Encouraging Multi-disciplinary Education and Inter-disciplinary Research

Chris T. Hendrickson

Abstract

Multi-disciplinary education and inter-disciplinary research are often sought, but significant barriers exist. Impediments to such activities include unfamiliar jargon, dissemination of results to different audiences, increases in teaching loads, loss of overhead and research volumes, curricular restrictions, prejudice and time constraints. I suggest approaches to overcome these impediments. Indicators of inter-disciplinary activity include the variety of publication outlets, co-authors and enrolled students.

Introduction

Multi-disciplinary education and inter-disciplinary research are frequently touted as goals, but just as frequently flouted as a practice. In this paper, I will discuss some of the rationale for multi-disciplinary education and inter-disciplinary research, discuss ways to encourage this behavior, and provide some possible measures of inter-disciplinary activity. I write as someone who has both taught in multidisciplinary courses and participated in inter-disciplinary research.

The Accreditation Board of Engineering and Technology (ABET) provides explicit encouragement for inter-disciplinary education. The Engineering Criteria 2001-2002 requires undergraduate programs to insure that prospective engineers have “an ability to function on multi-disciplinary teams” [ABET 01]. In practice, this requirement often leads to project assignments in which students take on different roles such as designer or contractor.

This past year, a colleague and I served as advisors to a small multi-disciplinary team investigating the possibility of using pressure sensors embedded in asphalt to replace the common (and often broken) loop detectors for vehicles [Blair, Lim and Miyakawa 01]. The project involved modeling of pavement stresses due to vehicles, sensor

1 Duquesne Light Professor of Engineering and Head, Department of Civil and Environmental Engineering, Carnegie Mellon University, Pittsburgh, PA 15213, phone 412-268-2941, cth@cmu.edu
selection and circuitry, laboratory experiments, design of a new system and cost estimation. It was a true multi-disciplinary challenge for the students involved. The project required close co-operation among civil and electrical engineering students, including writing a joint final project report. This is the type of experience that insures students will have the skills to work on a multi-disciplinary team. By the way, the project suggested that pressure sensors could be more cost-effective than loop detectors, but we will need some more work to check on the durability of the pressure sensor.

Civil engineers are well aware of the prevalence of such multi-disciplinary teams in professional practice. For example, project teams for buildings often include architects, structural engineers, mechanical engineers, and construction specialists, plus supplemental professionals such as lawyers or marketing specialists. Successful professional practice requires such team collaboration.

Inter-disciplinary research can also have significant benefits. Technology and new methods can be rapidly transferred from discipline to discipline. The boundaries between disciplines have research opportunities that are difficult to exploit in traditional research practice. Indeed, all the existing disciplines can be traced back to pioneering inter-disciplinary research. Inter-disciplinary research can also expand the boundaries of existing disciplines. For example, civil engineers can be significant contributors to micro-electrical mechanical systems or nano-technology research.

Most importantly, interdisciplinary work tends to be problem focused. Universities tend to get polarized and have faculty working on narrow problems or on engineering science that is not problem focused. Engineers in practice work on problems without regard to disciplinary boundaries. Interdisciplinary work can teach students to solve real, important problems, and this is good training for professional practice.

Interdisciplinary work does carry the danger of producing interdisciplinary dilettantes who never learn any subject in depth. Even undergraduates need to learn some area in depth, though not necessarily an entire discipline. Educational and research programs need to maintain a balance of breadth and depth in their portfolio of work.

Overcoming Barriers to Inter-Disciplinary Education and Research

Inter-disciplinary education and research are not easy, especially with the departmental structure of most universities. These barriers can be administrative, cultural or inherent in any multi-disciplinary undertaking. Below, I discuss some important problems and some amelioration approaches.

1. They don't speak my language.

All academic and professional disciplines tend to develop their own language or jargon that can be incomprehensible to outsiders. A specialized jargon provides greater speed in communication and a means to summarize common findings and
methods. For example, all economists know about a “Pareto optimum,” but outsiders may need an explanation. All transportation engineers know the characteristics of a “user equilibrium.” Undertaking inter-disciplinary work requires translation from such jargon or spending the time to learn a new language.

2. Where will we publish the results?

Disciplines have their own journals, with varying levels of readership and prestige. There are far too many journals for anyone to read, so professionals concentrate on journals in their own specialization. But this focus creates difficulties for inter-disciplinary research. If I undertake inter-disciplinary research with an economist, I may end up publishing my research results in the economics literature rather than the civil engineering literature. Quite possibly, my civil engineering colleagues will never read such papers, and my research reputation will be thereby diminished. This is particularly a problem for academics relying upon outside letters of reference for promotion from members of a particular discipline. Fortunately, web sites and digital search engines make literature much more accessible now than in the past. There may also be problems in finding appropriate reviewers for inter-disciplinary research, but this is a problem that good editors are able to solve.

3. Won’t multi-disciplinary increase the teaching load?

A first reaction for any course with an inter-disciplinary component is to have two instructors, thereby doubling the teaching load (measured in faculty time per credit). By extension, a multi-disciplinary course would have multiple instructors, although this rarely happens. Not involving an expert in each discipline runs the risks of having knowledgeable students hoodwinking a specialist instructor or not covering concepts outside of a single specialist’s purview adequately. The practice of guest lectures and project review teams can help here.

4. What about my overhead and research volume?

Academic departments often receive a portion of indirect or overhead research charges as a means of financing department expenses. All academic departments are happy with greater research volumes. Indeed, research expenditure per faculty member is one measure used to rate the quality of engineering colleges [USNEWS 01]. As a result, administrators are loathe to permit inter-disciplinary work to redirect research budgets to other departments. This problem has an easy solution, but one seemingly beyond the capabilities of many university accounting systems. Budgets should be allocated to different units so that research expenditures can be tracked within each unit.

5. We don’t have room in the curriculum for multi-disciplinary work.

There is no end to the number of desirable topics in a civil engineering program. Moreover, new topics continually appear. For example, many argue that modern
biology should be required for all engineers. It is difficult to agree on priorities among the possible topics. Given the importance in professional practice of multi-disciplinary projects, making room in the curriculum seems to be important. For example, more civil engineers will work on multi-disciplinary teams than will design a roadway pavement or a hydraulic structure.

6. Inter-disciplinary research just isn’t very good.

Academic disciplines evolve with considerable effort from a large number of professionals. As a result, the disciplines become increasingly sophisticated and problems are examined repeatedly. In contrast, inter-disciplinary problems have received less attention and are often treated with less sophistication. A good metaphor for the research enterprise is an elastic sheet that is pushed up to greater sophistication by the support of disciplinary research. The areas below disciplines tend to sag below these high points. Assessing inter-disciplinary research requires a correction for the maturity of the research endeavor.

7. I don’t have time for inter-disciplinary research.

Inter-disciplinary research has activation costs associated with learning new jargon and reviewing a new literature. Many researchers don’t want to pay such a price. That is fine, as it means there are more opportunities for researchers willing to commit to inter-disciplinary endeavors.

Measures of Multi-disciplinary and Inter-disciplinary Activities

Interdisciplinary work is frequently cited as a goal, but not actually pursued in practice. In this section, I will suggest some measures of the extent of actual inter-disciplinary work. These can be useful for research proposal reviewers or advisory committees.

1. Co-authors: Have potential collaborators written joint papers?
2. Diversity of journals: A researcher pursuing inter-disciplinary work will usually publish in a variety of journals, often spanning several professional societies.
3. Course enrollments: How many non-majors enroll in the various courses offered by a department? For example, are construction courses in civil engineering attracting architects or mechanical engineers?

Conclusions

Inter-disciplinary education and research have significant advantages but also some substantial barriers. The administrative and cultural barriers to interdisciplinary can be removed or substantially ameliorated with proper attention.
Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. 9700568. Thanks to my colleague Lester Lave for helpful comments.

References

