INTERDISCIPLINARY DESIGN TEAMS OF PRE-SERVICE AND IN-SERVICE TEACHERS: ISSUES WITH COLLABORATION

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ABSTRACT
Two post-secondary instructors and one K-12 Learning Commons teacher describe how interdisciplinary units of study were designed by undergraduate pre-service teachers and by in-service teachers in a junior high school. The interdisciplinary units focused on two or more disciplines and aimed to engage student learners in understanding a complex issue. Using a collaborative action research approach and through ongoing dialogue, the three educators worked together throughout the year to improve processes for supporting teachers in designing interdisciplinary units of study. Findings suggest teachers experience common challenges when working on interdisciplinary design teams regardless of the extent of their teaching experiences.

KEYWORDS: Interdisciplinary, pre-service teacher, in-service teacher, professional learning, collaboration

INTRODUCTION
Interdisciplinary learning (IL), described as teaching that draws from two or more disciplines (Newell, 2001; Strober, 2010), can be used to study real-world problems or issues (Campbell & Henning, 2010). For example, pollution may be examined from a scientific, social science, and mathematical perspective, involving a design team with individuals having corresponding expertise. IL may involve one or multiple teachers from one or more schools who design, teach, and assess learning outcomes, and may occur for part of a learning cycle or during a whole course (Klein, 2005, 2006).
Working collaboratively with individuals having disciplinary expertise can be a powerful approach in designing authentic IL experiences. Teachers work in close proximity to colleagues who have various backgrounds and expertise, so it would seem natural for them to work together. However, teachers encounter challenges when working collaboratively (Thomas & Brown, 2017). To overcome these challenges, teachers need strategies promoting collaboration when designing IL (Berlin & White, 2012).

Collaboration is defined in the Merriam-Webster Online Dictionary as working “jointly with others or together especially in an intellectual endeavor”. Researchers have argued designing IL requires teamwork among teachers (Klein, 2006), including collaborative teaching (Campbell & Henning, 2010). Examining teaching teams Ronfeldt, Farmer, McQueen, and Grissom (2015) found the quality of collaboration positively influences teacher performance and student achievement. However, in a study on integration of mathematics, science and technology education with pre-service teachers, Berlin and White (2012) found teamwork is difficult to manage and can be perceived as less efficient. These authors also argued teachers need to design and enact IL in collaboration with colleagues with different disciplinary expertise, and, to do so, need strategies for effective and efficient collaboration (Berlin & White, 2012). As such, quality teacher collaboration can be challenging for teachers to manage and may be perceived as an inefficient approach; however, teacher collaboration can also positively influence both teacher performance and student learning.

Despite the challenges in teacher collaboration, it is a necessary competency for today’s teachers. Researchers have connected quality teacher collaboration to improved student learning (Learning Forward, 2011; Ronfeldt et al., 2015). Friesen (2009) describes teacher collaboration as a core principle for effective teaching. This creates collective responsibility and accountability with a shared focus on continuous improvement. Clearly, teachers need to collaborate when designing IL experiences for students, and quality collaboration can benefit both teachers and students.

**SOCIAL CAPITAL AND SOCIAL NETWORK THEORY**

Social capital and social network theory help explain the significance of developing collaboration skills for both pre-service and in-service teachers. Developing social capital (networks of relationships) is necessary in schools so teacher teams can collaborate to achieve a common goal (Field, 2003; Hargreaves & Shirley, 2012). For example, many schools promote professional learning communities (PLCs) as a means to foster peer interactions and teacher collaboration (DuFour, DuFour, Eaker & Many, 2010). In PLCs, teachers work collaboratively towards a common goal, generally selected and directed by teachers involved. These forms of peer interactions are valuable for schools (Fullan, 2008) and worth considering building social capital (Hargreaves & Shirley, 2012).

Interdependent relationships, where teachers work and learn together, are further explained by social network theory. When teachers work together, they develop interpersonal interdependence (Moolenaar, Sleegers, & Daly, 2012). Shifting from
independence to interdependence is recommended to facilitate teacher growth (Johnson, 2012). It is important to engage practicing and aspiring teachers in collaborative experiences that promote positive interdependent relationships that in turn develop positive social networks.

Coburn, Russell, Kaufman, and Stein (2012) showed a relationship between teachers’ social networks and the sustainability of new practices. New practices can be advanced when teachers have access to expertise, time for experimentation, and opportunities to dialogue with colleagues and generate positive social networks (Coburn et al., 2012). As well, developing social capital through a PLC model can also impact group norms and beliefs (Servage, 2009). These beliefs indicate a connection between self and collective efficacy (Bandura, 2001). Bandura (2001) posits that less efficacious individuals may have difficulties collaborating because of personal self-doubts, whereas if the highly efficacious individuals can effectively work together. However, social networks are susceptible to inefficiencies or sabotage (Field, 2003), preventing sustainable change (Datnow, 2012). Promoting positive social networks, including positive experiences and beliefs, is essential for effective teacher collaboration.

In summary, social network theory explains interdependent relationships and how continued collaboration among teachers requires positive social networks. Effective teacher collaboration is fostered when teachers work in PLCs, which results in positive experiences and the development of social capital. Social capital and social network theory provides evidence for greater attention to developing collaboration skills with pre-service and in-service teachers.

**Teacher Collaboration: Benefits and Challenges**

Teacher collaboration can both benefit and present challenges for pre-service and in-service teachers. Teacher collaboration supports PLCs. This is beneficial as PLCs collectively aim to improve student learning and share the responsibility for teaching and learning (Hargreaves & Shirley, 2012). Collaboration can also benefit teachers socially. For example, Brynjulf Hjertø, Merok Paulsen and Petteri Tihveräinen’s (2014) research on social learning theory found teachers form social bonds when working and learning together, which influences organizational commitment and develops shared responsibility. Clearly, teachers interdependently working to improve student learning can benefit from developing social bonds and shared responsibility.

A further benefit of teacher collaboration is engagement in critical dialogue with peers. Joyce and Showers (2002) found when teachers have access to expertise through long-term coaching, an increase in implementation of new classroom practices results. Dialogue may include offering and receiving feedback from peers and sharing resources; this opportunity to improve practice alongside peers is a principle of teaching effectiveness (Friesen, 2009). Creating the space and time for teachers to collaborate on a regular basis and with disciplinary experts provides timely support (Fogarty & Pete, 2009).
Although teacher collaboration has benefits, there are also challenges. One such challenge is creating a time and place for teacher collaboration (Battersby & Verdi, 2015), and embedding this into workplace practice (Sparks & Hirsh, 2000). Recurrent collaboration time is essential for the exchange and negotiation of ideas while problem solving together (Thomas, 2016). In a social network analysis of collegial interactions, Penuel, Sun, Frank, and Gallagher (2012) examined the effects of professional development. Results indicated if collaboration is to be effective, it must be frequent. Teachers need ongoing time for collaboration.

Designing authentic IL experiences requires teacher collaboration. Quality teacher collaboration can be inefficient and challenging to manage; however, teacher collaboration, can improve teacher and student learning (Ronfeldt et al., 2015). Furthermore, teacher collaboration in IL is not well defined or understood in the literature. The findings from this study serve to inform how pre-service and in-service teachers collaborate to design interdisciplinary units of study.

**Methodology and Methods**

One Learning Commons (LC) teacher worked with a design team of in-service teachers to develop IL units for students in an urban junior high school. The LC teacher is an educational technology specialist who supports task design and just-in-time learning needs for staff and students. In the same year, two post-secondary instructors (Instructor A and Instructor B) taught an undergraduate IL course for pre-service teachers. Instructors A and B organized the pre-service teachers in the undergraduate course into small teams to develop IL units for students in K–12.

Instructor A, Instructor B and the LC teacher (also the three coauthors of this paper) used an action research approach (Hendricks, 2013; McNiff, 2016) to explore IL designs and inform practice. Specifically, the action researchers wanted to explore the design process and challenges in engaging both in-service and pre-service teachers in IL. The following questions guided this inquiry: What is the design process for engaging in-service and pre-service teachers in developing IL? What are the challenges encountered when designing IL?

The interdisciplinary design process used was grounded in the principles of the teaching effectiveness framework (Friesen, 2009) and inquiry design process (Friesen et al., 2015). The teaching effectiveness framework has five principles: (a) teachers are designers of learning, (b) work students are asked to undertake is worth their time and attention, (c) assessment practices improve student learning and guide teaching, (d) teachers foster a variety of interdependent relationships, and (e) teachers improve their practice in the company of their peers (Friesen, 2009, pp. 4–6). The inquiry design process was guided by criteria describing authenticity in learning, academic rigor, assessment that sponsors deep learning and improved instruction, learning that adds value beyond the school, learning with digital technologies, engagement in active exploration, connections with disciplinary experts, and using elaborated forms of communication (Friesen et al., 2015). Bridging the principles of teaching effectiveness with a rich inquiry process provided both the in-service
and pre-service teachers with a common framework for developing interdisciplinary units of study.

The collaborative action research process used in this study involved planning, enactment, and reflective inquiry, with the intention to use the results in future iterative cycles (Hendricks, 2013). In this context, Instructors A and B taught an IL undergraduate course for pre-service teachers. The LC teacher facilitated the development of interdisciplinary units of learning with a team of in-service junior high (grade 8) school teachers. The authors each maintained reflective journals and shared artifacts of their planning and learning during one term and one school year respectively.

Data were gathered over a one-year period using reflective journals, maintained while enacting the interdisciplinary design process. The LC teacher documented the process when collaborating with seven junior high teachers as part of a design team. Instructors A and B shared a course syllabus and week-by-week plan to work with two classes of pre-service teachers (36 students in each class), and maintained documentation of their work. Pre-service teachers were divided into teams of four to six to design an interdisciplinary unit of study. Ongoing dialogue and artifact sharing among the three instructors occurred during the same time period. Main ideas from these conversations were recorded as notes. Artifacts shared included instructor planning documents, and IL units and assessments such as a course syllabus, unit plans, task descriptors, assessment rubrics, blog posts, and class slides. The dialogue allowed the instructors to engage in collaborative reflection and act as critical friends towards improving their own practice (Hendricks, 2013; McNiff, 2016).

Examination of qualitative data gathered over a one-year period, along with the literature in the field, involved identifying corroborating evidence and conducting a thematic analysis. Credibility was strengthened by triangulation of sources (different perspectives, over time, held up against the literature) that also served to inform subsequent iterations of the IL design process for both in-service and pre-service teachers. Furthermore, critical aspects of interdisciplinary design work that requires further study were identified.

RESULTS

Findings related to the collaborative action research phases have been organized into three categories: planning, enactment, and reflective inquiry. First, Instructors A and B briefly discuss how they planned for engaging students in designing interdisciplinary units of study. A discussion of how the design process was enacted during the pre-service IL course follows. The two post-secondary instructors also reflect on enactment and share insights about designing interdisciplinary units of study with pre-service teachers. Second, the LC teacher provides an example of how an interdisciplinary unit was designed and enacted with a team of grade 8 teachers. She also reflects on enactment and shares insights about designing and enacting an interdisciplinary unit of study with in-service teachers.
Pre-Service Interdisciplinary Unit Design

Planning. Instructors A and B used a common syllabus for teaching an undergraduate course on IL. In the syllabus, learning outcomes for learning tasks were clearly established. An assessment rubric was developed, guided by principles of teaching effectiveness (Friesen, 2009) and the inquiry process (Friesen et al., 2015). One learning task organized pre-service teachers into design teams to develop an interdisciplinary unit for grade school students.

Enactment. During enactment, pre-service teachers were divided into design teams. Drawing on ideas of affinity spaces (Gee, 2004) to gather students together around shared interests, Instructor A invited pre-service teachers to pitch ideas using the following framework:

- What matters about this topic?
- What are the issues surrounding this topic?
- What are the questions and/or what problems are unresolved?

Ideas pitched were listed in a shared online document. Pre-service teachers were then invited to sign up for one topic and form teams. Most pre-service teachers were able to identify an idea of interest; however, in her reflective journal, Instructor A noted some pre-service teachers needed guidance in shifting to new ideas when insufficient interest from peers presented.

In contrast, Instructor B divided pre-service teachers into grades K–6 and 7–12 teams. Pre-service teachers were then instructed to form a team of five with individuals from a different disciplinary expertise. Team names, disciplines and grade levels were recorded in a shared online document. Prior to identifying a topic, pre-service teachers discussed how to identify a concept and derive an essential question. Pre-service teachers examined curriculum from different disciplinary perspectives and identified transferable disciplinary concepts. Next, each team drafted an essential question and brainstormed possible provocations. Teams used criteria provided from the course readings to evaluate their essential question (Mackenzie, 2005). Instructor B wrote the following in her reflective journal:

The concept of sustainability was identified by one team. This connects to multiple disciplines and represents a real-life problem students can authentically engage in solving. Consequently, this developed into the following essential question: How can our school contribute to community sustainability?

Discussing a concept to derive an essential question was helpful for pre-service teachers in generating unit plan ideas.

Instructor B then organized a jigsaw activity where each pre-service teacher formed a new team to solicit feedback. Here, each individual shared their concept and essential question. Once peers offered feedback on proposed ideas, pre-service teachers returned to original teams, discussed feedback, and made necessary revisions.
Instructors A and B supported pre-service teachers in planning interdisciplinary units of study once teams were formed in both classes. To guide planning, Instructor A supported pre-service teachers in working through a design process (Friesen et al., 2015), as shown in Figure 1.

![Design process](http://inquiry.galileo.org/ch2/a-design-for-inquiry/). Copyright 2015 by Galileo Educational Network. Reprinted with permission.

Students discussed the constraints of developing interdisciplinary unit plans during the design process. The following questions recorded in Instructor B’s reflective journal highlight some common questions asked about IL designs:

Do we need to cover all curricular outcomes for each subject area during an interdisciplinary unit? How will this work in a semestered system? Is this approach feasible in upper grades with standardized tests? Why do we need to design an interdisciplinary unit when our field experiences and practicum teachers are not doing this?

Instructor A noted pre-service teachers wrestled with curricular restraints, such as finding cohesion between curricular outcomes and the designed unit plan. Concerns with the learning task’s time commitment and whether this would impact the obligation to meet the necessary curricular outcomes also arose. Instructor A invited the LC teacher as a guest speaker to share classroom examples from her work, help pre-service teachers envision
what interdisciplinary teaching and learning could look like, and explore the challenges inherent to working in interdisciplinary design teams in a school setting.

Pre-service teachers engaged in feedback loops and an iterative process of redesign throughout the design process. Instructor A invited disciplinary experts from the Galileo Educational Network to one class. Each design team was provided with 15 minutes to ask questions and gather design advice from the experts. Instructor B asked her pre-service teachers to view videos illustrating interdisciplinary unit plan design and implementation from different grade levels developed by classroom teachers. These examples were used to help pre-service teachers envision what was possible; Both Instructors A and B paired design teams together to provide peer feedback. The instructors also met with each team during class, providing ongoing feedback to improve designs. Once unit plans were ready for public presentation and classroom use, pre-service teachers used a common rubric to self-reflect, including an individual statement of contribution, and provide a team self-assessment. Pre-service teachers were required to provide evidence in meeting rubric criteria. Both instructors noted in their reflective journals and through dialogue that team self-assessments also included comments about collaboration challenges experienced when designing the interdisciplinary unit.

Reflective inquiry. Upon reflection, both Instructors A and B noted challenges related to establishing design teams, overcoming curricular restraints, fostering collaboration among design team members, and fair assessment. First, inviting pre-service teachers to pitch ideas and form design teams around ideas proved challenging for some teams. Second, the instructors recognized pre-service teachers had difficulties seeing how curricular outcomes could be addressed using an interdisciplinary approach when considering time constraints and the need to meet curricular outcomes. Third, instructors noted some design teams collaborated with difficulty. For example, when team members did not contribute or contributed work later than expected, this performance was problematic for the team. Some teams also experienced difficulties making decisions and negotiating ideas. In her reflective journal, Instructor B noted, “Two different ideas emerged during the design process, and in the end the team split into two smaller groups to accommodate different interests and resolve the conflict.” In cases where challenges with collaboration presented, teams required instructor support to solve design problems. Fourth, it became evident the assessment rubric could be improved to include more detailed learning criteria related to teacher collaboration and individual project contribution.

In-Service Interdisciplinary Unit Design
Planning. Salt & Freshwater Systems, a problem- and project-based collaborative interdisciplinary unit based on the principles of the teaching effectiveness framework (Friesen, 2009), was designed by a team of seven grade eight in-service teachers at a public junior high school. The full-time LC teacher (one of the authors of this paper) was invited by a science teacher to facilitate the teacher collaboration (Sparks & Hirsch, 2000) and share her curriculum design and educational technology expertise with the team.
Together, this design team planned an IL unit with a focus on water systems for approximately 250 grades 8 students:

This task utilized interdisciplinary connections with Science, Social Studies, English Language Arts, and Information & Communication Technology (ICT), and required students to work collaboratively with peers. The culminating learning task required students to create a news clip on a global water issue. Students worked on the learning task during their block schedules (i.e., math/science blocks and humanities blocks). The flexible and lengthier periods of time were intentionally timetabled to support interdisciplinary collaboration. (LC teacher reflective journal)

The design team met to discuss the interdisciplinary unit during common planning time which was scheduled every two weeks. As documented in the LC teacher’s reflective journal, the following essential question guided the inquiry: What are the characteristics of freshwater and saltwater systems, and how do they affect living things, including humans? From here, the task was collaboratively designed using Wiggins and McTighe’s (2005) GRASP model (goal, role, audience, situation, and products), integrated with principles of Friesen’s (2009) teaching effectiveness framework. The team worked to improve their practice in the company of their peers by collaborating on assessment criteria.

Each team member volunteered for different responsibilities based on their disciplinary expertise. For example, the science teachers agreed to provide content scaffolding, known as a holistic approach for embedding guidance or tailoring supports for learners’ individual needs (Reiser & Tabak, 2014). The humanities teachers focused on skill development (Alberta Education, 2000, 2005) and the LC teacher focused on infusing ICT program outcomes (Alberta Learning, 2000).

Enactment. Enactment of the learning design began in science class, where grade 8 students were provided curricular scaffolding by three different teachers. Each student received the same learning tasks to meet curricular objectives and develop understanding. Learning outcomes were articulated and an assessment rubric based on the teaching effectiveness framework (Friesen, 2009) and Building Better Rubrics (Bennett & Mulgrew, 2013) was shared with the students. Science teachers communicated with their partner humanities teachers when students were ready for instruction in language arts. At this point, four humanities teachers provided instruction for conducting research and creating a bibliography. Humanities teachers collaborated on this instruction and shared templates across the grade to ensure consistency. For example, when in science class, students had the correct tools and skills to research effectively. Using the school LC (formerly the library), two classes were able to research and write their news scripts in the same space, resulting in collaborative teaching within the science team. Humanities teachers provided research and writing time as well, so students could engage in both teacher and peer feedback loops. Collaborative teaching across curricular areas occurred. This approach also resulted in colleagues interacting in close proximity, enabling them to engage in critical dialogue.
Prior to beginning their final artifact, a guest speaker with media expertise was arranged to share the integral components of an effective news story and provide an authentic, real-world connection to their finished work. When ready to create their final product, the LC teacher provided students with instruction and support using various forms of technology. Podcasting technology using Garageband on school or personal iPads and Audacity on school computers was supported. A news desk was set up, and, using school iPads with the Do InK app, a green screen was made available. As well, iMovie and Movie Maker software were provided for film editing. Tutorials and support both inside and outside of class were provided by the LC teacher through the school's virtual LC, an online resource developed to support 24/7 access to learning supports. The grade 8 students participated in a culminating class showcase where the humanities and science teachers were present. This time was used to collaboratively assess each project according to criteria that complemented their subject area. According to her reflective journal, the LC teacher was present for many of the presentations, but was not formally engaged in student assessment.

Reflective inquiry. From the perspective of the LC teacher, the design team engaged in an effective collaborative process when planning and enacting the Salt & Freshwater Systems interdisciplinary unit. The task itself was planned in collaboration with the seven-member in-service team providing input into scaffolding activities, outcomes for the final task, and assessment criteria for their respective disciplines. The in-service teachers allowed for collaborative IL by focusing on their own disciplinary expertise when enacting the task, to guide students in their learning (Berlin & White, 2012). Science teachers became the topical curricular experts, while humanities teachers focused on skill-building, and the LC teacher was the technology expert and led the scheduling.

Collaborative teaching occurred (Campbell & Henning, 2010) both within subject departments and across partner-teaching pairings. The LC was used as a space for students to work across classes and receive just-in-time learning supports for resources and technology. Students benefitted from receiving feedback from all humanities and science discipline experts. In-service teachers were able to receive assistance, when needed, from the LC teacher. In her reflective journal, the LC teacher noted positive social networks emerging as teachers were able to take risks and advance their practice, particularly in relation to technology integration.

The in-service design team also experienced challenges in enacting and reflecting on the interdisciplinary unit of study. While the teachers were provided with common planning time for lesson and unit development, during class implementation, the entire design team failed to meet or continue to discuss project details. Working with peers to improve practice (Friesen, 2009) was limited to the planning phase for the in-service teachers. Scheduled meeting time for the seven-member design team to discuss what worked well and what could be improved during the next iterative cycle was absent.

In this section, findings were discussed during three phases of IL (planning, enactment, and reflective inquiry) with pre-service and in-service teachers. The two post-secondary
instructors (A and B) noted common challenges in designing interdisciplinary units of study with pre-service teachers, such as establishing design teams, overcoming curricular restraints, promoting collaboration among design team members, and defining assessment criteria. Likewise, the LC teacher found the design team discontinued collaborative planning sessions during the enactment of the interdisciplinary unit of study, which may have contributed to inconsistent expectations for the junior high school students. Findings suggest pre-service teachers and in-service teachers working on interdisciplinary teams experience challenges in collaboration.

**DISCUSSION**

The authors noted common challenges in teacher collaboration when working in a university setting with aspiring teachers and when working in a school setting with practicing teachers. Teachers with disciplinary expertise and varying ranges of teaching experience have difficulty in working on interdisciplinary design teams. Three common challenges were identified in the reflective journal data from Instructors A and B and LC teacher: establishing design teams, fostering collaboration among team members, and limited time for reflection.

**Challenge 1: Establishing Design Teams**

Pre-service teachers formed teams either by common interest (idea pitch) or by grade level interest (elementary and secondary). In-service teachers were grouped based on teaching assignments and subject integration. Despite the differing approaches, challenges were evident during the planning phase in all scenarios. Instructors A and B and the LC teacher all noted common issues at this stage in their reflective journals including a lack of buy-in by all the team members and a resistance to work with interdisciplinary teams. In-service teachers voiced concerns with timelines and altering year-long plans to accommodate the interdisciplinary unit. Questions asked by pre-service teachers indicated they have difficulties in envisioning how interdisciplinary approaches work in schools. Pre-service and in-service teachers were challenged in shifting from following a static sequence of prescribed textbook or curricular topics in one discipline to a more dynamic sequencing of interdisciplinary curricular outcomes when connecting two or more disciplines. IL designs required teachers to shift from working in isolation to working within a collaborative design team. Interdisciplinary designs also required teachers to shift from static planning to dynamic design teams.

**Challenge 2: Fostering Collaboration among Team Members**

Following the establishment and agreement to work on an interdisciplinary design team, issues in collaboration persisted with both pre-service and in-service teachers. Researchers noted collaboration challenges during the planning phases were connected to making design decisions. Pre-service teachers had difficulty in narrowing focus, delineating relevant curricular outcomes, and selecting an optimal number of tasks and assessments related to outcomes. Often, too many ideas were presented, requiring negotiation with one another. Some ideas remained as others were dropped from the plans. Similarly, when making design decisions, it was necessary for in-service teachers to negotiate ideas. For
example, the IL task offered the junior high students flexibility and choice of activities, but the in-service teachers had difficulty in making this design decision. Opinions differed as to providing a set list of options or giving students a greater extent of flexibility in designing their learning artifact. Evidently, both pre-service and in-service teachers were challenged when collaborating with team members and negotiating design decisions.

Pre-service teachers established timelines for unit plan completion as a strategy to guide collaboration. However, Instructors A and B noted challenges when pre-service teachers expressed concern of team members failing to adhere to the set timeline. Consequently, collaboration breakdowns occurred. Maintaining agreed-upon timelines was also an issue with the in-service teachers. The LC teacher noted in her reflective journal limited communications among in-service teachers during the enactment phase may have contributed to inconsistent expectations being communicated to students. For example, one teacher extended the due date for certain students; however, a different design team member did not. Pre-service and in-service teachers may have difficulty maintaining timelines as originally planned. Perhaps more attention needs to be directed to project management. Furthermore, ongoing communication is necessary for collaborative teams planning and enacting IL designs, whether they are practicing classroom teachers or aspiring teachers.

**Challenge 3: Having Limited Time for Reflective Inquiry**

Issues may occur post-enactment and during the reflective inquiry phase. Instructors A and B noted in their reflective journals that some pre-service teacher teams developed cohesive and quality LC units whereas other teams simply collated a series of individual contributions. Instructors A and B also provided pre-service teachers with an opportunity to reflect on their learning designs and provided the individual contributions to the team. Pre-service teachers were unable to distinguish their own individual contributions in some teams. The LC teacher also noted that in-service teachers may lack the time or opportunity to reflect on their work together and discuss ideas for improvement and subsequent iterations. Perhaps greater time for reflective inquiry could help pre-service and in-service teams improve future collaborative design work and discuss characteristics of quality LC learning units.

We identified three common challenges as evidenced from our own practice when working with pre-service and in-service teachers in designing interdisciplinary units of study: establishing design teams with a common focus, managing collaboration among team members, and making time for reflection. Together these issues can have an overall impact on effective collaboration.

**Strategies for Supporting Interdisciplinary Design Teams with Collaboration**

We addressed collaboration challenges using various strategies supported by literature, such as leveraging external experts for guidance, establishing criteria for individual and team contributions, providing opportunities for peer feedback, using participatory technologies, administering self-assessments, and embedding time during class (pre-service) or during the work day (in-service) for teacher collaboration. However, we
recognize further study and evidence-informed action are needed to improve collaboration among teachers working on interdisciplinary units of study.

**Invite external experts.** Instructors identified challenges related to establishing design teams, including lack of buy-in and perceptions of curricular constraints. One strategy we used to help teachers embrace interdisciplinary design was make ourselves available as experts and invite external experts to meet with interdisciplinary design teams. Pre-service and in-service teachers needed support and guidance in understanding how curricular outcomes from the program of studies could be addressed in a timely fashion and align with IL intentions. Friesen et al. (2015) indicates a strong command of the program of studies is required for teachers to see themselves as agents of change and capable of rearranging curriculum when designing such experiences. Pre-service and in-service teachers were supported in using the program of studies, rather than textbook chapters, as their guide when designing IL units. This access to expertise (e.g., instructional leaders, coaches, teacher leaders) is valuable for supporting teachers (Friesen, 2009; Joyce & Showers, 2002; Thomas, 2016). Collaborative design teams require instructor support and can also benefit from other external interdisciplinary experts providing guidance for negotiating ideas.

**Establish criteria for team and individual contributions.** Both pre-service and in-service teachers experienced issues in collaboration relative to communication breakdowns. The LC teacher noted in-service teachers lacked time for collaboration and ongoing communications during enactment of the IL unit. Pre-service teachers experienced difficulties collaborating with team members and associated issues of noncontributors and late submissions. To address these challenges, Instructors A and B established criteria for assessing both team and individual contributions.

**Provide peer feedback loops.** Instructors A and B also provided peer feedback loops to help make student thinking visible, identify strengths and weaknesses, and elevate accountability (Dijkstra, Latijnhouwers, Norbart & Tio, 2016). These feedback loops helped teams negotiate individual contributions and inform next steps (Darling-Hammond et al., 2008).

**Embrace participatory technologies.** Another strategy used by pre-service instructors was to capitalize on participatory technologies (e.g., Google Apps, VoiceThread, Dropbox). These technologies helped teams divide responsibilities, identify individual contributions, and organize work during the planning and enactment phases. Participatory technologies are useful for designing learning during collaboration (Clark & Blissenden, 2013; O’Donnell & Hmelo-Silver, 2013).

**Use self-assessments.** One further issue for pre-service teachers was assessment. Instructors A and B used a rubric to assess the teams’ interdisciplinary unit plan designs, but it was difficult to assign a grade for teamwork when individual contributions were inequitable. The rubric could be improved to include more detailed learning criteria related to team collaboration and individual contributions to teamwork. Instructors A and B
addressed this issue by asking students to complete self-assessments using the rubric along with a statement of individual contribution. Bransford, Brown and Cocking (2000) suggested the use of self-assessment as a way to monitor individual progress and make thinking visible. The students’ self-assessments were submitted with the final unit plan and were used as evidence to support each individual’s contribution to the work.

**Embed time for inquiry and experimentation.** Providing time for inquiry and experimentation is another strategy that aids in collaboration (Timperley, Wilson, Barrar, & Fung, 2008). The value of embedded time for collaboration has been recognized by other researchers (Sparks & Hirsh, 2000). Instructors A and B allocated time for collaboration and unit design so pre-service teachers would have opportunities to work with their peers, brainstorm, exchange, and test ideas. Pre-service teachers had difficulties deciding on an interdisciplinary unit topic. Instructors A and B met with pre-service teacher teams to troubleshoot and offer advice and support in their decision-making processes. The embedded time allowed for this dialogue and support to happen. Likewise, the LC teacher facilitated collaborative time with in-service teachers during the planning phases of the interdisciplinary unit.

A common challenge and issue researchers recognized was lack of time for collaboration. For pre-service teachers, the strategy Instructors A and B used mitigate this challenge was to offer time within the designated course schedule for collaboration. This was effective, but only when all team members were present. Time for collaborating during the planning, enactment, and reflection phases was intentionally embedded into the course. For in-service teachers, time was embedded in teachers’ schedules for the planning phase. The LC teacher noted that no time was scheduled for collaboration during the enactment or reflection phases. This oversight prevented teachers from making improvements to their design and informing their decision-making for next steps. Embedding time for collaboration (Sparks & Hirsh, 2000; Timperley et al., 2008), modifying work structures, and rearranging schedules for common planning times (Killion & Hirsh, 2013; Yuan & Zhang, 2016) are necessary steps for establishing conditions that support collaboration (Yuan & Zhang, 2016). It is also important for all team members to be committed and actively participate in collaborative meeting times, whether they are scheduled as part of class time for pre-service teachers or as part of meetings for in-service teachers.

We recognize further ideas from literature could inform future collaborative action research phases of planning, enactment, and reflective inquiry. For example, instructors working with pre-service teachers could place expectations and boundaries around embedded times for collaboration (Robinson, 2011) and take measures to gather self-assessments throughout the process to ensure time is used purposefully and effectively (Timperley et al., 2008). Teacher leaders or school administrators working with in-service teachers may consider providing opportunities to expand the collaborative team in order to expose team members to diverse ideas and new insights, and to reduce the homogeneity that occurs with long-time established teams (Yuan & Zhang, 2016). Our attempts to support collaboration when working with pre-service and in-service teachers on design
teams illustrates more study are required to explore strategies for effective collaboration and evidence-informed action.

CONCLUSION
In this article we (two post-secondary instructors and one LC teacher) described how teams of pre-service and in-service teachers worked on design teams to plan, enact, and reflect on interdisciplinary units of study. A common feature of all interdisciplinary units designed was a focus on two or more disciplines with an aim to engage student learners in an authentic issue. Using a collaborative action research approach and through ongoing dialogue, we found quality IL designs require effective collaboration among interdisciplinary design team members, and that both pre-service and in-service teachers experience collaboration challenges when working on interdisciplinary teams. Moreover, challenges related to collaboration are present when planning, enacting, and reflecting on the IL designs. Three common challenges were identified: (a) establishing design teams, (b) collaborating with team members, and (c) making time for reflection. We presented several strategies for supporting interdisciplinary design teams with collaboration. Further study is needed to explore strategies for teacher collaboration so pre-service and in-service teachers can design quality learning experiences for their students.

REFERENCES


**Biographical note:**

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