The writer has had the experience to introduce open-ended, team-based design projects to freshmen in an introductory course and, as well, supervise open-ended, team-based design projects to upper classmen who had not experienced the noted introductory program, e.g., Introduction to Engineering, Introduction to Engineering Technology, etc. Both student groups were required to follow the same format with respect to time, group size and written report requirements. The report would be a comprehensive and chronological development and discussion of the continuing effort and manner in which the disparate ideas were synthesized towards a reasonable and efficient solution. Included in the report were the necessary graphics, tables, costs and other factors necessary to finalize the solution.

In team-based, open-ended design projects, it would be reasonably expected that team members who were very familiar and friendly with one another, e.g., senior mechanical engineering technology students, would develop their team’s requirements in a very acceptable manner. It would also be expected that the common friendship that existed would be a positive motivation to ensure an equitable effort. And, further, due to the continual exposure to the technical literature encountered at this stage, it would be reasonable to expect that these (senior) students would engage a large number of references towards solution of their team’s design project.

On the other end of the spectrum, it would seem quite reasonable to expect that entering freshmen, (some of whom were not even sure of their decision to study engineering technology), would (1) find it difficult – if not impossible – to work with ‘strangers’ on an open-ended, team-based design project, (2) find it unreasonable to be expected to provide a uniform team effort, and (3) not even begin to address the search for information and data that is essential to ensure a successful project result. We found, however, that seniors typically responded with reports that were rather minimal in effort and which did not reflect their technical maturity. The freshmen, on the other hand, provided reports many of which were what one would have expected of the seniors. This paper will discuss the manner in which the teaming skills were introduced to freshmen; the manner in which they responded; the typical response of seniors who were not exposed to an introductory course; and, finally, what is recommended to extend the freshmen experience throughout the curriculum so that the seniors would clearly demonstrate they have attained the benefits of a planned curriculum.
The *Introduction to Engineering Technology* course at Eastern Michigan University is designed to enable the entering freshman to fully participate in the activities of an ET via a wide variety of projects that are carefully designed to illustrate the kinds of projects that are serviced by engineering technologists. The activities that ensue serve as a vehicle for motivating students to pursue a clearer understanding of the factors that drive technology. Our initial objective is to make the students particularly aware of the importance of working effectively in a group, because that is the way things are commonly done in the professional world. Some of the things that are discussed include: that it is essential for all members of the group to establish a harmonious relationship; that it is essential for all group members to provide a reasonably equivalent effort; and that it is essential for all members to seek a common goal, namely, a quality effort within the time period specified. It is urged that if someone in the group is not providing an equivalent amount of effort, the initial approach would be to discuss it with that person. If that doesn’t work, then the instructor should be notified. We have found this approach to work effectively.

Our next objective is to develop the procedures that effectively implement an open-ended design project. The following procedures are discussed, with accompanying handouts:

1. **Clearly Define the Effort:** Make sure all the requirements are fully and clearly understood.
2. **Identify All The Components:** If all sizes and/or specifications are not fully provided, then establish them, with the understanding that they may be subject to change as the project develops.
3. **Find Out About Items That Are Not Clearly Understood:** Use the library or other sources.
4. **Develop Several Preliminary Ideas:** Initially sketch, and then draw to scale. Consider developing simple models, if appropriate.
5. **Continue To Refine The Preliminary Ideas:** At some early point in the design process, develop a time schedule and a design procedure.
6. **Consider The Organization Of Your Group:** It is of value to select a group leader who is typically someone that is sincerely motivated to develop the project to a successful conclusion. The group leader may assign specific activities to members of the group.
7. **Develop A Consistent Attitude:** Work on the project in a consistent, methodical manner. A project is rarely developed and completed successfully if the activities are erratic and/or marginal.

Each student design group is required to provide one-or-more oral reports prior to the project’s completion. The completed project will include a comprehensive design report and oral presentation. The oral report’s grade is based upon several items: Content; Organization; Delivery & Effectiveness; and Discussion. The design report’s format is equally comprehensive and includes the following components:

1. **Purpose:** To clearly list, develop, explain, itemize all the work performed; and to enable the work to be reviewed and graded.
2. **Suggestions:** Keep track of all efforts. Take notes of telephone calls, conversations,
group discussions and any and all thoughts and ideas.

3. **Report**: The report shall include: Title; Table of Contents; Introduction; Technical Body; Results; Conclusions; Appendix; References. The figures and tables shall be entitled and numbered consecutively. (Note: all of these components are appended with additional data and requirements).

4. **Last Page**: The final page of each report is a ‘signature page’ in which each group member who has actively participated in the project and report work, and has provided a fair share of effort throughout its development, may sign to attest to that effort.

Each report is graded on the basis of attributing a value to each of the above-noted components; and includes a ‘comments’ section which clarifies the reasons for the final grade. This not only assists in the grading but it also enables the students to understand any report weaknesses so that they can improve upon them in their next report. An overall project memorandum is distributed which discusses the specific problems found in the reports and re-emphasizes the requirements.

The freshmen course is designed to enable three, team-based, open-ended design projects to be developed in one semester. Some of the projects that have been introduced are listed below:

1. **The Ideal Classroom**: Redesign your present classroom in order to satisfy specifications that would enhance the room’s functions for lecture, lab and design projects.
2. **Self-Contained Speaker’s Podium**: Design an all-purpose, portable podium that has built-in facilities for professional lectures.
3. **Access to Campus Facilities**: Survey/examine all buildings and campus facilities to determine accessibility to the handicapped. Provide recommendations.
4. **Manufacturing Process Review & Selection**: Review several manufacturing processes and re-design a part to suit each process.
5. **Fabricating and Machine Shop**: Develop a comprehensive plan and cost schedule for creating and fully-utilizing a new shop facility.
6. **Multifunctional Device for the Handicapped**: Design a mechanism for people missing both hands.
7. **The Simple, Effective, Child-Proof Bottle Opener**: Design a medicine bottle opener for the elderly and others who lack the physical strength and/or dexterity to open and close child-proof medicine bottles.

Graphical depiction is an important component in these design projects, so there was an overt attempt to include at least one group member - in each of the groups - that possessed some graphical experience. Other than that, each group was randomly developed and quickly adjusted to the project’s requirements. It is instructive to note that students at this formative level not only have a great deal of creativity but also are not ‘restricted’ by their lack of experience in constructing concepts which more mature students might not wish to entertain. There have been some very fine reports; but one in particular shows how well students, at this early stage of their career, can develop excellent results. In reference to number ‘7’ above, we entered our class in an ASEE national design contest with the noted project requirements. One
of our freshman design groups was awarded third place in an ASEE National Design Graphics Competition for their graphical and written development of the child-proof bottle opener. Their outstanding effort is testament to the fact that team-based, open-ended design projects can be effectively developed by students at a formative educational level.

Seniors who were not exposed to the noted introductory course were provided with the same report requirements and group instructional material as were the freshmen. One of their assignments was to design a gear reducer to satisfy given operating conditions and to determine the optimum location of an idler pulley to minimize resultant shaft loads. They were assigned to work in groups of four and, owing to the fact that they were seniors, their efforts were not carefully monitored. Their final design reports did not include all the listed requirements: they wrote in the ‘first person’; their use of references and other resources was minimal; and they failed to provide the necessary graphical requirements, magnitudes and sense of the resultant shaft loads. Missing, also, was the requirement to write the report in a manner that indicated their chronological development of design effort – they typically gave a general overview of their work. But their lack of uniform effort was noted when the final oral presentations were given. It was apparent that only one-or-two of the four group members fully participated in the project effort. A concerted effort was made to discuss the noted problems and to promote a better effort in subsequent reports. Appendixes A & B illustrate some of the report documentation by freshmen (Appendix A) and MET seniors (Appendix B).

Conclusion

The engineering technology program, by virtue of its hands-on approach to technical application and reasoning, helps to develop a realistic foundation for extending the design effort throughout the curriculum. Also, the introductory freshman design experience has been found to nurture an awareness of and interest in further pursuing the formal course structure in, for example, mechanical engineering technology. The project design skills and learning aids developed at the formative level have been found by the author to be readily applicable in subsequent courses that stress the application of open-ended design problems. We also want to develop a format that will provide a linkage between design skills and the ET curriculum. And the overriding goal is to fully-develop the knowledge and skills to successfully implement a capstone design program based upon a collaborative, pre-professional foundation.

In the development of a consumer product, the concept of Industrial Design is employed to integrate the required technology with the necessary design skills. The successful product will satisfy human needs with respect to function, aesthetics, quality and cost. Satisfying this goal will require a curriculum that provides an overview of the principal manufacturing processes and materials, an introduction to aesthetic relationships, ergonomics, creativity enhancement, market analysis, and prototyping. The academic foundations will also feature stress and failure analysis. Development of teaming skills will continue throughout the curriculum by including

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team-based, open-ended design projects in the engineering mechanics, fluid mechanics, thermodynamics and machine design courses. The author has employed his mechanics and machine design courses as precursor for the capstone effort by promoting the project requirements initially implemented in the freshman introductory course. The capstone effort is then no longer afflicted with an uncertainty regarding reporting; the principal effort is directed towards the design and its specifications. The Industrial Design capstone program, typically of a two-semester duration, would be initiated in the Fall semester with the following components: Retrospective Search; Marketing Analysis/Consumer Surveys; Development of Ideas; Introduction to Aesthetic Relationships; Development of Initial Proposal; Progress Reports; Preliminary Design Report; and Submission of Initial Proposal. With the initial proposal having been returned with comments, the Spring semester would include: Re-Development of Design as Appropriate; Re-Development of Scheduling; Manufacturing Interface/Prototype; Testing & Structural Analysis; Revision of Design as Necessary; Development of Final Report; Project Presentations.

We can effectively meet the needs of student and industry by providing the engineering technology student with a comprehensive design experience that closely matches that encountered by professional design engineers. We can seek to develop the communication and teaming skills that are an inherent and vital part of design activity and address the need to promote the creative capabilities of the entering student.


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Appendix A

Example from a Freshman Design Report

Assignment: Review the two principal components of the Idler Yoke. Review the Casting, Machining and Weldment processes. Redesign the components as a steel member for each of the specified processes. Develop each re-design as a fully-dimensionalized drawing. Recommend the processes with respect to: most suitable to least suitable for the part provided. Provide a full design report, following the specified outline.

Instructor Comments: The technical descriptions of each process are very good and reflect a clear understanding of how parts are made. The design drawings of the object for each of the three processes are well done and shows that your group has a sincere interest in this activity. The conclusion was not developed as specified. You were required to determine which single manufacturing process would be most suitable for the given part. Instead, you recommended using all three processes to make the part. That was not an appropriate recommendation.

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Appendix B

Example from a Senior Design Report

Assignment: Include an idler gear in the two-gear set to determine its optimum location for minimizing resultant shaft forces. Develop the shaft load for each idler position and show all forces on a drawing of each system. Select and specify the idler gear. Provide a full design report, following the specified outline.

Instructor Comments: It was required to determine the resultant loads and reactions on all gears and shafts and show those on a drawing of each system. Neither Option A or Option B show any of the required forces. What purpose do those figures serve? In your technical discussion you referred to Options A and B and stated a value of 2858 pounds. Assuming this was the lower of the two possible values, what was the magnitude of the higher value? And on which of the three gear shafts was this force located? Your technical solution is suspect because no definitive results are either given or shown.

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