Balancing Act: Creating a Multidisciplinary Blended Introductory Statistics Course

Brenda Ravenscroft, Victoria Chen
Queen's University

Authors' Contact Information

Brenda Ravenscroft, Associate Dean, Faculty of Arts and Science,
Queen's University
Dunning Hall, University Avenue
Kingston, ON, K7L 3N6
Phone: 613 533-6000 ext. 77181
Email: ravenscr@queensu.ca

Victoria Chen, Ph.D. candidate, Faculty of Education,
Queen's University
Email: victoria.chen@queensu.ca

Abstract:

Teaching introductory statistics, a required component of the undergraduate curriculum for many university disciplines, often occurs in multiple, discipline-specific courses[1], which leads to duplication, curricular inconsistencies, and understaffing challenges. This paper describes our institution's solution to these challenges: the creation of a shared multidisciplinary blended course. After a brief description of the course redesign project that provided the context for the initiative, the paper focuses on the experiences of the faculty members involved in the team development of the course. A description of how the cross-disciplinary discussion was facilitated and agreement was reached is followed by the design team's collective perceptions of the benefits and challenges of creating a multidisciplinary course and working with a multidisciplinary team of experts. Keys to success are highlighted for other higher education professionals contemplating similar innovations. The article concludes with a discussion of the project's next steps.

Key Words:

multidisciplinary, introductory statistics, blended learning, design team.

[1] Here, and throughout, 'course' is used in the North American understanding of the term as a component of an academic program, equivalent to the British and Australian terms 'module' or 'unit'.

Introduction

Introductory statistics is recognized as an integral component of the university curriculum for disciplines ranging from biology to sociology to economics, but teaching intro stats frequently presents challenges. One of these challenges is what Flaherty (2015) refers to as the modern day "math wars," the conflict arising from differing views between faculty members in the math department and those outside the math department on how to approach teaching courses such as intro stats.[1] This tension stems from how much math theory should be included; generally math instructors believe all students should learn foundational theories in math, while instructors in non-math disciplines argue that their students should focus only on applicable aspects of math and spend less time on theory. In addition to debates on the material itself, students in math and non-math disciplines tend to view statistics differently. In particular, students in non-math disciplines report experiencing anxiety in their introductory statistics studies—sometimes as a result of less familiarity with math—an impediment that can negatively impact their ability to learn effectively (Onwuegbuzie & Wilson, 2003). In response, disciplines often develop their own versions of an intro stats course in an attempt to cater to what they perceive as their students' unique needs (Lahey, 2014). However, statistics runs the risk of getting "splintered" when it is specialized for every field (Flaherty, 2015).

These single-disciplinary courses frequently raise more questions than they address. Math instructors interviewed by Flaherty (2015) expressed concerns about the consistency of curricula across disciplines, observing that what they viewed as essential math components were sometimes discarded or compressed to create time for other material perceived to be "more relevant" to the specific discipline. The instructors argued that students, especially those in the sciences and humanities, take courses in multiple disciplines and, depending on which discipline's intro stats course they take, may not be adequately prepared for advanced material in a particular subject. Lidgren (2006) extends this concern, pointing out that the single-disciplinary approach may not prepare students for real world problems, which are inherently interdisciplinary. In addition, the duplication of intro stats courses in different disciplines is inefficient from an institutional perspective. Drawing heavily on teaching resources, staffing can be problematic if there are not enough suitable or willing experts to teach these courses in individual departments (Lahey, 2014), a situation that can be exacerbated by retirements and budget cuts.

Our institution—a mid-sized, research-intensive university with a strong undergraduate program—faced both a threat and an opportunity in terms of teaching introductory statistics. On the one hand, a growing shortage of expert instructors was undermining our ability to staff the eleven intro stats courses offered across the disciplines. Some academic departments had resorted to removing intro stats as a degree requirement, leaving students ill prepared for advanced courses that assumed a basic knowledge of statistics. On the other hand, a very successful course redesign project, focused on improving student engagement in large, introductory courses through blended models, offered a mechanism and resources for reconceptualising the way in which introductory statistics was being taught, and for bringing disciplines together.

In 2013, a project was initiated to examine the feasibility of creating a single, multidisciplinary intro stats course that would solve staffing issues, create greater consistency in the university's intro stats curriculum, and enhance learning for students. Led by the Associate Dean of Teaching and Learning in the Faculty of Arts and Science, who was also responsible for the course redesign initiative, the project was structured to meet its goals by fostering open dialogue between all the parties, building consensus, and supporting faculty members.

This paper, co-authored by the Associate Dean and the project's research assistant, describes the team-based design, development and implementation of a multidisciplinary, blended introductory statistics course. After opening with a short description of the larger course redesign project, the paper discusses the process that led to the creation of the intro stats course, focusing on the experiences of the faculty members involved in the project. Information was gathered by the second co-author through semi-structured interviews with each member of the intro stats design team, asking them to reflect back on the two years of the course development and course enactment. The shared/common themes from the interviews provide the framework for describing the project and the experiences of the design team members. The paper concludes by critically examining the benefits and challenges, and suggesting next steps for the project.

Course Redesign Project

Like many institutions of higher education, enrolments in our foundational courses are very high, ranging from several hundred to well over a thousand students. While traditional lectures are an efficient way to teach these large groups, the students' passive classroom experience often leaves them unengaged and distracted. Higher levels of student engagement lead to better learning outcomes and superior knowledge retention (Kuh & Associates 2005), and engagement is associated with active learning (Zepke & Leach, 2010). Over the past decade institutions have started to redesign courses to address the challenges of large classes (Brown 2016; Twigg 2000), and, in 2011, the Faculty of Arts and Science launched its own course redesign project.

The Faculty project involves redesigning traditional lecture courses into blended (flipped) models in which the transmission of information takes place online, and face-to-face classroom time is focused on applying knowledge through active and group learning (Garrison & Vaughan, 2008). The project uses a team-based approach to the process of redesign, involving the instructor, an instructional designer, a web developer/learning management system expert, a subject-specialist librarian, and a graduate student who becomes the head teaching assistant during the delivery phase. Now in its fifth year, there are thirteen blended courses in a range of disciplines including the sciences, social sciences, humanities and creative arts, involving over 10,000 student enrolments annually. A longitudinal research study using the Classroom Survey of Student Engagement tool (Ouimet & Smallwood, 2005) shows statistically significant improvements in mean engagement scores in blended over traditional versions, particularly in the subscale "active learning during class." The courses in Table 1 are all first-year gateway courses to concentrations, with the exception of Classics and Drama, which are both large second-year elective courses.

Table 1. Descriptive Statistics per Course, Year, and Subscale and Results of Post-hoc tests Using Bonferroni correction for Mean Scores in Blended Formats versus those in Traditional Format

		Active Learning During Class		
Course	**Year**	**Mean**	**SD**	**N**
Biology	Year 1 (Traditional)	1.34	0.55	905
	Year 2 (Initial Blended)	1.88*	0.87	372
	Year 3	1.73*	0.84	319
Chemistry	Year 1 (Traditional)	1.48	0.78	474
	Year 2 (Initial Blended)	2.24*	1.00	191
	Year 3	2.14*	1.03	239
Classics	Year 1 (Traditional)	1.15	0.41	106
	Year 2 (Initial Blended)	2.85*	0.78	476
	Year 3	3.15*	0.66	174
Drama	Year 1 (Traditional)	1.58	0.74	132
	Year 2 (Initial Blended)	2.72*	0.72	97
	Year 3	3.13*	0.73	58
Calculus	Year 1 (Traditional)	1.36	0.60	125
	Year 2	1.36	0.61	739
	Year 3 (Initial Blended)	1.95*	0.87	216
Psychology	Year 1 (Traditional)	1.64	0.85	495
	Year 2 (Initial Blended)	2.46*	0.93	1372
	Year 3	2.37*	0.94	1164
Sociology	Year 1 (Traditional)	1.56	0.75	180
	Year 2 (Initial Blended)	2.69*	0.90	454
	Year 3	2.79*	0.95	122

***Note*. In each course, Year 1 served as the control group and * indicates where the mean difference is statistically significant using α = 0.05 significance level**

The Introductory Statistics Project

Getting Started

The project was initiated in June 2013 when the Associate Dean brought together faculty members and administrators associated with the university's eleven introductory statistics courses: biology, psychology, kinesiology/nursing, sociology, politics, economics, geography, commerce, epidemiology, industrial relations, and the intro stats course offered by the department of mathematics. Representatives included statistics instructors, departmental undergraduate chairs, and heads of department, as well as a statistics librarian and an instructional designer.

Multidisciplinary collaboration was central to both the initial conversation and the design phase. Ideally, a collaborative team of faculty and staff from various disciplines bring the range of unique perspectives and expertise needed for a project of this magnitude (Bellanca, 2009; Ritchie & Rigano, 2007; Stewart, Cohn, & Whithaus, 2016). According to Austin and Baldwin (1991), when faculty from different disciplines engage in collaborative teaching, the benefits parallel those of collaborative research: maximizing limited resources, decreasing isolation associated with the autonomy of faculty, and enhancing the quality of the product. Furthermore, by including faculty from all disciplines with intro stats courses, it was hoped that the tension between math and non-math departments would be decreased.

Having multiple disciplines involved in the design and development stages was seen to be key to increasing the chances of the initiative going beyond the discussion phase. Over the previous two decades the concept of a single introductory statistics course had come to the fore several times within the Faculty of Arts and Science, but, although departments were interested in the idea, it had never been successfully pursued because of concerns about which department would control the development of the course, and scepticism about whether the needs of other disciplines could be accommodated.

Starting in the summer, monthly meetings were coordinated to facilitate group discussions, following the timeline in Figure 1. The face-to-face nature of the meetings was essential for opening the communication process, building trust, and increasing motivation to engage in the task (Thompson, 2009). After each meeting, attendees were asked to consult with their departmental colleagues to solicit feedback on emerging plans, thereby allowing others in the departments to have input into a course that was core to their programs. Materials such as course syllabi and summaries of feedback were available online to all participants. They were also given an annotated bibliography and had access to research articles on teaching statistics. These included a meta-analysis by Larwin and Larwin (2011) presenting a comprehensive investigation across 70 studies of the effectiveness of computer-assisted instruction on student achievement in statistics, an example of a successful cooperative teaching approach to statistics by Rumsey (1998), and the American Statistical Association's (2005) guidelines for teaching intro stats courses. In addition, a compiled list of examples of redesigned statistics courses from databases such as the National Center for Academic Transformation (http://www.thencat.org/) was available for the group.

Figure 1. Steps and timelines

- Identify needs and challenges through discussions with all parties – summer 2013
- Analyze syllabi for all introductory stats courses to identify common topics and levels at which topics are taught – summer 2013
- Develop 2 options (small group) – August 2013
- Discuss 2 options (larger stats group) – September 2013
- Seek feedback from all relevant departments – September/October 2013
- Make decision and commit to proceed with specific model – early October 2013
- Develop the course using a small team with input from all participating departments – starting late October
- Submit curriculum documents for approval – November 2013
- Deliver first offering of the course – fall 2014

Reaching Agreement

Three main challenges arose as the group developed a shared vision.

Challenge 1: Giving Up Departmental Statistics Courses

Although the departments came together with the intent of discussing a unified course, in early meetings they still resisted changing their existing statistics courses, stating their discipline had specific needs. As one team member said, “There was that tension of, sure, we generally want to accomplish the same things, but in biology we want them to do this, and in psychology we want them to do this.” In response, syllabi from all of the introductory statistics courses were gathered and compared. Analysis of the syllabi showed that the topics and learning outcomes across the disciplines were generally the same, demonstrating more similarly than had initially been perceived. One team member elaborated, “The commonality was striking. A lot of us had the same basic material covered. I think there is a movement in general towards more emphasis on critical thinking, problem solving, and not just memorizing or how to do a t-test or ANOVA, well they want them to know that but they also want students to know the concepts. It was really heartening to see this, and it might make good sense to do it as a multidisciplinary course.”

Challenge 2: Deciding on the Level of Statistics Knowledge

Discussions then focused on the level of statistical knowledge needed by students. The issue was described by one team member, “One of the challenging things to teaching students statistics who need it, but really don’t want to develop the math theory, is how do you achieve a balance of teaching them the foundations that they can use it and apply it into tools without getting into so much detail they become disinterested in it. At the same time, the course needs to have the ability for other courses in the department to be able to mount on to it. That’s not an easy balance.” To enable comparison, departments rated the open-source Carnegie Mellon online introductory statistics course materials, as being above, below or at the same level as their course. Initially, there was support for the idea of creating two streams of statistics to address differences in students’ mathematical backgrounds, but this plan was discarded in favour of a single general introductory statistics course because of the complexity of the project.

Once the learning outcomes and level of statistical knowledge were agreed upon, the Associate Dean assembled a design team, comprising three faculty members and an instructional designer. The statistics librarian served as a consultant. Two of the faculty members were experienced in course redesign, having transformed large introductory courses in calculus and psychology from traditional lecture-based courses to blended formats as part of the Faculty’s Course Redesign Project, while the third faculty member taught introductory statistics instructor in the Mathematics Department. The team was charged with developing two models for the larger group’s consideration, and, once the group had approved one of the designs, with developing the course itself.

After due consideration of possible designs, the group decided that a flexible blended model was the best solution. The model’s three components complement each other: online materials introduce the content, the weekly in-class “lecture” reinforces the content, and weekly in-class labs allow students to apply the content. Five departments chose to commit to the project—Sociology, Geography, Biology, Kinesiology, and Nursing—with a total of 675 students.

Challenge 3: Finding Common Ground

A single course serving the needs of five groups of students presented its own challenges. What should be taught? How should it be taught? Which textbook should be used? What type of examples should be given?

For the content component of the blended course, the design team selected an evidence-based general statistical teaching software, *Acrobatiq*, developed from Carnegie Mellon's Open Learning Initiative. The non-discipline specific nature of the program was compatible with the multidisciplinary approach being contemplated, and the learning outcomes appeared to correspond to those identified for our institutional introductory statistics course. Furthermore, the software was advertised as being adaptable to students' needs and thus able to improve their retention of conceptual knowledge. Using online *Acrobatiq* lessons as the foundational teaching material, a weekly in-class, large-group gathering or "lecture"—taught by an experienced statistical instructor—was designed to help students with areas of struggle in the lessons. Finally, team members developed interactive labs for students to apply the concepts from the online material, working in small groups and using authentic real life statistical scenarios and data available through the university's library.

In semi-structured interviews conducted two years after the initial development of the course, the design team members reflected on the benefits and challenges of creating a multidisciplinary course and of working with a multidisciplinary team. These are presented in summary below, together with critical keys to success.

Creating a Multidisciplinary Course

Benefits

The multidisciplinary course addressed a staffing risk by enabling departments that might otherwise have had to remove statistics as a requirement due to the lack of instructors, to have an introductory statistics course. The efficiency of the format and structure of the course allowed several hundred students to learn the same content, a benefit highlighted by team members as facilitating student movement between majors and providing students with the appropriate background for upper-year courses in other disciplines. Furthermore, the labs gave students the opportunity to work on applications of statistics in various disciplines, and allowed them to collaborate with other students outside of their discipline.

Challenges

Although having a single foundational intro stats course was seen as efficient and beneficial for students regardless of whether they continued into research-intensive disciplines, the team encountered concerns from departments about whether the students would be prepared for their advanced courses: "There was the concern that departments might have another course and students need to be able to do certain types of research. Students need to be at a certain place to be able to do their course. So as a multidisciplinary course, can we guarantee students will be there?" In addition, students with weaker mathematical backgrounds tended to struggle in the course, and students told instructors they wanted more in-class lectures instead of learning from the online software.

Another team member mentioned the complexities of finding and hiring qualified teaching assistants (TAs) for a multidisciplinary stats course,

> We don't have the TAs with the stats knowledge [although] some have developed it while TAing for the course. A lot of the terminology is crossing disciplines: terms a psych student would know, but not a biology student. It's really hard to find students who can do that. So we can't expect our TAs to answer knowledge about the material, so it falls on the instructors and so we run the office hours.

There were also unexpected challenges from logistical and administrative standpoints, with complexities concerning finances, scheduling, and classroom booking. One team member explained, "There is an assumption the department deals with that, but once you are crossing the barriers among departments all of a sudden no-one is sure who is supposed to do this. Finance, budget, course room bookings, timetabling, exam requests—it's things you don't even think about when it's a course run in the department."

Keys to Success

To ensure the course provides students with levels of statistical knowledge needed for advanced courses, and at the same time enable students with weaker math backgrounds to succeed, the team compared the course learning outcomes to the of the American Statistical Association's curriculum guidelines for non-statistics majors (http://www.amstat.org/asa/files/pdfs/EDU-guidelines2014-11-15.pdf). As explained by a team member,

> We are delivering everything in there. It's important to keep in mind—I struggled with students—they want to see less material, but it's the same material you see in other universities. Their background getting to this point has lacked statistics, that's partly a fault of high school curriculum. Problem is our students will go on to do clinical work, sociology work, medical, a ton of different work where they need the tools and when they go on from here many professional schools require stats of a certain quality.

The team also developed real life interdisciplinary statistical problems for case studies and labs, allowing students to see the relevance of statistics in everyday life. For example, determining the crime rate in rural versus urban areas by analyzing the statistics, or advising a relative whether to get a prostate exam based on the statistical data for their age, ethnic group, and considering the PSA cut off for prostate cancer. One team member explained the benefits of this approach, "A student who is looking to understand the material will understand it a lot better by seeing it in different disciplines. The stats are the same." Establishing a clear link between statistics and its uses in the real world is an effective way for all students to learn statistics (Yilmaz, 1996).

With the difficulty of finding qualified TAs for a multidisciplinary course, the instructors of the course ended up having to answer the bulk of the content questions. The solution was to create weekly "office hour" sessions for each class, held in a large seminar classroom. Students could come in and ask the instructor questions about the content, and the instructor provided additional practice questions and solved them with the students in the classroom. Additional office hour sessions were added before exams.

To address logistical complexities, it is recommended at the start of the project to decide on a department where the course will be housed. One team member elaborated, “This helps with budget, invoicing (e.g., TA and instructor contracts), photocopying, room booking, because it’s a central place and we bill outwards to the departments.”

Finally, all team members advise others planning to undertake a similar project to be prepared for an intense level of scrutiny by critical eyes—several hundred students, numerous departmental heads and deans. The stakes are high for a multidisciplinary course, and it needs to be polished and at a higher level of professionalism than a smaller, single-discipline course.

Working with a Multidisciplinary Team

Benefits

The team members all agreed that, despite the challenges of creating a multidisciplinary course, working with a multidisciplinary team was one of the highlights of their careers. It was a rare opportunity to work with experts in different disciplines who shared a common passion: to create a successful multidisciplinary stats course. As one team member stated, “The development process was a lot of fun, working with people very excited about stats, and getting that team development environment is a rare opportunity in teaching - so it was fun and productive.” Another added, “I found it very rewarding to work on designing this course, working with other people who bring all sorts of expertise and design knowledge and knowledge of resources. It was a very pleasant, friendly atmosphere.”

Two of the team members had been involved in course redesigns within their own departments and the combination of skills sets in the multidisciplinary team made it possible for this large-scale course redesign to take place in a short period of time. One team member elaborated, “A team is a good thing to be doing this with. When one person is working alone it take a lot longer. It’s so dependent on that one person whereas in our team it was wonderful having people backing us up, that was a really good team. People had different areas of expertise.” The team members embraced different disciplinary approaches. This not only created harmony among the team members, but also created holistic outcomes from the different perspectives (Kier, Park & Jugdev, 2013).

Challenges

Inevitably, ownership issues continued to arise, and it was sometimes difficult for faculty members and departments to see the course as a shared course, particularly since the single multidisciplinary course retained different course codes and numbers for students registered in different departments. As one team member explained, “Because this a course that is owned by the departments and still has their course code on it, there’s a higher level of interest, and concerns about how it’s going to be run. The students are more likely to take complaints to the departments when it's not going well, so they are more aware of it on that front."

There were also issues of continuity and sustainability: what would happen when the original team members could no longer be part of the course? As expressed by one team member, "You don't want it to change every year when it's a different department's instructor teaching—continuity was so important!" Another team member added, "Continuity was the goal of this on the teaching side, but it also turned out to be a surprisingly important thing on the administration management side because it is such a stand-alone course and requires so many unique relationships for that to happen."

Keys to Success

Two effective ways in which the ownership issues were mitigated in this multidisciplinary project were to have a neutral body coordinate and facilitate the project, and to ensure that the course design team comprised diverse individuals. The amalgamation of introductory statistics courses had been discussed for decades, but had always faltered because agreement could not be reached about which department and individual would develop the course. Moreover, constant communication was critical: transparency in all decisions was ensured through the creation of an accessible location (in this case a Dropbox folder) to house information, and everyone was included in communication emails. The recognition of shared expertise among the group was also important in combatting the issue of ownership; team members viewed one another as equals with different strengths, for example some had expertise with technology while others excelled at designing creative activities. Stewart et al. (2016) found that embracing collaborative group member expertise allowed the group to resist the typical top-down model of controlling course design and implementation; in the opinion of team members, this was key to the success of the intro stats project.

Having a plan for continuity and sustainability from the start of the redesign is strongly advised. In our case the course was housed in the Faculty Office, and, as one team member explained, this worked well, "The instructors have changed every term; we have run it for four terms now. That's why the course has stayed in [the Faculty Office] for as long as it has, and probably will continue to. You need someone to be the oversight, and know the history of the course, why we did it this way and not another way. You don't want it to change back. To keep the integrity of the course you need to have documentation, so when someone asks about something we can say we made that decision because of this thing. It's good to have it in a central location and mentor the next instructor for a year to assist with the transition."

Critical Assessment of Project

Initial Implementation

A few unforeseen challenges occurred during the first iteration of the multidisciplinary course. Most importantly, the version of the software being used did not adequately meet the needs and expectations of the course. First, there were too few concept and practice questions to prepare students adequately for the face-to-face components of the course, necessitating the in-class sessions to be used as lectures on the online lessons. Second, the software, which was still undergoing development, did not yet have the desired level of sophistication in terms of its ability to adapt to individual student needs. Technical issues in the labs—for example, certain Excel applications did not work on Mac computers—further complicated the students' learning experiences. Through weekly meetings, the team was able to respond to most concerns quickly and effectively, but the larger issues of design and materials required longer-term solutions.

Preliminary Assessment

Evaluating the effectiveness of the redesigned intro stats course through assessments of student learning was considered to be a high priority, although the initial results were inconclusive. Because the Course Redesign Project already had strong evidence of improved student engagement scores in blended over traditional versions of courses, the team decided to focus assessment of student learning on knowledge retention rather than engagement, comparing the multidisciplinary course with two single-discipline intro stats courses. Statistical knowledge retention was assessed using the Comprehensive Assessment of Outcomes in Statistics (CAOS) (delMas, et al., 2007), a non-discipline-specific, standardized instrument that uses 40 multiple-choice questions to assess students' statistical thinking and reasoning. Unfortunately, the response rate was too small to provide meaningful results, with only 15% of the participants completing the third and last assessment.

After the assessment outcome was shared with the team members, they suggested that the challenges experienced by students during the first offering of the course may have negatively impacted their willingness to complete the assessment. The decision was taken to suspend further assessment until the course has stabilized, and to modify the assessment when it resumes. In addition to using the CAOS, the team plans to include a single complex case study task, similar to ones done in the labs, which might better capture students' achievement in statistics learning outcomes. This follows suggestions by Tintle, VanderStoep, Holmes, Quisenberry, and Swanson (2011) and Ziegler (2014) to use supplementary assessments to the CAOS due to the limitations of the instrument's multiple-choice format, which allows students to guess the right answer and may not accurately assess their understanding of the statistical concepts.

Second Implementation

In the second iteration of the multidisciplinary course, the software was replaced by customized material created in-house by an experienced statistics instructor from the Biology Department. Fifty-seven online lessons using voice-over-PowerPoint slides were developed to prepare students for the in-class components, with students expected to spend five hours on online learning per week. Each lesson includes six components: 1) Reminder of some key concepts, 2) Present new material, 3) Checkpoints containing practice problems and quizzes, 4) Case studies (currently 67 have been developed covering multiple disciplines), 5) A look ahead at next week's material, 6) Review of key ideas from the lesson. During the large-group session (one hour per week), the instructor now briefly recaps the major themes of the online lessons and focuses heavily on new case studies that apply these themes, ending with a question and answer period. The lab sessions (one-and-a-half hours per week) are largely unchanged other than modifications to the cases based on student and TA feedback. Students engage in practical applications of online and class materials, answering scientific questions by analyzing data and communicating results in small groups. Additional daily instructor office hours have been added to provide students with more support.

Future plans include revisiting the idea of offering two introductory statistics courses, one for Arts majors and one for Science majors, an approach that is more attractive to several of the social science disciplines not yet involved in the multidisciplinary course. Although the topics would be the same in the two courses, modifications would be made in terms of emphasis: in the Arts course more time would be spent on developing mathematical ideas to address the statistics anxiety discussed in the introduction, and some concepts of less relevance for students whose statistical applications are likely to be in arts-based contexts might be removed.

Conclusion

Despite the challenges experienced as this ambitious and innovative multidisciplinary introductory statistics course has evolved, there is little desire to return to the individual courses of before, either from the disciplinary or course design perspective. As one team member explained, “I don’t think going back to a lecture style will do students any favours. They might think ‘I enjoyed it more because I sat there and had a three-hours-a-week lecture,’ but they would not perform any better.” The team and the participating departments believe their students are getting better statistical preparation through the multidisciplinary approach, and the staffing issues that prompted the project have been alleviated. We are optimistic that once the course has stabilized enough to be evaluated using the methodology described above, the results will be consistent with other studies, supporting our hypothesis that this model will improve student outcomes in statistics.

Although only five of the eleven possible disciplines initially agreed to participate in the multidisciplinary intro stats course, since its implementation more departments have become interested in having their students enrolled in the course, and the Politics Department has signed on to the project for next year. As one team member shared,

> I’m really hoping people in other departments that have taught stats would be keen to see this through… If we get more departments involved, we get the opportunity to do this for a lot of students. Over all the years I have taught stats, the quality now is doing nothing but improving it. It’s been a privilege to work with people who have high skills in teaching, most of have won awards. So the quality being delivered is high. Hopefully enough departments stay on.

In order to circumvent the controversial issues of power associated with collaborative teaching, we recommend that collaborations begin with a small group of select members and clearly established policies around support; in our case this model has clearly led to an overall positive experience and successful outlook. On balance, the design team’s reflections on their experience indicate that the benefits of the multidisciplinary model outweigh the difficulties, both in terms of the course itself and in terms of the team approach to development. Furthermore, the team members remain highly engaged in the project and enthusiastic about its future.

References

American Statistical Association. (2005). *Guidelines for Assessment and Instruction in Statistics Education: College Report*. Alexandria, VA.

Austin, A. E., & Baldwin, R. G. (1991). Faculty collaboration: Enhancing the quality of scholarship and teaching. *ASHE-ERIC Higher Education Report No. 7*, 1991. ERIC Clearinghouse on Higher Education: Washington, DC.

Bellanca, L. (2009). Measuring interdisciplinary research: analysis of co-authorship for research staff at the University of York. *Bioscience Horizons*, 2(2), 99-112. https://doi.org/10.1093/biohorizons/hzp012

Brown, M. G. (2016). Blended instructional practice: A review of the empirical literature on instructors' adoption and use of online tools in face-to-face teaching. *The Internet and Higher Education*, 31, pp.1-10.

delMas, R., Garfield, J. Ooms, A. & Chance, B. (2007). Assessing Students' Conceptual Understanding after a First Course in Statistics. *Statistics Education Research Journal*, 6(2), 28-58. Retrieved from http://www.stat.auckland.ac.nz/serj

Flaherty, C. (2015, April 24). Math wars. *Inside Higher Ed*. Retrieved from https://www.insidehighered.com/news/2015/04/24/just-how-much-math-and-what-kind-enough-life-sciences-majors

Garrison, D. R., & Vaughan, N. D. (2008). *Blended learning in higher education: Framework, principles and guidelines*. San Francisco: Jossey-Bass.

Kier, C. A., Park, C. L., & Jugdev, K. (2013). Breaking the rules: A reflective processual analysis of multidisciplinary academic collaboration. *Transformative Dialogues: Teaching and learning eJournal*, 6(3). http://www.kpu.ca/sites/default/files/downloads/TD.6.3.7_Kier_etal_Breaking_the_rules.pdf

Kuh, G. D., J. Kinzie, J. H. Schuh, E. J. Whitt, et al. (2005). *Student success in college: Creating conditions that matter*. San Francisco: Jossey-Bass.

Lahey, J. (2014, October, 6). Teaching math to people who think they hate it. *The Atlantic*. Retrieved from http://www.theatlantic.com/education/archive/2014/10/teaching-math-to-people-who-think-they-hate-it/381125/

Larwin, K., & Larwin, D. (2011). A meta-analysis examining the impact of computer-assisted instruction on postsecondary statistics education: 40 years of research. *Journal of Research on Technology in Education*, 43(3), 253-278.

Lidgren, A., Rodhe, H., & Huisingh, D. (2006). A systemic approach to incorporate sustainability into university courses and curricula. *Journal of Cleaner Production*, 14(9), 797-809.

Onwuegbuzie, A. J., & Wilson, V. A. (2003). Statistics anxiety: Nature, etiology, antecedents, effects, and treatments—a comprehensive review of the literature. *Teaching in Higher Education*, 8(2), 195-209.

Ouimet, J. A., & Smallwood, R. A. (2005). CLASSE—The Class-Level Survey of Student Engagement. *Assessment Update*, 17, 13-16.

Ritchie, S. M., & Rigano, D. L. (2007). Solidarity through collaborative research. *Journal of Qualitative Studies in Education (QSE)*, 20(2), 129- 150. https://doi.org/10.1080/09518390601159610

Rumsey, D. J. (1998). A cooperative teaching approach to introductory statistics. J*ournal of Statistics Education*, 6(1). Retrieved from https://ww2.amstat.org/publications/jse/v6n1/rumsey.html

Thompson, J. L. (2009). Building collective communication competence in interdisciplinary research teams. *Journal of Applied Communication Research*, 37(3), 278-297. https://doi.org/10.1080/00909880903025911
Stewart, M. K., Cohn, J., & Whithaus, C. (2016). Collaborative course design and communities of practice: Strategies for adaptable course shells in hybrid and online writing. *Transformative Dialogues: Teaching & Learning eJournal*, 9(1).
Tintle, N., VanderStoep, J., Holmes, V. L., Quisenberry, B., & Swanson, T. (2011). Development and assessment of a preliminary randomization-based introductory statistics curriculum. *Journal of Statistics Education*, 19(1), n1.
Twigg, C. A. 2000. Course-readiness criteria: Identifying targets of opportunity for large-scale redesign. *Educause Review*, 35 (3), 41-49.
Wilson, S. G. (2013). The flipped class a method to address the challenges of an undergraduate statistics course. *Teaching of Psychology*, 40(3), 193-199. https://doi.org/10.1177/0098628313487461
Yilmaz, M. R. (1996). The challenge of teaching statistics to non-Specialists. *Journal of Statistics Education*, 4(1). Retrieved from https://ww2.amstat.org/publications/JSE/v4n1/yilmaz.html
Zepke, N. & Leach., L. (2010). Improving student engagement: Ten proposals for action. *Active Learning in Higher Education*, 11(3), pp.167-177.
Ziegler, L. A. (2014). *Reconceptualizing statistical literacy: Developing an assessment for the modern introductory statistics course.* (Doctoral dissertation, University of Minnesota).