Multiple Layers: Education Faculty Reflecting on Design-Based Research focused on Curricular Integration

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Abstract

What insights emerge through researcher reflections on a Design-Based Research (DBR) curricular integration project that contribute to the professional learning of education faculty/ researchers? To answer this question, two researchers captured their debriefing discussions and reflections after monthly meetings with participating teachers. The meetings familiarized the teachers with DBR methods and enhanced teachers' understanding of integrating literacy and science instruction. Data were open coded, collapsed into sub-categories and interpretations were then clustered into three themes. The first theme is our acknowledgement of the layers that needed to be peeled back to understand teacher participants' planning and assessment. The second theme is the realization that the teacher participants were novices with respect to understanding and practicing curricular integration. The final theme honors the value of DBR as a research and professional learning method. Findings are discussed in light of the scant literature that describes the experience of DBR educational researchers.

Keywords: design-based research; education faculty; reflection; professional learning; integrated curriculum

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Capas Múltiples: Reflexionando sobre la Investigación Basada en el Diseño Centrada en la Integración Curricular en la Facultad de Educación

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Resumen

¿Qué ideas surgen a través de las reflexiones de los investigadores sobre un proyecto de integración curricular de investigación basada en diseño (IBD) que contribuya al aprendizaje profesional de los docentes e investigadores en educación? Para responder a esta pregunta, dos investigadores capturaron sus discusiones y reflexiones después de las reuniones mensuales con los maestros participantes. Las reuniones familiarizaron a los maestros con los métodos IBD y mejoraron la comprensión de los maestros acerca de integrar la instrucción de alfabetización y ciencias. Los datos se codificaron en forma abierta, se colapsaron en subcategorías y las interpretaciones se agruparon en tres temas. El primer tema es nuestro reconocimiento de las capas que debían eliminarse para comprender la planificación y la evaluación de los maestros participantes. El segundo tema es darse cuenta de que los maestros participantes eran novatos con respecto a la comprensión y la práctica de la integración curricular. El tema final honra el valor de IBD como método de investigación y aprendizaje profesional. Los hallazgos se discuten a la luz de la escasa literatura que describe la experiencia de los investigadores educativos de IBD.

Palabras clave: investigación basada en el diseño; facultad de educación; reflexión; aprendizaje profesional; currículo integrado

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"Infinite Onion"
You keep peeling back the layers.
Starting from the surface.
Working hard you grit your teeth.
You think you are getting to the bottom, but I grow more layers underneath.

Clark Faint (2015)

The verse above serves as an analogy for the realities uncovered by education faculty as they engaged as facilitators and researchers (hereafter referred to as, "the authors") of a design-based research (DBR) study. This study presented the authors with a rare opportunity to illuminate the elusive role that DBR might play in the professional learning of education faculty/researchers who were facilitating professional learning for practicing teachers. Thus, the purpose of this paper is concentrated on the learning of the authors as a function of their reflection and collaboration while conducting the research. The findings describe the complexities discovered by observing and participating over the course of two academic years with elementary teachers in curricular integration. Researchers' reflections reveal unanticipated learnings that are framed by the lines found in the verse, "Infinite Onion" (Faint, 2015). Accordingly, the lines of the verse are referenced in the presentation of the findings as response to the question: What insights emerge through researcher reflections on a DBR curricular integration project that contribute to the professional learning of education faculty/researchers?

Literature Review

Design-Based Research and Reflection

Several definitions of DBR exist with the following common aspects (Design-Based Research Collective, 2003): DBR seeks to design learning environments (in authentic settings) while concurrently developing theories through iterative cycles of design, enactment, analysis and redesign. There is documentation of these cycles, and implications of the outcomes inform practitioners and educational designers (Design-Based Research Collective, 2003). As a research approach, DBR has emerged over the past two decades

in response to the need to address problems of practice while accounting for the outcomes of learning and instruction that might further inform (quasi) experimental studies (National Research Council, 2002).

DBR has been embraced by the educational research community as a method for not only designing curriculum, but also for enacting interventions to enhance teaching and learning environments (Anderson & Shattuck, 2012). DBR also seeks to further understand learning through extending existing theory (Kennedy-Clark, 2015). As well, DBR is particularly enticing as a means to address the persistent conundrum of how to bridge the gaps between theory, educational research, and instructional practice (Vanderlinde & van Braak, 2010). Other common applications of DBR include establishing communities of practice (Wenger, 1998) among researchers and practitioners premised on collaboration (Wang & Hannafin, 2005). Consistent with a review on DBR and communities of practice (MacDonald, 2008), the present study sought to meld these approaches as educational faculty/researchers facilitated a DBR project to support curricular integration of literacy, science and technology among practicing middle school teachers.

A key feature of DBR includes the multiple iterations of analyzing, designing, implementing, evaluating and revising interventions (Plomp, 2007). In the present study, all phases of the DBR process unfolded over the course of two full iterations, with each iteration undertaken in one academic year. It is noteworthy that the researchers (and authors) were cognizant of the differences between DBR and action research and adopted the former method based on the fact that they had a theoretically-based research question and were addressing a problem in context while collaborating with teachers (Stemberger & Cencic, 2014). The authors strived to be flexible as they also took on the multiple roles of designers, advisors, and facilitators (Plomp, 2007).

Engaging in DBR often involves instructional design and may provide practitioners with the pedagogical content knowledge and ultimately the confidence that they require to support their professional learning (e.g., Onguko, Jepchumba, & Gaceri, 2013). These outcomes of DBR for participating practitioners have been well documented in a decade-long literature review (Zheng, 2015). But what is the experience and learning outcomes for the DBR researcher(s)? In a review of the literature (Kennedy-Clark, 2015) on researchers' learning as a function of using DBR in

education, it was noted that effective DBR researchers come to understand the teachers' problems of practice and are flexible to adapt the research design to their needs. During the course of the study, we viewed design both as a problem solving process and reflection-in-action (Fazio & Gallagher, 2009). In this paper, we focus on the latter paradigm as we are interested in the role that DBR might play in the professional learning of education faculty/ researchers who were facilitating professional learning for practicing teachers.

The role of reflective practice in teaching and in educational research has a storied history (Urzua & Vasquez, 2008). The seminal work of Schön (1983) supports the use of reflection in action and reflection on action for practicing teachers and researchers. In the present study, the authors reflected in action (during the facilitation) and on action (in retrospect of the facilitation). Schön (1983) also noted that within a context, design could include reflective conversation with the context. The authors engaged in abundant conversation with the context (i.e., planning, assessment and instruction in the middle school classroom). A useful description of reflection comes from LaBoskey (1997) who believes that the fundamental goal of teacher education is reflection, whereby individuals temper their judgments, replace unsubstantiated opinion, and move beyond the tendencies of their current circumstances so as to consider alternative interpretations and possibilities. From this foundation, LaBoskey expounds on three domains that constitute the construct of reflection. The first of these is the content that is to be reflected upon, along with the theoretical orientation of the reflective content. The second domain of reflection is the process by which rational and intuitive thought processes are brought to bear on the content under reconsideration. The third domain involves teachers' attitudes of open-mindedness, responsibility, and wholeheartedness.

Curricular Planning and Assessment Practices

Planning for instruction is the foundation of effective teaching (Kauchak & Eggen, 2014). This includes selecting topics, specifying appropriate learning objectives, choosing instructional methods and activities, and assessing student work. An integral component in planning is ensuring that curricular standards are being addressed and that instruction and assessment are aligned with the learning objectives outlined in the standards. Classroom assessment

should also be authentic in accordance with the skills and knowledges that students demonstrate during the learning process. In addition to planning for instruction, teachers need to deliberately plan for assessment before, during and after instruction. This has been identified as the instruction-assessment cycle and includes: (1) planning; (2) monitoring; (3) evaluating; (4) reflecting (Tierney, 2005).

Planning for curricular integration honors a combination of concepts and skills from various domains (Wiles & Bondi, 2011). To create an integrated unit of study requires teachers to draw on content knowledge and create connections across domains and skills to support students' learning. To develop a unit that integrates literacy and content-area curriculum, teachers need to choose a topic and a few associated big ideas that will be central to the unit of study (Tompkins, 2016). These big ideas are central understandings embedded in content-area curriculum. After identifying curriculum standards, instructional and assessment methods, resources (print and digital) should be selected based on how they support inquiry and learning of the big ideas. Students might be evaluated on how they use language in ways that are complementary to the processes and activities within a given domain. Integrated assessment addresses the realities that students are using language to make meaning, communicate, and create in a discipline (Brock, Goatley, Raphael, Trost-Shahata, & Weber, 2014). Academic vocabulary and differentiated learning should be attended to during planning through explicit instructional strategies (Brock et. al., 2014).

Literacy and Science Integrated Instruction

Over the past decade there has been a growing appreciation for the mutual benefit of integrating literacy skills into science content learning. Specifically, embedding literacy instruction (e.g., comprehension strategies) enhances both reading and writing skills and content area knowledge (e.g., science) (Duke & Pearson, 2002). This is particularly the case when literacy instruction addresses both receptive (i.e., listening, reading) and expressive (i.e., speaking, writing) language (McDonald et al., 2010). This is encouraging given the recent emphasis on the standardized and national testing of students' abilities to read and write informational texts, especially in the elementary grades (Moss, 2005). Moreover, reading to learn in the content areas such as science, builds domain-specific knowledge (Saul,

2006) that further bolsters vocabulary and comprehension of informational text (Hirsch, 2003).

However, teachers often separate the instruction of literacy skills from those skills required to be literate (Moss, 2002). They struggle to support students as they learn the processes of reading and writing while learning in a domain. This learning is essential as building and activating background knowledge and vocabulary in a domain such as science predicates the use of learning strategies and encourages students to read, write, and think like scientists (Fisher, Grant, & Frey, 2009; Fisher, Lapp, & Grant, 2007). Reading, discussing, and writing about informational texts should be seamlessly infused into content-area curriculum in a way that is representative to the disciplinary learning that is taking place. Additionally, engaging students in authentic tasks that are typical of the inquiry and learning in a discipline, supports domain-specific knowledge and vocabulary acquisition– these are significant challenges for teachers to accomplish (Parsons & Ward, 2011).

This was the focus of our comprehensive DBR professional learning project: to support middle school teachers to integrate literacy, science and technology to plan and implement an instructional unit of study through multiple iterations. This project involved various methods of data collection to derive at findings related to teacher change (Fazio & Gallagher, 2016) and student academic growth (Gallagher & Fazio, 2016), however, the current paper includes only findings related to the authors' experiences and learning with DBR during the iterations of the curricular integration project. Accordingly, the purpose of this paper is narrowly concentrated on the professional learning of the authors as a function of their reflection and collaboration while facilitating professional learning for practicing teachers. The research question that guided our inquiry into our experience and learning as DBR researchers was: What insights emerge through researcher reflections on a DBR curricular integration project that contribute to the professional learning of education faculty/ researchers?

Project Context

The middle school site (Grades 4-8 only) where this DBR study was situated is in a low- to moderate-socioeconomic demography in Southern Ontario, Canada. The total duration of the study was over the course of two academic

years (September-June). Participants were recruited from this school as it had several classes of the same grade level. Teachers are responsible for teaching all curricular areas (i.e., language, mathematics, science, social science, arts, etc.). The Grade 5 teachers involved willingly volunteered to participate and were motivated to design and implement an integrated literacy, science and technology unit. In Year 1, the authors and teachers met to build relationships, and to document teacher participants' instructional practices and their perceptions of effective integrated instruction. The authors facilitated discussions based on scholarly and practitioner oriented articles related to integrating literacy and science. By the end of Year 1, the two teacher participants had planned and implemented an integrated literacy and curriculum unit (*Properties and Changes in Matter*) that incorporated both digital and print-based text resources. One teacher did not participate in Year 2 as she was re-assigned to another school.

For the first half of Year 2, the authors met separately with the three teacher participants. The two teachers that were new to the project met monthly for the discussions similar to those at the beginning of Year 1. Concurrently, there were meetings among the authors and the Year 1 teacher participant to revise the instructional unit with additional multimodal instructional strategies and resources. In the middle of this Year 2 iteration, all three teachers and the authors met to review the designed instructional unit. The two teachers new to the project chose to use the Year 1 instructional unit, 'as is' without technology enhancement as they did not have easy access to additional classroom instructional technology and were less confident in technology-enabled instruction. Year 2 ended with a focus group meeting to debrief about the implementation of the teachers' respective units.

Methods

For this project, DBR was used as a theoretical and research framework. As a research framework, the iteration cycles of the DBR project offered opportunities for the authors to reflect on the activities. Given that DBR is descriptive and explanatory in nature (McKenney & Reeves, 2012), qualitative methods were employed for this study.

Participants

There were two Grade 5 teachers in Year 1: Linda (16 years' experience in the same board); and Jasmine (2 years' experience as a beginning teacher). Linda continued into Year 2 and was joined by Grade 5 teachers, Joanne (17 years' experience in various school districts), and Mitch (9 years' experience). These teachers were new to this school and on short-term teaching contracts.

The authors that facilitated this project hold complementary expertise related to teacher professional learning in science and literacy instruction. Xavier is a middle and secondary school science methods instructor with research experience in initial science teacher education and professional development for science teachers. He brings expertise of the Science curriculum (Ministry of Education, 2006) and instructional resources to the DBR project, as well as how to facilitate the learning of practitioners. Tiffany is an English language arts methods instructor with knowledge of the Language Arts (Ministry of Education, 2007) standards. Her research experience is in literacy assessment and instructional strategies as well as exceptional learners. The complementarity of the authors was an asset to the project as according to Kennedy-Clark (2015), a condition for the conduct of DBR research is that the facilitator(s) have the expertise and skills to create and execute iterations of the design and then objectively analyze the outcomes.

Data Collection

There is evidence of the use of journaling in both oral and written texts to archive and enhance the reflective process (Mortari, 2012). The present study employed both oral (i.e., debriefing discussions) and written (i.e., journal entries) reflection as a means to critically evaluate participants' interactions and as a method of data collection. Thus, there were two forms of data collected: researchers' debriefing (transcribed) discussions and journal entries. During the two years of the study, the authors met (half-day meetings) with the participating teachers to familiarize them with DBR methods, enhance their understanding of integrating literacy and science instruction and to plan the unit of study (see Table 1. for meeting and data collection dates).

After the meetings, the authors debriefed privately to discuss their interactions and the teachers' knowledge and beliefs about DBR and integration. There were no prompts for these discussions - they were open-ended expressions of how each of the authors evaluated the dynamics of the meetings. These debriefing meetings were 20-30 minutes in length and were audio recorded and transcribed. In keeping with the purpose of this paper, the focus of these discussions was on the authors' professional learning about how reflection drives collaboration. At the conclusion of each of the meetings, both the authors and participants wrote journal entries as a reflection on the collaboration process and the impact of the meeting on their practice. The journal entries generated by this process were also used as a data source for the study.

Table 1
Meeting and data collection dates

Year 1	Dec. 13	Jan. 31	Feb. 21	**Mar.4**	**Mar.26**	**Apr.22**	**May 6**	**May 23**
(Sept./13 -June/14)	*Linda + Jasmine*	*Linda + Jasmine*	*Linda + Jasmine*	*Linda + Jasmine*	*Linda + Jasmine*	*Linda + Jasmine*	*Linda + Jasmine*	*Linda + Jasmine*
Year 2	**Sept.18**	**Oct 28**	**Nov. 17**	**Jan.15**	**Feb. 5**	**Feb 12**	**Feb. 26**	Jun. 23
(Sept./14-June/15)	*Linda*	*Linda*	*Mitch + Joanne*	*Mitch + Joanne*	*Joanne*	*Linda*	*Linda, Mitch + Joanne*	*Linda, Mitch + Joanne*

FORM OF DATA COLLECTED: **Researchers' Debriefing Discussions**

FORM OF DATA COLLECTED: Researchers' Journal Entries

Data Analysis

The text from the journal entries and transcriptions from the debrief discussions were open coded by colour highlighting common meanings (see Table 2. for colour codes, categories, and analogies). The colour codes were labelled with nine meaningful phrases that the authors agreed were representative interpretations; text excerpts were then selected as quotes (Creswell, 2012). The interpretations were synthesized and sorted into categories that related to: the researchers' impressions of the teachers' practices; misunderstanding integration and disciplinary-based literacy;

researchers' experience of 'doing' DBR. These categories were independently identified by the authors who then came together to cross-confirm them and identify themes (Gay, Mill, & Airasian, 2012). Initially, the authors had varying labels for their respective categories, however, after prolonged discussion, they recognized that they indeed had analogous thematic meanings.

Considering the themes, the authors sought an image that would represent the nature of how their reflections illuminated the challenges and accomplishments of the collaboration. The authors then selected the poem, "Infinite Onion" (Faint, 2015) to frame their unanticipated learnings as an analogy and means to thematically present the findings. The categories were then translated into three themes based on the three phrases in the poem. The themes describe the insights that the authors experienced about the teacher participants' knowledge and practices of integration and the process of practicing reflection and collaboration while engaged in DBR. This was a trace of their professional learning as education faculty/ researchers. It should be noted that the researchers' acknowledge the inherent challenges of research on the reflective process and took the above measures to instill a degree of trustworthiness in the data analysis procedures.

Table 2.
Colour codes, catagories and analogies

Colour Code	Category	Analogy from Poem
light blue = researchers' impressions of teachers' planning skills red = researchers' impressions of teachers' assessment skills olive = researchers' impressions of teachers' use of resources (e.g., curriculum, print-based, digital) bright blue = researchers' impressions of teachers' pedagogies and classroom management	***Researchers' Impressions of Teachers' Practices*** (impressions of practicing teachers' planning, resource use, pedagogy and assessment)	**"The Surface Layer: Teachers' Planning and Assessment Practices."**
yellow = researchers' reaction to teachers' mis/understanding of integration green = researchers' recognition of the continuum of integration to disciplinary-based instruction	***Misunderstanding Integration and Disciplinary-based Literacy*** (realization that teachers misunderstand integration and they are on a continuum toward disciplinary-based literacy)	**"Gritting Teeth: Misunderstanding Integration and Disciplinary-based Literacy"**
gray = researchers' affordances/tensions of engaging DBR instead of directives pink = researchers' evaluation of their role/relationship with the teachers dark navy = researchers' gauging the perceived benefits of DBR	**Experience of 'doing' DBR** (experience of DBR as researchers, teacher educators and teachers)	**"Getting to the Bottom Layer: 'Doing' DBR"**

Findings

The three themes that were distilled from the data analysis emulate the message in "Infinite Onion" verse (Faint, 2015). The first theme is our acknowledgement of the layers that needed to be peeled back to understand teacher participants: "The Surface Layer: Teachers' Planning and Assessment Practices." The second theme, "Gritting Teeth: Misunderstanding Integration and Disciplinary-based Literacy" is our realization that the teacher participants were novices with respect to understanding and practicing integration. Finally, we reflected on the value of "Getting to the Bottom Layer: 'Doing' DBR" as a research method and as professional learning facilitators.

The Surface Layer: Teachers' Planning and Assessment Practices

Scaffolds for planning

The first year of the study was dedicated to curricular planning and the first implementation of the integrated unit. It became apparent after meeting with the two teacher participants that they were not consistently planning in advance. Interestingly, this was the case for both Jasmine (novice teacher) and Linda (veteran teacher). This was the first reveal after peeling back a layer in an attempt to understand our participants' practice. We ascertained that the teachers needed a planning organizer as a scaffold to ensure that they included the necessary pieces for the curricular unit. This would lay the groundwork for subsequent iterations of the unit and provide documentation of the design process. Xavier speculated that this trace would convince the teachers' of the value of planning.

> Tiffany: They need a scaffold.
> Xavier: A unit plan organizer [to prompt their] assessment? What are you going to do here? What are you going to collect? …Maybe, we can put together resources that can be used for unit planning…an organizer…I think that's what they have to do. (Discussion, Year 1, March 26)

What caused us to take pause was the fact that these planning skills using unit organizers were what we were teaching to our teacher candidates. Tiffany compared their planning to the beginning skills that teacher candidates have; specifically, Tiffany remarked that Jasmine should have these planning skills as she was a recent graduate of teacher education. Referencing our provincial context, this caused us to further question: Is the practical application inadequately covered during teacher education? Does the disconnect between theory and practice ever unite in classroom practice?

> I feel like I'm in October of my classes and I'm talking about this alignment and coherence…The course is just beginning… but then it starts to take form, as they [teacher candidates] start to hand in their first drafts of their units. 'Ah ha' moments come. (Tiffany, Year 1, May 6)

In situ, we acknowledged that our focus for the DBR study had inadvertently shifted to support the teachers' professional learning in curriculum and unit planning. Xavier acknowledged that we made presumptions about the teachers' knowledge of the backwards design planning process. We came to recognize that an unintended outcome of the study would be supporting the teachers' *general* planning and assessment skills. We agreed that the project had become a realization of the teachers' need to align curriculum, instruction and assessment.

> Xavier: I think we are also measuring the impact of their ability to effectively align their structure with the assessment with the curriculum.
> Tiffany: The project is becoming more of that than it ever was.
> Xavier: Well. It's more than I expected… we made presumptions about their understanding with regard to curriculum, instruction and assessment. (Discussion, Year 1, May 6)

Despite the passage of time, in Year 2, the veteran teacher still did not demonstrate systematic planning when considering how to include technology-enhanced resources. We recognized that she needed our support to filter the purview of resource choices. Again, as DBR researchers we grappled with the planning scaffolds we chose to erect vis. á vis. adhering to the principles of DBR design and the original intent of this project.

The next layer: assessment skills

After peeling back the first layer and uncovering the teachers' lack of planning skills, our attention was drawn to the layer below this: assessment that drives planning and instruction. We recognized that basic assessment skills and strategies undergird the notion of integrated assessment. It was obvious that both Jasmine and Linda neglected to identify the core ideas that needed to be assessed in the integrated culminating task.

> Actually creating an integrated assessment plan may be challenging. In other words how does their evaluation go to a language arts mark versus a science mark versus used for both? That's how they struggle. That's challenging. That's not easy to do, but unless you are clear on the curriculum measures, they almost can't go there... Common assessment tools have to line up together and we may have to remind them...[the culminating task] doesn't address all the key ideas in the unit. (Xavier, Year 1, March 4)

Xavier ascertained that the teachers held basic assessment skills and this was why assessment was not used to guide their planning. They did not have the readiness to use formative assessment to make instructional decisions based on assessment data. Again, Xavier related this back to our experience in the teacher education program.

> The other aspect I am noticing is that they don't have a schema for planning, unit planning, or using assessment as a driver for planning nor are they doing a good job linking assessment with their expectations. This is the kind of stuff that we cover in teacher education programs and in teaching methods courses. They don't have an idea of how to do this. (Xavier, Year 1, March 26)

Background knowledge was provided to discuss the creation and use of assessment tools and we noted that the teachers had difficulty operationalizing criteria for the processes and products of integration. We speculated that without prompting and support that the teachers would not have created a rigorous assessment tool for this unit.

> Xavier: They clarified some of the challenges that they had [with the rubric] which I thought was really good. I liked that they went through some of the potential pitfalls that could happen and started to think more about it [the rubric] . They were aware where students struggle and what they may need prompting on, what they can do well.
> Tiffany: If we wouldn't have been here this afternoon, if we had not interrogated each word and each criterion [in the rubric], how would they've used this draft rubric? (Discussion, Year 1, April 22)

Influence of instructional resources

There was an unanticipatedly 'tough layer' beneath the planning and assessment layers: instructional resources. The influence of this layer on teachers' practices was salient and almost impermeable. As DBR researchers we had the perspective to objectively evaluate the role of instructional resources, whereas, the teacher participants seemed to be ruled by them. In the initial planning, the two teachers were attracted to practical, easily implemented resources and were less likely to look to standards documents for instructional design principles.

> We brought a cross section of different types of resources: professional development resources, trade books, resources that claim to be integrating science and language, ones that focus on aligning children's books with science topics, etc. They gravitate towards very practitioner-friendly, ease of reading, visuals at-a-glance. This speaks to how they consume educational concepts and ideas and they only consume things visually or things that are in one page format, almost like students reading webpages (Xavier, Year 1, May 6).

After the first year of work, after months of revision and prior to the second iteration, Linda had integrated digital resources meaningfully into her unit to augment the language experience and enhance her science instruction.

> I'm starting to see her recognize the opportunities to enhance both the literacy aspect of her teaching [with ICT]. She is using digital books, multimodal digital books, augmenting reading with materials, videos, etc…She's enhancing some of the comprehension

> inadvertently and using multimodal texts for science outcomes... I'm starting to see the potential that ICT has to disrupt [pedagogies]… I still see it as an augmentation of the existing overarching pedagogical model (Xavier, Year 2, Feb. 12).

In Year 2, a paradoxical situation came to light when Linda shared the integrated unit with the other two teacher participants (who had not contributed to its inception). Despite all of our work with Linda in integration and assessment, she focused with the new instructors on how to use the instructional resources. This was disappointing to Tiffany as she held expectations that Linda would lead her teacher colleagues in understanding integrated curriculum methods.

> The unit was in the organizer that we have been referring to for over a year now, but Linda centered in on the books from the kit, the websites, the videos. She did not talk about pedagogy. She did not talk about integration. I think she used the word 'language' once. She did not talk about assessment, until I kept prodding her to do that. So I was disappointed with all the time that we spent with her and it came down to: here's the resource; this is how I used it, how I displayed it or handed it out to the kids or I did centres with it. And Joanne and Mitch didn't seem to want any more either… she gave them, what she knew they needed. (Tiffany, Year 2, Feb. 26)

Gritting Teeth: Misunderstanding Integration and Disciplinary-based Literacy

What really is literacy and science integration?

At the beginning of Year 1 of the project, we as DBR researchers quickly realized that the teachers' understanding of integration was superficial despite their teaching experiences. Their integrated curriculum knowledge was tacit and not conscious; it was like a thin onion skin layer. Consequently, we abandoned our plan to begin with discussing *how to* integrate science and literacy to *what is* integration in science and literacy. This entailed providing examples, video segments and concrete tools for curricular integration.

> They are starting to make more deliberate links between the science program and the language program. I started to wonder today what is prompting this? I really believe that it is having them examine the curriculum that really gave them a concrete language or description of what is writing, what is reading, what is communication and how is this manifested in the science program (Xavier, Year 1, March 4).

In the initial planning of the unit, both Jasmine and Linda were still designing parallel tasks for literacy and science and not integrating the two. Tiffany conjectured that in general, teachers are not emphasizing the transfer of reading and writing skills into content areas. She was also bothered by the surface level integration of oral communication – there were many opportunities for rich discussion in the unit plan that were not realized by the teachers.

> I noted this in my reflections: they don't see the opportunities or value how much language richness that's here [in the unit plan activities]. For example, are they going to have their students ask their peers questions after they've done their PowerPoint presentations? (Tiffany, Year 1, May 6).

After Year 1 implementation of the unit, Xavier and Tiffany concluded that these teachers were able to enact some curricular integration. Xavier believed that the teachers were internalizing the principles of integration, however, supporting the application of the students' knowledge was difficult to foster when the students were being taught with basic knowledge transmission methods.

> I think I'm starting to come to the realization that teachers in general are not able to do a full integration with language and science, but they can do a partial integration. This [unit plan] is a good example for partial integration, but other aspects have to be planned for accordingly. (Xavier, Year 1, May 23)

We were encouraged to hear that one of the teacher's students had difficulty distinguishing between science and language arts instruction - this was evidence that there was integration happening in this unit.

> Tiffany: Those comments from the kids, "Are you doing science today? Or is this language arts?"
> Xavier: Perfect…It was just telling…If the students don't even know what subject, it's revealing the [student] experience that it's happening. I think that this is at least giving evidence that they [the teachers] are attempting to integrate and making some kind of blurring of lines [between science and literacy]…It's good, that bit of ambiguity. (Discussion, Year 1, May 6).

As Year 2 of the project commenced, we were optimistic that the time that the teachers had spent planning and implementing the first iteration of the unit would position the veteran teacher to further enhance her curricular integration with technology. Linda still lacked appreciation for the conceptual models of integration and the hands on experiences in science that could enhance communication.

> Investigations, experiences, activities, rather than just looking at it through a video is really is critical for science and I am hoping that she [Linda] modifies her unit to find that. I think that is really critical…I mean, it's just a missed opportunity. It links to literacy because the hands on experience [in science] is exactly what literacy researchers talk about when they say things like 'gesturing' or 'linking multi-modalities using touch screens.' (Xavier, Year 2, Sept. 18).

Our experience in the first year of the project inoculated us for the integration unfamiliarity of the teachers at the beginning of the second iteration of the project. Tiffany perceived that Mitch and Joanne had a surface-level conceptualization of integration and their practices were low on the continuum of integration.

> They [Mitch and Joanne] say one thing, but they practice another. They talk about authenticity and student experience, but then they say this list of words comes from this place [graded word list] and students have to learn them and I'm testing them. (Tiffany, Year 2, Nov. 17)

We recognized that we needed to meet the teachers on common integration ground: they were comfortable discussing their practices in

teaching content-based vocabulary. Yet, we noted that their vocabulary instruction needed to address the challenges in science-based words and explicitly teach students how to spell them.

> I mean, conceptually, it does not matter how you spell it… here we are trying to bring [students] into a world, an area of science, yet they we don't encourage them to learn the language. We want to let them have the experience…but we are putting our students at a disadvantage by us not identifying the words. (Xavier, Year 2, Nov. 17)

Given our position as educational researchers and teacher educators, we had the perspective to compare and evaluate the two iterations of the unit. In the first and second iterations of the unit, there was a lack of explicit instruction in oral communication as a means for students to articulate what they were learning when engaged in science. Xavier speculated that the teachers regarded oral communication as a deficit default: it is what students do when they can't read or write.

> Tiffany: There were lots of times kids were talking to their elbow partner [peer] and, you know throwing things [ideas] around…But the teachers didn't acknowledge it.
> Xavier: But I think they are using it in a different way, though. Linda and Jasmine were using oral communication as a way to enhance students' communication…I think they are using it as an entry level for them [students] expressing…it doesn't mean it's productive unless you tie it to writing, reading, oral and visual communication… It doesn't matter if it's hands on. It can be hands on, and mentally off. (Discussion, Year 2, Nov. 17)

The hard work: disciplinary-based instruction

After two years and two iterations of the DBR process, we came to the realization that the teachers were just beginning to integrate and are far off of disciplinary-based literacy. Why? Xavier conjectured that only partial progress was made because of the teachers' lack of knowledge of curriculum. He generalized that Linda is like most teachers who are aware of distinctions

between disciplines and they are challenged to integrate disciplinary content and pedagogical knowledge.

> I think the concept of integration is a difficult concept for teachers. I don't think a lot of teachers know how to integrate. I think they understand that it involves many levels of thinking about the discipline as well as the pedagogy behind these disciplines. You have to integrate both the disciplinary knowledge as well as pedagogical knowledge of these two areas and that is challenging to do. (Xavier, Year 2, Sept. 18)

Xavier concluded that the teachers involved in this project needed an assessment of their pre-integration skills as a foundation to begin to embrace integrated instruction pedagogies. He drew a comparison to his teacher candidates who are learning how to use a curriculum standards document and explicitly connect its components across domains. Xavier believes that the lack of basic integration pedagogies reveals the professional development shortcomings in the school board. This DBR project is a test of the classroom system to see how it responds to curricular innovation.

> I'm thinking of a self-diagnostic instrument that teachers could use to assess their ability to integrate. I think that it would be an important tool because good teachers are struggling in particular areas and these are points that they have to be reminded about. Until we can get over the basic knowledge clusters of assessment and instruction and discipline similarities and differences, we can't move forward. We are stuck. (Xavier, Year 2, Feb. 5)

We resigned ourselves to the conclusion that some progress was made: a few layers of the onion had been peeled back to reveal a few realities. In Year 2, the second layer of ICT integration was aptly timed as Linda needed the first iteration opportunity to begin to integrate science and literacy. There was also a re-calibration of the goal of this project: we recognized that it had become a study of teacher development on the continuum of integration and the hard work of disciplinary-based instruction had not yet begun.

> I'm convinced that integration in general is such a high order skill for teachers that it needs a lot of prior learning for teachers to do it

> effectively. It is not innate by any stretch of the imagination. This is a challenge. (Xavier, Year 2, Feb. 12)

Getting to the Bottom Layer: 'Doing' DBR

Sticky layers: the tensions of DBR

Our roles as DBR participants and authors created tension throughout the two year study; there was some resolve at the end of Year 2 that is described below. In particular, at the beginning of Year 1 it was difficult to define our roles and function in light of what we perceived that the teachers needed to be provided with to effectively design an integrated unit. Xavier identified a boundary that he had as a DBR researcher: to step in and provide the teachers with clarifications about content and/or pedagogy when they demonstrated misconceptions. We struggled as DBR facilitators to provide the background knowledge and supports that we could see that the teachers needed, without directing or lecturing them. We opted to create a repository of digital resources for teachers to access and we hoped to guide them there for self-directed support. In the end, this repository was not accessed, and used only for the transmission of information from the researchers. The DBR process was particularly arduous for us as researchers given the reality that these teachers were not self-regulating their own professional learning.

> Xavier: I'm sometimes frustrated by wanting them to follow some key ideas with respect to integration…We try to bring it in subtly…with the videos, and question prompts or resources that we're providing on the learning management systems. In terms of their knowledge of integrating, I still see a lot of work and learning that is required. I think we have enough good resources to get them going.
> Tiffany: We talked about this weeks ago: the tension around spoon feeding [them] too much [professional knowledge] versus letting it go where it goes and realizing that it might not going the right way…I don't think there is one right way. (Discussion, Year 1, March 4)

We both recognized that capturing the teachers' unit planning process is not just for their instructional purposes, but importantly this is also an artifact

for us to use about the DBR process. Xavier saw that the Year 1 iteration of the unit was somewhat of a pilot test given the teachers' basic planning skills – it was essential that this baseline and the change process were captured.

> I was under the assumption that they could develop fairly robust units by the end of the [first] year ready for implementation, but they are just going to be developing a baseline unit which is still going to need more improvement. (Xavier, Year 1, March 26)

By the end of Year 1, we came to the realization that the DBR process will take time to encourage teachers' creativity and reflection prior to rolling into a second iteration. This was recognized by Tiffany as an affordance of doing DBR without a tight timeline: the latitude to discuss and reflect. Xavier added that the DBR process does need an end goal in mind and some non-negotiable factors.

> Xavier: We do have the luxury [of time] but if you don't give time to plan accordingly, you are never going to be come up with a plan with a successful product.
> Tiffany: No, it's 'half baked.'
> Xavier: It's incomplete. I think this speaks to some of the DBR challenges in our research. They [DBR authors] always warn about giving it time to happen… Don't rush it through. It is not about trying to get things in to get it complete because you miss opportunities for learning. You miss opportunities for creativity. You miss opportunities for enhancement. So, I like that it [our study] is not rushed. (Discussion, Year 2, Oct. 28)

From experience, we learned of the importance of pacing and building in time to let the teachers control their own planning, practice, and implementation evaluation. Linda benefitted the most of all the educators from the multiple iterations of the intervention and the opportunity for her to make her own decisions for digital enhancements that she felt comfortable with. We underestimated how difficult it would be as DBR researchers to relinquish some control back to the participants and not intervene during the conduct of the meetings.

> It [DBR] just moves it forward... in an evolutionary way…Good work takes time. We planned accordingly. I think that is important with the DBR process to have an end in mind, and a design outcome of what you are trying to accomplish… We knew it had to involve these features: integration of technology, literacy and science…We could have easily identified the [tablet] app best suited for knowledge construction, student appropriateness. I think we have the schema [about integration]…I don't think she [Linda] does. (Xavier, Year 2, Oct. 28)

Elastic layers: responsiveness to the teacher participants

We note that it was not until after the fourth meeting that the two Year 1 teachers were developing rapport with us as researchers. Into Year 2, Tiffany recognized Linda's comfort in working with us as researchers and the relationship that took almost an academic year to develop. We became aware of our implicit influence on the conversations during our meetings with the teachers. We moved in and out of active participation within the discussions as a response to how the teachers were interacting with each other and with us. As illustration, Xavier perceived that the teachers were looking for validation from us of the rubric that they had completed. Tiffany adopted an alternative stance: the teachers should be given more time to discuss things together without the researchers hovering.

> Tiffany: I think it was after the first rubric was revised, there was kind of let's turn it over to them [the researchers] and see it's ok. So I got this little bit of this power dynamic thing.
> Xavier: It's hard to avoid it. The only way would be to let them work on their own. I suggested that they didn't have to do it all today. Talk on your own, don't talk in front of us. I think there's bit of power dynamics. I don't think it's bad. I just think it's there.
> Tiffany: I think we need to give them that space that they need.
> Xavier: At the end when we do the final interviews, we should ask them about the process. Did you feel uncomfortable in anyway about how it worked out because we can certainly modify our role? (Discussion, Year 1, March 26).

We recognized that conduct between us and the teachers was influenced by the teachers' commitment and dedication to the DBR process. Our approach for working with the second year teachers was different based on what we gauged as a need for their immediate buy-in. Joanne presented as more invested in the DBR process than Mitch and this was evident in her open-minded, talkative contribution during a meeting that the researchers had with just her. The dynamics of working with the teachers who are on different trajectories was a consideration that evolved as the researchers worked through the study.

> But think again of doing it differently [with the Year 2 teachers]…Giving them an example of a unit and a rubric and asking them to critique that…it is how they approach professional learning…Why they are so against theory? They will look at an article about integration, regardless if it is written for teachers, and they will say, 'Oh, that is so theory based.' But they are not seeing it for what it is because their lens, their perceptual filter, is always focused on the immediate and the practical. Then interrogating it backwards from that point is not a better way to go. (Xavier, Year 2, Oct. 28)

Apex of the onion: perceived benefits of DBR

While engaged in the process of doing DBR with the teacher participants, we came to recognize that the iterative steps that are necessary for enacting DBR, were assistive to the teachers' planning and unit revisions. Moreover, the teachers' planning discussions and unit drafts were needed to archive as concrete evidence of the DBR process that we were observing. The fit among the theoretical framework, research method and the intervention was perfectly aligned.

> We are doing this unit planning now, because it's going to prompt them to get a better unit done before they have to implement it. I think the quality of the work is going to be much better and the DBR design prompts you to do prototypes - try out the effect. Where does it [the unit] stumble? How does it work? Let's do it again. What needs improvement? I think all of these will help create a better

> quality product before we look at its [the unit's] implementation in the classroom. (Xavier, Year 1, March 4)

Involvement in the DBR project forced these teachers to activate their prior knowledge, challenge their beliefs and assumptions and use resources in a meaningful way. We perceive that the teachers have benefitted from the time to talk about their students and their teaching and that this reflection opportunity is a positive by-product of the DBR process. We noted that a benefit of DBR is that both novice and experienced teachers professionally benefit from the process.

> I don't think enough teachers actually take time to reflect on what they did and how it went. I think the forum that we provide gives them that opportunity to help them to grow once they reflect on their priorities... You can imagine what teachers are not getting if they don't get themselves involved in some professional development opportunity. How would you expect any teacher to simply integrate science and literacy without having any schema, and how to do that? And if they even want to do it where would they look? Who would guide them? (Xavier, Year 1, May 6).

Xavier evaluated the work from the past two years and contends that he has the perspective to propose a model for professional development in integration. This model requires a professional self-assessment of integration readiness.

> I believe that we have enough evidence to come forward with a professional development model for integration. I think we really saw a connection to identify the gaps in what teachers know and don't know. We can at least identify criteria that would exemplify knowledge, simplify process, [perhaps] a scale of some sort. I think we have a model based on what we've seen in terms of growth and lack of growth and what the teachers are focused on and not focused on...The conceptual piece is tacit…I think we can ask them to self-assess in particular categories and if they are honest, I think we can get a lot of feedback *if* [sic] they self-assess (Xavier, Year 2, Feb. 26).

Discussion

As authors, we have reviewed the process of engaging in DBR and reflected on the multiple layers of meaning that we have learned from as education faculty and educational researchers. Perhaps, we have learned as much as our teacher participants? Our learning began when we were awakened by the awareness that our teacher participants were not using general planning and assessment skills or meaningfully selecting instructional resources. This neglect was despite their practical experience and their common initial teacher preparation that does cover backward design in planning. Not surprisingly, the teachers needed prompts, scaffolds and supportive recommendations to lay the foundation to curricular integration. This drove the nature of our collaboration with them. Indeed, the process of enhancing teacher participants' knowledge of how to implement curricular integration in science and literacy is a topic that we discuss further (Fazio & Gallagher, 2016). Herein, we are expressing how our learning is extended to now recognize how DBR researcher reflection is a valuable component to establish a collaborative foundation for DBR.

Next, we came to realize that the teacher participants were novices with respect to understanding and practicing curricular integration. Over the course of two years, integration began to take form with one of the teachers; the second cycle was necessary to further enhance the integrated curriculum unit and layer technology enhancements. It was evident that these stages were necessary as the veteran teacher required time to understand the principles of integration and implement the unit before it could be further and meaningfully enhanced. This is noteworthy as few DBR studies engage in multiple iteration cycles and cannot provide rigorous recommendations on how to revise the studied intervention (Zheng, 2015). We learned that there is a continuum of integration and the teacher participants were inching along this line, but there was still a distance to go to get to disciplinary literacy.

Finally, our most salient learnings were a function of the tensions of acting as DBR researchers who are teacher education faculty and professional learning facilitators. With this background experience, we were tempted to provide the teacher participants with the knowledge that would inform their professional learning. Instead, we retracted and allowed them to somewhat self-direct their own planning, practice, and implementation evaluation. According to Kennedy-Clark (2015) this flexibility in design

affords DBR researchers the opportunity to improve and further understand the problem intervention. Moreover, the inclusion of participants with varied expertise contributes to the effect of DBR projects: this is a lesson learned for education faculty/researchers. We discovered the relational dynamics of working with teachers who are on different professional learning trajectories. In this present study, Linda's prior experience and knowledge was honoured, and she was encouraged to support the reflection and evolving practices of her novice teacher colleagues. As recommended, part of this process included time to reflect on their differently evolving practices, their planning and their future instructional goals (Urzua & Vasquez, 2008). This dedicated time is integral for such experienced teacher participants as Linda to model and scaffold novice teacher participants. When designing a DBR intervention, we learned that the prior experience of the teacher participants might be first assessed and then considered as the participants assume active roles in their collaborative. Then veteran teachers should be given the opportunity to scaffold the professional learning of their novice teacher colleagues. At times, this was a challenge for the authors when they held different beliefs about integration of resources and instruction.

On the whole, we regard the significant benefit of engaging in DBR is not only the authenticity of the process and outcomes for practicing teachers but also the professional learning of education faculty/ researchers. When a context relevant goal is pursued through collaboration between teachers and researchers, the process and outcomes can be transformative and rewarding (Burke & Burke, 2007). In our study, the teacher participants' gradual responsiveness was typical as teachers are often sceptical about the value of educational research that is not overtly practical (Broekkamp & Van Hout-Wolters, 2007). By contrast, practicing teachers do value DBR work, particularly when researchers form professional learning communities with them (Vanderlinde & van Braak, 2010). The teacher participants in this study expressed their appreciation for the value of DBR as impactful on their practice.

After two years of working at this school-site, we too, came to respect the utility of DBR as a theoretical framework, research method, professional learning intervention and facilitative of our own professional learning. As we now contemplate our professional learning, we express the integral role that reflection in DBR plays in the collaboration between teachers and researchers - this holds potential to be impactful on our practice. As education

faculty, we need to be willing to allow the DBR process and its participants teach us as researchers.

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