Fostering interdisciplinarity through blended learning

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Many of the complex problems we face in the 21st century necessitate an interdisciplinary approach. However, most university curricula still prioritize discipline-focused education. There is, therefore, an urgent need to train students to deal effectively with such real-world problems. To foster interdisciplinarity, we implemented blended learning in a mandatory PhD course which has so far relied on didactic modes of instruction. For one of the topics in the course, we included various online activities, e.g. micro-lectures, asynchronous forum discussions, instructor and peer feedback, which were designed to help prepare students for summative group presentations. When we analyzed their presentation scores, we found that they had performed better on the topic supported by blended learning than the one that followed the traditional didactic format. The survey and interview responses suggested that the instructor feedback, peer feedback and micro-lectures promoted interdisciplinary thinking. Even though students did not like using the forum to discuss their projects, they agreed that the instructor's contributions to the forum discussions were helpful in guiding the interdisciplinary conversation. Overall, our findings suggest that blended learning helps to promote interdisciplinarity in the postgraduate classroom.

Keywords: PhD students, interdisciplinarity, blended learning, instructor feedback, peer feedback, micro-lectures, forum discussions

Introduction

A traditional Doctor of Philosophy (PhD) programme trains its students to become highly specialized and independent researchers, usually in a particular field or discipline. However, solutions to complex 21st-century problems require input from multiple disciplines. Examples of such complex problems include climate change, renewable energy, public health, and sustainability. To prepare students for careers that may call upon them to address such complex problems, they need to be trained to be bold enough to transcend disciplinary boundaries and situate their work in broader contexts. In other words, PhD students should be given opportunities to engage in interdisciplinary learning.

The ability to think innovatively and across interdisciplinary boundaries has been identified as a key skill by those calling for a reform of doctoral programmes, along with other skills that the authors identified as being essential for the 21st-century PhD holder, e.g. creativity and self-directedness, competence in epistemology and sound research conduct, commitment to high ethical standards and teamwork, and effective communication and leadership. The overall goal of such reform would be to train students to be thinkers rather than just specialists (Bosch & Casadevall, 2017). Simply put, the "Philosophy" needs to be put back into "Doctor of Philosophy" (Author, 2019). Further, it has been suggested that to create powerful learning experiences for PhD students in a revamped curriculum, the above elements need to be combined with passionate student engagement and genuine meaning-making in an active learning context (Bosch & Casadevall, 2017).

At the National University of Singapore's Graduate School for Integrative Sciences and Engineering (NGS), we endeavour to foster a spirit of interdisciplinarity in our students through our interdisciplinary curriculum. As part of their mandatory coursework, our students have to complete a course titled "Interface Sciences & Engineering", which is meant to expose them to various research areas, including some of the complex problems mentioned above, i.e. climate change, renewable energy, and sustainability. However, this course has traditionally relied upon didactic instruction and assessment modes that primarily test a student's content knowledge. As a result, the learning becomes more passive than active. This focus on content also makes it less likely that they will cultivate skills essential for interdisciplinarity, such as collaboration and communication. According to Repko and Szostak (2017, p.21), interdisciplinarity is defined as a "process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline, and draws on the disciplines with the goal of integrating their insights to construct a more comprehensive understanding". Moreover, our students' tendency to be reserved during face-to-face sessions (which seems to be a general observation in the Singapore context) will further inhibit collaborative discussions.

To promote interdisciplinarity in the above course, we decided to implement blended learning as an instructional mode to deepen students' learning both inside and outside the classroom. Blended learning is defined as the "organic integration of thoughtfully selected and complementary face-to-face and online approaches and technologies" (Garrison & Vaughan, 2008). We believed that this instructional mode would help us transcend the limitations of our traditional classroom setting (De George-Walker & Keeffe, 2010). In the new format, students would watch micro-lectures on interdisciplinarity and participate in an asynchronous discussion forum designed to promote collaborative dialogue between students. In addition, the online environment would permit the exchange of feedback between peers and between the instructor and the students. Feedback is defined as "information used by a learner to close the gap between the level of his performance and the reference level" (Ramaprasad, 1983). Students like peer feedback because it strengthens their learning and augments their understanding (Ertmer et al., 2007). When students share feedback with their peers, they grow and learn from each other, which in turn facilitates co-construction of knowledge (Roehler & Cantlon, 1997). As feedback is important to student learning (Hattie & Timperley, 2007), we felt that it would facilitate the interdisciplinary learning process and thus guide them towards attainment of the module's overall learning objectives. Collectively, we believe that blended learning will help to promote deeper learning and nurture the skills essential to interdisciplinarity.

Problem statement

To prepare our students for the needs of the real world, they need to be trained in the process of interdisciplinarity. However, our compulsory interdisciplinary module has so far not explicitly taught them how to be interdisciplinary because it has relied upon didactic instruction and prioritized content knowledge in its assessments. As a result, students fail to collaborate well on their assessment tasks. To create opportunities for interdisciplinary discussions in a "safe" environment outside the classroom, and thus promote more interdisciplinarity, we have introduced blended learning into the module. We expect that this intervention will help our students tackle their assigned problem at a deeper level. We also expect the intervention to help develop their confidence for subsequent face-to-face discussions with their peers and instructors.

Purpose of study

The purpose of this study was to investigate the effects of blended learning on our students' ability to engage in interdisciplinarity. In particular, we wanted to examine whether online micro-lectures, forum discussions, instructor feedback, and peer feedback helped to improve their performance on group presentations.

Research question

Would blended learning facilitate interdisciplinarity amongst students enrolled in a compulsory interdisciplinary module and help improve their performance on the summative assessment task? [Interdisciplinarity was assessed through (1) a customized grading rubric, and (2) an analysis of discussion forum posts.]

Methodology

Participants

This study was reviewed by the National University of Singapore Institutional Review Board and found to be exempt. All data used are anonymous and cannot be linked to individual students. All twenty-seven PhD students who participated in this study were enrolled in a core interdisciplinary module. The topic that followed the traditional format lacked any online activities, while the redesigned topic consisted of both online and face-to-face sessions. The online component was delivered through the university's learning management system.

Design and procedure

A mixed-method, quasi-experimental approach was used to assess the effectiveness of blended learning. Topic 1 of the module followed the traditional format in which a two-hour didactic lecture was followed by face-to-face group presentations one week later. In contrast, Topic 2 involved our students in various online activities during the intervening week, such as micro-lectures, asynchronous forum discussions, and instructional scaffolding in the form of instructor and peer feedback. The online tasks culminated in face-to-face group presentations. We compared students' presentation scores from the scaffolded topic with presentation scores from the un-scaffolded topic. To better understand students' perceptions about our interventions, we conducted a survey after completion

of both topics and interviewed selected students. (The survey and interview guide included questions on the effectiveness of the blended learning environment, micro-lectures, forum discussions, instructor and peer feedback, in promoting interdisciplinarity). We designed the survey and interview guide ourselves, based on existing guides on research methodology (Kelley, Clark, & Brown, 2003; Rowley, 2013). Some questions were based on Repko and Szostak's definition of interdisciplinarity and corresponding model of the Interdisciplinary Research Process (ref), while others were based on key differences between the traditional and blended learning modes.

Data analysis

Students' presentation scores were analysed using the *R* software (RCoreTeam, 2018). A Welch two-sample t-test was performed to test for any significant difference between the mean score of the Topic 1 presentation and the mean score of the Topic 2 presentation. This t-test was also performed to compare scores that students had earned on individual components of the grading rubric. We tabulated the results of the survey. For each survey item, we calculated the percentage of responses for each answer choice. Interview notes were analysed for common themes. Interview responses were compared to the survey data to reveal correlations.

Results

Presentation scores

Since we wanted to find out the effect of our interventions on students' learning outcomes, we compared their presentation scores for Topic 1 (un-scaffolded) and Topic 2 (scaffolded). Students scored a mean of 75.50% on the first presentation and 80.34% on the second presentation. The t-test showed that students' scores on the scaffolded presentation were significantly higher than those for the un-scaffolded one ($p<0.001$). We also investigated which of the individual rubric components gave rise to such a difference by running t-tests on the five components. Students performed significantly better for *organisation* ($p<0.001$) and *interdisciplinarity* ($p<0.001$) for the scaffolded topic.

Survey and interview results

Micro-lectures vs. traditional lectures
Most students agreed that the micro-lectures prepared were clear and effective in explaining the topic content and they were able to list some important points of the lecture. However, they were ambivalent about whether they preferred micro-lectures to traditional lectures, with only 48.2% agreeing that they liked micro-lectures more than traditional ones. When interviewed, students revealed that they liked micro-lectures because they were convenient, and they could re-watch parts they did not understand. However, they were indifferent because they also liked the face-to-face interactions of traditional lectures where queries could be answered immediately.

Instructor and peer feedback
Almost all students agreed that the instructor's feedback on their presentation outlines was helpful and that it helped promote interdisciplinary thinking. Students overwhelmingly agreed that peer feedback was helpful in helping them improve their work. All the students agreed that they welcomed feedback from their peers. Most students felt that receiving feedback helped them think in a more interdisciplinary manner, and that they took these comments seriously. The majority made changes to their work in response to feedback. Most students also agreed that discussing feedback received with their own group members made them reflect more on their own work, and that the feedback given by their peers was helpful. [The traditional mode of Topic 1 did not feature instructor or peer feedback of the kind that was provided in Topic 2.]

Forum discussions
Generally, students did not like using the forum to discuss their projects. Only 29.6% agreed that the forum was a good platform for collaboration. Nonetheless, they agreed that guidance provided by the instructor helped to improve their discussions. 59.3% of them thought that the initial prompts provided by the instructor on the forum helped to scaffold their discussions. 63% of them agreed that the instructor's contributions to forum discussions was helpful in guiding their interdisciplinary conversations. The interviewed students revealed that the way forum posts were displayed by our learning management system (LMS) made it difficult to keep track of the discussion. They preferred more instant and user-friendly modes of communication such as instant messaging applications or the collaboration functions on Google Documents. Many revealed that they conducted discussions elsewhere and posted the most relevant posts from those external discussion platforms on the LMS forum merely to document their progress.

Blended learning

Most students agreed that blended learning was overall beneficial and said that they preferred it to traditional modes of learning. A majority of students thought that blended learning helped them learn better, with 63% agreeing that they learnt better through such a format. 59.3% agreed that it helped them take more ownership of their learning. Most students agreed that these activities were more effective at fostering interdisciplinarity than the traditional format. 66.7% of them believed that they were better prepared for their presentations as a result of blended learning. Most students agreed that a blended learning approach would ultimately be more suitable for this module than the traditional format. Most students agreed that they enjoyed the blended format more. Interestingly, during the interviews the students revealed that blended learning was a better instructional mode despite the heavier workload.

Discussion

We conclude that blended learning contributed to our students' improved overall performance on group presentations. Furthermore, it was the "interdisciplinarity" and "organization" components of the grading rubric that accounted for the improved scores.

An analysis of survey and interview responses suggest that the interventions that enhanced interdisciplinarity were the instructor and peer feedback, forum discussions, and micro-lectures. The benefits of teacher feedback have been well-studied, especially in helping to improve student understanding (Kluger & DeNisi, 1998; Ponte, Paek, Braun, & Powers, 2009), but the effect of instructor feedback on online platforms has only recently been investigated. According to Guo, Chen, Lei and Wen (2014), good instructor feedback improves online cognitive engagement. In our case, blended learning helped elicit better responses and thinking by students. Providing online feedback to fellow team members as well as to other groups, accompanied by the improvements that they made based on such feedback, are examples of "social reflection" and "articulation" (Herrington & Herrington, 2006), recognized as being important ingredients for authentic learning and collaborative knowledge creation.

Even though the forum discussions were not as popular with the students as we had hoped, we found that the forums were constructive to some extent. The online forum allowed students to analyse and share information with their group mates in a more organised manner because through forum threads and headings, students could keep track of all the ongoing discussions. While they might not have liked using the forum, there was some evidence of this organisation from their forum headings. Even if students used other platforms to complement their work, they were also digital, rather than face-to-face, suggesting the effectiveness of integrating technology into learning. The online platform facilitated discussions as students could respond to their peers at their own convenience, and present evidence (e.g journal articles) to back up their assertions and make their points better. All this made their responses clearer and more effective than a face-to-face conversation. Moreover, the instructor could interject by asking probing questions, guiding them towards clearer thinking or drawing their attention to issues they may have neglected. Nevertheless, we are currently exploring ways to further enhance these forum discussions.

Due to timetabling constraints, we were not able to follow up comprehensively on the micro-lectures in class, and thus what we had was not a fully flipped classroom but merely a form of blended learning (Reidsema, Hadgraft, & Kavanagh, 2017). A flipped classroom format which combines the best of both worlds would appeal to more students, on option which we are considering for future iterations of the course.

Our study advances the field of interdisciplinary doctoral education by demonstrating that blended learning is more effective than traditional didactic lecturing in fostering interdisciplinarity. What we found most encouraging was the fact that learning gains were achieved even though students faced a heavier workload under blended learning. Apart from blended learning, we intend to further augment this interdisciplinary module by incorporating authentic learning elements (Herrington & Herrington, 2006) that will help students to cultivate the skills that are essential for interdisciplinarity. In addition, we believe that we should also teach students *how* to be interdisciplinary, in other words they need to be taught interdisciplinarity as a process. We thus intend to ground our teaching in interdisciplinary research theory (Author, 2019; Repko & Szostak, 2017).

In conclusion, we believe that our findings will be relevant to ongoing efforts to reform PhD programmes. The results of this study will guide us as we revamp the rest of this module as well as other modules within our curriculum. Even though these results are based on a single course, we believe that they can be generalized to other courses as long as the group composition and learning objectives are similar. Further studies will help to validate our findings and refine the pedagogy used so as to achieve more effective learning outcomes.

Thus, our findings may be useful to those who are keen to enhance their interdisciplinary curricula, at both the undergraduate and postgraduate levels.

Acknowledgments

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