Merging Engineering and Architectural Pedagogy – a Trans-Disciplinary Opportunity?

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INTRODUCTION

Engineering has historically been a discipline of creativity and innovation. However, engineering education does not consistently address this vital skill and its relationship to research and design, or explicitly integrate it into an undergraduate student's training. Architecture, by contrast, is a discipline that actively and consciously fosters and rewards creativity, though students' technical competency is not that of an engineer. The authors are engaged in a three-year study funded by the United States National Science Foundation. The study is aimed at investigating the potential of architectural pedagogical models in developing new courses and teaching methods to foster creativity and innovation in engineering curricula. Part of this effort is a new experimental trans-disciplinary design seminar for architecture and structural engineering students. Given their potentially complementary skill sets, engineering and architecture students are a natural fit for investigations into creative pedagogy. The practices of both disciplines are intimately related but students, whose careers may be so closely linked, rarely have opportunities for cross disciplinary interaction in their formative years, particularly in design contexts where dialogue and collaboration could be so productive for both. The seminar accommodates creative and research activities such as open ended problem solving; resolving competing goals in a complex problem; balancing technical merit against architectural and aesthetic design values; evaluating the ability to incorporate and integrate real research into the education process; and positing speculative designs.

The evaluation of this course will be vital to both further refinement of its curriculum and to the potential dissemination of the teaching model. The Office of Professional Research and Development in the School of Education at Syracuse University is conducting the evaluation of the project. The first year evaluation plan includes written materials review, pre and post surveys, tests, interviews, and classroom observations. Students were surveyed at the start of the semester about their expectations of the course; their perceptions of their own discipline as related to a variety of attributes (including creativity, logic, ability to solve complex problems, etc.); their perceptions of themselves as related to the same attributes; and their cross-professional perceptions. After an initial analysis of responses, the survey was followed up with interviews for further depth.

This paper details the findings from that initial evaluation. Some of the early findings of specific interest from the interviews are suggestive of mutual benefits from the meeting between engineering students and architecture students. Some of the more interesting findings from the survey are in the dissonance between engineering students' perceptions of themselves and their perceptions of the discipline as a whole. There are three populations in the study, the thirteen architecture students in the course, the eleven engineering students in the course and, since the project as a whole aims to inculcate innovation and creativity in engineering education, the survey was also administered to a comparison group of fifty-six engineering students. Note that the course architecture students are a mix of second to fourth years, the course engineering students are all third year civil engineering students mainly concentrating in structural engineering, the comparison group were second year civil students who have not picked a concentration.

PERCEPTIONS OF ABILITY

The three groups of students were asked to rank their abilities relative to their fellow architecture or engineering students. Figures 1, 2 and 3 show the three student groups' perceptions of themselves within their field. The course architecture students were generally very confident in their abilities, with more than fifty percent ranking themselves as above average within their field with regards to originality, fluency and flexibility, and capacity to both understand and tackle complex problems. By contrast only thirty percent viewed themselves as above average in working with cross-disciplinary teams. It should be noted that the survey also revealed that most of the students had no previous experience in cross-disciplinary courses. Despite this, the course engineering students were more confident in their ability to work across disciplines with more than 50% ranking themselves above average. The other significant differences between the two groups' self-perceptions were in fluency and flexibility, and in confidence to tackle complex problems with less than 30% and less than 20% respectively ranking themselves as above average. The much larger comparison group reinforced these differences with the engineering students generally less confident in their abilities than the architecture students.

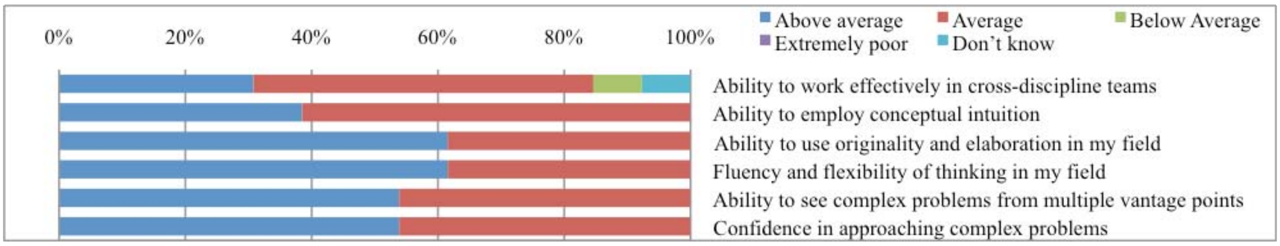

FIGURE 1
COURSE ARCHITECTURE STUDENTS' VIEWS ON SELF

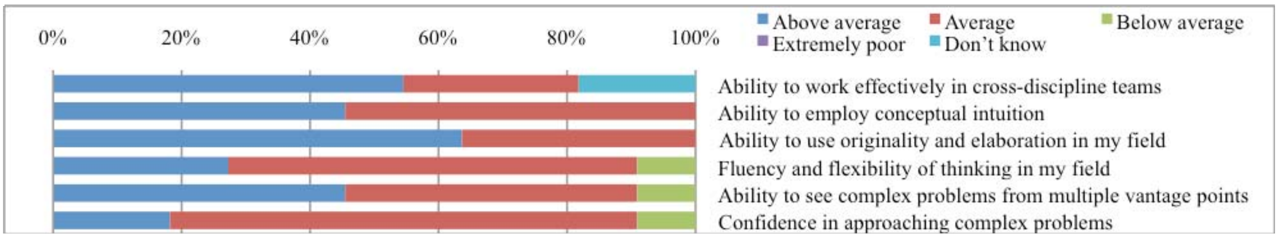

FIGURE 2
COURSE ENGINEERING STUDENTS' VIEWS ON SELF

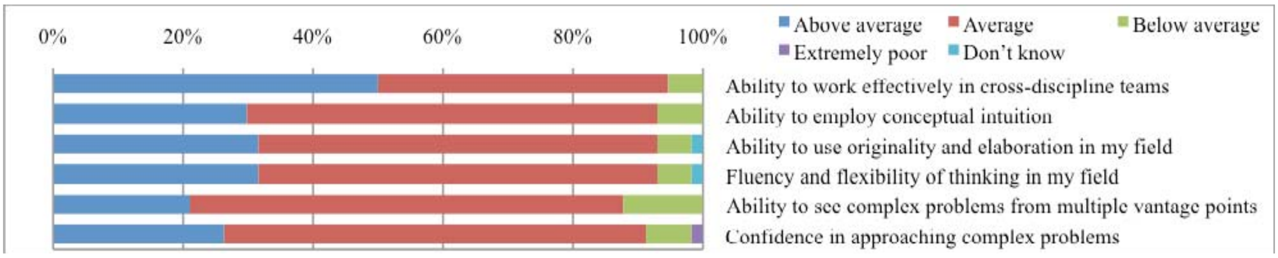

FIGURE 3
COMPARISON ENGINEERING STUDENT'S VIEWS ON SELF

PROFESSIONAL CHARACTERISTICS VERSUS OWN CHARACTERISTICS

Students were presented with a series of attributes and asked to identify the extent to which they believed them to describe the average professional engineer or architect. They were also asked to identify the extent to which they believed the same characteristics to describe themselves. Figure 4 shows the way the course architecture students view their chosen profession. Although they generally ranked their profession very highly, the characteristics assigned the most "extremely" rankings were intelligence, problem solving, confidence, innovation, and creativity. By contrast they least associated flexibility, capacity for analysis, team-work, logic, structure, and collaboration with their profession. In Figure 5 we see how the architecture students view themselves in terms of the same characteristics. For all characteristics they were much more likely to assign "extremely" to a professional and "very" to themselves. When you put together the "extremely" and the "very" responses the architecture students view of themselves is much the same as their view of the profession. The notable exception is in technical competence. While almost 80% of the architecture students ranked professional architects as extremely or very technically competent, just over 50% of them (10% extremely and 40% very) said the same about themselves. Engineering students displayed more dissonance than the architects between their view of their chosen profession and their view of themselves. The results are presented in Figures 6 and 7 for the course engineering students and Figures 8 and 9 for the much larger comparison group. The characteristics they were most likely to associate with their profession were: intelligence, technical competence, logic and problem solving. The characteristics they were least likely to associate with their profession were: flexibility, diversity, multi-talents, being artistic, innovation, and creativity. As a group the course engineering students viewed themselves as marginally more flexible and artistic, and more innovative and more creative than the average professional engineer. However, they viewed themselves as less intelligent, less technically competent, and slightly less logical than the average professional engineer. The larger comparison group of engineers showed this same effect, as a group ranked themselves as less intelligent, more flexible, and less technically competent than the average professional engineer. They did not see themselves as more creative, artistic or innovative, but were more likely to have assigned those attributes to the profession in the first place.

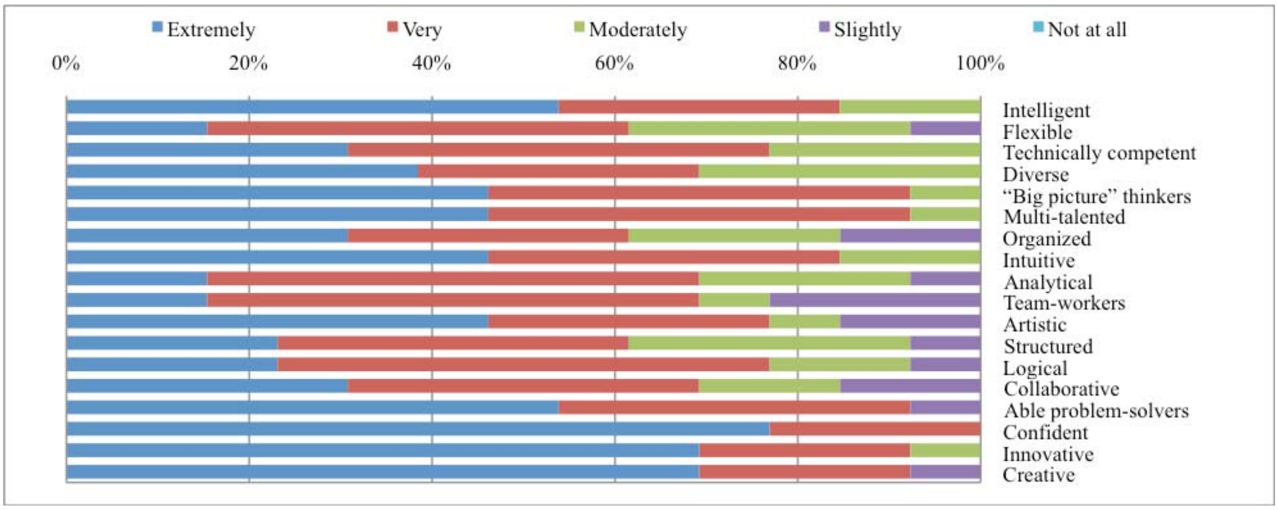

FIGURE 4
COURSE ARCHITECTURE STUDENTS ON ARCHITECTS

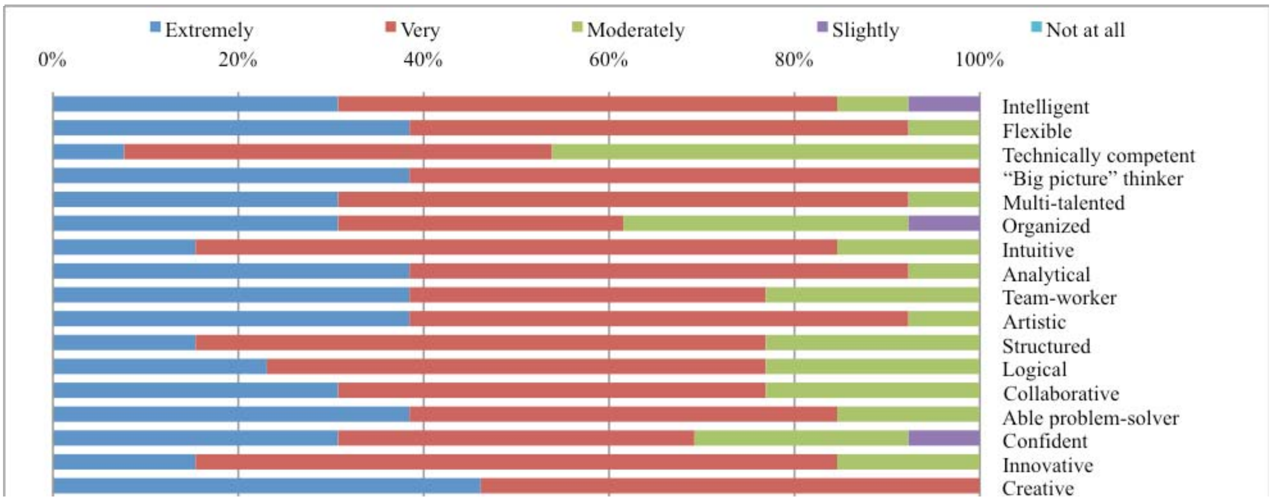

FIGURE 5
COURSE ARCHITECTURE STUDENTS ON OWN CHARACTERISTICS

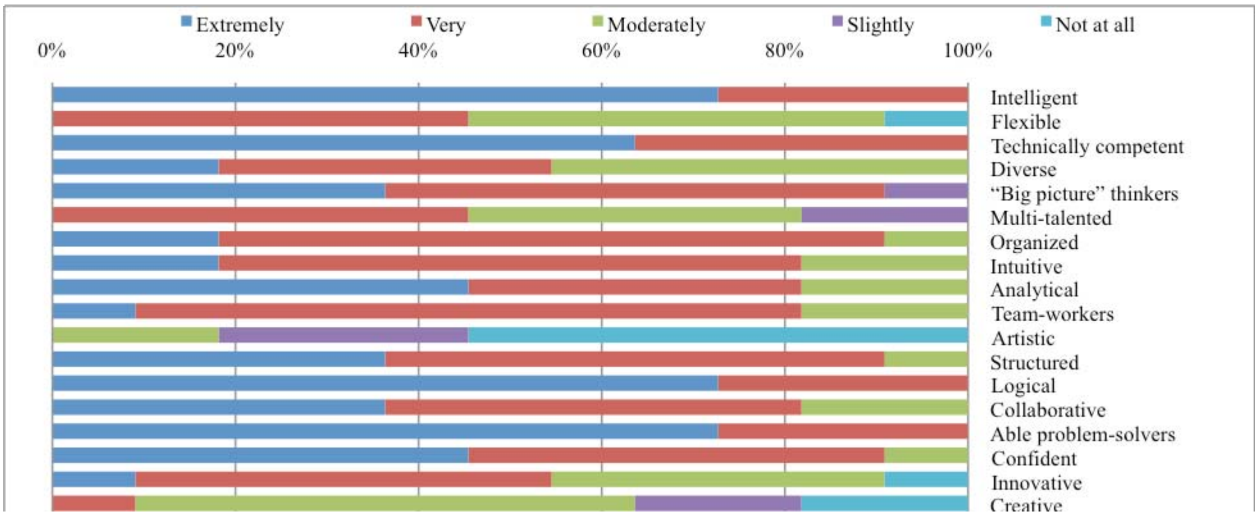

FIGURE 6
COURSE ENGINEERING STUDENTS ON ENGINEERS

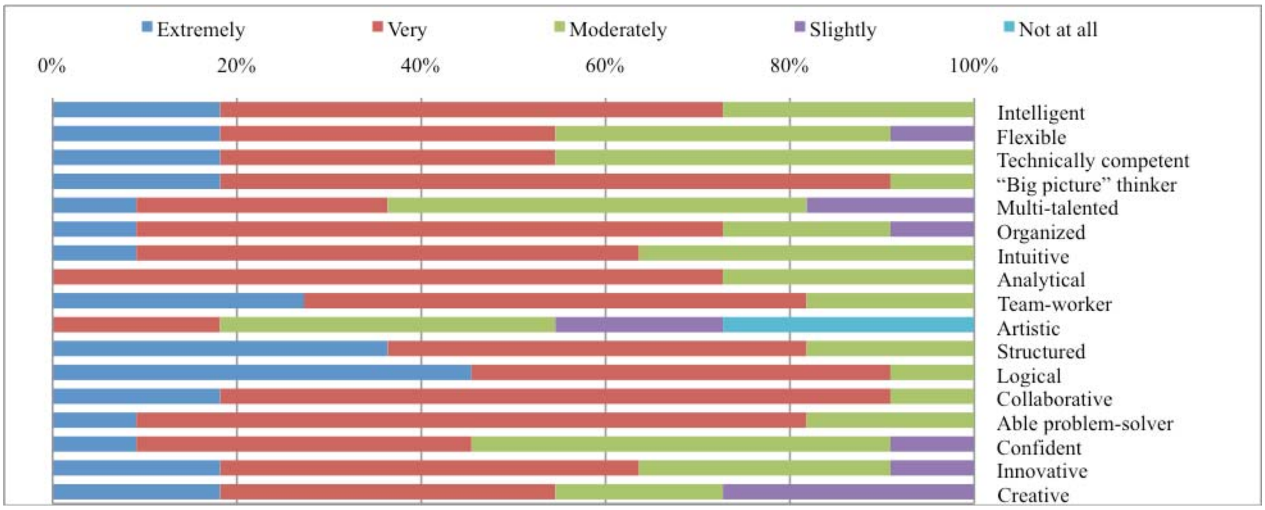

FIGURE 7
COURSE ENGINEERING STUDENTS ON OWN CHARACTERISTICS

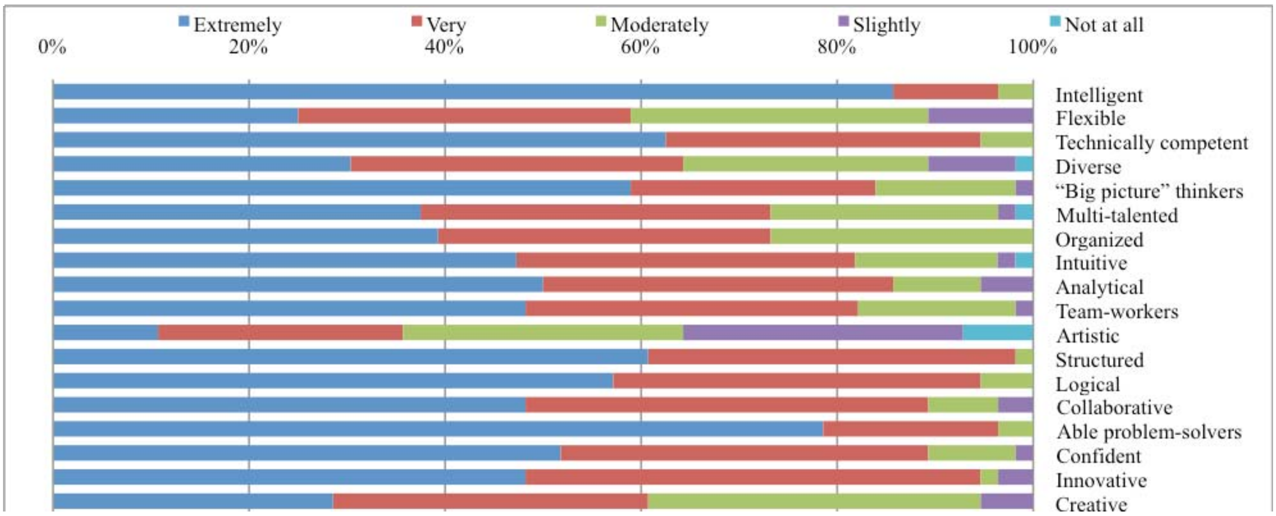

FIGURE 8
COMPARISON ENGINEERING STUDENTS ON ENGINEERS

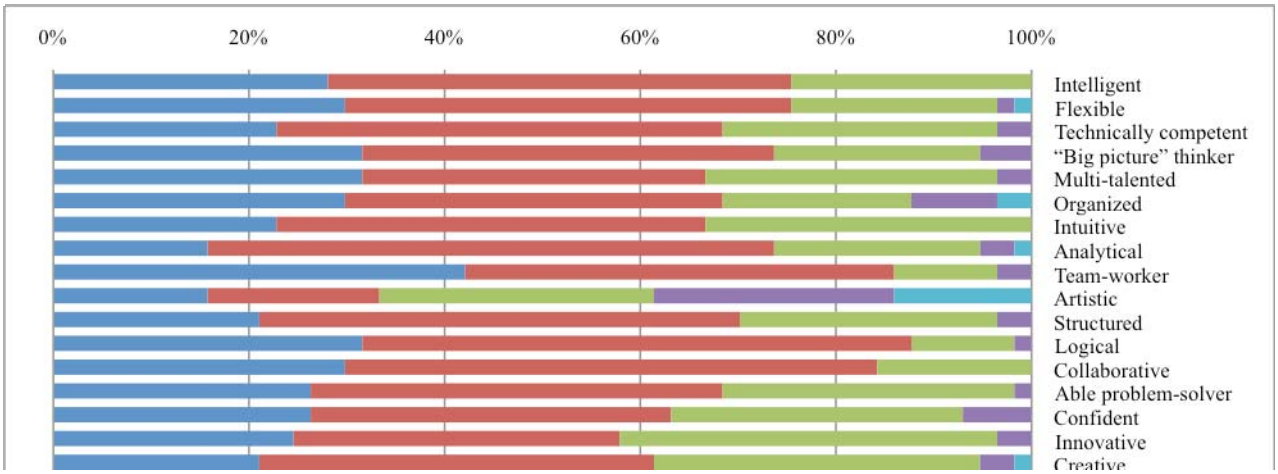

FIGURE 9
COMPARISON ENGINEERING STUDENTS ON OWN CHARACTERISTICS

CROSS PROFESSIONAL PERCEPTIONS

In order to inform the course planning for this and future trans-disciplinary design courses, each group of students was asked to evaluate the "other" profession in terms of the same characteristics. The results for all three groups are presented in Figures 10, 11 and 12. The results indicate the stereotypical strengths and weaknesses each group assumes the other to have. The architecture students almost all rated engineers as either "extremely" or "very": intelligent, technically competent, organized, analytical, structured, logical, and able problem solvers. They also ranked them highly in team-work, collaboration, confidence, and innovation. They were least likely to think that engineers were flexible, artistic or creative. Engineering students almost all rated architects as "extremely" or "very" artistic, innovative, and creative. They also ranked them highly as intelligent and confident. They were least likely to see architects as analytical, logical and able problem solvers. There are differences between the way each profession views the other versus how they view themselves. Architects rated their profession much higher in terms of problem solving, technical competence, logic and capacity for analysis, than did the engineers. Engineers rated their profession as more creative, more flexible, marginally more artistic and better at big-picture thinking than did the architects.

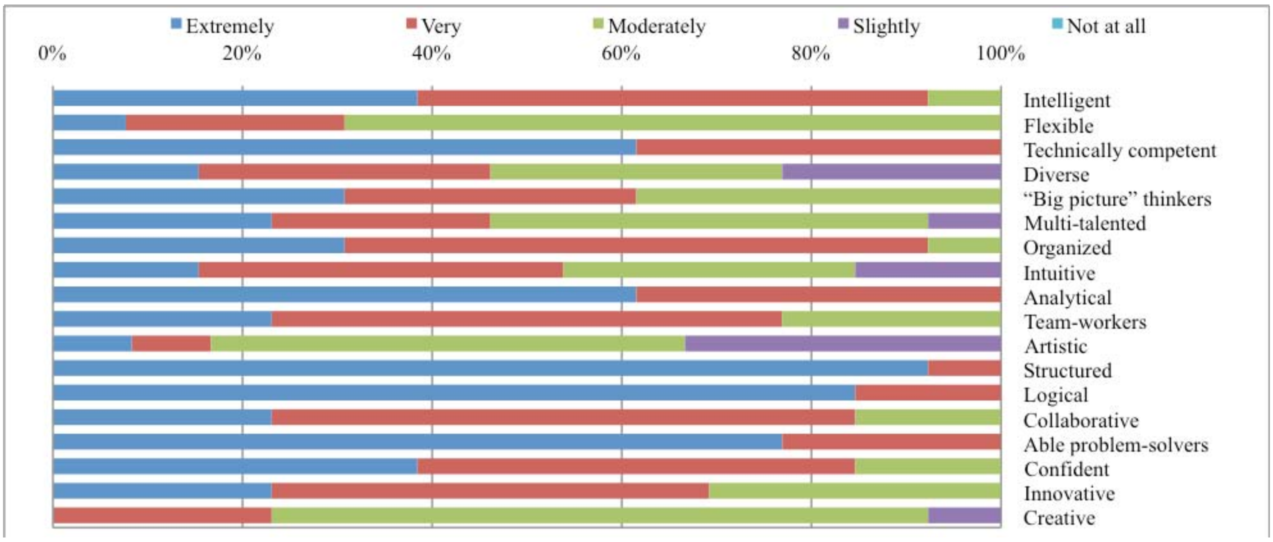

FIGURE 10
COURSE ARCHITECTURE STUDENTS ON ENGINEERS

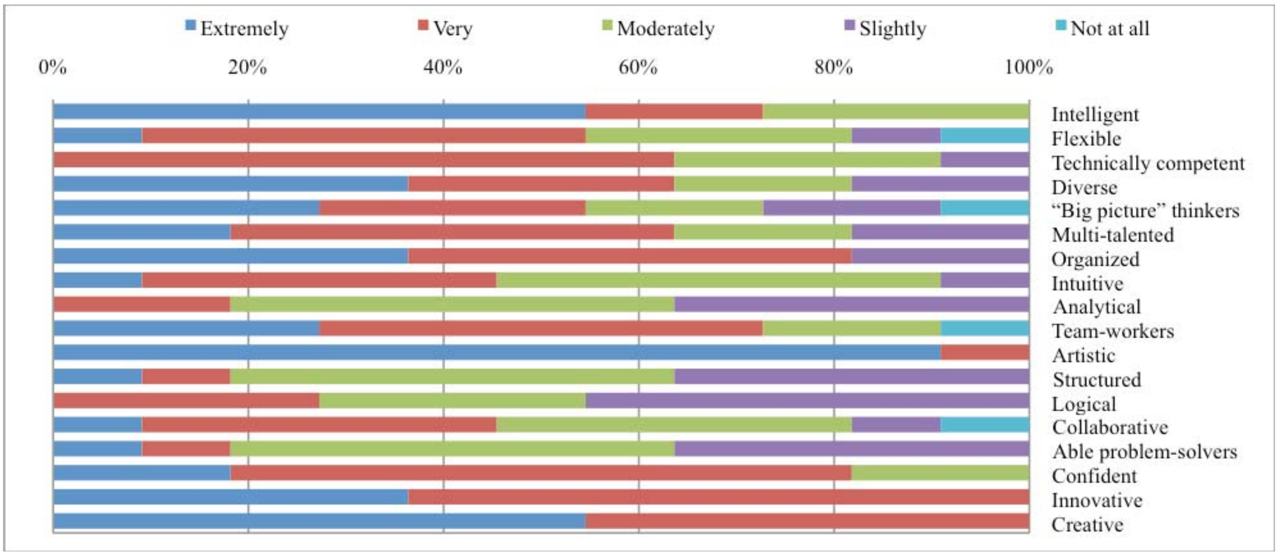

FIGURE 11
COURSE ENGINEERING STUDENTS ON ARCHITECTS

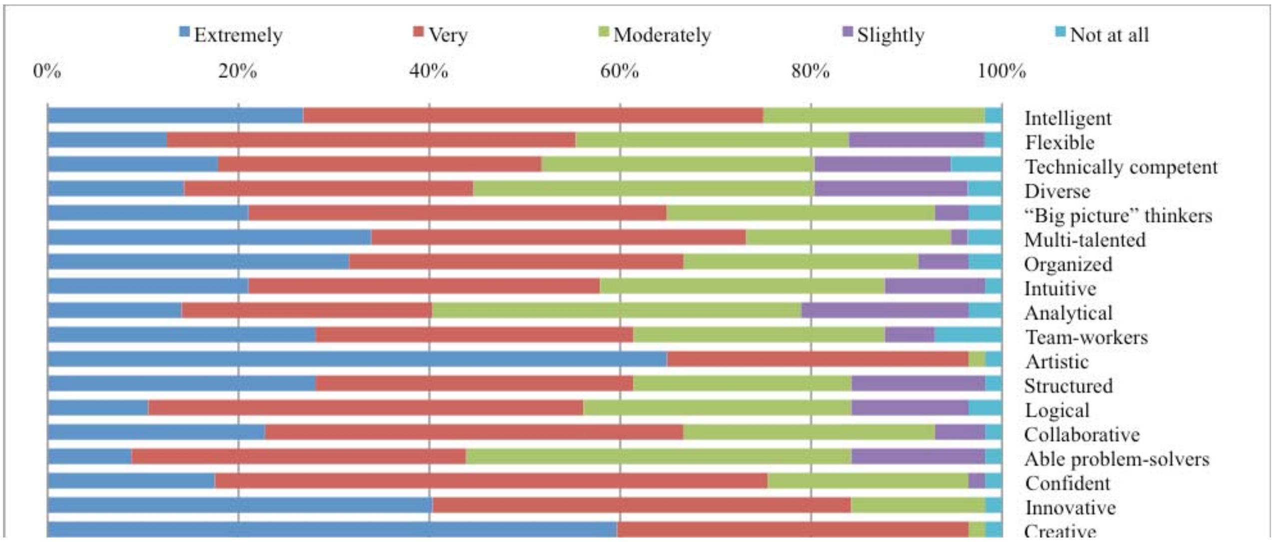

FIGURE 12
COMPARISON ENGINEERING STUDENTS ON ARCHITECTS

BACKGROUND KNOWLEDGE OF PROFESSIONAL ARCHITECTURE AND ENGINEERING

To better understand the common knowledge with which the two groups of students started the class a content survey was administered at the start of the semester. All students were asked to name three engineers and three architects whose work they found interesting. In a group of eleven only four engineering students even attempted the question. The four engineers they named were all historical figures (Leonardo daVinci etc.). They also identified four architects. Unsurprisingly, the thirteen architecture students could all name three architects and listed twenty four architects that were a mix of historical, 20th century, and contemporary figures. Slightly more surprisingly, ten of the thirteen architecture students could also list engineers whose work they found interesting. As a group they named ten engineers ranging from historical to 20th century and contemporary significant figures in structural engineering.

The students were asked to identify three buildings or structures they found aesthetically or architecturally interesting and three they found structurally interesting. The answers to this question were more encouraging. All of the students attempted the question. Engineering students had seventeen answers for architecturally interesting structures and twenty-five answers for structurally interesting (although if one removes Las Vegas hotels, SU campus buildings, and previous case studies encountered in required classes from the list, the numbers are twelve and fifteen respectively). Architecture students had twenty-seven answers for architecturally interesting structures and twenty-seven answers for structurally interesting.

Some background content questions on the topic of the seminar (shell structures) were also asked. The architecture students (77%) were twice as likely as the engineers (36%) to know that a well-designed dome works in compression (as opposed to tension or bending). Seventy percent of the architecture students and one hundred percent of the engineers could define a parabola, but the architects (77%) were more likely than the engineers (36%) to know that it was the most structurally sound shape for an arch.

OTHER OBSERVATIONS

During the initial organization, the first classes, and the focus groups a number of observations of interest in terms of evaluating the trans-disciplinary course were made. The course was very popular and filled very quickly (24 hours) upon initial advertising, with a considerable wait list for both architecture and engineering places developing quickly. No student gave up his or her place, and no student dropped the course. In the survey, 87% of students indicated that the multi-disciplinary nature of the course was a reason they applied for the course. In both the survey and the focus groups both engineering and architecture students expressed considerable enthusiasm for the opportunity to work with a group of students with different skills and outlook. Many cited their specific career goals and how those would bring them into contact with the other profession. It transpired that a significant number of the engineers who took the course had considered architecture as a college option (the reverse was not true).

CONCLUSIONS

The primary purpose of the broader study is to inculcate creativity and innovation in engineering education and these initial results provide some data to help steer that study. The primary trend that emerges from the data is that engineering students are far less confident in their abilities than their architecture counterparts. This is obvious both when the students are asked to rate their abilities and when they are asked to identify the characteristics most associated with the average engineer and then to rate themselves in terms of those same attributes. Logic and intelligence are generally thought of as intrinsic characteristics not learned skills, yet on average the engineering students surveyed (both groups) do not think they are as intelligent, as able in problem solving, or as logical as the average engineer. By definition, this cannot be true. They also do not see their profession as creative, and are largely unfamiliar with either historical or contemporary examples of its best practitioners and products (two facts that are possibly not unrelated).

We have learned that there is broad enthusiasm on the parts of both architecture and engineering students to work together. It is clear that architecture students value technical competency and see themselves as needing more exposure to technical material in order to successfully practice architecture. Engineering students do not see themselves as quite as lacking in creativity and artistic skills as they (or the architecture students) see their profession. Those students concentrating in structural engineering are, in particular, also anxious to learn more about how the two professions work together in the field.

These data will be useful as a baseline against which to measure any change of opinion that emerges in the students after the various planned interventions. They provided insight for the authors teaching first iteration of the trans-disciplinary seminar: we assigned precedent studies of exemplary shell buildings and instructed students to research the architect and engineer's respective roles, we had classroom discussions about the design process of both disciplines and about establishing a common vocabulary. The data will also useful in planning future activities and in preparing teaching materials for the future iterations of the trans-disciplinary seminar.