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Relationships in the Flipped Classroom

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Abstract
This study examines the effectiveness of flipped classrooms in chemistry, and identifies relationships as a major factor impacting the success of flipped instruction methods. Examination of student interview data reveals factors that affect the development of peer-peer, peer-peer leader, and peer-expert relationships in first-year general chemistry and second-year organic chemistry flipped classrooms. Success was measured in terms of student perceptions of the effectiveness of the instruction, as well as student academic development. Furthermore, analysis of research participant interviews reveals that academic reading circles, open-response multiple-attempt group quizzes, and peer leaders are important elements of a text-centric flipped approach at a small-classroom, commuter-campus university. Student reflections and classroom observations provide further support for these conclusions.

Cet étude examine l'efficacité des salles de classe inversées en chimie et identifie la création de liens en tant que facteur important qui affecte la réussite des méthodes d'instruction inversée. L'examen des données provenant d'entrevues avec les étudiants révèle les facteurs qui affectent le développement des rapports d'étudiant à étudiant, d'étudiant à leader et d'étudiant à expert dans un cours inversé de chimie générale de première année et dans un cours de chimie organique de deuxième année. La réussite a été mesurée en termes de perceptions des étudiants de l'efficacité de l'instruction, ainsi que du développement académique des étudiants. De plus, l'analyse des entrevues des participants à la recherche révèle que les cercles de lecture universitaires, les tests de groupes à essais multiples et à réponses ouvertes, ainsi que les leaders de groupes sont des éléments importants d'une approche inversée centrée sur un texte en petite salle de classe, dans une université de banlieusards. Les réflexions des étudiants et les observations en salle de classe soutiennent également ces conclusions.

Keywords
academic reading circle, chemistry, flipped classroom, instant-feedback assessment, peer-led team learning

Cover Page Footnote
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Flipped instruction refers to a collection of pedagogical choices made by the instructor to facilitate and promote flipped learning, a style of learning in which “direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment” (Bergmann & Sams, 2014, p. 6). The learning environment is then called a flipped classroom. Flipped classrooms are becoming increasingly common in higher education chemistry, with a number of recent studies examining their effectiveness (Christiansen, 2014; Fautch, 2015; Flynn, 2015; Hibbard et al., 2016; Morsch, 2016; Seery & Donnelly, 2012; Smith, 2013; Yestrebsky, 2016; Yeung & O’Malley, 2014). The variety of techniques that are often associated with the flipped learning movement is fairly broad. This includes peer-led team-learning (PLTL) (Gosser & Roth, 1998), peer instruction (Mazur, 1997), inverted classrooms (Lage, Platt, & Treglia, 2000), just-in-time teaching (JiTT) (Novak & Patterson, 2000), learn before lecture (Moravec, Williams, Aguilar-Roca, & O'Dowd, 2010), teaching naked (Bowen, 2012), and flipped classrooms (Bergmann & Sams, 2012). Dynamic student-centered instruction techniques, such as flipped learning, are designed to integrate interactive activities and technology into classroom learning (Cavanagh, 2011). The framework and intensity of active-learning in each course is variable as professors have the ability to tailor content to the students’ prior knowledge and to generate resources specific to the course or the instructor’s expertise (Hanson & Carlson, 2005).

Reports on the impact of flipped instructional methods on student performance reveal some variability in its effectiveness (Christiansen, 2014; Fautch, 2015). Despite a meta-analysis of 225 flipped STEM courses (Freeman et al., 2014) demonstrating that flipped learning can improve student exam grades by 6% and decrease failure rates by 1.5 times, student perceptions on the effectiveness of flipped instruction can run counter to student success (Van Sickle, 2016). Educators may feel frustrated if efforts towards a flipped classroom do not yield the desired educational gains or result in negative student responses.

While the variability in flipped instruction approaches may explain reported differences in impact, factors beyond the instructor should not be overlooked. In this study, we report on the unanticipated finding of relationships as a major factor influencing the success of a flipped classroom, which may explain the reported variability in impact. These relationships were categorized as peer-peer, peer-peer leader, and peer-expert relationships (sometimes referred to as student-instructor relationships), and observed in first-year general chemistry and second-year organic chemistry flipped classrooms. We discuss the factors that influence relationship development, and the impact of these relationships on student academic development.

Three prominent features of the flipped instruction method described herein are academic reading circles (ARCs) (Daniels, 2002; Shelton-Strong, 2011; Seburn, 2015), open-response multi-attempt (ORMA) group unit quizzes, and in-class peer leaders (Gosser & Roth, 1998). We will show that each of these features of our flipped classroom plays an important role in the development of relationships. Defining successful flipped instruction in terms of student perceptions of the effectiveness of the instruction, as well as student academic development, we argue that a better understanding of how relationships develop within a flipped classroom has the potential to lead to more successful flips, regardless of the instructor’s choice of flipped methods.

Method

Courses Involved

This study was conducted at a public undergraduate commuter campus in Canada, and was approved by the university's Human Research Ethics Board. In Fall 2015, three sections of first-year general chemistry were taught by the lead author. All sections had a maximum enrolment of 60-students and met twice a week for 80 minutes. Two sections were taught using the instructor's traditional active lecture approach that included assigned textbook readings, daily assigned problems, a 15-minute period at the start of class for student questions, and peer interactivity through clickers and brief discussions. Each week, the students in these traditional sections were assigned approximately two hours' worth of online homework to complete after the topics were covered in lecture.

The third section was taught using a variation on the flipped technique (Bergmann & Sams, 2012), illustrated in Figure 1, that also draws from the PLTL instructional method (Gosser & Roth, 1998). The online homework assignments were divided into two smaller assignments each week. They were assigned after the introductory lecture and due before the following class. The purpose was to provide learners with instant feedback on their understanding of the ChemWiki textbook readings (Allen et al., 2015), and prepare them for the in-class active-learning.

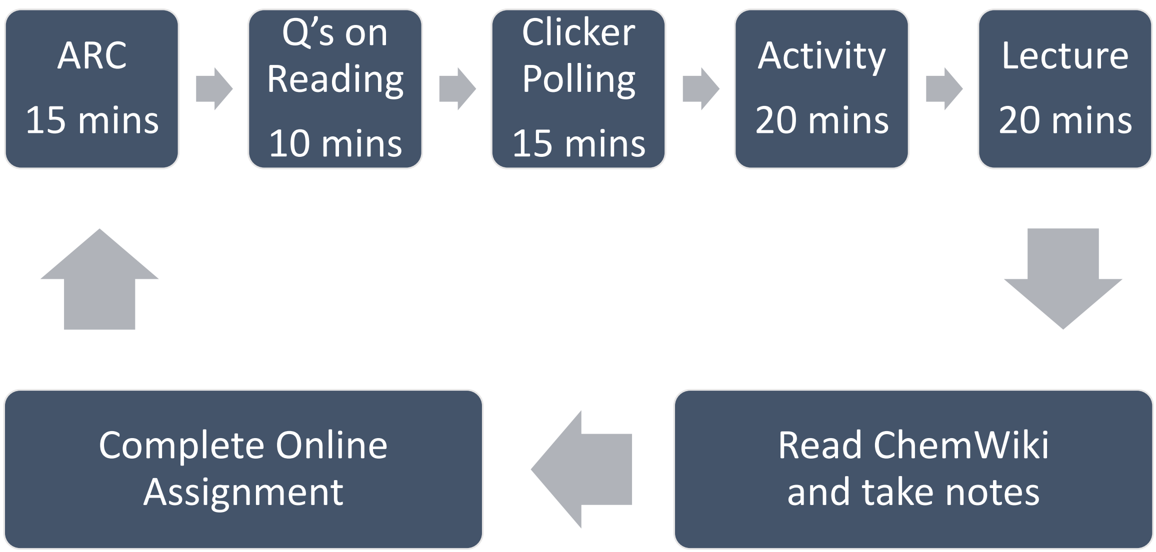

Figure 1. Sequence of class time (top) followed by student preparation (bottom) in the general and organic chemistry flipped sections. The 20-minute lecture at the end of a class is intended as an introduction to the assigned reading material. Students then explore this content outside of instructional time. In the next class, students engage with the assigned material through ARCs, a class-wide Q&A, clicker questions, and active problem solving. After each unit of course content, an ORMA group test was held in place of the clicker questions and problem-solving activity.

This flipped approach was repeated by the lead author in another general chemistry section during the Winter 2016 semester. The instructor also utilized this flipped approach with a 45-student section of second-year organic chemistry during Winter 2016. The organic chemistry section similarly met twice a week for 80 minutes. Two students in the Winter 2016 organic chemistry course had been in one of the instructor's Fall 2015 general chemistry traditional sections.

Course Demographics

The gender distribution of all sections was similar to the university student population (36% male, 64% female). The age distribution for the traditional and flipped general chemistry sections was comparable.

Our Flipped Classroom Design

A central characteristic of Bergmann and Sams' (2012) flipped technique is the use of pre-lecture videos that replace traditional lecture. However, our goal was to increase student reading habits, as described elsewhere (McCollum, 2016). The instructor was concerned that learners would use pre-lecture videos like PowerPoint notes, in place of engaging with the assigned academic text (Adams, 2006; McCollum, 2015; McCollum, 2016). As such, pre-lecture videos were not provided to students. Instead, our flipped methods for general chemistry were designed around an instructor-personalized ChemWiki Hypertext (Allen et al., 2015), hence our use of the phrase text-centric flipping.

Students obtained peer-support in comprehending their academic reading through ARCs. Student groups for the ARCs were originally formed using an activity based on the Hogan Personality Inventory test (Hogan & Hogan, 1997). After two weeks, groups were permitted to reorganize as students desired, so long as discussions were productive. Self-restructuring allowed students to avoid interpersonal conflict, and resolved issues of group collapse if members dropped or withdrew from the course. The purpose of an ARC is to provide learners with a regularly scheduled opportunity for small group discussion of course material during class time. During the ARC, students direct the open discussion. Using their class preparatory notes to identify themes, ideas, and the context surrounding the reading, they collaboratively explain and create visual representations, create meaningful connections between concepts, and facilitate lexical comprehension (Seburn, 2015). The instructor and peer leaders support and facilitate these conversations with simple prompts as necessary, but do not steer the conversations.

Groups were assessed on their understanding of course concepts after each unit using ORMA group unit quizzes. The ORMA group tests are a form of collaborative assessment with group members collaboratively answering written problems with a total of three attempts. Correct responses on their first, second, or third attempt earned the students 100%, 50%, or 25% of the possible points, respectively. The questions were graded throughout the examination period by the instructor or a peer leader. This assessment provided students with immediate feedback and opportunity for partial marks. The open-response nature of the quiz also required that students create any necessary chemical representations (as opposed to a multiple-choice exam). This approach builds upon the instant-feedback assessment technique (IF-AT) scratch card quizzes of Michaelsen and Sweet (2008) (see also Cotner, Baepler, & Kellerman, 2008; Mohrweis & Shinham, 2015), but the question style was changed from multiple-choice to open-response to better assess the group's ability to generate the variety of symbolic representations common in chemistry.

The third feature of our flipped classroom was peer leaders. Senior students in the BSc program were recruited to assist the instructor with facilitating the flipped classroom as peer leaders. These advanced undergraduate students further supported the flipped instruction by temporarily integrating into student groups during ARCs and problem-solving activities. During the ARCs and team problem-solving activities, two peer leaders would circulate the room to provide support to teams of 5-6 students. The instructor would provide complementary support as required. While the philosophy behind the peer leaders was similar to that of PLTL (Gosser & Roth, 1998; Gosser et al., 2001), various factors prevented complete adoption of the PLTL methods.

Data Collection and Analysis Methods

The qualitative data sets included in this study are research interviews (traditional $n_{\text{general chemistry}} = 2$; flipped $n_{\text{general chemistry}} = 6$; flipped $n_{\text{organic chemistry}} = 5$), student reflections and classroom observations. Most student reflections were brief feedback (2 minutes of writing) in response to a topic prompt, such as ARCs, reading assignments, or group work.

Interviews were transcribed and data sources were coded following the practices of thematic analysis (Braun & Clarke, 2006; Saldana, 2009), and grounded theory (Glaser & Strauss, 1967; Glaser & Strauss, 2009). Four researchers performed line-by-line independent parallel coding on initial interviews, which was then reviewed for overlap and redundancy to generate an initial code scheme.

As we coded these transcripts, similar codes were grouped into themes. Using an iterative process, the codes and themes were refined. The emerging themes then drove subsequent data collection and analysis, with additional coding iterations. During focused coding, this code scheme was also applied to student reflections and the remaining interviews (Charmaz, 1996; Thomas, 2006).

Grades on quizzes and tests were analyzed for meaningful differences between the traditional and flipped sections using Welch's t-test (Fagerland & Sandvik, 2009; Welch, 1947). The instructor's student evaluations of instruction were also analyzed for changes in well-established patterns as a result of flipped instruction.

Results and Discussion

While the original intent of the project was to assess how ARCs and ORMA group quizzes would impact student reading habits and perceptions of the flipped classroom, coding of the research interviews revealed an unexpectedly strong theme of relationships. The final consistent themes we identified using thematic analysis are shown in Table 1. For example, while there was significant discussion on ARCs, many of these comments overlapped with peer-peer, peer-peer leader, and peer-expert relationships.

Table 1
The Emergent Categories and Codes

Category	Code	Description of Comments
Relationships	Peer-Peer	Peer-peer relationships
	Peer-Peer Leader	Peer-peer leader relationships and the role of peer leaders in the learning process
	Peer-Expert	Peer-expert relationships and the role of the content expert in the learning process
Attitudes	Preparation	Connections between preparation for lecture and ARCs, ORMA group quizzes, in-class peer leaders or resources
	Confidence and Motivation	Associating confidence, motivation, and students approaches to learning or use of resources
	Environment	Influence of environment (e.g., home, campus, classroom, work) on a student's ability to complete activities or study
	Transference	Use of learning skills and strategies developed through the text-centric flipped class in other professional or educational settings
Learning	Flipped	Flipped approach
	Academic Reading Circles	Academic reading circles as a driver or barrier for learning
	Assessment	Assessments as a driver or barrier for learning
	Tutorial	Role of tutorials in the learning process
Resources	ChemWiki	Student use and value of open-education resources (ChemWiki)
	Print Text	Student use and value of print textbooks
	Online Homework	Student use and value of online homework (OWLv2)
	Other Digital Resources	Student use and value of other digital resources (e.g., Blackboard, iPad applications)

In this paper, we focus on participant comments pertaining to relationships within traditional and flipped classrooms. The relationships that students develop with their peers, peer leaders, and content experts (e.g., the instructor) appear to be key factors that determine whether flipped techniques are a success in the classroom. Herein we will describe conditions that support peer-peer relationships within a text-centric flipped classroom, the influence of peer-peer relationships on peer-expert relationships, and the impact that these relationships have on a learner's ability to recognize and accept their academic responsibilities.

All student quotes are attributed to study participants from a flipped section (F) or a traditional section (T). Additionally, study participants come from both our first-year general chemistry course (G) and our second-year organic course (O). Thus, a quote from a student in the flipped second-year organic class will be identified as F-O-*n*, where *n* is a participant identifier.

Finding 1: Peer-peer relationships are a key benefit of a text-centric flipped classroom, and ARCs and ORMA group quizzes support their establishment

Flipped instruction techniques typically rely on students problem-solving in groups. Thus, flipped learning provides an avenue for the development of peer-peer relationships, but it also relies on the successful development of such relationships. Consider the experience of a general chemistry student describing their flipped classroom:

> I like it. It’s easier to get to know people in the class. ... Whereas in other classes I’m not going to go and make friends `cause I’m just going to sit there and wait to see if anybody else will come talk to me. (F-G-1)

The situation described by this student is common on our campus, particularly in the first two years of study. Most rooms on our campus are designed for classes of less than 40 students. With section sizes near 60, we are usually scheduled into the large 120 student theatre-style lecture halls. Students tend to spread out and look at their phone or laptop until class starts. Their apparent interest in social media reduces the likelihood of having an uncomfortable first-time face-to-face interaction. This type of self-imposed isolation is a documented behaviour of university students at commuter campuses (Kodama, 2002; Lever, 2007).

In light of this common self-isolating behaviour, it is not a surprise that numerous students used their reflections to identify the formation of peer-peer relationships as a key benefit of the flipped classroom. For example, one student noted:

> This is the only class where I talk to people. I’m a pretty shy person, but the reading groups help me to interact with my peers. I also get different perspectives on ideas, and that helps a lot. Without the academic reading circles I would not have made friends. We often consult with one another out of class to discuss our readings and assignments. This is a big class, but it never feels that way. (F-G-8)

Consider that the ARC groups were assigned with an intention toward complementary personalities. We observed that in most cases students changed where they sat in the room to be near their ARC group, and remained in those groups during the problem-solving activity time. Some students also reported meeting outside of class time with their ARC as a study group.

Compare the two previous quotes from students in the flipped sections with the following quote from a student in a traditional section:

> It just comes down to [being in] such a large first year class. It’s very dependent on who you’re around. … If we didn’t [understand] the question we didn’t really try talk it out. It was really just waiting for [instructor’s name] to come around and just ask him. (T-G-2)

This perception of the large class, and the dependency on the professor, was commonly identified among the traditional class learners. After all, chemistry courses at our institution have enrolments that are twice the institutional average. However, the number of students attending the flipped and traditional sections was similar, approximately 60 students. Clearly, something made the class size seem less significant to students in the flipped sections. Our analysis suggests that it is elements of our text-centric flipped technique that facilitated the development of peer-

peer relationships within that context, and it is these relationships that made class size less of a concern for learners. One such element was ARCs. One student commented:

> I liked how we could have discussions with other people in the academic reading circles … we could ask specific questions we might have. … I liked how starting off you made your group, and then you kind of knew a few people from the [class] right off. And then you could always talk to them. Everyone knew each other by the end and kind of made friends. (F-G-3)

This learner identified the ARC specifically as an instructional element in the classroom that helped them establish friendships with their peers.

While reading is typically a solitary activity, it provides a means for an individual to connect to a wider community: all the other readers of the same text (Duncan, 2013). When readers have difficulty understanding text, reading circles provide an environment in which they feel comfortable asking for assistance from peers (Kim, 2004). Based on social constructivist theory, learners engaged in a reading circle are at the same time engaged in a transactional process with the text and their peers (McElvain, 2010). Therefore, not only have we shown that it is possible to flip a classroom using a text-centric approach, we have also found that it is important to use the assigned readings in coordination with ARCs to facilitate the development of these vital peer-peer relationships.

A second element that we implemented with the text-centric flip was group problem-solving and ORMA group quizzes after each unit. Participants from the general chemistry flipped sections identified ORMA group quizzes as a tool for strengthening the peer-peer relationships that had begun to develop. A student stated:

> I really liked the group test because it really encouraged everyone to share what they knew. I felt like after group tests, people who were lagging behind learned a lot, and people who did understand, when they taught it, they fortified what they understood while also helping other people so they were very useful. (F-G-6)

Early in the term, some students would stay in the same group, while others migrated to a different group to find peers they could rely on. This had consequences for students that were not putting in sufficient class preparation. Consider the comments from a student who initially struggled in the course, but later improved:

> F-G-7: "[The group quiz] has a lot of benefits. … You know several ways of how to answer a question and if you get stuck on one type of question they help you. I know for us we usually get a pretty good mark on it."
>
> Interviewer (I): "What about the group test for the second unit though?"
>
> F-G-7: "Second unit? No I didn't like the second unit."
>
> I: "Yeah?"
>
> F-G-7: "No, cause I didn't do good on it."

> I: "What differed from the first one?"
>
> F-G-7: "It was just me and one of my friends. And he slacked off a bit and I (breath). It just went downhill from there. But overall, had we put in the same effort that we did on the first group test, we probably would have got a better mark. ... it shouldn't be hard, as long as you know, as long as you do your readings and your assignments."

Due to their lack of class preparation, this student failed an ORMA group quiz and they were not happy with the result. Following that quiz, this student began attending office hours, completing the assigned readings, and became a leader among their peers in the tutorial. The actions of this student align with the self-orienting feedback loop of self-regulation theory (Ben-Eliyahu & Linnenbrink-Garcia, 2015; Schunk & Zimmerman, 1998). Through feedback, such as ARCs and ORMA group quizzes, this learner was able to self-regulate. In turn, we observed that his change in behaviour enhanced his peer-peer relationships.

At the end of the term, students completed a final anonymous reflection. Consider the following student's perception of instruction as related to the ORMA group quizzes:

> [Instructor's name]'s teaching style is both effective and efficient. Having the opportunity to work in groups, like on the unit quizzes, kept me on task during the semester and made the class fun. This class helped me ease into university. (F-G-9)

Similarly, another student identified the group work as a defining characteristic of the class: F-G-6: "I think I would have actually enjoyed [the class] less if there wasn't group work. It was just very helpful for everyone. It gave the class a lot of its characteristics I think. Being so open."

Perhaps one of the clearest indicators of strong peer-peer relationships emerged during the interviews. When discussing a learning activity that a participant had flagged as being their least-favourite of the term, they responded as follows: F-G-2: "If it helped someone else then it's worth it." Under most conditions a student would advocate to eliminate an activity they disliked. However, this student recognized the selfless value in supporting their peers.

Group work, particularly the ORMA group quizzes, was identified by the students as a key component of this flipped approach. The desire to contribute to the team, support one's peers, and express appreciation when assistance was received, all emerged connected to peer-peer relationships in the flipped classroom.

Grades on the midterm exams corroborated other evidences for the development of peer-peer relationships, as shown in Figure 2. While the average mark between the sections in Fall 2015 are similar, Welch's *t*-test (Fagerland & Sandvik, 2009; Welch, 1947) demonstrates that the range in the midterm grades for the traditional sections and the flipped sections in Fall 2015 are statistically different ($n_{\text{Section A}} = 53$, $n_{\text{Section B}} = 54$, $n_{\text{Section C}} = 31$, $P = 0.013 < 0.05$).

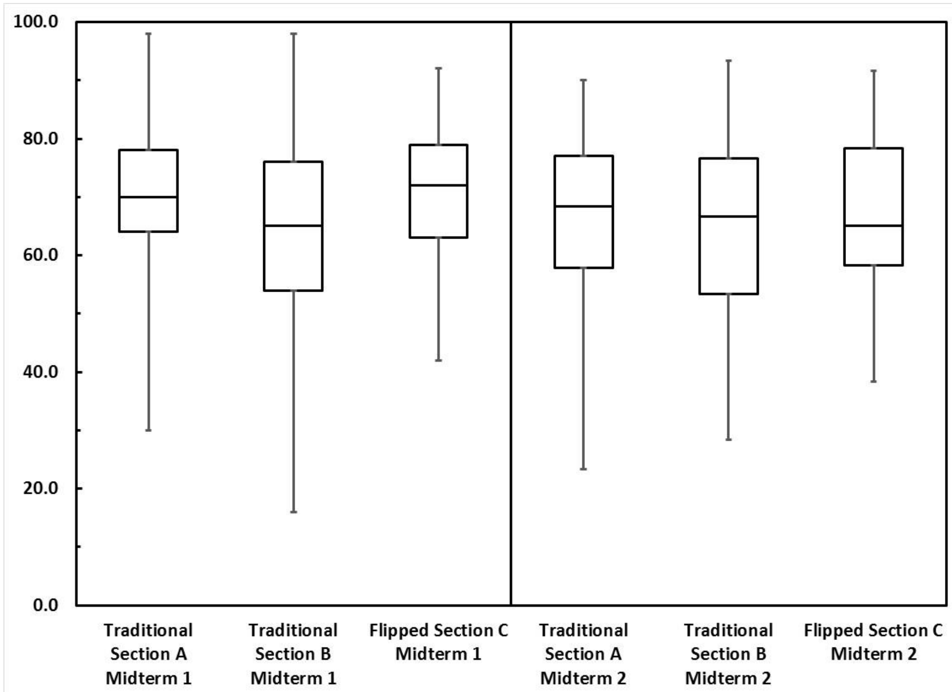

Figure 2. Box-plot of participant performance (grade percentages) on midterms 1 and 2 as a function of lecture style. The range of scores on the midterms are statistically smaller for the flipped class, with the lower quartile of students moving closer to the class average.

All students wrote the same exams. The peer-peer relationships within the flipped class functioned to support the academically weakest students without disadvantaging any other quartile.

Finding 2: ARCs seem to be a necessary element for peer-peer relationships in a text-centric flipped class

When planning the flip for second-year organic chemistry, it was thought that these learners would have better academic study skills and strong existing peer-peer relationship networks. Organic chemistry students begin the class already knowing many of their peers by name, sitting with friends in class, and often socializing with them outside of class elsewhere on campus. For this reason, we speculated that the ARCs would be an unnecessary element for this flip, and we instead allocated the ARC time toward longer problem-solving sessions. All other aspects of the flip were maintained, including the use of ORMA group quizzes and a peer leader.

The consequences were stark. Consider the approach to the problem-solving sessions as described by this student:

> I feel like with the activities, with the people I work usually around, we usually do it on our own. And then if we have questions we're like "what did you get?" "Did you do this right?" "Did you have the same answer?" And if we do, if we all agree, then we move on. (F-O-1)

This student was not describing the intended group problem-solving but rather solitary work that they verified with peers. This difference in behaviour between the general and organic chemistry students was immediately noted by a member of the research team while collecting classroom observations. The researcher noted, “They [the organic chemistry students] are totally different than the other class [the general chemistry class]. They [the organic chemistry students] are so quiet!”

The assumption that existing social networks among the students would imply academic peer-peer relationships was clearly not correct. However, this does not explain why peer-peer relationships failed to develop within the flipped organic chemistry class. Survey data revealed that student reading habits were generally non-existent. They were not completing the assigned preparatory reading from the common text, which in turn meant that students were not prepared to attempt the problem-solving activities in class even with the additional time.

This situation can be further understood through social-comparison concern (Festinger, 1954) and achievement goal theory (Dweck & Leggett, 1988; Pintrich, Conley, & Kempler, 2003). According to social comparison concern, learners assess their own qualities through comparisons to their peers. In achievement goal theory, learners adopt motivational orientations that influence their learning, and the motivations can either be mastery goals (for self-improvement) or performance goals (to demonstrate abilities to a particular audience) (Pintrich et al., 2003).

Without a chemistry degree at our institution, very few of the students in our organic chemistry course report enrolling because of personal interest (mastery goals). Instead, more than 90% of students enroll because it is a prerequisite for their degree or for a professional program (performance goals). Under these conditions, students’ anxiety increases when they interact with peers whom they consider academically superior at some task (Dijkstra, Kuyper, van der Werf, Buunk, & van der Zee, 2008). This can then hinder cognition and reduce a learner’s ability to problem solve (Brophy, 2005).

Without the ARCs to facilitate the establishment of trust and development of peer-peer relationships within the classroom academic environment, this fear of comparison with one’s peers, who have overlapping performance goals, resulted in students preferring to work on their own rather than problem-solving as a team. Their choice to not collaborate and instead only compare abilities (by comparing answers to questions) may have hindered or even harmed their peer-peer relationships.

Eventually, ARCs were introduced into the flipped organic class in an attempt to improve learner preparation and reduce anxiety. To support this late-stage adoption, learners were asked to complete a personal reading record before coming to each class (Stahl, King, & Eiler, 1996). As a team they would discuss their personal reading records and generate brief notes on their discussion, focusing on three key items: (1) what we understand from the reading, (2) what we don’t understand from the reading, and (3) what we were able to resolve as a group.

Initially, the group reading records were heavily weighted toward question 2 (what we don’t understand from the reading). Over time, this weighting shifted more evenly with question 1 (what we understand from the reading), and later across all three questions. However, for some students the introduction of the reading circles was too late to support the development of key relationships. One student commented: F-O-5: “The group of people that I am associated with don't really show up to class, so I always end up being with a different person who hasn’t done [the reading] `cause [they’ve] just been hectic [and] busy.”

Yet, for the majority of the organic chemistry students, within two classes of adding a 15 minute ARC at the start of each class, their complaints vanished. Both the peer leader and instructor observed increased use of correct disciplinary terminology, increased volume and animation of on-topic conversations, and increased learner capability during the problem-solving portion of the class. A student noted: F-O-8: “Personal and group reading records were great but [instructor’s name] only started that towards the end of the semester.” Comments like reveal that students want the opportunity to discuss course material with their peers in a structured manner and that these opportunities must be implemented as early in the term as reasonable. Our assumption that these second-year students would be prepared to function in peer groups without the ARC structure was a mistake. ARCs can create an environment of healthy peer-pressure, with learners desiring to come to the ARC prepared to contribute. This is an important driver for class preparation, which in turn is necessary for the establishment of peer-peer relationships. The ARC is a necessary element for peer-peer relationships in a text-centric flipped class.

Finding 3: Peer-peer leader relationships in a flipped classroom rely on instructor organization

The instructor originally intended to employ the Just-in-time Teaching (JiTT) method to adjust in-class activities to respond to student misconceptions or questions from the online assignments (Novak & Patterson, 2000). However, a JiTT approach did not allow the peer leaders to be sufficiently prepared for class. Consider the comments from an organic chemistry student:

> I find sometimes she would have to double check with [instructor name] to make sure the answers right or like um, have him like, review it with her a little bit, for her to remember what the actual answer was. (F-O-1)

When the peer leaders were not able to be appropriately prepared to support student learning, student trust in the peer leader’s abilities waned. This undermines the purpose of the peer-leader. “The [peer]-leader helps students build enough trust and understanding to communicate openly with each other, challenge each other, debate and discuss issues without being intimidated. Once this community of learners is formed, feelings of isolation should be alleviated” (Varma-Nelson, 2006, p. 20) In response to this need, learning materials were circulated to peer leaders at least a week before use when possible to increase peer leader confidence and effectiveness, which in turn improved peer-peer leader relationships.

Finding 4: Students describe peer-expert relationships differently in a text-centric flipped class than a traditional class

Compared to students in traditional sections, Yestrebsky (2016) found that comments from students in flipped sections shifted away from characteristics of the professor and toward characteristics of the course. She also identified a decrease in students rating the course as “very good” or “excellent.” Similarly, Van Sickle (2016) reported that while student success increased in a flipped algebra class, student perceptions of the instructor and course decreased. We questioned if these observations were evidence of changes in peer-expert relationships that coincide with the change in instruction.

Prior to this study, the instructor had taught general and organic chemistry for several years, with relatively consistent and successful student evaluations of instruction (SEIs). While some comments in the SEIs from flipped sections continued to focus on the instructor, there was a notable shift as demonstrated in Table 2. Notice that the major categories of comments in the traditional sections are all about the instructor. In contrast, the flipped students provided significant commentary about the course design and resources.

Table 2
Comparison of Student Comments on End-of-Semester Institutional Survey

Traditional Only	Flipped Only
Instructor is a great communicator	Instructor is a poor / great communicator
Instructor gives interesting lectures	Instructor does not teach enough
Instructor characteristics helped me to pass the course	Course characteristics helped me to pass
Wait for instructor when stuck	Work in teams and ask for help only when needed
Instructor notes are my main resource	Assigned ChemWiki textbook is my main resource

Consider the wording choices of this flipped student:

> His classes guaranteed students were caught up with their studies, and supported students with weaker understanding. Group work ensured that students had a profound understanding of the material, *since it required them to teach it, or that they learned from their peers who had a better understanding of the material*. He also provided an introduction to chapters assigned at the end of each class, and re-covered the topics to clarify any points of confusion the following class. In addition to a brilliant teacher, [instructor's name] is also a wonderful person to *study under*. (F-G-13) (Italics added)

This student identified peer-peer relationships as a key characteristic of the course, and their opinion of the professor was based on the facilitation of those relationships. Additionally, they stated that they studied under the professor, not that they learned from the professor. In our experience, this is significantly different from how most first-year students describe their academic responsibilities.

Instructors, departments, and institutions that endeavour to undertake flipped instruction methods must maintain an awareness that in the flipped classroom students become more dependent on their peers, and less on their instructor. While this leads to stronger academic skills, it also results in lower student evaluation of instruction. The professor is not worse at their instructional role, but rather has taken on a facilitator role in a student-centric learning environment. Peer-expert relationships can still develop in a text-centric or large enrolment flipped classroom, but in comparison with a traditional lecture class, there appears to be a different set of necessary conditions for them to develop.

Finding 5: Without peer-peer relationships, peer-peer leader and peer-expert relationships are strained in a text-centric class

The design of the flipped classroom intentionally redistributes instructional time from unidirectional discourse to small-group and one-on-one conversations. Flipped learning requires peer-expert relationships to function properly (Bergmann & Sams, 2014). Since our intent was to promote stronger academic reading skills through text-centric methods, pre-lecture videos were not used and the development of peer-expert relationships primarily occurred in the classroom. In the organic chemistry class, where peer-peer relationships were weak in the absence of ARCs, students struggled in the course and frequently requested that the instructor teach through traditional lecturing. Consider the following comments: F-O-6: “The textbook is too hard to understand. Do less activities and more teaching. I learn best by listening not doing.”; F-O-1: “I feel like the lecture should be just lecture. ‘Here’s the stuff’. … I would find that much more useful [if he] taught it … rather than introducing the concept and then saying ‘okay now go read’.”

The students in this class tended to work on their own during the problem-solving activities, and these two students in particular demonstrated a lack of class preparation. With peer-peer relationships and class preparation absent from their practice, these students described feeling frustrated with the flipped classroom design and did not trust in the instructor’s approach. Moreover, many organic chemistry students were hesitant to ask questions of the instructor or peer leader prior to the inclusion of ARCs. Through anonymous reflections, students admitted that they were afraid to reveal their lack of class preparation, further evidence of how social-comparison concern and achievement goal theory were impacting relationships development within this classroom. After ARCs were added to the class, learners began to engage with their textbook and each other. As peer-peer relationships developed, students became willing to establish peer-peer leader and peer-expert relationships, increasing the success of the flip technique.

While the late stage adoption of ARCs hindered relationship building and the flip was not as well received in organic as general chemistry, the changes in student behaviours near the end of term were remarkable. Consider the following organic chemistry student’s observation of the classroom near the end of term:

> During the activities, there’s a lot of questions that the students have. So I know that it’d be really tough for just [instructor’s name] to go around and explain. We’d run out of time, so having [the peer leader] there is a huge help. (F-O-4)

As the student noted, the number of questions from student groups had significantly increased after ARCs were added to the course. We also noted that the quality of the questions also improved. With the higher levels of trust and establishment of academic relationships, there were so many quality questions that the instructor could not have supported all the small group and one-to-one questions in the flipped classroom on his own.

Contrast the comments above with one from a student in a flipped general chemistry section. In this class the peer-peer, peer-peer leader, and peer-expert relationships were stronger.

Interviewer: “What happened if there was a concept your group struggled with?

> F-G-7: "We usually had one of [the peer leaders] or [instructor's name] to come help us. But mostly we first tried to look at it on our own and then see if we could find a solution. Think for a bit, and then if a minute, two, three passes by and we don't have any results we would ask for help. … [The peer leaders] were a big benefit. `Cause [instructor's name] can't really come around to all of us by himself and they sometimes give good techniques on how to think about the question."

While this student also raised the concern that the instructor would not be able to attend to all groups himself, their attitude toward group work was completely different than F-O-1 and F-O-6. This student was willing to struggle with peers before asking for help, demonstrating stronger peer-peer relationships. They went on to describe peer-peer leader relationships through interactions elsewhere on campus. Many learners in the flipped general chemistry sections agreed with F-G-7, that the peer leaders were "a big benefit," describing this element of the flip as a valuable component of the classroom instruction. With the peer-peer relationships in place, students were better prepared to develop relationships with the peer leaders and course instructor.

Finding 6: As relationships are strengthened, learners better recognize and accept their responsibilities

Benefiting from peer-peer, peer-peer leader, and peer-expert relationships, the students in the flipped general chemistry sections provided thoughtful and reflective comments on the instruction design that revealed keen understanding of their role in the academic environment. F-G-10: "The methods [instructor's name] used this semester to teach students was really helpful. Hope it stays the same. OWL assignments, tutorials, group quizzes everything was helpful. Rest is the students' part to do their best."

> The learning [instructor's name] provided was awesome. Lots of class work, weekly assignments that kept us on top of the lecture content. An online textbook meant I didn't have to pay for one!! He encouraged class discussion and asked us to ask questions. ... If anything, the grade I didn't achieve is from my own failures. (F-G-11)

As both of these students stated, the instructor designs and facilitates a learning environment; it is up to the learners to take advantage of this environment. It is doubtful that these students would have come to such a realization if they had not felt supported in the classroom through strong relationships. Compare these comments with ones from the flipped organic chemistry class: F-O-7: "The amount of unnecessary hours I had to put in outside of class to understand simple concepts was ridiculous."; and F-O-3: "I don't think that the lectures help so much with my understanding because I had to read and try to understand." These two students did not willingly accept their responsibilities within the academic environment; instead they expressed a preference for traditional authoritative didactic instruction, with the latter going so far as to suggest that a university class is unhelpful if it requires them to follow up by reading the textbook. In their group interview these two learners disagreed with a third student, arguing that the flipped approach was not effective for learning. Confident in how university courses should run, they did not trust their instructor to facilitate an alternative student-centric learning environment. Further comments in the interview revealed that they failed to understand the sequencing of the class time, as shown in Figure 1. In contrast, none of the students from the general chemistry flipped classroom populations expressed confusion about the flipped instructional sequence. One student noted:

> I think it encourages being involved because you're asking questions, then you're working on problems with other group member's, and then [instructor's name] gives you a summary of what's to come. Now you go home, look at it, and then the cycle repeats the next time in the lecture. So yeah, you're always doing something and it's always active. … It left learning the material up to the students but did give them an explanation of everything they would be looking at. He would give you a chance to learn it and then you would follow up with more class to make sure it was really affirmed. It seemed more engaging because it left more time for questions. It left more time for you to figure it out on your own, and I think that reinforced it more effectively than just a lecture where you go and listen to the prof for an hour. (F-G-6)

This student, like almost every other student in the Fall 2015 sections of general chemistry, was in their first semester of university. Their eloquent description of the flipped instruction design demonstrates that learners are capable of appreciating the structure of a flipped classroom when they have strong academic relationships within the learning environment.

Conclusions

Faculty can help foster relationship building in the flipped classroom, not only between peer and expert but also between peers and with peer leaders, by including elements that motivate class preparation and peer collaboration. The significant variability in the impact of the flipped classroom as reported in the literature is likely associated with differing strengths of these relationships.

Faculty that have attempted and later abandoned a type of flipped instruction in the past, perhaps because of student pressure, may wish to reconsider the approach, placing especial focus on techniques that promote peer-peer relationships. When properly introduced and regularly utilized, both academic reading circles and open-response multiple-attempt group quizzes can facilitate the relationship building necessary for a successful flip. When learners do not complete the necessary class preparatory assignments, they are less likely to engage in group problem-solving, which hinders the development of healthy peer-peer and peer-expert relationships, and students report poor levels of satisfaction with the course instruction.

Based on our analysis, we argue that differences in flipped instructional styles can have an impact on the peer-peer, peer-peer leader, and peer-expert relationships that develop within the flipped classroom, which in turn affect a student's ability to recognize and accept their academic responsibilities in this instructional approach.

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