

Mixing Business with Science: Graduate student perceptions of a pilot interdisciplinary course

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Abstract:

Interdisciplinary studies are increasingly getting attention for their potential to add value to graduate education. This study elicited the views of graduate science students who had completed a pilot interdisciplinary course integrating their normal graduate studies with business knowledge. The students were asked for their perception of the course's learning outcomes and the pedagogy associated with those outcomes. Their responses suggest high level cognitive outcomes, beneficial to current studies and future careers: exposure to other perspectives; increased self-awareness; enhanced communication skills; and an understanding of how their research "fits" into the business world. Because interdisciplinarity requires that students venture into unknown territory, the recommended teaching-learning approaches attempt a balance between encouraging risk-taking and eliminating it altogether: foster student ownership; provide low-risk assignments and detailed feedback; avoid disciplinary bias; and focus on communications.

Key Words:

interdisciplinary; course development; learning outcomes; student engagement.

Introduction

The last few years have witnessed increasing interest in interdisciplinary higher education, particularly with respect to the integration of science and business topics. This approach to education aims to help students “develop boundary crossing skills” whereby they “become capable of dealing with complex issues in both scientific and professional environments” (Spelt, Biemans, Tobi, Luning, & Mulder, 2009, p.366).

Fuelled in large part by a desire to increase graduate competitiveness in the job market, this trend is particularly reflected in the United States with the rapid growth of the terminal graduate degree variously known as “the science plus” degree, the 21st century MBA, and the professional science master’s (PSM) degree. A PSM degree combines graduate studies in science or mathematics with business management courses. Described as “one of the most important innovations in graduate science education” (Teitelbaum & Lynch, 2010), the degree has rapidly expanded in the last few years: from 2008 to 2010, the number of American universities offering the PSM increased from 58 to 103. (Rosenbloom, 2010) Examples of Canadian initiatives that also provide graduate science students and researchers with business knowledge and training include the University of Alberta’s joint MBA/Masters of Agriculture degree; and a collaboration between Concordia’s John Molson School of Business and the Research Institute of the McGill University Health Centre called the Graduate Diploma/Certificate in Business Administration.

The growth of interdisciplinary initiatives linking graduate science education with business knowledge will likely continue. Solutions to complex societal issues involving, for example, energy, food production, climate change, and biodiversity often spread beyond the boundaries of science into the business realm. Graduates and researchers who can competently traverse both realms are needed to fashion these solutions. They are also needed for another reason: personal self-development and career satisfaction. As Borrego & Newswander (2010) point out, “recent generations of college-age students are more interested in making a difference and solving complex problems (e.g., poverty, social justice) that will call for increasingly (inter) disciplinary approaches” (p. 79). Therefore, insofar as it targets students’ interests in making broad, meaningful contributions, an interdisciplinary approach in education is also a learner-centred approach.

Not surprisingly, interdisciplinarity is increasingly a focus of interest for researchers in areas such as the health sciences (Gilkey & Earp, 2006; Hanson 2010), arts and engineering (Costantino, Kellam, Cramond, & Crowder, 2010) and computer science (Spradling & Strauch, 2010). It is not, however, a widely studied approach: “There is virtually no archival literature identifying learning outcomes, methods, or benchmarks for assessing interdisciplinary graduate programs and associated student learning, particularly in science ...” (Borrego & Newswander, 2010, pp.61-62). Spelt et al (2009) concur, characterizing research on interdisciplinary education as “limited and explorative” (p. 365). And what research does exist tends to reflect faculty rather than student perspectives (Graybill et al., 2006). It is also worth noting that the majority of the previous work has focused on interdisciplinary programs rather than individual course offerings. This is clearly a gap in our current knowledge.

This study is intended to help address that gap. Graduate science students who recently completed an interdisciplinary course that integrated their studies with business knowledge were interviewed and surveyed to determine (i) their perception of the course's learning outcomes; and (ii) the teaching/learning approaches associated with those outcomes. Based on this feedback, recommendations for future interdisciplinary course development are provided.

The interdisciplinary course: Background

As part of a scholarship program sponsored by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), the University of Guelph developed a two-semester graduate course to introduce business concepts to Masters and PhD level science students. The specific intent was to provide students with an introduction to some business topics and, most importantly, a holistic view of the innovation process, from development to commercialization, in the context of the students' diverse career interests. The course was required for students who received the scholarship; not surprisingly, course enrollment was largely (80%) made up of these scholarship recipients. The remaining students took the course as an elective. Class composition for this pilot offering was as follows:

- 22 MSc students and 18 PhD students from diverse programs, including biomedical sciences, veterinary medicine, food science, bio-engineering, plant biology and animal science.
- 19 of the 36 students who completed the survey (53%) had no industry experience and no previous exposure to business training or concepts.

The course was offered once a week. Topics covered included communications (written and verbal), negotiations, marketing, business planning, leadership, strategy, intellectual property and innovation. Topics were introduced through lectures and presentations from the instructor as well as guest speakers from other departments and from industry. Lectures were augmented through facilitative tools such as large and small group discussion and individual and group presentations. Case studies were also used to encourage the application of concepts taught to real issues. Students were required to submit brief case write ups and then individual students would present their perspective to initiate a broader discussion. Students were also required to complete a major paper on a topic relevant to the course to provide the opportunity to explore an issue of interest to them in greater detail. They submitted a draft that was subject to peer and instructor review and then submitted a final paper.

Methods

After course completion, the students' views of the course's learning outcomes and teaching/learning approaches were elicited through two focus groups and an online survey. Previous researchers have taken the two pronged approach (see for example (Wutich, Lant, White, Larson, & Gartin, 2010)) as it provides a balance of perspectives. Our total sample was small (40 students) so there was clearly overlap between those that participated in the focus groups and those that completed the survey. Previous research has suggested that results are largely consistent between surveys and focus groups (Ward, Bertrand, & Brown, 1991). The qualitative information from the focus

groups was quantified through the administration of the survey. Almost every student in the class (36 of 40) completed the survey. Since it was anonymous we were unable to determine if there were differences in responses between focus group participants and non-participants but expect that since the survey built on the qualitative feedback from the focus groups which reflected on the course experience that the participation bias was minimal.

No specific theoretical framework was used to guide our analysis. Our goal was to provide a comprehensive and accurate summary of the participants' perceptions, and therefore we wanted to avoid compartmentalizing their feedback to fit a particular model or theory.

Details re the two-pronged approach:

1. Two 90-minute focus groups, the first with 12 students and the second with 10. (i.e., 55% of the class participated). All students were invited to participate. The twenty-two students who accepted the invitation were assigned to a focus group, with the intent of ensuring each group was broadly representative of the class as a whole in terms of graduate level (PhD and Masters).

Both focus groups took place one week after course completion.

Conducting the groups soon after the course ended had two benefits: the students' memories of the course were still fresh; and their focus and availability had not yet been re-directed to the next semester's courses and commitments. Consequently, the short time frame between course completion and the focus groups provided us with specific details and participant involvement that might otherwise have been lost.

The focus group questions were intended to initiate a discussion on the participants' level of motivation at the start of the course; perception of the course's value to their graduate program; and recommendations for changes to the course.

2. An online survey sent to the entire class two weeks after the focus groups had been conducted and their findings summarized. Eighty-five percent of the class completed this anonymous survey. Its timing – three weeks after the last class and two weeks after the focus group sessions -- allowed us to frame survey questions that followed up on the focus group findings in an effort to quantify the qualitative feedback. It also provided the students with some distance from the course, so that their responses would benefit from the reflection and objectivity that time allows – a complement, we felt, to the immediate feedback elicited from the focus groups.

Students were sent a link to the online survey and invited to participate¹. No incentive for participation was provided and the feedback was anonymous. The data were analyzed in SPSS.

¹ A copy of the full survey is available from the authors.

Learning outcomes

A “how to” orientation

The students’ emphasis on the course’s practical learning outcomes, as training for the workplace, was evident from the start: 87.9% of the survey respondents agreed or agreed strongly with the statement that they had entered the course believing that it “would better prepare me for my career”. (See Figure 1.)

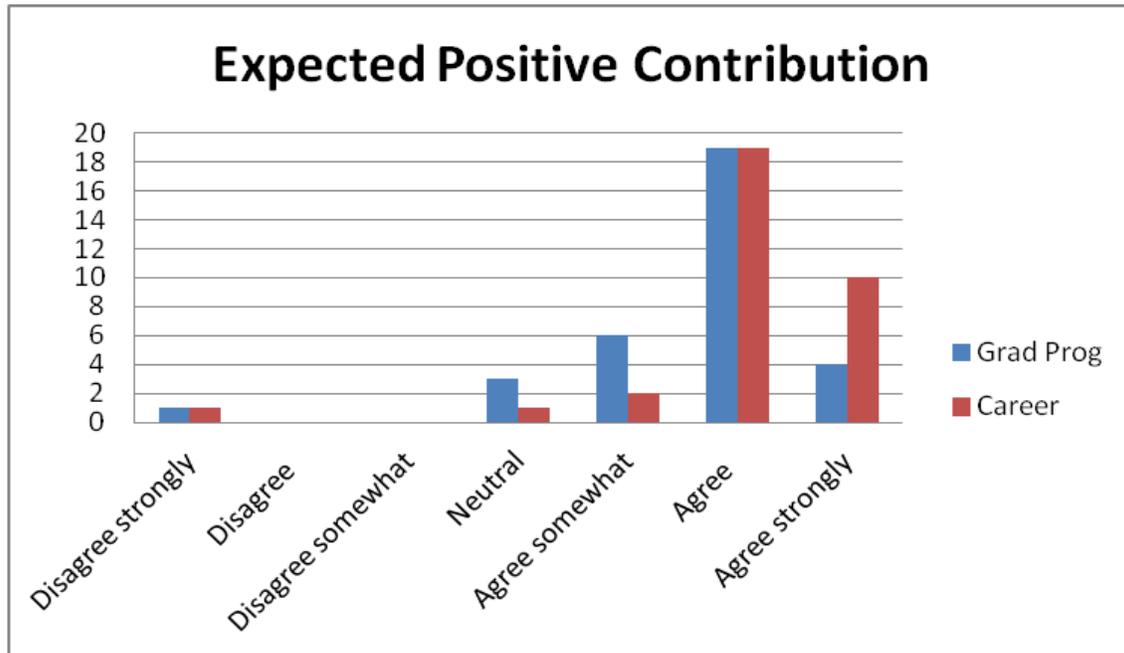


Figure 1: “The Course Will Make a Positive Contribution to My Career”

Interestingly, the diverse career interests among this group – industry, academia, and government – appeared to have no impact on their expectations; and neither did program level (Ph.D. vs. Masters) or previous industry experience. In short, almost 90% (32 of 36) of the respondents believed that exposure to business through this interdisciplinary course would help them in their careers, no matter what career they were aiming for or how much business exposure they already had.

The initial belief that the course would make a positive career contribution appears to have been confirmed after course completion. The students’ first responses when asked what they learned from the course reflected a “how to”, directly careerist, orientation: “I learned how to critique a business plan”; “how to identify a good idea for commercialization”; “how to apply the case studies to work experience”; “how to negotiate a middle ground”; and “how my original scientific data could be translated into a business plan”. As one student explained, the course was a valuable learning experience because it provided “practical skills for the real world”.

“A different lens”

These “practical skills” were intrinsically linked to another learning outcome: exposure to different perspectives. Not surprisingly, almost all (94%) of the survey

respondents agreed that “the course introduced...a perspective that I had not been exposed to before”; 85% of them agreed that the “diversity of programs represented added value to the course.”; and 76% believed that this new perspective would lead to insights “into the application of my area of research.” There are, as one student explained, career advantages in being able to “think from a customer’s point of view”:

In my field (applied nutrition), we have a different mentality. We don’t tend to think of the customer. Now, one thing I took home from this course is that I can think from a customer’s point of view. Before, it was enough for me to know that my data was good. Now I realize that’s not enough. I ask myself, “How can I convince others that it’s good”.

However, the oft-cited implication that an enlarged perspective is associated with affective learning outcomes of increased tolerance and conflict resolution was not completely affirmed in the focus group findings. (Borrego & Newswander, 2010). One student, who described herself as “anti-capitalist”, stated that the course allowed her to understand more readily an opposing perspective (“I’m now thinking about how the enemy thinks”), which she deemed useful in helping her “deal with” those opponents. In this case – and in the case of two others who agreed with her -- exposure to a different perspective did not change a previous way of seeing things or help reconcile opposing viewpoints. When the remaining participants were asked if their silence indicated their agreement with the “anti-capitalist” comments, they replied that it simply meant they had never actually thought about the matter in that way before.

For some students, thinking about matters in a different way did emerge as a significant learning outcome. And not infrequently, this learning outcome was associated with personal reflection and increased self-awareness. For example, one student described the impact of being exposed to such a diverse group of classmates:

The diversity of backgrounds gave us different perspectives. For instance, at the beginning of the course, when everyone was doing an introduction, we found out that one student, from a different country, viewed just getting this scholarship (i.e. the scholarship that required enrolment in this course) as the most important, proudest accomplishment of his life. That was eye opening. Learning something like that, from all these people with varied backgrounds, helps you get to the root of where your own values lie.

Getting to the “root” of those values sometimes led into a broader realm. In both the focus groups and the survey, students indicated an interest in developing a better understanding of social responsibility as a learning outcome. Eighty-two percent of the survey respondents agreed that “corporate social responsibility and alternatives to profit maximization” were important parts of the course content, with 46% believing these topics could have played an even greater role. As one student said, “the ethics was touched on lightly, but we needed more”.

A final learning outcome associated with exposure to other perspectives was intellectual satisfaction. The “opportunity to learn something new” and “to feel more knowledgeable” were cited as beneficial outcomes of this interdisciplinary course.

“Using more of my brain”

One reason some students felt “more knowledgeable” may be linked to the nature of the learning outcomes: generally, they were perceived as challenging, involving high-level cognitive skills. This characterization was confirmed by the students’ description of what they had learned, using verbs from the top tier of Bloom’s Taxonomy of Learning Objectives, such as “apply”, “translate”, and “critique”. One student voiced what appeared to be a majority opinion:

“I thought it (“the course”) would be math and equations and memory work. I was happy to learn that it wasn’t....No memorization. No regurgitation. Using more of my brain than some other courses.”

Further, when the survey respondents were asked whether the course material was “too rudimentary” (i.e., too focused on lower level cognitive skills), over half of them either strongly or somewhat strongly disagreed; and one third remained neutral. When asked whether the material was “too complex”, one third of the group either agreed or remained neutral. Certainly, the survey presented no evidence that the learning outcomes had set the bar too low. Instead, the findings suggest that these graduate students perceived the learning outcomes as challenging or, in one student’s words, “a bit trying”.

“The communication side”

At least one of the learning outcomes entailed venturing into unfamiliar – and sometimes daunting – territory for these graduate science students: enhanced speaking and presentation skills. For these science students, accustomed to lectures and labs, an interactive teaching approach meant learning to voice their opinions in “open ended” discussions. Enrolled in programs where definitive and statistically significant results are the objective, many students struggled with some of the case analysis. While they appreciated the approach, they were often uncomfortable submitting work based solely on their perspective. They regularly asked for feedback in the course about “right answers.” Moreover, the focus group students referred to the challenge of speaking up when they felt inhibited by the perception that others in this class of scholarship graduate students from different disciplines “knew more or had more expertise”. Despite the difficulty, however, the result for some was a more meaningful learning experience: “with courses that rely on memory, you don’t end up remembering much. With this course that relies more on interaction, you end up remembering more. Everything stays with you.”

A related learning outcome was the opportunity to develop ideas through group interaction, which led to “feeding off each other”. That is, listening to and speaking with students from different disciplines “made the discussions more interesting, more enlightening”, and sometimes led to new insights through the process of synthesis, another high cognitive level learning outcome. The value of these learning outcomes prompted one student to suggest that there should be more focus on “the communication side” (i.e., speaking skills and group interaction.) This sentiment was reinforced by the fact that 97% of the survey respondents agreed that the class discussions led to positive learning outcomes.

Contributing to their graduate studies

A quick survey of the learning outcomes above leads to the following conclusion: these outcomes add value to the students’ current graduate studies. Exposure to other perspectives, increased self-awareness, the use of high level cognitive skills, the ability to communicate more effectively – as well as an understanding of how one’s research “fits” into the business world – would all provide an enhanced learning environment for these graduate students. And, in fact, most of the participants agreed with this conclusion (Figure 1). Figure 2 provides a summary of the responses to questions about the contribution of the course in three areas: their specific research; their general area of study, and their broader perspective. The mean score of the three questions were not statistically significantly different. However, students responded somewhat more positively relative to their specific research than to their broad area of study. This outcome may be explained by the fact that many students completed a paper that took a business perspective on their specific research. Students also tended to say that the course contributed more significantly beyond their field of study rather than the specific technical aspects of the field of study. The responses for the course providing a broader general perspective were most positive.

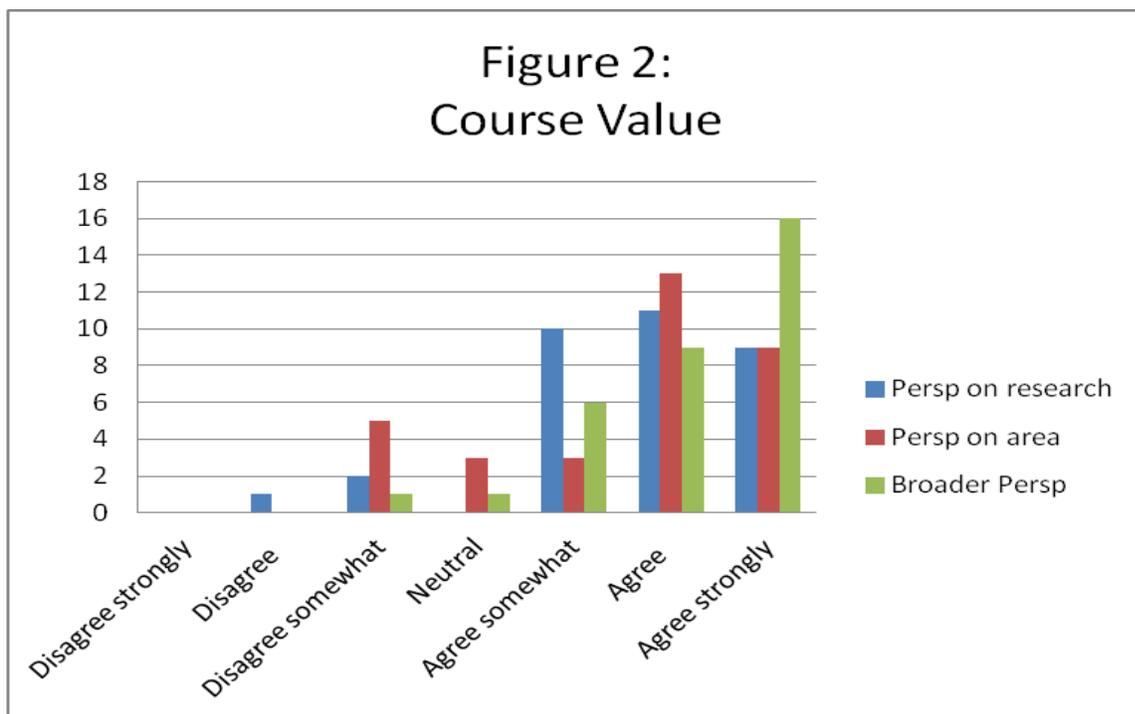


Figure 2: Contribution of Course

Teaching and Learning Approaches

The path to achieving the learning outcomes cited above is not without its challenges. The next section identifies some of these challenges and provides pedagogical approaches, based on the literature and the students’ feedback, on how to address them.

Addressing the central challenge of interdisciplinarity: risk-taking

Risk-taking is at the heart of a graduate-level interdisciplinary course. After all, its students are being asked to step outside their particular discipline, a place where, as Masters and PhD students, they have likely invested quite a bit of time being “actively trained and rewarded for mimicking the role of experts” (Burgett, Hillyard, Krabill, Leadley, & Rosenberg, 2011, p 484). An interdisciplinary course now puts them in a setting where they are no longer the experts and where an assumption they might have acquired “that there is only one right way”, (p. 482) that of their discipline, no longer holds sway. In fact, this particular interdisciplinary course, with its emphasis on case studies, often relied on the dictum: “there is no right answer.”

In such a setting, students may feel uncertainty or even fear – and therefore try to avoid the course altogether. Avoidance was not an option for most students in this particular course: it was mandatory for the scholarship recipients who made up the majority of the class. However, evidence suggests enrolment numbers would have been thin without this mandatory requirement: five out of 10 students in the first focus group agreed with the statement “at the start, I definitely did not want to take this course”; and 70% of the survey respondents -- dedicated students who had spent a considerable amount of time sitting in classrooms -- acknowledged being “apprehensive” about sitting in this particular classroom “because the course material was outside of my (discipline)”. Concerns over low grades were voiced.

A lack of external support did not help the situation. One focus group participant, who had taken course voluntarily, said that his advisor “was not happy about it. He asked me how I was going to explain the course to my (thesis) committee”. Presumably, the committee would be concerned that time devoted to an interdisciplinary course was time lost to the student’s own specialized studies and that his work would suffer as a result. This supervisor likely had no previous exposure to this sort of interdisciplinary course and, therefore, did not perceive its value. However, his negative response is not an isolated one. The literature is full of references to the “perceived tradeoffs of breadth and depth” to which interdisciplinary study is vulnerable (Borrego & Newswander, 2010, p 7) – as is, therefore, the academic reputation of those engaged in this study. This lack of support for interdisciplinary study would presumably exacerbate any student apprehension about the course – and undermine their motivation to do well in it.

Developing pedagogical approaches to overcome these fear-based barriers is a balancing act. Sometimes the objective is to foster risk-taking, and sometimes it’s to reduce or eliminate the risk altogether. Achieving this proper balance is a central component of the following teaching/learning approaches.

Foster student ownership of the course

Students in this course were given the opportunity to help shape course content and learning outcomes. After the first class meeting, the instructor e-mailed all registrants with the question “What do you want to get out of this course?” The informality of the question was intended to encourage a large response rate – and it did. Every enrolled student responded. Eliciting – and accepting without judgment -- student responses to this question, such as “I want something on innovation”, “provide one lecture on how to fill out grant applications for scientific research” or “I want to know what a business plan

is” sends a message to the registrants that may help allay apprehensions about unfamiliar course content and increase motivation: this learner-centred course aims to begin with – and address -- the students’ concerns and needs. The course schedule, therefore, was also flexible to allow more or less time for specific topics, depending on class interest.

Graybill *et al* (2006) reinforce the importance of this approach in their study of an IGERT (Integrative Graduate Education and Research Traineeship) program at University of Washington. One of their central recommendations is to provide students with a greater sense of course ownership by having them “develop and facilitate course themes, structure, and sessions” (p. 761). This approach implies, of course, that an interdisciplinary course is most effectively developed based on the principle of “adaptive flexibility”, changing each year to fit the needs of the new crop of students (Burgett *et al.*, 2011, p485).

Develop a highly structured, clearly articulated framework

The flexibility regarding course content that is embedded within the above recommendation does not extend to course structure. The focus group and survey participants were emphatic on this point, offering recommendations that, apart from their pedagogical value, aimed to tighten the course structure. The following matters were raised:

- Content sequence: follow a clear progression from basic information to more complex issues;
- Readings: Post them well in advance on the course management system and preface them with “‘thought’ questions to focus the reader and spark the main point”;
- Due dates: Ensure a project’s due date follows, not precedes, class discussion of that particular issue;
- Time management: Group presentations represent a more efficient use of time than individual presentations. Scheduling the class in the evening accommodates graduate students’ diverse schedules more effectively than a daytime slot; however, class time after 9:00 pm is tiring for students who may have been in the lab since 8:00 am.

Their concern with establishing a highly structured environment may be partially interpreted as a way of dealing with the anxiety associated with unfamiliar content and classmates.

Provide “low risk” assignments and detailed feedback

One way to bolster learning, and thus confidence, is to forego a major assignment, weighted heavily toward the final grade, in favour of a series of shorter, inter-related assignments, each comprising a relatively small percentage of the final grade. For example, the course’s major paper was structured to have several points of feedback: students were required to provide a proposal early in the first semester and a draft at the start of the second semester. This process, intended to emulate the submission of an academic paper to a journal, provided opportunity for blind peer review and instructor feedback before the due date. Nonetheless, one focus group participant suggested that

the final paper be even “more of a process, whereby students would get monthly feedback on it” before final submission. Indeed, the importance of ongoing, detailed feedback on assignments, particularly on writing and presentation skills, was a recurring comment in the focus groups. One student summed up the groups’ consensus: “more feedback would lead to more confidence”. This desire – and, perhaps need -- for increased guidance is understandable. These students were asked, after all, to venture into what was for most of them completely unknown territory.

Avoid disciplinary bias

At the risk of stating the obvious, an interdisciplinary course aims to help students understand and employ multiple perspectives. However, this undertaking is jeopardized when one discipline plays a more prominent role than others in the course. The focus group participants offered recommendations on how to avoid this bias:

- An instructor whose knowledge extends beyond disciplinary boundaries through “real world” industry experience
- Guest speakers whose presentations reflect a thorough briefing on the students’ backgrounds and the course objectives. For example, one focus group participant mentioned the problem of guest speakers who focused almost solely on their own disciplinary interests; their presentations were perceived as “self promoting” and lacking relevance.
- Case studies that, insofar as they focus on “real life” situations, encourage tolerance of, and comfort with, ambiguity, those “grey areas” that may not fit neatly within one’s preconceived views.
- Group (as opposed to individual) assignments to encourage more exposure to, and interaction among, students from different disciplines.
- An interactive classroom, with an emphasis on collaborative activities to ensure that the students “do not ... push only their individual or pre-existing idea(s)” (Burgett et al., 2011, p 483). To facilitate this interaction, the class took place in a seminar room with U-shaped seating so that all students could easily see and hear each other.

An emphasis on group assignments and collaborative activities might lead to another, long-term benefit: increased research productivity. A study conducted by Rhoten on interdisciplinary study (2004, p 9) found that “close and collegial connections” with those outside one’s own discipline led to sharing existing information or creating new knowledge. Thus, the connections forged in the interdisciplinary classroom can lay the groundwork for future research publications – an insight that may have prompted one student’s comment, “I wish people would talk more”, as he referred to the lost opportunity to learn from a particularly gifted, yet quiet, classmate. This insight also addresses the earlier mentioned concern that many academics have with interdisciplinary studies: the perception that it distracts from, or undermines, the participants’ research agenda.

Focus on communications

“Close and collegial connections” and all the benefits they bring, require effective communication skills. Speaking, interpersonal, and writing skills, therefore, should be a

formal and significant component of an interdisciplinary course. The literature is emphatic on this point (Burgett et al., 2011; Graybill et al., 2006; Lattuca, Voight, & Fath, 2004; Rhoten, 2004; Spelt et al., 2009) as were the focus group students. This particular course devoted the first three classes to writing and presentation skills; videotaped student presentations, allowing each student to view privately and critique his or her presentation; required short, bi-weekly writing assignments with low individual weights; and placed students in the role of facilitator during case study analyses and issue topic discussions. The students valued this focus on communications. In fact, one focus group participant asked for more: "I wish I had gotten more instruction on how to engage people, on the communication side, because it applies to everyone, to every situation".

Conclusion

Interdisciplinary studies aim high: to foster a holistic approach to problem-solving. The focus of this study – a pilot graduate course that integrated business concepts with graduate science training – illustrated some of the learning outcomes and pedagogical approaches associated with this effort. This course also illustrated another element of interdisciplinarity: its potential to provide students with an intrinsically satisfying learning experience that would benefit not only their future careers but also their present graduate studies.

The study participants overwhelmingly felt this course was both valuable and enjoyable and that they would recommend it to other graduate science students. The survey respondents also felt strongly that they needed more of this sort of interdisciplinary study. (See Figure 3). One survey participant expressed a recurring sentiment when he concluded, "This course helped me in ways I never expected when I started. Thank you." Their positive feedback may stem from this understanding: the challenges posed by their current graduate studies and their future careers increasingly require a multi-faceted approach. The business perspective could provide some context for the place of their technical research in a broader economy. These students will end up in a variety of roles (academia, government or industry) after graduation and the business training could help in any and all of them. As an example, academic grant proposals often require researchers to make a "business case" for their research and this training can help provide the skills for doing this.

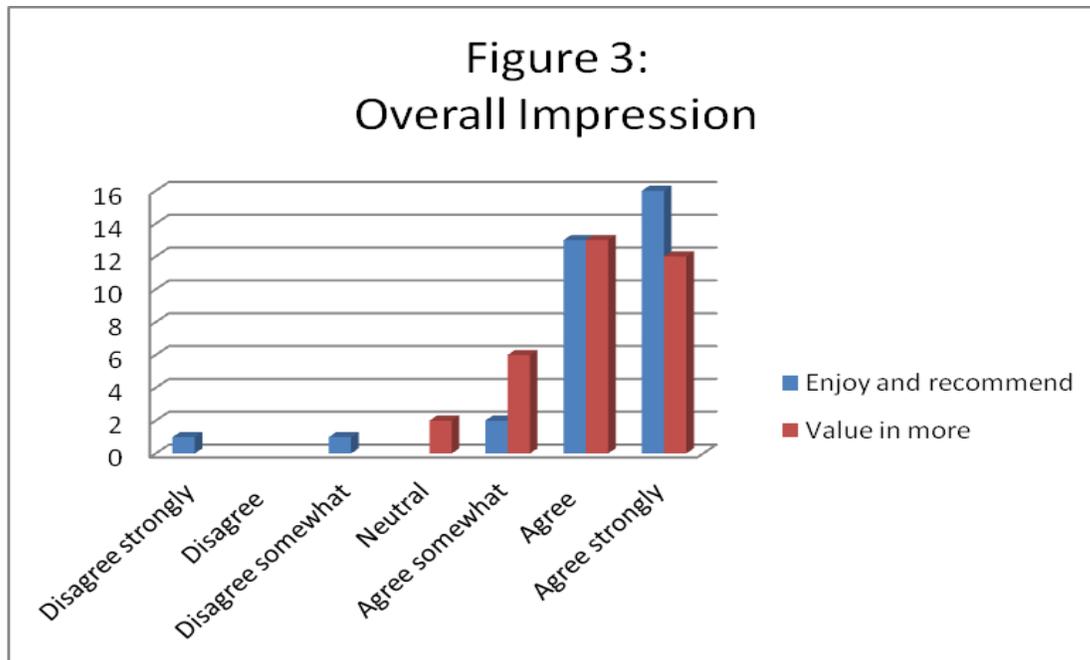


Figure 3: Overall Impression of Course

However, these optimistic findings about the interdisciplinary course’s value mean nothing if students are not in the classroom to receive, and contribute to, this value. This study suggests that student apprehension about the course’s unfamiliar content and pedagogical approaches, coupled with lack of encouragement from supervisors and graduate committees, would result in low enrolment numbers if the course were designated as elective. The mandatory requirement appears to be necessary, at least during the first years of the interdisciplinary course offering. We must recall that many science faculty have not received this sort of interdisciplinary training and may not perceive the value either.

Based on our analysis of the participants’ positive feedback, this study points to the success of a mandatory pilot course that (i) targets scholarship recipients; (ii) integrates graduate science with business; and (iii) exists outside of an interdisciplinary program. It therefore addresses the value of developing and delivering single, “stand alone” interdisciplinary courses. It also raises the question of whether such courses should be mandatory for *all* graduate science students. The strong learning outcomes and effective teaching/learning approaches described in this study suggest these would be fruitful research areas to pursue.

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