Executive Summary
As part of the Strategic Planning effort, our task force has been asked to consider cooperative learning and project-based education in the context of the future educational directions of the Institute. In its deliberations, the Task Force has identified a number of major issues, each of which has impact on the nature, quality, and educational effectiveness of our project and pedagogical structure:

- The educational objectives of course work; of project work, and of the unified whole are not clearly formulated or agreed upon by a large portion of the WPI community.
- There is uncertainty with respect to the desired or expected educational outcomes and level of performance of project work;
- There is little of no mentoring of faculty by faculty in matters of project advising and pedagogical innovation;
- Cooperative interaction skills are not modelled at the faculty level, so that there are expectations for students that faculty do not hold for themselves;
- The current loading model does not appropriately distinguish teaching, academic advising, and project advising, and seriously undervalues the latter;
- There is no system of rewards to encourage, rather than discourage, project advising;
- There is an inequitable project advising distribution, within (Suff, IQP, MQP) and across departments (IQP);
- Student retention of fundamental mathematical and scientific background from the first (and second) years is very poor, and students are unable to apply what they do remember to real problems.
The Task Force is concerned that WPI graduates are less well-prepared in basic knowledge and its application than their contemporaries from other educational institutions in this country and abroad.

The Task Force has formulated 18 generally-stated recommendations that address these issues. In addition, we have identified issues specific to each of the major components of our educational structure (the First Year, the Sufficiency, the MQP, the IQP) and have formulated approximately 30 additional recommendations addressing them. The Task Force has tagged a number of major budgetary implications of its recommendations, and has made estimates of initial and/or annual cost outlays. Finally, the Task Force has identified those areas in which its members were in disagreement.

Introduction
As part of the Strategic Planning effort, our task force has been asked to consider cooperative learning and project-based education in the context of the future educational directions of the Institute. These two educational facets of our charge are only tenuously related. Cooperative Learning is a term used to describe a particular pedagogical approach in which learning occurs in peer groups within a well-defined and structured framework. Project-based education, the mainstay of the WPI educational system since the adoption of the WPI Plan in 1970, takes as its fundamental premise that students learn best by doing; that is, by applying knowledge acquired in the classroom to real problems in science, engineering, mathematics, or humanities. Although projects may and often do involve peer cooperation, they need not. Thus most Sufficiency IS/P’s, many IQPs, and the majority of MQPs are carried out by individual students in collaboration with one or more faculty advisors. The connection between the two elements of our charge is thus not completely clear to us, even now. Our approach to our charge has therefore been to consider these two elements separately.

To facilitate our discussions, we have somewhat arbitrarily considered the WPI educational structure in terms of four components: the first year program, the Sufficiency, the MQP, and the IQP. We have focussed on the first year program rather than coursework in general, or distribution requirements, because it is widely recognized on campus that the first year program is problematic in ways that upper level coursework is not. Our basic operating premise, decided early
in our deliberations, is that the WPI project-based educational structure is essentially sound. Our discussions have therefore focussed on improving it, rather than dismantling and replacing it with something new. Despite this seemingly limited approach, we have discovered, or rediscovered, a number of major issues affecting the project structure as a whole, and have developed policy statements or recommendations addressing these issues. These issues, which impact the entire project system rather than particular components of it, will be addressed in the first major section of this report. Subsequent sections will then address, in turn, the Sufficiency, the MQP, the IQP, and the first year in that order. In these sections, perceived inadequacies will be addressed, and recommendations will be made for improving or enhancing the educational effectiveness of the project component. The role of cooperative learning will be discussed in several contexts. The final section of the report presents a brief discussion of the major areas of disagreement among task force members.

**Dominant Issues of the WPI Project-Based Educational System**

The Task Force on Project-Based and Cooperative Learning has identified the following major issues, each of which has impact on the nature, quality, and educational effectiveness of our project and pedagogical structure:

- The educational objectives of course work; of project work, and of the unified whole are not clearly formulated or agreed upon by a large portion of the WPI community.
- There is uncertainty with respect to the desired or expected educational outcomes and level of performance of project work;
- There is little or no mentoring of faculty by faculty in matters of project advising and pedagogical innovation;
- Cooperative interaction skills are not modelled at the faculty level, so that there are expectations for students that faculty do not hold for themselves;
- The current loading model does not appropriately distinguish teaching, academic advising, and project advising, and seriously undervalues the latter;
- There is no system of rewards to encourage, rather than discourage, project advising;
- There is an inequitable project advising distribution, within (Suff, IQP, MQP) and across departments (IQP);
Student retention of fundamental mathematical and scientific background from the first (and second) years is very poor, and students are unable to apply what they do remember to real problems.

The Task Force is concerned that WPI graduates are less well-prepared in basic knowledge and its application than their contemporaries from other educational institutions in this country and abroad.

Each of these issues will now be discussed in more detail, with attention to recommendations for eliminating problems and enhancing the overall effectiveness of the WPI educational structure.

The educational objectives of course work (particularly first year courses), of project work, and of the unified whole are not clearly formulated or agreed upon by a large portion of the WPI community. The following excerpts from the undergraduate catalog describe the three major project components of the WPI educational structure.

The "Sufficiency" is "a thematically related course and project sequence sufficient to allow students to acquire an idea of how knowledge is obtained and expressed in a non-technical discipline. The courses taken in a specified thematic area culminate in a final independent study, in which the student begins to do original work in an area of the humanities or the arts. The final accomplishment must sum up the previous work in the humanities and arts not only by drawing upon what has been learned in previous work, but also by exploring new territory."

The Major Qualifying Project should "demonstrate application of the skills, methods, and knowledge of the discipline to the solution of a problem that would be representative of the type to be encountered in one's career. MQP activities encompass research, development, and application, involve analysis or synthesis, are experimental or theoretical, emphasize a particular subarea of the major, or combine aspects of several subareas. In many cases, especially in engineering, MQPs involve capstone design activity."

The Interactive Qualifying Project "challenges students to identify, investigate, and report on a self-selected topic examining how science and technology interacts with societal structures and values. The objective of the IQP is to
enable WPI graduates to understand, as citizens and as professionals, how their careers will affect the larger society of which they are part."

In the view of the Task Force, it is important for the student to know in general terms at the outset of her/his education why it is important for her/him to do a project of each type; what level of preparation in mathematics, science, or humanities is necessary in order to achieve maximum educational benefit from a project; that the projects are not academic hurdles, but rather are essential in the development of the "technological humanist;" that the outcome of the project experience cannot be achieved without hard work, without the experience of failure, without the application of critical self-assessment, not only in the performance of the project, but in the acquisition of basic knowledge required for the project. We believe that students should view it as a privilege to have the opportunity to pursue each of these high level intellectual activities under the tutelage of a WPI faculty member, and that the activities leading up to the projects should be undertaken with the aim of earning that privilege. If students are to adopt this attitude, they must be told what we expect of them; and we must know what we expect of them. The catalog excerpts above inadequately convey the significance and interrelationships of these activities.

To address this issue, the Task Force recommends

1. That the Institute, via an appropriately selected group, consider the overall intent of its educational program

2. That the Institute convey specifically and in detail to the student body the overall intent of its educational program, via appropriate discussions in the undergraduate catalog and other important means of communication.

3. That the Institute examine its intellectual culture, with the aim of defining it, then instilling in the student body.

There is uncertainty with respect to the desired or expected educational outcomes and level of performance of project work. This is related to, but distinct from, the previous issue, because it may be better addressed at the
department level, at least for the Suff and MQP. What is it that each department would like to see students emerge from a project experience with in the way of attitudes, viewpoints, and specific skills? Against what specific criteria is the quality of student work to be judged? Is there a minimum input of time that must be invested in order that a project be judged acceptable? What are the standards of quality for the written report in terms of formatting, technical and graphical aspects, demonstrated level of knowledge of the discipline, data collection and analysis, literature review and referencing, etc.? What are the expectations regarding oral presentation, professional dissemination, and institute-wide display of the project results? There is evidence that individual advisors vary widely in their view as to what constitutes the minimum acceptable level of effort for an A, B, or C grade. At present, only half of the departments require a final oral presentation, and in many cases, this is considered more an obligation than a privilege. Similar questions can be asked about the IQP, but in this case must be addressed at the Institute level. It is clear, and somewhat disconcerting, that at present there are few guidelines for faculty or students that address the proper execution and evaluation of the project experience.

To address this issue, the Task Force recommends

4. That the Institute define the IQP experience in terms of what the project should be; what the student (and advisor) are expected to achieve and/or gain by doing it; and what acceptable standards for its evaluation are.

5. That the HU/A department clarify the educational objectives of the Sufficiency, and take steps to make these widely known to the WPI community.

6. That every department develop a clearly stated, sufficiently specific set of educational objectives, a definitive and well-publicized system/schedule of project and advisor selection, and an understanding of the attitudes and skills with which their majors should emerge from the project.

7. That every department consider a mandatory oral presentation of every project on Project Presentation Day; that the presentation process be treated as seriously as a national meeting of a professional society, with the
associated publicity and an audience of peers, parents, and invited professionals in the field.

In discussing the first two major issues above, the Task Force became convinced that it should make an additional recommendation, one that might ultimately facilitate resolution of the issues. This recommendation addresses the recognition that students frequently perceive their three major project experiences to be separate, mutually exclusive entities. Indeed, some question the purpose of the Sufficiency and the IQP entirely. The Task Force does not propose that the three project experiences should be thematically or topically related. However, we do feel that it is important for students to experience some form of closure with respect to their project activity, to perceive that the three experiences are intended to combine to a well-rounded whole. Thus the HU/A Sufficiency and the MQP provide fundamental knowledge and research experience in the two spheres of human knowledge. The IQP is in a sense a culmination, in which students are asked to explore the interaction of society and technology, a full understanding of which requires reliance upon knowledge from both spheres.

For these reasons, the Task Force makes the following recommendation.

8. That the Institute take steps to provide closure in the project experience.

The Task Force has considered two ways in which this might be done. First, we have discussed the possibility that students be advised to approach the projects in the sequence, Sufficiency (second year), MQP (third year), and IQP (fourth year). Over the years since the adoption of the WPI Plan, a number of unwritten "rules" have evolved and set (like cement). One of these is that students are to complete the Sufficiency by the end of the second year; undertake the IQP in the third year; and, finally, have the culminating experience in the major area in the fourth year. This ordering is almost universally recommended on campus, and is almost universally followed. For a number of reasons, the Task Force questions the purpose of and the desirability of this ordering. First, students tend to view the MQP as the culmination of their education, hence its most important component; and they are understandably eager to get to it. Yet they must wait through 3 years to reach it. There are several detrimental effects of
this. First, the IQP is viewed as a barrier standing between the student and the MQP, rather than as the important educational activity that we deem it to be. Second, much of the fundamental knowledge gained in the first year is lost in the intervening period, and is therefore not manifested in the MQP. Third and perhaps worst, students are expected to carry out a project involving the interplay of their major field of study with society before they have developed an appreciation for the nature of research, design, and application in their major field. Finally, of the three major projects, the IQP requires the greatest intellectual maturity.

Some potential advantages of this ordering in addition to those mentioned above are that as freshmen, students will perceive the MQP to be much closer temporally, and might therefore take the first year foundation program more seriously than they now do; b) that students will have the option to continue the MQP work beyond the required 1 unit of work, if it is mutually desirable to student and advisor; c) that students will be better prepared both academically and in terms of emotional and intellectual maturity to undertake the IQP; d) that students will more fully appreciate the dual nature of the IQP after having project experiences in the scientific/technological and humanities spheres of knowledge.

A second solution to the closure problem discussed by the Task Force is the creation of an interdisciplinary senior seminar course, the purpose of which would be to provide a forum for discussion of societal/technological issues. We envision such a course to be team-taught by faculty from engineering, humanities, social science, and science. It would be strongly recommended for all students, following completion of the IQP, as a lively, interactive closure experience.

There is little or no mentoring of faculty by faculty in matters of project advising and pedagogical innovation. New faculty are given a brief introduction to the projects system during the new faculty orientation program; and are then left to acclimate themselves on their own to a mode of teaching that, with high probability, they have not been prepared for. In most cases, Sufficiency and MQP advising can be approached from the standpoint of the research experience, but faculty still need to learn about project teaching.
For the IQP, new faculty have no precedent. An additional barrier is that faculty may feel uncomfortable with the state of their knowledge in the subject matter of the IQP divisions. The Task Force believes that the project system is such an important aspect of our educational approach that the absence of such mentoring systems is nothing short of astounding. We recommend

9. That the Institute establish a system whereby new faculty are systematically introduced to and mentored in IQP advising by faculty experienced in advising IQPs.

This might (but need not) work something as follows. Early in their first term at WPI, new faculty would be asked to affiliate themselves with a group of faculty in one of the IQP divisions, this affiliation being made on the basis of interest in and/or knowledge of the general subject areas of the division. Such affiliation must be encouraged by the groups of faculty associated with the division, via invitations to meetings, email "publicity", and the like. For the first, say, 2 years at WPI, new faculty would be actively involved in coadvising IQPs in the chosen division, teamed with an experienced advisor. At the end of this "apprenticeship" period, new faculty would be experienced enough to undertake "stand-alone" advising if desired, though continued coadvising activities would be desirable.

10. That each academic department establish a structure for the effective mentoring of new faculty in MQP advising. In the case of the HU/A department, a structure for mentoring of new faculty in sufficiency IS/P advising would also be recommended.

This might take a number of forms, from a small group of experienced faculty who meet regularly with new faculty during their first year to discuss the "tools of the trade"; coadvising of MQPs, in which new faculty are paired with experienced faculty advisors; or other mechanisms.

11. That the Institute establish a group of pedagogically innovative faculty to mentor other faculty in effective teaching methods.
Such a group might fall under the domain of CED; or it might be completely independent of CED. One useful concept might be to compose the group from among previous winners of the Trustees Award for Outstanding Teaching. Permanence with continual turnover of membership could be assured if the group were constituted of, say, the winners of this award for the previous 5-year period. This would enable the Institute to take advantage of the excellence in teaching that it recognizes each year in order to benefit the entire faculty.

Surely there are countless ways in which the recommended mentoring systems could be established and maintained. The Task Force emphasizes only that something should be done in this vein.

Cooperative interaction skills are not modelled at the faculty level, so that there are expectations for students that faculty do not hold for themselves. Particularly lately, students are expected to emerge from a 4-year university experience with sound knowledge of their discipline; well-developed group interaction and processing skills; leadership skills; effective communication skills, written and oral; critical thinking skills; the ability to learn on their own; and the ability to synthesize basic concepts in numerous (complex) ways. The argument could be made that it is impossible to acquire all of this in four years. Indeed, many of us probably would admit that it has taken us years (decades) to acquire many of these skills and abilities, and that we are still learning. But putting the fundamental impossibility of achieving all of this in four years, employers none the less tell us that these things are what they are looking for. Interestingly, many of these skills result from extensive work in groups; so more and more we encourage our students to work in groups, and attempt to sell them on the benefits thereof. Yet we faculty only very infrequently practice what we teach. On the WPI campus, there is a paucity of team teaching activity; of coadvising of projects; and of cross-disciplinary research activities. We are in the awkward position of having to say to students, "Do what we say, not what we do." Ultimately, of course, students perceive that we do not do what we are telling them to do, and they take what we say less seriously, with uncalculable consequences. The Task Force recommends

12. That the Institute encourage team teaching initiatives, both within and across departments.
Such faculty cooperation, in addition to modeling the kind of group dynamic that we would like our students to adopt, has tremendous potential to enrich and challenge both faculty and students in ways that are currently not experienced on campus.

13. That the Institute and its academic departments encourage, promote, and reward coadvising of MQPs and IQPs and co-developing cross-disciplinary Sufficiency areas.

14. That the Institute and its academic departments encourage, promote, and reward intra- and inter-departmental research collaborations among faculty.

Showing our students the positive potentialities of group efforts will provide impetus for them to emulate these efforts. Holding expectations for them that we do not hold for ourselves undermines our credibility and the effectiveness of our educational program.

The current loading model does not appropriately distinguish teaching, academic advising, and project advising, and seriously undervalues the latter. The existing loading model equates 1/3 unit of Sufficiency, MQP, or IQP advising with one classroom student. Thus a faculty member advising 50 MQPs students in one term, each student registered for 1/3 unit, is considered to work no harder than a faculty member who teaches a 1/3 unit course to 50 students. The message to faculty is clear: you will be given very little credit for the hard work that you do in advising Sufficiencies, MQPs, and IQPs. The outcomes of this policy are that many faculty choose to advise few or no projects; and others, though they do advise projects, resent it in varying degrees. The Task Force finds it ironic that the primary way in which the college presents its educational distinctiveness is the least recognized in the evaluation of faculty time.

It is extremely important that the community recognize and acknowledge the unique aspects of project teaching. The project experience is distinctive because it grows out of the activity of exchange itself, including the negotiation of a project’s focus, the emergence of a research plan or creative path, the
search for appropriate means of analysis, response to things going awry, and the completion of a final result and written document. Project-based learning is highly labor-intensive for faculty. Its practice pulls the thesis or dissertation experience of graduate education into undergraduate education, inasmuch as the working group is small, the subject area is highly focused, and the activity continuous. It is a teaching-learning process with no given boundaries of class hour, containable result, or predictable need.

The Task Force recommends

15. That the Institute discard the current faculty loading model and replace it with one that encourages project advising by properly recognizing and distinguishing the varied educational responsibilities of its faculty.

There is no system of rewards to encourage, rather than discourage, project advising. At present, a faculty person who is heavily involved in, say, MQP advising in his/her department is treated no differently in salary deliberations than is a person with a light advising load, as long as overall teaching loads (as measured by an inappropriate model, as discussed above) are comparable. How do we now recognize and reward those faculty who, year after year, skillfully guide their project advisees through the a major project component of the WPI experience? Unfortunately, we do not. There is unfortunately no clear and tangible reward for project advising; consequently, many people find little motivation to do it.

The Task Force recommends

16. That the Institute recognize and reward project advising activity of all kinds in a tangible way that is consistent with the high profile of project activity in our educational program.

Reward might come in the form of a merit raise; a contribution to a discretionary account; the purchase of computer hardware/software; or the purchase of instrumentation or equipment supportive of the individual's project or research activity; or a reduced classroom teaching load. The promise of such
rewards could impact the quantity and quality of project advising, and the currently inequitable distribution of advising loads, as discussed just below.

There is an inequitable project advising distribution, within (Suff, IQP, MQP) and across departments (IQP). That such inequity exists is obvious, and need not be further substantiated. The Task Force has discussed this issue, with no clear policy recommendations emerging. However, some of our earlier recommendations, made primarily to address other issues, might also positively impact this one. For example, the creation of an IQP mentoring system for new faculty would virtually insure, over time, that all faculty had been exposed to and had participated to some extent in the advising of IQPs. It would seem to follow that these faculty would then be more likely to continue advising IQPs. The rectification of current loading practices, and an appropriate reward system for project advising, might very well provide stimulus for faculty who are now indifferent to this type of activity. With the heightened interest and heightened involvement of faculty, the inequity in loading will diminish.

Student retention of fundamental mathematical and scientific background from the first (and second) years is very poor, and students are unable to apply what they do remember to real problems. Hearsay evidence indicates that many students are disappointed by their initial experiences at WPI, because they do not receive the type of experience that they were led to believe that they would receive. In its publicity, WPI stresses the small-group project experience; one-on-one interaction with faculty; access to state-of-the-art technology; and application of knowledge to real world problems. This is what incoming students expect to find. Instead, they experience, at least in the first 2 years, a very "standard" educational structure consisting of large classes, very little group experience, very little interaction with faculty other than HU/A, very little exposure to technology; and almost no application of basic knowledge. The resulting disappointment is difficult to counteract, and may be one factor in the failure of students to apply themselves rigorously to the foundation course material in the first and second years. There are many other contributing factors, including but not limited to a poor work effort resulting from unchallenging high school experiences; the stratification of our program, in which all science and math courses are to be taken in the first year and early part of the second year, with little or no connection made to applications of
supposedly important ideas and concepts; the 7-week term, in which students are exposed to material at approximately 1.7 times the rate in a 14-week basis system; the unfortunate fact that much of what is taught in the foundation courses is in fact not very useful, relevant, or interesting. We acknowledge that the responsibility for retention and elaboration of knowledge lies primarily with the student. This is a fact that many of us lose sight of. The problem then becomes not what can we do to increase students' retention of what we teach them; but what can we do to help students see the importance of retaining what we teach them.

The Task Force recommends

17. That the foundation scientific and mathematical disciplines critically examine their curricula with an eye to what should and should not be taught, and how it is taught.

18. That individual faculty in science, engineering, and mathematics consider the creation of (interdisciplinary) team-taught courses that simultaneously address concepts and scientific, mathematical, or engineering applications.

In subsequent sections of this report, the major project degree requirements will be considered in turn. Discussion will center on the strengths and weaknesses of each activity, and on recommendations to eliminate or reduce the latter. Problems discussed under the major issues delineated above will not be addressed in the following sections.

The Task Force is concerned that WPI graduates are less well-prepared in basic knowledge and its application than their contemporaries from other educational institutions in this country and abroad. Anecdotal evidence from WPI graduates, employers of WPI undergraduates, and WPI faculty indicates that in many cases our students are underqualified. Graduate schools and employers find our graduates lacking in mathematical skills and adequate work ethic. One WPI graduate, currently a graduate student at WPI, has stated that he was shocked at his lack of ability compared to beginning grad students from elsewhere. He maintains that there is an absence of connectivity in the
undergraduate program; that a smooth flow in material from one class to the next in sequence is absent. He believes that the 7-week term undermines the abilities of students to absorb material. Our reluctance to specify prerequisites is another obvious contributor to a lack of connectivity.

There is a sense among Task Force members that expectations at the university level have been steadily eroding. There is the sense of a trend to undercut technical knowledge and replace it with knowledge of public relations skills; that is, skills that will help the student to sell himself in the employment market, despite that fact that s/he may be seriously deficient in substantive knowledge. There is a sense that the very noticeable increase in pedagogical innovation is almost an act of desperation born out of the realization that we are not getting through to students.

Clearly, if true, this is a problem of such scope that it cannot be addressed by one or a few recommendations. However, if the recommendations above, and those to follow, are heeded, it is possible that the cumulative effect will ultimately be to rectify this problem.

The Sufficiency

Strengths of the Sufficiency

Of the three major project activities at WPI, the Sufficiency is perhaps the least problematic. It would seem to be on the whole an effectively run program, that is effective educationally in providing technologically oriented students with an immersion in the Humanities and Arts, where the language, style of discussion and argument, mode of presentation of knowledge, and the very nature of knowledge differ substantially from the technical sphere. The Sufficiency provides the first opportunity for students to have an independently researched paper evaluated by a faculty member. It provides the first opportunity for the student to interact one-on-one with a faculty member.

Because students are able to choose their area of concentration, they are motivated to be more serious about their non-major interests, more purposeful in selecting courses, and more responsible for identifying the subject matter of the final IS/P. The final IS/P provides an opportunity for student-faculty exchange akin to honors programs at liberal arts colleges in which the learning
experience is controlled by student initiative and independent research. Through Sufficiency work students often initiate life-long learning through interest in a particular aspect of history, literature, or architecture, involvement in theater or music, or pursuit of philosophical or religious questions.

Weaknesses of the Sufficiency
Despite its strengths, there is room for improvement in the Sufficiency activity. A number of problems exist, most recognized in the Second Quadrennial Review of the Sufficiency Project, reported on in August, 1996. First, judging from the catalog description, there is a lack of clear educational objectives. Given the diversity of areas encompassed by this department, however, the Task Force recognizes that it may be neither desirable nor possible to establish objectives acceptable to the entire HU/A community. Second, clear guidelines for performance IS/Ps are lacking. The HU/A department is considering the formation of a committee, including representatives from Music, Theater, and other disciplines, to develop guidelines. Third, there is no mechanism for the evaluation of foreign language sufficiencies. HU/A is considering the feasibility of hiring outside consultants to evaluate these. Fourth, there is variability in the quality of the written Sufficiency report. The department is considering a recommendation that they develop a manual establishing minimum standards of mechanics required of all written Sufficiency reports (use of a word processor, thorough proof reading, pagination, observation of format requirements, uniform and complete documentation and referencing). Further, the department recognizes that Sufficiency advisors should more actively urge students to use the Writing Resource Center. Fifth, project quality seems to be, to some extent, a function of course preparation, with students who have participated in a 3000-level course prior to the IS/P producing on average better work than those who have not. Finally, there is a lack of community awareness (non-HU/A faculty, students) of effective mechanisms for sufficiency theme design, and for choosing an advisor. Recently this has led to more and more last-minute advisor selection. This problem was not explicitly recognized in the 1996 Quadrennial Report.

The Task Force recommends
19. That the HU/A department enhance student and non-HU/A faculty awareness by providing the community with information on typical time frames; examples of thematic selections; examples of final reports; recommended course sequences and levels.

20. That the HU/A department consider the possibility of mentoring activities involving non-HU/A faculty, such as individual attention to new faculty and including major advisors in IS/P discussions.

The MQP

*Strengths of the MQP*

The Task Force recognizes a number of major strengths of the Major Qualifying Project, at least some of which are manifested in every MQP on campus. The MQP

- Promotes development of the capacity for independent learning;
- Requires integration of knowledge areas;
- Encourages students to choose and develop an area of interest;
- Provides a forum for intensive and extensive faculty-student and student-student exchange in a small group with shared interests;
- Provides the opportunity for a high level of student initiative and involvement in designing a learning experience;
- Gives students a realistic appreciation for success/failure rates;
- Contributes to the development of self-confidence and self-sufficiency.

In addition, the MQP promotes the development of a number of skills, including team work and team learning skills; the ability to apply course knowledge; logical thinking skills; the planning and development of a proposal; the ability to learn via independent reading; design; literature searching and critical reading skills; knowledge of and skill in the use of equipment; oral and written communication skills; analytical and computational skills; organizational skills; the ability to be resourceful; and critical self assessment.

*Inadequacies of the MQP Structure and Recommendations for Improvement*
The Task Force also recognizes flaws in the current MQP structure, in addition to those already touched on in the discussion of major issues. Some discussion of these flaws follows.

There are no institute-wide criteria for

- Desired learning outcomes (what is gained from a project that is not gained from a class?)
- Appropriateness of the project idea or concept
- Minimum level of science and math evident in the project
- Grading/Evaluation (there is lack of uniformity from department to department with respect to the minimum requirements for the A, B, and C grades; there is too frequent use of the SP grade; there is failure on the part of some faculty to observe the policy for completing and submitting CDRs)
- Whether or not a proposal is required
- Report quality (writing, referencing, proper presentation, analysis, and interpretation of data)
- Deadlines
- Publicizing MQP opportunities and process
- Oral presentation

The Task Force recommends

21. That the Institute more clearly define global objectives for the MQP, with a focus on learning outcomes that students may expect to achieve.

For example, some possible learning outcomes might include the ability to define a problem; the ability to ask appropriate questions; the capacity for critical self-assessment; the ability to critically read the literature in the field; some modicum of group skills; and the development of a realistic appreciation for success/failure rates.

22. That there be a faculty presentation day in each department at which faculty give brief presentations of MQP opportunities;.
23. That there be a common set of procedures and schedule for dissemination of information.

24. That the Institute encourage and fund off-campus presentations; and that publication of results and research proposals based upon results should be supported.

25. That steps be taken to improve the written product.

26. That each department implement a system of writing deadlines;

27. That the written report be included as an element in selection of MQPs for awards;

28. That a proposal with literature review should be required prior to beginning the MQP, and preferably in the second year (this is based on our previous recommendation that student do the MQP in the third year).

29. That each department establish well-defined grade criteria, and that every effort be made to make these reasonably consistent across departments. In this context, the Task Force endorses the CAP grading guidelines.

30. That the SP grade be eliminated and a grade that accurately reflects work accomplished in that term be awarded;

31. That the faculty advisor write and submit a summary evaluation form with each MQP.

32. That each department distribute each year a collection of the best MQPs, one per faculty advisor; That these be circulated institute wide and made available to first and second-year students so that they may see what is expected.

33. That faculty strictly adhere to the Institute policy for handling CDRs.
The level of Institute funding of the MQP is inadequate. This is a matter of administrative support that is in addition to the problems with loading and reward discussed earlier. The Task Force recommends

34. That the budget for MQPs be increased, and that a system of accountability be implemented whereby feedback is provided to Projects Administration regarding funds spent.

There is a problem with individual accountability of MQP team members. It is clear from departmental MQP reviews of 1995 that it is common for group MQPs to involve widely-varying individual efforts on the part of team members, with outright coat-tailing in a number of cases. The Task Force recommends

35. That faculty familiarize themselves with the elements of cooperative learning, and teach them as an explicit part of the project. In particular, it is crucial that positive interdependence be created and nurtured in the group experience.

36. That faculty attempt to role model group dynamics through enhanced team teaching and coadvising activity.

The majority of projects done on campus involve a single student and a single faculty member. The Task Force was quite surprised to learn this, because it indeed suggests that to a large extent we are not providing what we advertise. The Task Force recommends

37. That coadvising be encouraged and rewarded

38. That students be encouraged to work in teams where appropriate, and be explicitly taught how to do this effectively.

"Default" advising seems to be a problem in departments with many majors and a substantial proportion of externally generated projects. By default advising, we intend to describe the phenomenon whereby students select a project that has no affiliated WPI advisor, then must seek a faculty advisor willing to advise
the project. Often students select an advisor almost by "default" in these circumstances, and the quality of the product suffers. The Task Force recognizes this problem, but has no recommendations for resolving it.

The IQP

**Strengths of the IQP**

The IQP has a number of clear strengths. The IQP is virtually unique to WPI and is a tremendous selling point. It prepares students in atypical ways for their careers because it requires that they engage in cross-disciplinary work and think critically about the social implications of their professions. Off campus IQPs have been significantly improved in recent years, the global experience providing a wonderful opportunity for students. The strengths of the IQP are best expressed in the Zwiebel Committee Objectives of 1972. These objectives are

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

Finally, there are a number of specific skills promoted by (or that should be promoted by) the IQP, some of which are also common to the other projects. These include writing, the use of statistical methods, survey design, analysis of results, the analysis and interpretation of data; communication skills (telephone, face-to-face verbal, written); problem definition; writing a proposal; time management; group interactions; and literature research.

**Weaknesses of the IQP**

The Task Force has identified a number of weaknesses in the IQP structure in addition to those already discussed under major issues.
The nature of the IQP is insufficiently defined. Perhaps more than for any other project activity, the catalog description of the IQP is vague and uninformative. The Zwiebel Committee objectives, still considered to define the IQP, are not even stated in the catalog.

The Task Force recommends

39. That the Zwiebel Committee objectives be explicitly communicated via the Undergraduate catalog.

40. That the Institute consider the desired educational objectives of the IQP with an eye toward better defining this educational activity.

There are issues of quality; specifically

- Some faculty are apparently willing to accept inadequate effort from students;
- Off campus projects are generally perceived to be superior to on-campus projects;
- There is a failure to apply relevant methods of analysis or knowledge drawn from social sciences, humanities, and other disciplines;
- The quality of writing is highly variable, and often poor;
- There is a problem with grade inflation;
- There is still an inadequate societal component in some IQPs.

The Task Force is particularly concerned at the growing perception that off-campus project are in some way superior to those carried out on campus. It is true that the off campus projects are more visible, more glamorous, and provide a strong selling point for prospective students. However in these projects, students are often given a pre-defined topic, and are thereby absolved of the often difficult task of project definition that is an important element in project education. Further, off-campus projects are generally not held to the critical goals of the Zwiebel Objectives. Overall more is expected of students and advisors on campus, but they are given less support and less credit for a job well done.
The Task Force recommends

41. That appropriate expectations be defined.

42. That an IQP Procedures Manual be created and made available on the Projects Program web page.

43. That an annual IQP review be carried out, with results communicated to the advisor.

44. That on-campus IQPs be placed on equal footing with off-campus IQPs.

45. That timely completion of background coursework be strongly recommended.

46. That improved training in analytical methods be provided.

This might include such specific actions as the creation of a Statistical Methods Resource Center, or requiring that all students take ID 2050 prior to the IQP.

47. That more emphasis be placed on writing throughout the curriculum, and that existing centralized mechanisms (Writing Resource Center) be strengthened.

48. That well-defined grade criteria be established.

Lack of strong hands-on management. At present, the IQP program is lacking leadership, and there is continued insufficient promotive activity on the part of IQP Division Coordinators. The quality of attention and resources given to strengthening the global program also needs to be given to on-campus programs that serve the majority of students.

The Task Force recommends

49. That division coordinators become more proactive in creating, developing, and publicizing IQP opportunities.
A possible consideration would be to create one IQP coordinator for each academic department who would encourage involvement by department faculty in any or all IQP divisions.

50. That the Projects Office web page, "Directory of Available Projects," be regarded as the main vehicle for dissemination of project proposal information to students.

51. That the IQP be tied more clearly into a range of course work in different departments. Possibly groups of relevant courses could be listed with each IQP division.

52. That the college consider developing a course for the first term of the IQP to teach data gathering, analysis, and interpretation and to teach critical thinking about society and technology.

There is a problem with individual accountability of IQP team members. This problem is common to both MQP and IQP, and has already been discussed.

The First Year Program
It is widely believed that our first year program is problematic, and considerable attention has recently been given it, thus far without much tangible result. Notably, a Future Search conference on the First Year was held in June, 1994, resulting in a clear articulation of a number of the problems in the first year, and a number of recommendations for addressing them. One concept that emerged from that conference was that of "Bridge Projects" in first year courses, the purpose of which would be to enable students to make connections between mathematical and scientific concepts and theories, resulting in a more holistic first year experience. This idea has been pursued, and has recently been funded by the National Science Foundation. Thus efforts are underway to improve the first year experience. Yet a number of problems remain.

Strengths of the First Year Program
As one faculty member has said, and many believe, our first year is distinguished by its lack of distinction. It is distressing that it is hard to find
strengths to include here. But there are a few. First, many of the introductory science and math courses are well taught, given the limitations of format (that is, large classes, taught largely via lecture). Secondly, attempts are made to expose students to modern laboratory applications of technology. And students are broadly exposed to computer applications (Maple and Mathcad in mathematics; word processing, spreadsheets, and instrument interfacing software in chemistry). The new freshman level courses in the engineering disciplines may offer a modicum of excitement to the freshman.

**Problems and inadequacies of the First Year Program**

It seems to be problematic that basic skills are compressed into the first year; skills atrophy between freshman and junior years, so that students do not have them in hand for the challenging upper level majors courses or the Major Qualifying Project. For the most part, first-year courses are large, impersonal, and taught via traditional lecture/examination methods, primarily for budgetary reasons. There is little or no involvement of students with the faculty. Many students maintain that they come to WPI expecting such involvement. Failing to find it in the freshman year is disappointing and disillusioning. Students do not perceive the importance of the first-year courses to their major areas, unfortunately because these courses often fail to make this clear, or attempt to demonstrate it in ways that are unconvincing. Potentially strong students are unengaged; weak students are lost in the shuffle. In many ways, the first year is an island of tradition in an otherwise unique educational program. It is viewed as something that students must "get through" in order to get to the interesting things later on. In a number of courses, curricula are badly in need of revision. There is no overall curriculum design in many departments, a problem that begins with the freshman year. There is a failure to develop or to stimulate students to develop a "culture" of hard work, of desire for knowledge in the crucial first year, problems which then persist. A number of faculty feel that students are grossly underworked in the first year, being required to take only three courses at a time that make few demands on them.

**Complications in Dealing with the First Year**

There are conflicting pressures. On the one hand, engineering faculty want the math and science courses to focus on fundamentals in the first year with no
frills. On the other hand, there is pressure to extend the project-based education to the first year, with either a stand-alone project, or use of projects within courses; and to expose students to a variety of experiences that will take away from the time available to focus on fundamentals. Clearly these aims are mutually exclusive.

There is a problem with the intellectual culture in the high schools and colleges of America. Many of our first year students have been "successful" in high school (meaning that they received high marks), virtually without lifting a finger. They come to us devoid of work ethic, and often devoid of very fundamental knowledge that we incorrectly assume them to have. Many of them seem interested and eager to learn; but the solid basis--the readin', writin', and 'ithmetic--is not there. Our first year courses then have the difficult task of trying to instill rigorous fundamentals at the university level, when the underlying fundamentals are not in place. An additional complicating factor is the increasing tendency for colleges, as well as students and their parents, to view the latter as "customers." There is a tendency to attempt to satisfy the customer, and it is unclear what that means. One detrimental aspect is the tendency for students and their parents to believe that, because they have paid their money, the degree is deserved. This notion is clearly highly destructive to the mission of higher education. A final factor contributing to an anti-intellectual culture is that upperclass students teach freshmen the shortcuts and angles of the WPI system, how to "slide through" with the minimum of work. This is the antithesis of the atmosphere that we might wish to have.

Possible Innovations in the First Year

A stand-alone freshman project. This concept was considered during the 1994 Future Search conference, and discussed again by the Task Force. An appealing twist on this idea is that such projects be largely supervised, perhaps even designed, by an interested, committed upperclassman in the major field of the freshman group. Despite the appeal of this idea in the ideal, our sense is that most freshmen are simply not mature enough, or knowledgeable enough, to successfully complete a major project, independent of course work, in the freshman year. In addition, a stand-alone freshman year project would diminish
the core course opportunities for freshmen, exacerbating the already-existing perception that they know very little when they enter upper level courses.

**Attachment of freshmen to MQP teams.** This idea, by which each freshman student is assigned to an MQP team to participate at a low level and to experience the excitement of project work, is one that sounds wonderful in the ideal. There is a very real possibility, however, that it would be disastrous in practice. First, in light of the claim that coursework has not adequately prepared juniors and seniors for the MQP, how can we expect a freshman to have anything near the preparation needed to comprehend the basis of, purpose of, and workings of the MQP project? It is questionable that this would be time well spent for a freshman. Second, and potentially more serious, MQP teams are under no small amount of pressure to carry out and complete a project in a somewhat limited amount of time. How willing will fourth year students be, under this pressure, to take time to explain what is going on to the freshman team member? Is it not likely that the first year student will be considered as an impediment to progress of the group, and that s/he will be treated accordingly? In this circumstance, will the first year student enjoy a positive experience of the WPI project system? This concept of first-year affiliates to MQP teams carries with it many potential pitfalls.

**Interdisciplinary Bridge Projects.** Projects designed to link scientific concepts with mathematical principles will be designed and built into first year foundation courses in chemistry, physics, and mathematics. This will ensure that virtually all freshmen and many sophomores will take part in bridge projects. In doing so, they will experience many of the desirable aspects of project work at an appropriate level, and will experience the team approach to problem solving. Bridge projects can be developed and incorporated with only minor disruption to the existing freshman/sophomore year structure, at relatively low cost, but with potentially great benefit. They will also serve to extend project-based education into the freshman year, making the overall program more unified.

The Task Force recommends
That the bridge project concept be fully explored and tested on a trial basis, with the purpose of injecting some of the excitement of interdisciplinary activity and project activity into the freshman year.

More extensive use of cooperative learning in courses. Cooperative learning works best in classes having relatively small populations of 50 students or less. Thus it is difficult to see how they could be applied in the large first-year courses without a large increase in faculty loading in the science and mathematics departments. Provided that a creative solution to this problem could be found, faculty are very polarized on the issue of the effectiveness of learning in groups. To pursue cooperative learning on a large scale would require addressing and somehow overcoming this polarization.

A tutorial system, involving permanent student/faculty groups. This concept was spawned in the 1994 Future Search conference, and was explored further by a group of faculty during summer 1996. Briefly, the idea is that tutorial groups consisting of a number of freshmen students (say, 20) and a number of faculty (say, 5) would be formed at the outset of the freshman year. The purpose of the groups would be to foster an intellectual climate in which students and faculty could exchange thoughts and ideas on a broad range of subjects in a relaxed environment. Such a tutorial system might "capture" students interest, show them that faculty are interested in them, and importantly show them that faculty do not have all the answers. Tutorial groups would meet once per week, perhaps in the evening, to discuss in depth a scientific, mathematical, or philosophical idea or concept, chosen by a member of the tutorial group. The difficulty with such an activity, other than the obvious ones of scheduling and faculty loading, is in how to grade it. There is a valid worry that without a grade, students will not attend.

The Use of Student and Faculty Base Groups. The core of this idea is that as entering freshmen, students should be formed into "base groups" of their peers, each base group to consist of 4-6 students, possibly all with the same advisor. Membership of base groups would be randomly determined, but with an eye to maximum heterogeneity in ability, race, gender. The purpose of the base groups would be to provide a social, emotional, and academic support system for students, with all of the established benefits thereof. Base groups would be
expected to meet regularly and frequently to provide and benefit from this support structure. An additional aspect of this idea entails that faculty form into base groups of 4-5 members, with a membership that would be heterogeneous as to discipline, age, gender, and race. The purpose of the groups is to provide a social, emotional, and professional at-work support structure for faculty. Groups would be expected to meet at least once per week to provide support, to discuss pedagogy, problems, collaboration, course content, and the like.

**Interdisciplinary Courses.** To overcome the problems associated with stratification of knowledge in our program, it is conceivable that freshman level courses in which the fundamentals of math and science are blended with engineering, mathematical, or scientific applications might be created by pairs or teams of faculty, who would then team teach the courses. This idea has merit. The obvious difficulty is that the science and mathematics departments might be viewed more as service departments than they are at present. This problem might be avoided if such courses were to grow from the interests of individual faculty from crucial departments discussing, designing, and offering such courses. Via such a "grass roots" approach, as contrasted with a top-down policy, the problem of individual identity of departments would not arise.

The Task Force recommends

**54. That faculty in science, mathematics, and engineering who are interested in the concept of blended courses proceed as individuals to develop and offer such courses on an experimental basis, with the understanding that such courses are to supplement, not replace, existing departmental courses.**

**Issues on Which the Task Force Members Disagreed**

The Task Force was unable to come to agreement on a number of issues, which are consequently not stressed in this final report. However, we felt it important to mention them, and to present the differing viewpoints, because our disagreements may foreshadow responses on campus when the issues are confronted by the WPI community.
The Task Force was split on the suggestion that courses should be used to prepare students for projects. This suggestion was made by two interested faculty at the open meeting held by the Task Force for the WPI community. These faculty, and at least one member of the Task Force, maintain that we do very little if anything to prepare students during their first 2 years for the demands of the MQP and IQP; that we have expectations of students in the context of these projects that are unrealistic in view of this lack of preparation. The alternative argument is that we offer projects as the vehicle by which students may learn what they need to learn to carry out a project; that to try to use the course structure as preparation for projects would mean that critical fundamental knowledge would not be taught in these courses; that the purpose of the courses is to transmit this fundamental background knowledge; and finally, that it is completely unrealistic to expect to be able to teach all of the things that we are now expected to endow students with, and at the same time adequately prepare them in the fundamental knowledge of the field.

The Task Force was split not only on the extent to which Cooperative Learning should be recommended to faculty as a useful and effective pedagogical tool, but on the desirability of recommending it at all. Some members of the Task Force believe that, properly and fully used, cooperative learning has been demonstrated to be superior to competitive and individualistic modes of instruction and learning. Other members made the argument that in their experience, and in the experience of their colleagues, students learn less in groups than they do on their own; that learning occurs at the lowest common denominator. Still other members were troubled by the manner in which the Task Force charge was presented, almost as a statement that cooperative learning would be the way of the future, and it was the responsibility of the Task Force to figure out how to make that happen. There was even the suggestion that the phrase "cooperative learning" in our charge was meant as a code to represent a variety of learning strategies that encourage interaction in some cooperative way. It was agreed among Task Force members that CL is a "volatile" issue, engendering very strong feelings for both viewpoints. For these reasons, the Task Force has completely forgone the notion that some type of cooperative community can be established in a top down fashion. Yet we believe that grass roots efforts of interested faculty to employ CL and to
convince their colleagues to employ it should be encouraged, as long as there is no hint of a mandate.

The Task Force was split on the issue of grade inflation in projects. In the course of our deliberations, we learned that a very large percentage of students are awarded the A grade for both the MQP and the IQP. In this situation, the spectre of grade inflation inevitably rears its head. At least one Task Force member believes that the percentage of A's is far too high; and that the distribution of grades probably does not reflect the quality of the project efforts. At least one Task Force member maintains, however, that the high percentage of A's is not a problem, because there is such close contact throughout the project between advisor and advisee that the probability of A work is much enhanced. S/he further maintains that the emphasis should be on the educational and skill outcomes of the project--the learning experience--rather than on the project grade. Finally, another Task Force member maintains that students in some sense negotiate with the project advisor as to what level of effort will secure the A grade. The students then proceed to produce this level of effort. Although the notion of negotiation in the assigning of grades is somewhat disturbing, the fact that students are willing to go the extra mile is a positive factor.

During discussion of the issue of grades, one Task Force member recommended that advisors not grade their own MQPs. Instead, all MQPs generated within a department during a year should be graded by an elected committee of the department. This suggestion generated substantial disagreement. In the end there was recognition that the political and personal pitfalls inherent in such an approach would outweigh any advantages.

**Budgetary Items Consequential to Task Force Recommendations**

Several of our recommendations will entail substantial commitment of Institute funds. A number of these are listed below, with some indication of the anticipated cost.

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<td><strong>Writing Resource Center</strong></td>
<td>Increase budget</td>
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<td>Establish and fund at the same level as the Writing</td>
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<td>Statistical Resource Center</td>
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<td><strong>Mentoring programs</strong></td>
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<td>Support for creation and training of IQP Mentoring structure</td>
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<td>Support for creation and training of Departmental MQP and Suff Mentoring structures</td>
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<td>Incentives for participation</td>
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<td><strong>MQP</strong></td>
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<td>Increased funding level (e.g., double the current level)</td>
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<td>Incentives for MQP advising</td>
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<td>Faculty discretionary accounts?</td>
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<td>Reduced classroom teaching loads?</td>
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<td>Increased Dissemination and On-campus promotion</td>
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<td>Travel for students and faculty advisors to professional meetings</td>
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