed explanation of the analytical techniques employed and the steps followed to conduct the analysis, to reach conclusions and to make recommendations. An alternate model, that of a journal article addressed to an expert audience already familiar with the literature, not requiring all steps of analysis spelled out in detail, and looking essentially just for the new knowledge provided by the research, would hardly seem to
be an appropriate model for undergraduates who are typically not even majoring in the disciplines involved in the study.

Advisors should, logically, require that projects meet their expectations adequately to receive a passing grade and meet them in an outstanding fashion to receive a grade of A. Their grading standards could conform to those adopted by the faculty in its Resolution on Project Grading Adopted on May 5th, 1994 and presented below in the appendix to this chapter.
Chapter 4: The Interactive Qualifying Project: Selection and Design

The Interactive Qualifying Project (IQP) at WPI is an undergraduate degree requirement which is equivalent to three courses and is normally completed by students in their junior year. The IQP is designed to address the societal impacts of a technological development or the converse. It may involve investigation, analysis, description, and/or forecast of such an impact or the design of policies to cope with the societal problems (or to take advantage of the opportunities) created by technological change. In the course of doing their IQP, students are expected to achieve at least some of the following educational objectives: become aware of the many important links between technology and social systems; learn to question existing social values and mores; learn to integrate the skills of analysis in science, engineering, social science and the humanities; and assess the impact of technology on society and the conditions of human life.
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Part III: Beginning the Project

Experience has shown that carefully prepared project proposals and thorough literature reviews are virtually essential to successful project outcomes. Consequently, it has become the norm for work on projects at WPI to focus initially on those important phases of project development. Proposals and even literature reviews for off-campus projects are largely completed during a 1/6 or 1/3 unit PQP prior to going abroad while the entire first term of work on on-campus projects is normally devoted to their preparation. This section of the IQP Handbook contains two chapters providing advice to students on how to write project proposals (Chapter 5) and how to conduct literature reviews (Chapter 6).

Chapter 5: How to Write a Project Proposal

Lance E. Schachterle

Why a Project Proposal?
Writing a good proposal is a very important tool for organizing time and resources to complete a project which fully realizes its objectives. Whether the proposal is done as a PQP for credit separate from the one-unit project, or as the first fraction of credit towards the one-unit requirement, a project proposal will be invaluable in structuring the students' ideas about carrying out their research and writing their conclusions. Some faculty use it as an informal "Contract" to establish an agreement about the content and limits of the final project report. Also, since the project proposal is a widely used communications tool in the professional world, students will have the advantage of learning what goes into a proposal as part of their undergraduate education.

At WPI, only those students who present budgets in conjunction with a project proposal will be considered for funding toward IQP expenses. Students should consult with their advisors in framing a proposal and a budget, and some modification of these guidelines may be needed to accommodate their subject. But since money for proposed budgets will be allocated competitively, they should be sure to cover the basic points outlined here.
What is a literature review? It is literally that: a "re" view or "look again" at what has already been written about the topic. It is not a literary review, which usually is a review of a literary work such as a play, novel, book of poems or a review that has some artistic merit.

There are a variety of purposes of a literature review. The first and most obvious one is to provide background for the problem the students are attacking or put the problem into historical perspective and, at times, show how others handled similar problems in the past.

Students should ask themselves what are the different schools of thought that exist, what has happened over time, what exists that they had no idea existed that is related to the topic?

Sometimes, the literature discussed will be related to the subject but will not necessarily be in the exact form that directly addresses the topic. It may, nevertheless, help suggest alternative ways to approach the topic and reveal previously unknown sources of data. Finding that sort of information will help students determine and evaluate their own budding methodology and enable them to get an idea of theoretical bases, if any, underlying the problem they are addressing. In addition to an historical perspective, literature reviews often contain different points of view of a variety of experts. Sometimes there is consensus, but usually there is no single point of view. Controversies raised by the works of different researchers will add richness to the review and will provide the basis for a discussion of those controversies. Therefore, the reviewer is looking for the full array of perspectives. Make certain opposing points of view are not eliminated in the discussion as some people are tempted to do when a view is counter to their own beliefs.

It is important to remember that the objective is to synthesize the material through a discussion of all of the sides of an issue. Then the project’s essential research question can be stated - either as an hypothesis or as a field to be described.

An important first step is to identify the major researchers or organizations that deal with the topic. Ultimately research will continue until material overlaps and until the reviewers are sure that they know the recurring themes and can recognize the work or perspectives of the major authors in the field. However, students must be careful that they do not adopt the biases or values of other authors. Whenever an author makes definitive statement, one should look for the supporting data. The fact that authors are often sure of their own opinion or conclusions does not guarantee that they have discovered "truth." It's easy to fall in love with a particular view,
especially if it confirms one's own values and opinions. Use intellectual skepticism. Always ask, "Where is the evidence?" or "Who says?"

For many projects, there are published, relevant case studies that can illustrate the complexity of the problem or elucidate alternate solutions. Reviewing them helps the students become more sophisticated in their own ability to use analytic thinking to define their project.
Part IV Conducting the Project

This section of the handbook presents advice to students and faculty on carrying the project to a successful conclusion after the initial proposal and literature review stages are completed. Chapter 7, the first in this section, discusses the problems that are involved in building and maintaining successful project teams whose members cooperate effectively. Chapter 8 discusses student and advisor meetings, the preparation and submission of drafts, grading procedures, and the structure of the final report. It also contains a glossary of grammatical errors and a typical schedule for a one term project.

Chapter 7: Team Dynamics - A Manual for Team Building

James Groccia, John T. O'Connor, and Susan Vernon Gerstenfeld

The development of a team follows a series of predictable stages. How well the team negotiates those stages will affect the outcome of the project. Projects in which students learn to work together effectively by recognizing different styles and abilities, and maximizing their interactions, are likely to be much better learning experiences than projects where partners fail to address problems with team interactions.

This chapter attempts to provide useful advice to students and faculty concerning common issues that arise in trying to solve problems together, and how those issues can be addressed. In doing a WPI Qualifying Project (IQP or MQP), what the students learn about working together may well be as valuable as what they learn about the topic, since most professional work is done not by isolated individuals but by teams bringing together people with different skills, areas of expertise, and working styles. Such professionals know that cooperation is crucial, and that problems which interfere with successful dynamics MUST BE ADDRESSED BECAUSE THEY CAN BE FATAL TO THE PROJECT. They also know that abundant opportunities exist for dysfunctional teams to get help, and that the first step is identifying the problem.

This chapter is intended to help students and advisors begin that process of honest problem identification, from which solutions can be developed.
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Chapter 8: Project Control and Evaluation

From "IQP Guidelines" By John T. O'Connor

This chapter is based largely on a set of IQP guidelines prepared by Professor John T. O'Connor several years ago. It also contains Professor Michael Gennert's, Gennert's Project Guidelines in Appendix B. Both sets of guidelines should be viewed as examples that faculty may want to follow in establishing project control and evaluation procedures to assist their advisees. However, it is worth noting that there is a great deal of commonality between not only the O'Connor and Gennert guidelines but with those developed by a number of other faculty who have shared their personal guidelines with their colleagues.
Handbook for IQP Advisors and Students
Part VI: Quantitative Methods for IQP's Common IQP Methodologies

Prepared for The Interdisciplinary and Global Studies Division
by Douglas W. Woods
SS&PS

General Introduction
Part VI reviews quantitative methods for IQPs in four broad areas: Investment Decisions and Life Cycle Costing (1), Regression Analysis (2), Econometric Modeling (3) and System Dynamics (4). These areas were chosen because of their relevance to interactive project work. Past experience has shown that the need for these techniques arises more frequently in IQP’s than most other types of quantitative analysis.

Of the four topics discussed here, the last three listed above are presented briefly, with just enough information to enable the reader to understand the purpose of the methodology, the types of problems in which its application may be required and to a limited extent, how to use it. Readers who need to employ these techniques can obtain the necessary additional information from the references listed at the end of each section.

The aim of Chapter 12, which discusses Investment Decisions and Life Cycle Costing, however, is more ambitious. The reader willing to invest several hours studying this section should acquire the ability to analyze thoroughly the financial aspects of most types of investment decisions. The reader should come away with an understanding of how these methods of analysis work, why they yield correct decisions and how to apply them. This chapter is accompanied by an available computer disk containing electronic spreadsheet solutions to a set of sample problems. Many readers will find that these solutions can be applied to their own problems simply by changing the input data.

Chapter 12: Investment Decisions - Life Cycle Costing

Introduction
The analysis of investment decisions and life cycle costing are closely related methods for evaluating investments involving initial expenditures for equipment, installation, service and/or training etc. that will have future benefits or will impact future costs. In business financial management the process of evaluating and choosing from among such investments is termed capital budgeting. In engineering economic analysis this process is referred to as "economic
evaluation of investment proposals" or as "comparison or selection of alternatives". All of these terms refer to a common body of analytical techniques that are essential tools for investment decision making by government, private agencies, homeowners or business firms. Any IQP or MQP which recommends or evaluates courses of action involving investments requires the use of these techniques to support its conclusions.

The essence of an investment is a sacrifice now in exchange for future benefits. In a typical investment decision the question is, should a project be undertaken? Do the future benefits from doing so outweigh the initial costs? Examples would be a decision by a state DPW to construct a new highway or a power company to build a hydroelectric plant. The benefits may be in the form of additional future income or revenue or may be intangible and non-pecuniary in nature. (This chapter deals only with the analysis of the quantifiable, financial aspects of investment decisions. Methods exist for assessing intangible costs or benefits, in some cases quantifying them, but are beyond our present scope. They are discussed in the literature referenced at the end of the chapter.)

In life cycle costing, the issue is how best to accomplish a given task - what is the least cost method, taking into account both the initial outlay required and future operating costs. An example would be determining which system among several alternatives for heating a new house would be most economical over the system's entire operating life. Life cycle costing also involves investment decisions, in the sense that some of the methods under consideration will require larger initial outlays but achieve lower future costs than others.

Because of the need to consider relevant intangible benefits (and costs), the analysis of investment decisions is broader in scope than life cycle costing. What both techniques have in common is the requirement that future costs (life cycle costing) or net benefits (investment decisions) must be measured on a common scale along with the initial outlay. In doing so, account must be taken of what is called the "time value of money." The latter refers to the fact that money in hand right now could be invested elsewhere, i.e. in stocks or bonds, at a positive rate of interest. That money with accumulated interest would amount to more in the future than it does right now. Consequently, any money to be received or spent in the future is equivalent to a smaller sum of money to be received or spent right now.

This chapter focuses on the various methods available for taking account of the time value of money, the interest factor, in evaluating investments. Use of these methods (frequently, referred to as discounted cash flow or DCF techniques) is not optional. Failure to employ them will result in erroneous economic evaluations and incorrect decisions.
CHAPTER 10: Introduction to Survey Methodology and Design

Research projects like the IQP that examine the interface between science and technology and society often require the collection and analysis of social data. The most common response from beginning researchers to this need for data is to conduct a survey. After all, everyone has had experience answering surveys, and it is usually a simple and straightforward procedure. Many people conclude from this experience that writing and administering their own survey will be a simple and straightforward matter as well.

However, in actuality, the intuitions people form about survey research from their own experience are often incorrect. To test your own intuitions, you might consider how you would answer the following true/false questions (answers appear at the end of the chapter just ahead of the References):

T/F 1. Determining the opinions of the population of a city of 10,000,000 people requires a much larger sample than an opinion survey of a city of 100,000 people.

T/F 2. Randomly choosing names from a telephone directory is the best way to choose a sample for a telephone survey.

T/F 3. Survey questions should appear in random order.

T/F 4. Posting a survey on a web site is a good way to reach large numbers of people and to increase sample size.

T/F 5. If too few people from the first survey sample chosen fail to respond, a second sample should be chosen to increase the number of respondents.

An understanding of the answers to these and many other questions is essential for conducting scientific surveys that yield accurate, unbiased, and generalizable results. Yet it is a rare person indeed who can explain the reasoning behind such questions correctly without having made an effort to study survey design and methodology. In fact, there really is little reason to expect
success in survey research without formal study of the topic. Basic social science research methods are often more complicated, more difficult to learn, and more counterintuitive compared with basic methods in other sciences since the subjects of study, human beings, are more complicated. Atoms and chemicals, for example, don't try to figure out the goals of your research, don't have a bad day, and don't change their minds from one moment to the next!

Social scientists, by conducting countless studies and experiments over the past several decades, now have a good understanding of how to conduct a survey. From such obviously important questions as how to select a random sample to seemingly trivial details such as whether it is better to include a preprinted business reply envelope or a stamped envelope for people to use to return mail surveys, the answers are available in the published academic literature and in textbooks. There are even excellent books on the subject written especially for beginning researchers [see, e.g., Rosnow and Rosenthal (1996) and Salant and Dillman (1994)].

Thus it is now possible for students who have never conducted a survey before to learn about and implement the basic principles of scientific survey design and methodology as part of their IQP. The goal of the present work is to introduce you to these basic principles and to describe where you can go to learn more.
Handbook for IQP Advisors and Students
Chapter 11: Introduction to Interviewing Techniques

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Department of Social Science and Policy Studies

Introduction
When researchers new to a subject area come across an important question that they don't know the answer to, their first reaction is often to interview people who (hopefully) do know the answers. Since these interviews seem like the everyday conversations that we are all familiar with, they are often conducted in a casual manner with little advance preparation. The results of such casual efforts, however, are almost always disappointing.

What these researchers fail to realize is that a research interview — an interview that can provide reliable evidence to answer a research question or to help solve a social problem and that can be defended against skeptical critics — bears little resemblance to an ordinary conversation. In fact, some of the best techniques for conducting valid, reliable interviews directly violate the conventions of everyday conversation. For example, in ordinary conversation it is considered impolite to remain silent after someone has finished speaking, yet an interviewer must at times do exactly this in order to encourage participants to elaborate on what they are saying. Also, in some interviews protocol requires the interviewer to ask questions that participants have already answered, which almost never happens outside of interview studies due to social norms that dictate that conversations should not be repetitive.

Because research interviews require the use of skills — for example, careful listening, noting nonverbal cues, monitoring the progress of a conversation while participating in it and taking notes — that aren't typically acquired from our experience with everyday conversations, they require careful planning and preparation. To conduct interviews that are useful for research purposes, researchers must, among other things, develop as much expertise in relevant topic areas as possible so that they can ask informed questions; consider very carefully such questions as who to interview, how many people to interview, what type of interview to conduct, and how the interview data will be analyzed; and learn established techniques for ensuring that the interview data are unbiased (even seemingly subtle factors like the interviewer's mood, personality, dress, and manner can alter participants' responses and bias the data!).

The aim of this paper is to introduce you to what social scientists know about how to design, implement, and analyze an interview study and to explain how these techniques can improve the quality and utility of IQPs that employ interviews as either the main focus of the project or as a
complement to other methods of data collection or analysis. As is appropriate for an introductory monograph that is intended to be portable and therefore relatively brief, the scope is limited and only three main interviewing techniques -- in-depth qualitative interviews, focus groups, and standardized interviews -- out of a wide variety of available alternatives are discussed. It is therefore recommended that students use this paper as a starting point to a more detailed exploration of the literature on interviewing techniques. Suggestions for where to begin this process are included in Section IX.
Handbook for IQP Advisors and Students

Chapter 13: Regression Analysis

Definition

In economics, regression analysis is used to estimate quantitative functional relationships between dependent variables and one or more independent causal variables from actual data - experimental, time series, cross sectional - when the relationship among the variables is statistical in nature rather than exact. By a statistical relationship it is meant that the dependent variable's observed values are generated by a probability distribution that is a function of other causal variables.

The values of economic variables are determined by the behavior of people and hence these variables are stochastic. Empirical investigation of the relationships among them requires the tools of statistical inference, including regression analysis. This is true, whether the purpose is to forecast future sales or the performance of an economic system or to predict the impact of a new innovation or government regulation.

For example, an economist might wish to estimate the relationship between the quarterly sales of a product in a given geographical area and the total personal disposable income earned per quarter by all individuals living in that area.

If this relationship is assumed to be linear, the hypothesis is that

\[ Y = a + bx + u \]

13.1

where \( Y \) = expected quarterly sales, \( X \) = total income, and \( u \) = error term.

This relationship is represented graphically by the upward sloping line in Figure 13.1. The data that will be used to estimate the parameters of this relationship consists of paired observations of \( X \) and \( Y \): \( X_i \) and \( Y_i \), for \( n \) quarters \( i = 1, ..., n \) and are represented in Figure 13.1 below by the points plotted around the line.
The errors, $u$, in equation 13.1 above consist of differences between the actual observed values of $Y$ and the expected or average values of $Y$ determined by the linear relationship with $X$. They are represented graphically in Figure 13.1 by the vertical distances between each point (representing an $X$, $Y$ observation) and the line (representing the relationship between $X$ and the expected value of $Y$).

There are a number of reasons why these errors will arise:

a. **Measurement**: The sales figures may have been inaccurately recorded.

b. **Causal factors left out of account**: Sales may have been affected by changes in prices or other variables influencing consumer purchase decisions that have not been included in the hypothesized relationship.

c. **Random behavior of people**: People do not always behave the same way each time they confront the same circumstances.

d. **Misspecification**: The functional form of the relationship may have been incorrectly specified.

Least squares regression is a means of estimating the parameters of the equation hypothesizing $Y$ as a function of $X$. Graphically, it is a means of fitting a line to the scatter of paired observations of $X$ and $Y$ in Figure 13.1. It involves choosing $\hat{a}$ and $\hat{b}$, estimators of the true parameters $a$ and $b$, so as to minimize the sum of the squared differences between the actual values of $Y$ and the estimate of $Y$ given by the regression equation. These differences are the estimated values of the errors, $e_i$ for $i = 1...n$. The least squares estimators $\hat{a}$ and $\hat{b}$ minimize

$$\sum_{i=1}^{n} e_i^2$$

where $e_i = Y_i - \hat{Y}_i$, $\hat{Y}_i = \hat{a} - \hat{b}x_i$, and

$n$ = the number of observations

Expressions for $\hat{a}$ and $\hat{b}$ can be derived by setting the first partial derivatives with respect to $\hat{a}$ and of the sum of the squared estimated errors equal to zero and solving the two simultaneous equations that result, to get
If the errors are random with a zero mean, that is $E(u) = 0$, the estimators, $\hat{a}$ and $\hat{b}$, of the parameters, $a$ and $b$, of the true relationship obtained through least squares regression are statistically best. They will be closer on average to the true parameters than any other unbiased estimators in general use, regardless of the number of observations.

In the example cited above there is a one way causal relationship between $X$ and $Y$. Income effects sales but not vice versa. Frequently in economics a two way causal relationship exists between variables, as is illustrated below in the section on Econometric Modeling. In that case the methods of simultaneous estimation described in that section are required to obtain unbiased parameter estimates.

**Multiple Regression**

Where two or more independent variables affect the dependent variable, it is important to include them in the regression equation.

If the true relationship is

$Y_i = a + b_1 X_{i1} + b_2 X_{i2} + u_i$

the regression equation is

$Y_i = \hat{a} + \hat{b}_1 X_{i1} + \hat{b}_2 X_{i2}$

The estimators $\hat{a}$, $\hat{b}_1$, $\hat{b}_2$ are chosen so as to minimize

$$\sum_{i=1}^{n} e_i^2 = \sum_{i=1}^{n} [Y_i - (\hat{a} + \hat{b}_1 X_{i1} + \hat{b}_2 X_{i2})]^2$$

The values of the estimators can be determined by setting
and solving these equations to get three simultaneous "normal" equations that can in turn be solved to get $\hat{a}$, $\hat{b}_1$ & $\hat{b}_2$.

Note that $\hat{b}_1$ is the best estimate of the effect on $Y$ of changes in $X_1$ when $X_2$ is constant, and $\hat{b}_2$ is the best estimate of the effect on $Y$ of changes in $X_2$ when $X_1$ is constant.

All important causal variables must be included in the equation. If some are omitted and they are correlated with those included, the least squares estimators will be biased.
Handbook for IQP Advisors and Students
Chapter 14: Econometric Modeling

Definition
Econometrics has been variously defined as "the quantitative analysis of actual economic phenomena based on the concurrent development of theory and observation, related by appropriate methods of inference" - Samuelson, Koopmans and Stone, 1958 - "and as the art and science of using statistical methods for the measurement of economic relations" - Chow, 1983.

These definitions imply that econometrics and regression analysis, as described above in chapter 13, are closely related, and, indeed, least squares regression is a cornerstone of econometric techniques.

As the definitions above also suggest, however, econometrics is far broader than simply regression, encompassing all methods of statistical inference that can be employed to produce "quantitative economic statements that either explain the behavior of variables we have already seen or forecast (i.e., predict) behavior that we have not yet seen, or both" - Christ (1966). In defining their field, many econometricians would emphasize those techniques - typically extensions or adaptations of regression analysis - created to cope with the special problems that often arise in estimating economic relations. Those that particularly come to mind are techniques to measure and eliminate autocorrelation among residuals and to model lagged relationships among variables in regressions on time series data.

To many practitioners, however, the term "econometrics" when coupled with "modeling" tends to have an even more specialized meaning. It applies especially to the body of techniques utilized to estimate the parameters of economic systems.

An economic system typically consists of many interdependent variables and the relationships among them. In estimating the equations of such systems, econometricians frequently encounter an obstacle known as "the identification problem." The latter is most easily illustrated by reference to the process of determination of price and output in a market. In Figure 14.1 below price and output are shown being simultaneously determined by the intersection of a demand and a supply curve. To model this process the econometrician must develop a quantitative estimate of both the demand and supply functions. Typically the data used to estimate these functions are past observations of price and output determined by the points of intersection between the demand and supply curves. If, in the past, the supply curve has been shifting (due, say, to production cost changes) while the demand curve has
remained fixed, the resultant intersection points trace out the demand function, as shown in Figure 14.2. If the demand curve has shifted (due, say, to income changes) while the supply curve has remained fixed, the intersection points trace out the supply curve (Figure 14.3). The most likely outcome is movement of both curves yielding a pattern of price, quantity intersection points (as shown in Figure 14.4) from which the econometrician will be unable, without further information, to distinguish the demand curve from the supply curve or estimate the parameters of either. This is the identification problem.

Methods of Simultaneous Estimation
In the illustration discussed above price and output are determined by the solution of two simultaneous equations and price and output are said to be jointly determined. This is a very common occurrence in economics. Thus, the statistical methods required to estimate equations for jointly determined economic variables find frequent application. Student projects in which the need to estimate explanatory equations for economic variables arises, - whether for forecasting, policy analysis or impact assessment - will generally require their use.
Several techniques have been developed for the estimation of the structural parameters of an a priori specified system of simultaneous stochastic equations. These include indirect least squares, two stage least squares, instrumental variables, three stage least squares, full information maximum likelihood, limited information maximum likelihood, etc. Of these, only indirect and two stage least squares will be discussed here.

To illustrate the use of these techniques assume that the objective is to develop a model to forecast the annual sales and output of new cars in the United States and that the hypothesized demand function is

\[ A = a + b_1 P + b_2 (\Delta Y) + b_3 Y + u_d \]

(\text{where } A = \text{new car sales}

\[ P = \text{new car prices} \]

\[ Y = \text{total personal disposable income and} \]

\[ \Delta Y = \text{change in income per capita} \]

Suppose further that car prices (P) are believed to depend linearly on auto sales (A) as well as an index of production input costs (C) and production capacity (K). Thus, a simultaneous two way relationship is assumed to exist between A and P. These variables are determined simultaneously by the solution of the demand function given above and the price or supply equation:

\[ P = e + d_1 C + d_2 K + d_3 A + u_s. \]

**Indirect least squares:**

To develop an equation to forecast auto sales the analyst can estimate an equation for the reduced form, which is obtained by substituting the price equation for price in the demand function to get:

\[ A = a + b_1 (e + d_1 C + d_2 K + d_3 A) + b_2 (\Delta Y) + b_3 Y \]

If A is regressed on C, K, \(\Delta Y\), and Y as described above under Multiple Regression (13.3), the result will be an equation with quantitative estimates of the parameters of the reduced form equation for A given above which could be used to forecast future auto sales; moreover, in some cases (though not in the present example) it may be possible to derive estimates of the parameters of the original structural equations from the reduced form coefficients.

**Two Stage Least Squares:**

An alternative is to employ two stage LS regression by first estimating an equation for P by regressing P on all of the independent variables in the demand function for A, plus one or more other determinants of P, in this case C and K, that do not appear in the demand function. The result is the 1st stage regression equation:
\[ \hat{P} = \hat{\theta} - \hat{j}_1 C + \hat{j}_2 K + \hat{j}_3 (\Delta Y) + \hat{j}_4 Y \]

In the second stage A is regressed on Y, \( \Delta Y \), and P, the estimate of \( \hat{P} \) given by the first stage regression rather than the original observed values of P, to get:

\[ A = \hat{\alpha} + \hat{\beta}_1 \hat{P} + \hat{\beta}_2 (\Delta Y) + \hat{\beta}_3 Y \]

The regression coefficients obtained from this second stage regression are unbiased, consistent estimators of the parameters of the original demand function.

References for Econometrics (14.3)
**Handbook for IQP Advisors and Students**

**Chapter 15: System Dynamics**

*Prepared by Prof. Michael J. Radzicki*

**What is System Dynamics**

System dynamics is a computer modeling technique that has its origins in control theory, cybernetics, organizational theory, behavioral psychology, economics, and digital computer simulation. It is used to build models of systems that are experiencing problems and/or exhibiting behaviors that are not well understood. The completed models are used as "laboratories" for testing policy changes aimed at improving system behavior.

One of the great strengths of the system dynamics method is its ability to span disciplinary boundaries. System dynamics modeling is problem-oriented. That is, problems are modeled, not systems. Any information that is thought to be relevant to the modeling problem at hand, therefore, regardless of academic discipline, can be (and is encouraged to be) formally incorporated into a system dynamics model. Technically speaking, the non-discipline-constrained nature of the mathematics of dynamics enables any relationship -- biological, physical, or social -- to be represented formally in a system dynamics model. It is not unusual, therefore, for system dynamics models to embody knowledge from both the natural and social sciences.

A system dynamics model can be thought of as a "computerized case study." Unlike a traditional case study, however, "what-if" scenarios can be tested on the model. The structure of a system dynamics model consists of an extremely "rich" collection of stock and flow structures embedded in an interacting web of feedback relationships. These stocks, flows, and feedback relationships map-out the actual structure of a system -- including any physical and biological flows, nonmeasured or nonmeasurable variables that are important to the problem being addressed, and actual (as opposed to idealized) human decision making structures.

**Stock and Flows and Dynamic Behavior**

A fundamental idea in system dynamics modeling is the "principle of accumulation." This principle says that all dynamic behavior in the world occurs when flows are accumulated (integrated) in stocks. A stock can be thought of as a bathtub. A flow can be thought of as a pipe and faucet assembly (a time derivative) that either fills-up or drains the tub. Figure 15.1 below shows some examples of stock and flow structures.

**Feedback**

In a system dynamics model, stock and flow structures are embedded in feedback loops. There are two kinds of feedback loops -- positive loops and negative loops. Positive loops generate self-reinforcing behavior and negative loops generate goal seeking behavior. An example of a
positive loop is presented in Figure 15.2. Inspection of the figure reveals that as VHS VCRs become more prevalent, there is more demand for VHS format tapes, which feeds back to generate more demand for VHS VCRs.

An example of a negative feedback loop is presented in Figure 15.3. Inspection of the figure reveals that if the actual temperature in a room drops below the desired temperature, the operation of the furnace increases (i.e., the furnace turns on), and the actual temperature is brought back into line with its desired value (goal).

Reference Modes
As mentioned above, system dynamics modeling is problem-based. Thus, a system dynamics model cannot be built until a definition of the problem to which it will be addressed is arrived at.

System dynamicists define their dynamical problems with "reference modes." Reference modes are time series graphs of important system variables that are behaving problematically or in a perplexing way. In additional to helping the modeler identify important variables, the specification of a system's reference modes helps the modeler identify the time scope of the study (e.g., years, months, weeks, minutes; beginning in 1900, 1980, the first month of 1992, etc.), and the relevant behavior the model is supposed to mimic (e.g., oscillation, overshoot and collapse, sigmoidal growth.) Replication of a system's reference modes is one way that a system dynamicist builds confidence in a model. Finding policies that alter a system's problematic reference modes is the usual goal of a system dynamics study.
Handbook for IQP Advisors and Students
Appendix 1: Guidelines for Project Grading
Approved by Faculty on May 5, 1994

Background
Pronounced grade inflation for MQP, IQP, and Sufficiency activity is evident over the last twenty years. This has, in turn, resulted in a steady increase of the percentage of students graduating with honors. Furthermore, data indicate that project grading standards vary considerably from department to department. This not only creates an inequity with respect to honors, but may create barriers to student or faculty participation in multidisciplinary project activities.

Recommendations
Each term a student is registered for a project, the student receives a grade reflecting judgment of accomplishments for that term.

Upon completion of the project, students will receive an overall project grade. It is important to note that this grade reflects not only the final products of the project (e.g., results, reports, etc.), but also the process by which they were attained. No amount of last-minute effort should turn a mediocre project effort into an A.

The available grades and their interpretations are as follows:

- **A**: a grade denoting a consistently excellent effort which attains the stated project goals.
- **B**: a grade denoting a consistently good effort which attains the stated project goals.
- **C**: a grade denoting an acceptable effort which partially attains the stated project goals.
- **SP**: a grade denoting an effort sufficient for the granting of the credit for which the student is registered. This grade provides students with no feedback, and its use is discouraged, except for circumstances in which the faculty member is unable to judge the quality of the work (yet can still determine that the granting of credit is appropriate).
- **NA**: a grade denoting an effort unacceptable for the credit for which the student is registered. Note that this grade is entered into the student's transcript.
- **NR**: a grade denoting an effort insufficient for the credit for which the student is registered. This grade is appropriate when the project has not proceeded due to circumstances beyond the control of the student, or for project extensions which do not represent the full amount of credit for which the student is registered.
The results of a project should be such that an outside reviewer would reasonably deem the project as being worthy of the credit and grade given, based on evidence such as the project report.

In light of the above grading criteria, it is strongly suggested that a formal project proposal or contract be developed early in the project activity, so that all participants in the activity have a clear understanding of the project goals and advisor and student expectations. [It is worth noting that many faculty communicate their expectations to students in the following form: to qualify for an A a project must exceed established expectations, for a B a project must meet established expectations fully, and for a C a project must satisfy established expectations.]
Handbook for IQP Advisors and Students

Appendix 2: Budget

BUDGET REQUEST for (project named below)

Title:

1. Type of Project (circle)  MQP  IQP
2. Department (MQP) or Division (IQP)
3. Faculty Advisors' Initials
4. Project Registration Number

STUDENTS  BOX  MAJOR  YEAR  TERM AND UNITS

6. Total Cost of Project (supply details on separate sheet)
7. Total Amount of Support Request
8. Total Amount of Support from all other Sources (see instructions)
9. Will any funds in addition to the above be required later in the project?  Yes  No
11. I have reviewed the project proposal and budget detail which are attached to this Budget Request for approval.

Project Advisor's Signature

Submit to Interdisciplinary and Global Studies Division Office
COMPUTERS AND EDUCATION
An Interactive Qualifying Project Report
submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the
Degree of Bachelor of Science
by
Paul M. Jones
Jane W. White
John R. Smith
Date: May 20, 1993

Approved:
Professor Susan B. Anthony, Major Advisor
Professor Robert C. Benchley, Co-Advisor

Global Perspective Program - Worcester Polytechnic Institute
100 Institute Road, Worcester, MA 01609-2280
Phone: +1-508-831-5547 - Fax: +1-508-831-5485 - global@wpi.edu
Handbook for IQP Advisors and Students
Appendix 4: Example of Faculty Project Guidelines

IQP Expectations and Schedule
Your IQP should be a valuable educational experience which integrates material you have learned in classes as well as allowing you to explore new topics. Your faculty advisors and company liaisons will guide you but you should take responsibility for your own project. In one word, this means that you should take INITIATIVE!!! Come to project meetings prepared, with an idea of what you think should be done next, or with specific questions or problems if you are encountering difficulties.

The benefits you gain from the IQP experience will be proportional to the effort that you invest. Make sure the project you select is interesting to you. Also understand that you and your teammates may have somewhat different expectations regarding the effort you plan to expend, and the ways you will work together. You should discuss your expectations at the beginning of the project.

Weekly Report
You should spend 15 hours per week per person working on your project. We will meet weekly to discuss your progress and plans. You should submit a brief weekly report, preferably the day before the meeting, with the following sections:

1. Progress Report - what you accomplished during the preceding week.
2. Weekly Plan - what you plan to do in the coming week.
3. Problems/Obstacles - any concerns you might have that you want to discuss at the meeting.

The weekly report gives us an agenda for each meeting, ensuring we discuss important issues, and also helps me monitor your progress. You are encouraged to submit the report via E-mail.

I am also happy to speak with you at any time outside of the weekly meetings.

Project Schedule
During the first term, you will work to develop a clearer understanding of the sponsoring company's environment, the problem you will be addressing, and the activities you will carry out to complete the project. You should develop a better understanding of the scope of the project, and the range of solutions or techniques that are feasible. By the end of the first term, you will complete a project proposal. The attached handout details what the project proposal should contain. The proposal will be distributed to your liaisons at the sponsoring company for feedback, and to ensure that everyone agrees on the scope of your project. At the end of the first
term or the beginning of the second. You will also present the proposal to the sponsoring company.
During the second term, you will do the work you outlined in the proposal. You should try to complete the work that you promised the sponsoring company.

During the third term, you will complete the final report. You should allow time for both the client and faculty advisor to provide feedback before you write the final draft. The project will be completed with a formal presentation to the client. A separate presentation to WPI faculty and students on April 21 is also required.

You can expect me, except during conferences or exam week, to read and respond to anything that you give me within 3 days. Sometimes I can provide faster turnaround time, but that depends on my schedule. If you want feedback quickly, it helps to tell me that you will be handing something in several days in advance, so that I can make a note on my calendar. Feel free to ask questions if my comments are not clear.

**Grading**

I will give you a letter grade evaluating your performance each term. This grade is from the final project grade, and is not likely to be changed at the end of the project (although I have this option). I will also try to give you specific feedback on your performance around midterm. Grading criteria are difficult to articulate, but A, B, and C projects can be characterized as follows:

- An **A** project is one in which students identify clear objectives, and then follow through to meet their objectives. The students take the initiative to identify what must be done to meet their goals. Finally, they write a good clear project report describing their efforts.

- A **B** project is one in which students accomplish their objectives, but they rely heavily on their faculty advisor(s) for guidance. In other words, they do everything they are told to do and do it well.

- A **C** project is one which the sponsoring company claims is satisfactory, but the quality of the work is less than the faculty advisor anticipated.

The grading criteria emphasize initiative as well as work quality because both will be important to your success after graduation.
Handbook for IQP Advisors and Students
Appendix 5: Common Problems in Report Writing

Instructions to Advisees

a. Grammar/Spelling/Punctuation
   1. **Misspelled** word.
   2. A sentence should not end with a **preposition**.
   3. Incorrect in **number**. Should be singular (or Plural).
   4. Do not switch **tenses** of verbs.
   5. Incorrect **punctuation**.
   6. Not a **complete** sentence.
   7. Use a dictionary to **hyphenate** words.
   8. Avoid **run-on sentences**.
   9. Work should be **proofread** before being submitted.
   10. Avoid **split infinitives**.
   11. **Verbs** must agree with subjects in person and number.
   12. Check on the correct use of **colons** and **semi-colons**.
   13. "**Data**" is a plural word, so it takes plural modifiers and plural verbs.
   14. Use **personal pronoun** (not impersonal pronoun) here.
   15. **Pronouns** must agree with antecedents in person and number.
   16. This should be an **adverb**, not an adjective.

b. Format (Arrangements of Parts, Typing, Form, Etc.)
   1. Except for portions of the 'Introductions' Chapter, the report should (generally) not be written in the **first person**.
   2. Table of Contents, Table of Tables, Table of Figures and Charts are to be understandable without reference to the text accompanying them. Therefore, **unexplained abbreviations** are not to be used and sources are to be cited in full.
   3. **Foreign phrases** ARE (usually) underlined or italicized in the text.
   4. Check Kate L. Turabian manual (*A Manual for Writers*, latest edition) for correct **typing format**.
   5. **Slang** and **colloquialisms** do not (generally) belong in a formal report.
   6. **Incorrect** citation.
   7. **Incomplete** citation.
   8. **Divisions/subdivisions** are not correct. Check Turabian.
   9. Make sure **titles** and **subtitles** of each chapter are exactly the same in "Table of Contents" as in the text.
   10. Refer reader to appropriate **appendix**.
   11. Would not this material be more appropriately placed in an **appendix**?
   12. Be consistent re **capitalization**.
13. The first time an **abbreviation** is used it should be placed in parentheses, preceded by the spelled out version; e.g., "The Interactive Qualifying Project (IQP) is..."

14. **All titles and subtitles** in the report need to be self-explanatory so that readers skimming the report can correctly assess its contents.

15. None but the most common of **abbreviations** should be used in report titles and subtitles (see #14 above).

16. **Footnotes** may be placed at the end of the chapters as "end notes" (for easier typing).

17. **Abstract** has to be less than eighty (80) words (WPI rule).

18. No citations in **abstract**.

19. All sources used in **endnotes** (or **footnotes**) should be listed in the **bibliography**.

c. **Content** (Research Report Procedures, Style, Clarity, etc.)

1. Full citations are necessary for all **quoted material**, all specific facts which are not general knowledge, and all quantitative data.

2. Use **parallel** construction.

3. Personal **biases, sarcasm, etc.**, should not be evident in a formal report.

4. Avoid **value-laden** words and expressions; attempt a **more objective** presentation.

5. Do not draw conclusions which do not follow from your data/analysis. **All speculations** should be clearly identified as such.

6. Make sure all your **assumptions** are clearly stated.

7. Meaning is **unclear/ambiguous**. Rework.

8. For the sake of clarity, keep **modifying clauses/words** close to the word(s) they modify.


10. **Poor/awkward** English.

11. Words are (apparently) **missing**.

12. **Logic** is unclear.

13. A bit more **variety** in wording would be welcomed by the reader.

14. **Organization** is a problem for you. Please hand in a brief paragraph by paragraph outline with your submissions.

15. Avoid **categorical, unqualified statements** which are either not documented or not attributed to experts in this area.

16. Usually it is necessary to quote only when the particular wording is essential. Otherwise, **paraphrase** appropriately for the point you are making, and cite source.

17. You’re **begging-the-question**; explain more fully.

18. **Inappropriate wording** for a formal report.

19. Please discuss only **one idea per paragraph**.

20. This is too **wordy**.
Handbook for IQP Advisors and Students
Appendix 6: Gennert's Project Guidelines

PROJECT GUIDELINES apply to all projects: Sufficiency, IQP, PQP, MQP, Independent Study, Directed Research, Research Assistantships, Thesis, although certain items may not be applicable to all projects. A successful project includes the following ingredients:

Getting Started

- Relevant coursework should be taken before the project is started. Isn't that the whole idea of The WPI Plan?
- A well-written proposal will be due at the beginning of project work. This may be part of an earlier PQP if appropriate. The proposal must explain what the problem is and why it is important, and sketch a method of attack. The proposal does not need to be comprehensive, but it should let a reader know that you understand the problem.
  
  Read [How to Write a Project Proposal](#), available online and at the Project Center. You must follow the instructions in HtWaPP in order to receive funding.
- A schedule, covering the entire project, must be developed at the beginning of the project. The schedule should include milestones and deadlines.
- The topic must be well-researched. The library is an invaluable resource; all project students should be familiar with it. If you do not know how to perform a literature search, the library staff will help.
- Attend relevant seminars and colloquia on campus and nearby. This is one of the best ways to learn what others are doing.
- A project should represent a significant effort. The average amount of work will be 15--20 hours per week. Sponsored Research Assistants should spend 25--30 hours per week on the project.

Meetings and Reports

- Project review meetings will be held every week. If you will be unable to attend a scheduled meeting, call or email ahead of time.
- Written progress reports will be submitted at, or better yet, emailed prior to, the weekly meeting, with a summary at the end of every term or semester. The weekly progress report can be short --- 1 or 2 pages --- but must state what has been accomplished since the last report, what is expected to be accomplished in the next interval, and what obstacles were encountered. One progress report per project. The end of term/semester summary, project proposal, or final report may be substituted for the weekly progress report.
• You are strongly encouraged to submit condensed versions of high-quality reports and theses to conferences and journals. All thesis students must submit at least one paper based on the thesis.

Final Report
• A well-written final report or thesis is required. Correct spelling and grammar are mandatory. Contact the Writing Center if writing assistance is needed.
• A complete draft must be submitted at least 10 days before the final deadline. Expect revisions. Submitting sections earlier is encouraged. Thesis readers must be given at least 10 days to review submitted materials. If the project advisor is to review a draft before the reader, submit the draft at least 20 days before the deadline.
• You must prepare copies of final reports for all interested parties, including advisor, thesis reader, off-campus advisor or sponsor, and registrar.
• All submitted work must be original.
• There are occasions when direct quotations are unavoidable. Indicate exactly which material is a direct quotation, and provide a reference including page numbers.
• Minimize direct quotations; quote only the material needed to support the point.
• Always quote the original source; never quote one author quoting another.
• Rules of attribution apply equally to drafts and finished work. Do not let anyone suspect plagiarism.

Presentation
• A well-organized final presentation is required for IQP, MQP and thesis projects. This may be satisfied by an on-site presentation for off-campus work, or CS Colloquium, CS MQP presentation, Research Group meeting, or other forum.
• Use professional tools for your presentation, e.g., PowerPoint, Presentation Manager, Light Pro and browser.
• Expect to go through a dry run of the presentation with the project advisor.

Software
• All software must be of professional quality.
• It must be thoroughly documented, including a User’s Manual, if appropriate.
• It must be thoroughly demonstrated. Warning: Normally well-behaved demos have been known to break in the presence of a project advisor!
• It must be thoroughly debugged. If written in C, it must pass through lint.
• It must be portable. Use makefiles or imakefiles. If your project advisor cannot compile and run it, it isn't good enough.

The Web
• You are expected to find and post information on the World-Wide Web.
• Maintain a current homepage, with a link to Your project.
Let your advisor know where you and your project's web pages may be located.

**Responsibilities**

- You are responsible for finding out exactly what administrative paperwork is required and for preparing same. This includes Completion of Degree Requirements (CDR) forms, Thesis forms, etc.
- All project students share responsibility for the project's success. All team members should understand the entire project, and should read all weekly progress reports, term/semester summaries, proposal, and final report.

**Grading**

- All project students will usually receive the same grade, although exceptions can be made.
- No passing grades will be awarded until all borrowed materials have been returned.
- Grading policy: "A" indicates exceptional work, not just good effort. Significant original ideas, effort that goes far beyond what is expected, and meticulous implementation all contribute to an "A". "B" indicates good work, while "C" is for acceptable performance. "SP" indicates satisfactory performance at "A," "B," or "C" level. An "NR" grade will be given when little or no work has been performed during the grading period or when awarding additional credit is inappropriate. The final grade for a multiple-term/semester project may, at the advisor's discretion, supersede intermediate grades. "NAC" indicates unacceptable work.