

Assessing Student Preparation for Senior Capstone Design Projects

M.H. Gordon¹

Abstract – Virtually every engineering program has a senior design project. Ideally, the students' path to this capstone course prepares them for what will be required. At the University of Arkansas, we have a two semester Creative Project sequence. To assess their preparedness, all Creative Project students were surveyed. One of the findings is that the majority of students said that they were either only exposed to design/hands-on projects in their senior year, or in just a handful of previous classes. This is in contrast to their perception upon entering the university where they thought most classes would involve such design work. In addition, a majority of students said they only became aware of what would be required in this Creative Project course either in the course itself, or the year before. Lastly, a majority responded that they would have greatly benefited from involvement with this course while they were freshman.

Keywords: creative project; preparedness survey; freshman and senior integration

Introduction

The majority of engineering programs today have considered moving away from the so-called engineering science model¹⁻² where the curriculum is very structured (early courses emphasizing fundamentals followed by engineering courses). Partly in response to ABET³, a more open-ended approach is now typically adopted, centered on a senior capstone design course where students apply their acquired knowledge to a problem with no single answer. The specific type of problem varies from institution to institution. In some universities, there is an emphasis on problems directly from industry⁴. The rationale is that the majority of students will work in industry, so the more experience obtained in school the better. In other cases, projects involve competitive design contests (typically national contests) such as those sponsored by ASME, IEEE, etc. Such projects do not require any special contacts with the outside world, provide new problems each year, and offer cash prizes for extra motivation. Alternatively, these design projects often result from on-going research at a given university. Although convenient, some projects do not involve design, a critical component of the ABET requirements.

Once the project is chosen, there have still been issues relating to the overall impact on both the engineering curriculum and on the individual student. For example, it is commonly accepted now that simply providing a senior design experience, however effective, is not sufficient to ensure high retention of freshman who are often not impacted by this course until their senior year. As a result, many programs have added similar design projects suitable to incoming freshman. Some programs have added a special five-week project for freshman⁵. Skurla et al. argue that their year-long freshman design experience has significantly increased their retention⁶. An obvious extension of this idea is to add such design experiences to the sophomore and junior years. Howell et al. detailed one such effort in 1995⁷. Carroll described a similar integration 2 years later, though with an emphasis on mechanics courses⁸. More recent attempts are described by Bailey and Qammar et al.⁴⁻⁵

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At the University of Arkansas (UA), we focus on the freshman and senior years, though at present there is no effort to integrate them together. The focus of this paper is on the seniors, so detail on the UA approach is now provided. Seniors sign up for two required courses which must be taken concurrently in the first semester, and one course in the second semester. The first is a 2 unit course where they are told of the available projects and kept informed of the various dates during the semester when project milestones are due (2 presentations, a project poster, and a project report). They are given until the end of the third week to select their project. Projects must be supervised by department faculty and include industry sponsored projects, national design contest projects, and on-going faculty research projects. All must include design, but each individual faculty makes this assessment. Although the 2 unit course discusses student projects, the grade in this course is based only on their performance in the topics of engineering ethics and engineering economics. The other first semester course is for 1 unit credit and relates directly to their chosen project. Students arrange meetings with their faculty sponsor, who has sole discretion for the 1 unit project grade, and proceed accordingly. Their objective is to complete roughly 25% of the work such that they will have identified the problem, investigated 2-4 possible solutions, and quantitatively determined the most promising for further exploration. At the end of the first semester, they present their project poster in front of industry judges to compete for cash prizes.

During the three unit second semester project, the students complete the remaining 75% of the work. No formal class time is scheduled and the students continue to meet with their faculty sponsor as needed. At the end of the second semester, the students again generate a poster for the same competition (against other 2nd semester students) in addition to the final project report. As before, all project work is graded by the faculty sponsor, though copies of the poster and report are retained by the department. Selected posters are framed and displayed on the department walls for current and future students, parents, and visitors to see.

The author has taught the first semester 2 unit course for the past five years, and has sponsored several projects as well. It has generally been assumed that students come in well prepared to undertake this design project, but this assumption had never before been formally studied. In this paper, a survey of these first semester creative project students was conducted to determine the effectiveness of the current UA program in preparing these students for their projects. In addition, we explored the expectations of these students both as entering freshman and as entering seniors.

Survey Details

The survey asked five questions and was given to 30 seniors during their first week in the creative project course (before they had selected a project). The first asked how often they were involved in a design/hands-on exercise during their undergraduate curriculum. They were to choose for the following four answers: every class; one class per semester; one class per year; and only in the senior year.

The second question asked when they were first aware of what is expected in the senior capstone project. They were to respond with either 'freshman', 'sophomore', 'junior', or 'senior.'

The third question asked whether they would have benefitted from being involved with the current senior design project when they were freshman. Answers ranged from strongly disagree to strongly agree.

The fourth question asked if they would benefit from having freshman involved in their upcoming senior design project. Answers again ranged from strongly disagree to strongly agree.

The fifth and last question asked them to rank their interests in the following four types of design projects: national competitions, industry sponsored, supporting faculty research, and topics of personal interest.

Results and Discussion

The first question was designed to assess the how often students were exposed to design or hand-on projects to prepare them for their senior capstone project. As Figure 1 shows, none of the 30 had such projects in every class, only 17% responded that they had such a project in at least one course per semester,

56% responded once per year, and 17% indicated that such projects were only offered in the senior year. Interestingly, and perhaps as expected, in a related informal survey of entering freshman, roughly one third expected to have design experience in every class, and the remaining two thirds expected a design experience at least once per semester. It appears we are not meeting their expectations, and based on the literature, we are not alone in this respect.

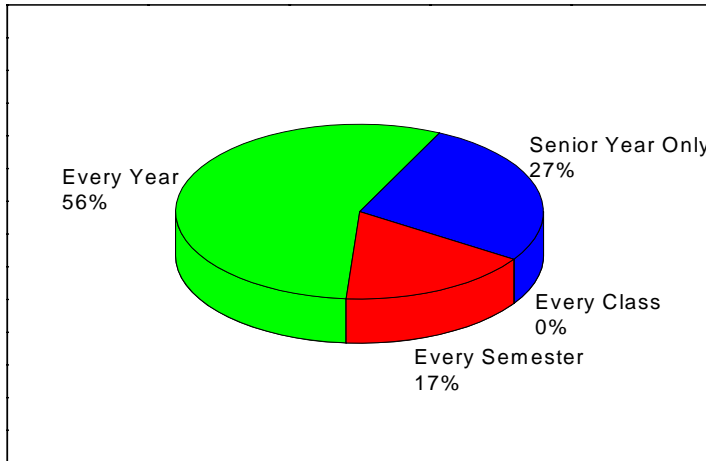


Figure 1 Breakdown of 30 responses to the question 1 - How often were you exposed to design experiences?

The second question assessed when the entering seniors knew what to expect in the senior capstone project. One third said they were only made aware in their senior year. Another third said they were only made aware their junior year. The remaining third said they were aware of expectations either their freshman or sophomore year. For better retention, we believe that we would benefit from significantly increasing the awareness of students in their first two years. Figure 2 summarizes these results.

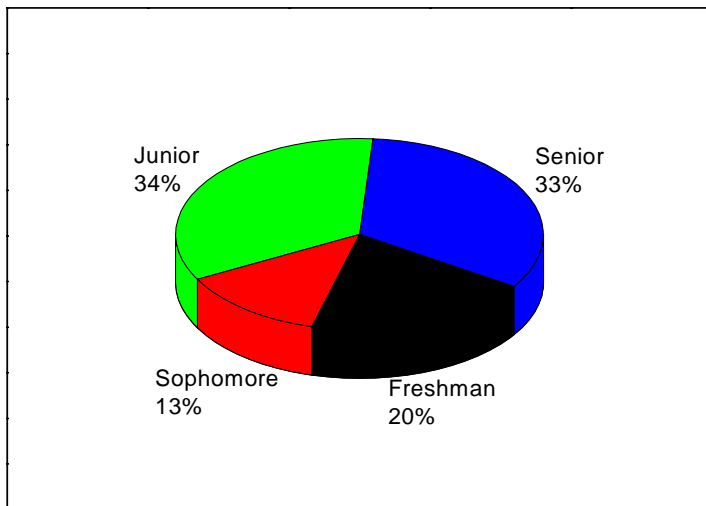


Figure 2 Breakdown of 30 responses to question 2 - When were you first aware about the requirements for creative project?

The third and fourth questions explored the value of a hypothetical partnering of freshman with them on the creative projects. Such a partnership would address the problems indicated by the first two questions. As shown in Figure 3, over 50% of the seniors agreed or strongly agreed that they would have benefitted from such a partnership as freshman. Only 10% disagreed. The remaining students were neutral. As to whether these seniors would benefit from having current freshman work with them, Figure 4 shows that only one third thought they would benefit, while nearly one third thought they wouldn't. The remaining students were neutral. Thus it seems that such a partnership would be of greater benefit to the freshman, perhaps not a surprise. This result is again consistent with reports from other universities. However, a better question might have been whether the seniors would be willing to work with the freshman. It would then be up to the professors involved to ensure that there is value to all involved.

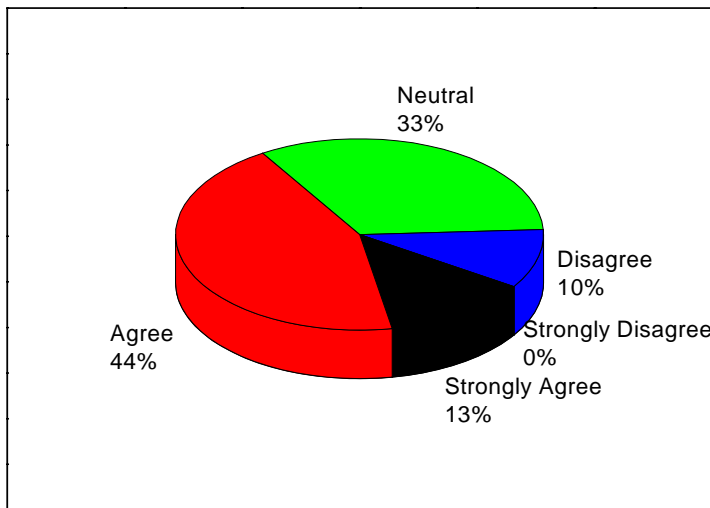


Figure 3 Breakdown of the 30 responses to question 3 - As a freshman, would you have benefited from being involved with seniors on their creative project?

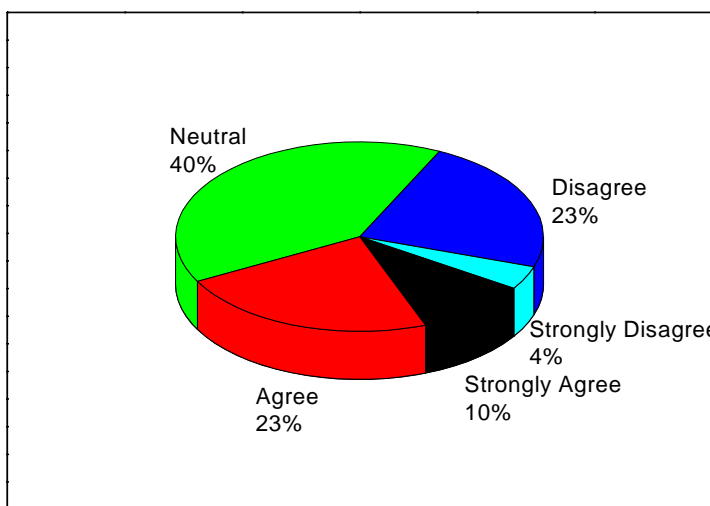


Figure 4 Breakdown of the 30 responses to question 4 - As a senior, would you benefit from having freshman involved on your senior project?

The last question was designed to assess which style of design project students preferred. As shown in Figure 5, more than 50% listed topics of personal choice as their first choice, and all but one of the remaining students listed national competitions as their first choice. It is interesting to note that one student listed industry sponsored and none listed those supporting faculty research. Such information should help faculty choose future projects.

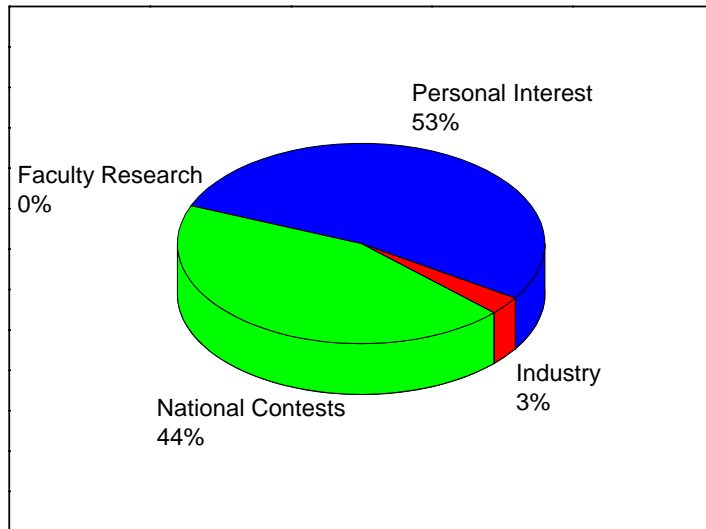


Figure 5 Breakdown of 30 responses to question 5 - Which design project type interests you most?

At the UA, we are strongly considering using only national competition projects. Projects from each of the main mechanical engineering thrusts could be chosen (thermal, mechanical, and materials) allowing students to choose the area that most interests them. In addition, it would be simple to distribute the work load among faculty. Those faculty most closely aligned with each thrust area would be responsible for advising and grading the students that chose that project. In addition, we are exploring ways to couple freshman with seniors on their projects. This would enable students to better understand the project expectations earlier, and also to expose students to design problems more often. This would address problems highlighted in the survey in addition to the more general issue of retention. Ideally, we would eventually include students in the sophomore and junior years as well. Such programs would be relevant to other institutions with similar circumstances.

Conclusions

The senior design capstone project is a key component of the majority of engineering curriculums. At the UA, a survey of entering seniors was conducted to assess their preparedness and expectations for such a course. Responses indicated that seniors were only exposed to design type problems once or twice per year, and some not until their senior year. In a related informal survey of freshman, in contrast, the majority expected such projects at a higher frequency. The survey also indicated that the majority of seniors were not aware of expectations in the capstone project until their junior year or later. Lastly, the majority of seniors said they would have benefitted as freshman from partnering with seniors on their design projects. Based on these results, changes to the UA program will be implemented to improve effectiveness. Results of such changes will be of interest to both our program and other national programs where similar issues are present.

References

- [1] Dym, C.L., "Design, Systems, and Engineering Education," *Int. J. of Engineering Education*, v20-3, 305, 2004.
- [2] Dym, C.L., and Little, L., *Engineering Design: A Project Based Introduction*, 2nd edition, New York, NY, Wiley, 2003.
- [3] Felder, R.M. and Brent, R., "Designing and Teaching Courses to Satisfy the ABET Engineering Criteria," *J. of Engineering Education*, v92-1, 7, 2003.
- [4] Bailey, R., "Effects of Industrial Experience and Coursework during Sophomore and Junior Years Student Learning of Engineering Design," *J. Mech. Design, Transactions of the ASME*, v129-7, 662, 2007.
- [5] Qammar, H.K., Cheung, H.M., Evans, E.A., Spickard, S.P., Broadway, F.S., and Ramsier, R.D., "Impact of Vertically Integrated Team Design Projects on First Year Engineering Students," *ASEE Annual Conference Proceedings*, 6737, 2004.
- [6] Skurla, C., Thomal, B., and Bradley, W.L., "Teaching Freshman Engineering Using Design Projects and Laboratory Exercises to Increase Retention," *ASEE Annual Conference Proceedings*, 13579, 2004.
- [7] Howell, S.K., Collier, K.W., Larson, D.S., Hatfield, J.M., Hoyle, G.W., and Thomas, G.A., "Integrated Engineering Design Experience: Freshman to Senior Level," *ASEE Annual Conference Proceedings*, 2598, 1995.
- [8] Carroll, D.R., "Integrating Design into the Sophomore and Junior Level Mechanics Courses," *J. of Eng. Education*, v86-3, 227, 1997.

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Dr. Gordon is an associate professor of mechanical engineering at the University of Arkansas where he joined the faculty in 1992. He obtained his PhD in 1992 from Stanford University. In addition to regularly teaching Professional Engineering Practice where the senior design capstone project is introduced, he regularly teaches thermodynamics, fluids, and advanced numerical methods. His research interests included thermal and mechanical issues in electronic packaging and the study of plasmas and their applications, primarily involving materials.