

SCIENCE TEACHERS' CONCEPTIONS AND EFFICACY OF ASSESSMENT

**Exploring Science Teachers' Conceptions and Efficacy of Assessment
in Manitoba Schools: A Case Study.**

By

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Abstract

Contemporary classroom assessment practices have been identified as a promising pedagogical approach to improve students' learning and the development of their metacognitive skills; however, the complexities inherent in assessment point towards the need for careful consideration of the educational context of such practices, as well as the numerous factors influencing teachers' assessment practices. Research has established that such factors include teachers' conceptions of assessment, particularly in terms of the purpose assessment plays in the classroom and teachers' perceived self-efficacy. In science education and particularly in Manitoba, there is an opportunity to further investigate the relation between these concepts, especially since the publication of some provincial guidelines on assessment a little more than a decade ago. The purpose of this multiple case study research is to provide insights into three Manitoban high school science teachers' conceptions of assessment, classroom assessment practices, and their perceived self-efficacy in developing and using contemporary assessments in their science classrooms. The data from one-on-one interviews with the three teachers and the assessment artifacts they shared were analyzed using qualitative content analysis. Results corroborate literature that indicates a strong connection between assessment conceptions, perceived self-efficacy and classroom practices, and suggest an interesting relationship to provincial assessment recommendations, despite teachers' stated unfamiliarity with one of these documents. Implications of the study for science teacher's practices, science education, policymakers, and future research are presented.

Keywords: assessment, self-efficacy, science education, Manitoba

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Dedication

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Chapter I - Introduction

The growth in accountability and standards-based education movements in some parts of Canada has influenced the need for increased teacher competencies in assessment and evaluation (Klinger, DeLuca, & Miller, 2008). In recent times, assessment use has advanced from traditional classification and sorting of students to include teaching, learning, and accountability purposes (Gordon, 2008). Accordingly, assessment may be summative, that is, used for establishing the extent to which students have mastered information, “to measure students’ achievement,” or “informative,” (Mussawy, 2009, p. 1), to improve and design instruction (Danielson, 2008). In addition, excellent assessment processes assist teachers in drawing precise judgements about individual student accomplishment, transmitting such information to students and parents in an understandable form, and directing further instruction towards functional knowledge (Earl, 2003). Using classroom assessment inappropriately often has negative implications on its validity and reliability, leading to improper and misleading educational decisions (Brookhart, 1999). Therefore, DeLuca and Klinger (2010) opined that 21st century teachers require adequate assessment literacy to implement assessment strategies that would improve teaching and learning.

Although assessment has been affirmed as a strong element in the instructional process, the range of assessment strategies utilized by teachers in practice was more limited, according to research conducted in the early 2000s (Goodrum, Hackling, & Rennie, 2001). More recent research indicates that teachers employ a variety of strategies, even though frequencies of use differ based on the assessment types teachers are comfortable with and jurisdiction policies in existence (Chu & Fung, 2018). Particularly in science education, efforts to improve assessment

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strategies used in K-12 science classrooms have been advanced, however, significant use of such efforts to improve practice have been unprogressive (Shepard, 2000).

In Manitoba, teachers are encouraged to follow the document *Rethinking Classroom Assessment with Purpose in Mind* (Manitoba Education, Citizenship and Youth, 2006a). As a foundation for Manitoba assessment initiatives, this document was developed to assist teachers in “assessing their students effectively, efficiently, and fairly, communicate assessment information accurately to students and parents, and to serve as a basis for designing professional learning” (Manitoba Education, Citizenship and Youth, 2006a, p. vii). Since the publication of this document, based on my search results, no independent investigation of Manitoba teachers’ assessment practices has been conducted in science education to explore whether the advent of the recommendations put forward in this document had any practical impact on science classrooms in this province.

Outside Manitoba, the literature indicates that several factors seem to be responsible for teachers’ classroom assessment practices. Such factors include influences from pressures generated from standardized test reforms, teachers’ confusion over the purposes of assessment due to school and student accountability reasons, and teachers’ pedagogical views of teaching and assessment (Aydeniz, 2007). Likewise, in science education, teachers’ assessment practices are often determined by their “epistemic views of science, pedagogical conceptions, and conceptions of assessment; and the cultural and political influences on their conceptions and practices of assessment” (Aydeniz, 2007, p. 5). Thus, in terms of assessment, what happens in classrooms is the result of a complex interaction of personal and institutional factors that require careful investigation and is both time and place specific.

Statement of the Problem

Teachers' classroom assessment practices have been well studied and documented in the literature; however, while there exists a wealth of literature on assessment and science learning, science teachers' conceptions have not been extensively researched (Bell, 2007). Literature on science teachers' conceptions and perceived self-efficacy in developing and implementing assessment is limited and, where found, such studies are out-dated given contemporary reforms in education. In addition, the existing studies mainly examined pre-service teachers (e.g., Alkharusi, 2009; Huai, Braden, White, & Elliott, 2006; Ogan-Bekiroglu, 2009). In terms of methodology, research conducted on teachers' conceptions of assessment in various disciplines has utilized quantitative approaches (e.g., Alkharusi, 2009; Brown, 2006; Brown & Remesal, 2017; Lam, 2019; Levy-Vered & Alhija, 2015), including those in science education (Ogan-Bekiroglu, 2009) and qualitative approaches (e.g., Lam, 2019; Leong, 2014; Remesal, 2011).

Given the lack of current studies focusing on in-service science teachers' conceptions and perceived self-efficacy of assessment specifically in Manitoba, there is an important lacuna to be filled in science education research on assessment in this province, particularly since the introduction of assessment reform initiatives, and given suggestions that teachers often do not rely on policy documents in their assessment decisions (Alkharusi, Aldhafri, Alnabhani, Alkalbani, 2012; Aydeniz, 2007), as well as the context-dependent nature of teachers' conceptions and practices of assessment (Opre, 2015). Therefore, there is a unique opportunity to explore, through a qualitative case study investigation, Manitoba science teachers' conceptions and practices of assessment and the potential connections between these and their perceived self-efficacy of assessment.

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I was motivated to explore these research questions from my experience of working with educators at K-12 and post-secondary levels in Nigeria and the United Kingdom. Having worked as a science and chemistry teacher and as a program/training administrator, I often found teachers struggling to conduct effective assessments even though they had very strong pedagogical and content knowledge. At the onset of their teaching careers, most teachers I have interacted with (myself included, when I started teaching) had little to no experience of assessment pedagogies and, in most cases, they rarely participated in professional development programs on how to effectively assess students' learning. Hence my interest in exploring teachers' experiences in the classroom with regards to assessment in Manitoba, where the current curriculum documents emphasize formative assessment and assessment as learning (Manitoba Education, Citizenship & Youth, 2006a), as opposed to the previous emphasis, which was placed on assessment of learning. Furthermore, I believe that to assist Manitoba science teachers in advancing their classroom assessment practices, there is a need to understand their conceptions of assessment and their perceived self-efficacy in developing and implementing assessment, according to the expectation of provincial curriculum documents, as research has already established that both conceptions and perceived self-efficacy influence assessment practices (Alkharusi, Aldhafri, Alnabhani, & Alkalbani, 2014; DeLuca & Klinger, 2010; Opre, 2015).

A literature search for assessment related articles guided my inquiry towards what could be teachers' barriers to effectively assess students' learning using recommended, contemporary practices. There, I came by the works of Brown, DeLuca, and other researchers in the field of assessment. Having identified that teachers encounter various dilemmas while adopting and engaging in the use of contemporary assessment practices in classrooms, DeLuca, Luu, Sun, and Klinger (2012) collated barriers to effective implementation of assessment for learning: "(a)

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misalignment in educational and assessment priorities; (b) conceptual confusions; (c) differences in letter and spirit of AfL [assessment for learning]; (d) teachers' and students' perceptions of AfL; and (e) practical barriers to integration" (p. 7). From these articles, I was challenged to find the accounts of science teachers' assessment practices and how they conceive of assessment, as well as their perceived self-efficacy to develop and use assessments, especially in the context of Manitoba, which has not received much attention in recent time. I was also curious to know Manitoban science teachers' reactions to the *Rethinking Classroom Assessment with Purpose in Mind* document (Manitoba Education, Citizenship and Youth, 2006a) after I read through the document and realized that it provides recommendations for teachers' classroom assessment practices that are aligned to contemporary assessment practice recommendations available in the research literature. However, several literature searches conducted in person and with a librarian on Manitoba science teachers' assessment practices yielded no result. This further strengthened my desire to research science teachers' assessment practices and how this relates to their conceptions and perceived self-efficacy within the Manitoba educational context.

Purpose of the Study

This research proposes to add to the body of literature on assessment in science education by contributing a qualitative investigation of in-service science teachers' conceptions of assessment and how these relate to their perceived self-efficacy in developing and using assessment, as well as their classroom assessment practices. Exploring teachers' conceptions and practices of assessment from an inductive and interpretive approach "allow[s] participants to speak their minds and bring their own voices to the foreground" (Remesal, 2011, p. 474). Moreover, given the multiple assessment purposes and the complexities of assessment implementation, an interpretive study of selected cases of science teachers who self-identify as

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passionate about assessment may contribute important insights into this area. Case study research designs have been argued to provide in-depth descriptions of participants' responses to research questions that seek to explore reasons behind particular actions (Gay, Mills & Airasian, 2009).

Thus, the purpose of this research is to explore the relationship between conceptions of assessment and perceived self-efficacy and practices of three high school science teachers in urban schools in Manitoba, who self-identified as passionate and innovative in their use of assessment in science classrooms.

Research Questions

The following research question guides this thesis: *What is the relationship, if any, among conceptions, perceived self-efficacy, and practices as these relate to classroom assessment in the cases of three Manitoban high school science teachers?*

The following sub-questions provide more specific direction to this study:

- What are the conceptions of assessment of these three Manitoban high school science teachers?
- How efficacious do these three Manitoban high school science teachers perceive themselves to be in the development and use of assessment strategies in their science classrooms?
- What are these three Manitoban high school science teachers' classroom assessment practices?

Significance of the Study

Teachers' conceptions of teaching and learning have a significant effect on the processes they adopt in supporting learning (Aydeniz, 2007). Researchers have also argued that teachers' conceptions account for the assessment practices they adopt in classrooms (Brown, 2002, 2004),

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which is also the case in science (Ogan-Bekiroglu, 2009; Remesal, 2011). Although the relationship between teachers' conceptions of assessment and the practices they adopt has been well researched, Opre (2015) argued that little has been done to research the type and strength of this relationship. To Opre, studies that address this relationship are important to open-up new research directions, which in turn could lead to "reconceptualization of the development process of the pedagogic expertise" (p. 232); that is, the findings of studies focused on the relationship between assessment practices and the various factors influencing these practices could provide insights for the development of new resources for training pre-service and in-service teachers. It is certainly my hope that this study will contribute a small part of the said insights.

Furthermore, as Aydeniz (2007) identified, science education initiatives are often comprised of curriculum, pedagogy and assessment components; therefore, it is important to explore teachers' conceptions of assessment in science to understand the influences on their teaching and assessment choices in classrooms. In light of Manitoba Education's recommendations for teaching and assessment practices (Manitoba Education, Citizenship and Youth, 2006a) further research on Manitoba science teachers' conceptions of assessment and perceived self-efficacy is called for.

Definitions

One of the key factors affecting students' learning is assessment. Dhindsa, Omar, and Waldrip (2007) contended that assessment is a vital element in teaching and learning, and defined assessment as "a systematic process of data gathering about students' progress" (p. 1261). Assessment has also been defined as a means by which teachers measure the extent of students' learning (Levy-Vered & Alhija, 2015). According to Liu (2010), assessment involves the gathering and interpretation of data following a systematic, multistage, and multiform

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process. Furthermore, assessment can be described from the perspective of its purpose, the types of methods and processes adopted, its validity and reliability, use of results, and its relationship to external school activities (Butler & McMunn, 2006). Also important in defining assessment is the description of its components in such a way as to highlight its planning, analysis, and effective implementation processes. According to Liu (2010), a combination of four components form assessment:

- 1) Data use: intended use of assessment results such as grading students, planning instruction, improving curricula, and comparing students;
- 2) Data collection: the target on which assessment data will be collected, such as student achievement, inquiry, ability and students' attitudes towards a subject;
- 3) Methods to collect data: the specific ways to collect data, such as paper and pencil tests, interviews, and performance tasks;
- 4) Users of data: people or organisations that will be interested in or utilize that data, such as students, teachers, and universities. (p. 3)

For the purpose of this thesis, assessment is defined as the process teachers engage in to adequately understand and document students' knowledge of concepts, skills and attitudes related to science education goals, with the purpose of improving students' science learning experiences and/or reporting on students' learning progress (Liu, 2010). Although teachers' personal definitions of assessment may vary, I believe the above definition accommodates most individual conceptualizations of assessment, while also reflecting definitions presented in the educational research literature on this topic.

Because the term assessment is used often in this thesis, assessment practices will be used to refer more specifically to concrete actions teachers perform in their classrooms when

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assessing. Thus, *assessment practices* involve the design, administration, use, and reporting processes to present information on students' knowledge and skills (DeLuca, Valiquette, Coombs, LaPointe-McEwan, & Luhanga, 2016).

Other terms frequently used in this thesis are defined as follows:

Conceptions: mental representations or ideas people hold regarding how an action or behaviour ought to be (Brown, 2002). More specifically, *teachers' conceptions of assessment* are those ideas and mental representations teachers have about what assessment is and how and why it should be used in classrooms (Brown, 2002).

Self-efficacy: a person's ability to perform certain actions effectively while leading to specific intended results (Brown, 2002). In this thesis, I will use the terms *teachers' perceived assessment self-efficacy* as the teachers' own account of their ability and self-confidence to execute effectively the goals they intend assessment to play in their science classrooms.

Assessment instruments: refers to any process, procedure or method used to collect information about students' learning experiences and skills (Brown, 2002).

Chapter II - Literature Review

Research clearly states that teachers' beliefs about instructional pedagogies are influenced by several factors (Brown, 2002; Kuusinen, 2016); similarly, the literature on teachers' assessment practices in education points out the myriad of factors influencing teachers' decision-making when it comes to assessment (Aydeniz, 2007; DeLuca et al., 2012). In an attempt to provide an overview of what is currently known about teacher's conceptions of assessment, their perceived self-efficacy and practices related to assessment, this literature review begins by highlighting the various definitions of assessment and its components, as described by educational researchers. In sequence, I synthesize scholarly discussions about the development of classroom assessment over time, and then, I present purposes for classroom assessment.

Subsequently, I emphasize in particular the Manitoba context on assessment, as this pertains directly to this study. Although some Canadian provinces collaborate through the *Western and Northern Canadian Protocol for Collaboration in Education* (WNCPE) to develop educational programs, each province develops their own curriculum documents and assessment policies alongside implementation strategies based on its unique context. Therefore, Manitoba assessment documents were reviewed to present efforts geared towards assessment advancement in general. Recommendations from the latest provincial reforms to science education and assessment are also presented. I then present an overview of recommendations for assessment in science education in Manitoba.

Continuing this literature review, I introduce a discussion of classroom assessment implementation practices, including specific information about these practices in science education, and the challenges to assessment implementation. Subsequently, I explore teachers'

conceptions of assessment more broadly, and follow with a focus on the context of science education more specifically. Further on, I present definitions and findings from the literature on teachers' assessment self-efficacy. Finally, teachers' conceptions of assessment models and assessment types are presented to provide a background for the analytical framework used in this study.

Classroom Assessment

In the past five decades, schools have witnessed restructuring processes due to cultural, societal, political, and economic influences; assessment of students' learning has not been left out of these reforms (Manitoba Education, Citizenship and Youth, 2006a). Researchers have argued that major influences on assessment policy and practice stem from societal and political sectors. For example, Bell (2007) identified that greater attention is being given to political views, which continue to demand developments in assessment practices. Such views emanate from stakeholders in education (government officials, teachers, parents, employers, and other school authorities) and influence how assessment is practiced in the classroom, its purposes, and how it is reported. Furthermore, in a review of trends in literature on assessment and political contexts specific to a number of countries, such as New Zealand and the United States of America, Bell (2007) emphasized the influence that politicians have especially on high stakes assessment, certification, and accountability of teachers, which have historically affected the assessment decision-making processes of many teachers.

The first developed educational evaluation approach, dominating educational systems up to the current day (Zeng, Huang, Yu, & Chen, 2018), was a form of assessment of learning that relied mostly on classroom tests and exams. For a large part of the 20th century, assessment was viewed and used as a means for providing learning evidence with a pattern of "teachers taught,

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tested the students' knowledge of the material, made judgements about students' achievement based on the testing, and then moved on to the next unit of work" (Manitoba Education, Citizenship and Youth, 2006a, p. 3). Classroom tests were majorly used to sort students into higher education programs, for educational decisions, and to communicate students' learning to parents, policy makers, and employers. Negative effects of assessment of learning of this kind on teaching and learning were reported from research conducted in the late 1990s (Zeng et al., 2018), arguing that summative assessments of this type principally focused on providing evidence, very little feedback, regurgitation of information, and had very little to no relevance for future classroom instruction. This resembles Paulo Freire's "banking concept of education" (Freire, 1993, p. 72), where teachers deposited knowledge onto students and expected students to regurgitate such knowledge as they were taught. In his book *Pedagogy of the Oppressed*, Freire argued for a problem posing education model, which promotes teacher-student communication, liberation, and praxis. To Freire, student-teacher communication and on-going dialogue allow students to take ownership of their learning and assist teachers in developing effective teaching pedagogies. Furthermore, a problem posing education model "enables teachers and students to become Subjects of the educational process by overcoming authoritarianism and an alienating intellectualism; it also enables people to overcome their false perception of reality" (Freire, 1993, p. 86).

The quest for a form of assessment to be employed during instruction, as opposed to the after instruction features of assessment of learning, resulted in the movement from assessment *of* learning to assessment *for* learning (Mok, 2010, emphasis added). Assessment for learning is used to provide effective feedback to students, to assist students in better understanding of the

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level at which they are learning, and by teachers to design instruction that fits each individual student (Bell, 2007).

Delandshere (2002) argued that, though researchers hold different perceptions regarding the use of assessment, the current school of thought is on the value of formative assessment for supporting learning. Formative assessment, primarily, is used for students' learning improvement (William & Thompson, 2008); moreover, among other things, it is used for planning and it is characterised as complex and highly skilled, interactive, purposeful, self-assessed and monitored, and majorly involves teacher professional development (Bell, 2007). Formative assessment involves "using assessment to inform next steps in teaching and learning; teachers giving feedback for improvement; (teachers) learning about children's learning; and children taking some control of their own learning and assessment" (Hargreaves, 2005, p. 213). It has also been defined as "the systematic process of continuously gathering evidence about learning" (Heritage, 2007, p. 141). Moreover, as McMillan and Nash (2000) highlighted, formative assessment is focused on improving teaching and learning processes, while summative assessment represents a rather competitively organized system where students and teachers are accountable for their performances.

Planning and development of future educational goals, and educational growth monitoring of students and teachers are purposes for adopting formative assessment strategies (Calveric, 2010). For Wiggins and McTighe (2007), formative assessment can be embedded into instructional processes, involves established forms and conventions, and sometimes involves student-designed techniques. Likewise, Chappuis and Stiggins (2003) identified that formative assessment is peculiar in its ability to effect sound student learning outcomes and the development of their metacognitive skills. According to Bell (2007), planning formative

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assessment involves sourcing, analyzing, and acting on assessment data for obtaining information about the learning progress of each student as specified in curriculum documents. Interactive formative assessment involves non-anticipated assessment practices that occur during student-teacher interactions such as noticing, observing, identifying, and responding during activities (Bell, 2007).

The interaction and convergence of teaching, learning, and assessment in school processes and the resultant discussions on formative assessment have received much attention in recent times (Dixon & Haigh, 2009). However, the importance of formative assessment to students' classroom learning had been emphasized much earlier (Black & Wiliam, 1998); results of the effective implementation of formative assessment have been shown to significantly improve students' learning and also reduce the achievement gap between low and high-achieving students (Black & Wiliam, 1998). The shift in discourse to formative assessment has redefined the roles and responsibilities of teachers and students with regards to assessment. At the onset, formative assessment was used by teachers and learners to define and establish learning goals, students' learning abilities, where students are in terms of a knowledge continuum, and how best to lead students towards achieving expected learning outcomes (Calveric, 2010). Formative assessment has been used by teachers to improve their instructional practices and by students to advance their learning, and it continues to evolve through improvements over the years (Zeng et al., 2018).

This continuous effort at critically refining formative assessment resulted in the inclusion of assessment *as* learning (similar to metacognitive assessment), which is characterized by students' active involvement in the appraisal of their personal learning experiences, employs metacognition, assists students in becoming independent learners and in connecting concepts

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they are learning through the integration of their assessment and their learning (Earl, 2006).

Assessment as learning involves teachers assisting individual students to experience learning by doing, understanding of concepts, present ideas in their own understanding, self-assessment, and providing constructive feedback to students (Dixon & Haigh, 2009). Assessment as learning is part of the learning process rather than a means of providing evidence through formative assessment (Dann, 2002). As Dann further argued, assessment as learning is guided by constructive learning principles, and it supports students in examining their learning experiences to further develop their active participation in their learning processes.

For some researchers, though, teachers have conceptually advanced their assessment practices to include assessment as learning; however, in practical terms, this is not the case (Dann, 2014; Torrance, 2007). For example, Torrance argued that “practice has moved directly from assessment of learning to assessment as learning, but this is justified and explained in the language of assessment for learning: providing feedback, communicating criteria to the learner, and so forth” (p. 291). Similarly, a substantial part of Dann’s (2014) argument for assessment as learning usage focused on blurring the boundaries between assessment and teaching in classrooms and the active engagement of students in learning processes. To Dann, teachers’ feedback to students needs to be minimally focused and less directive, and majorly concerned with how students understand and interpret such feedback, drawing “from their self regulatory and self-productive identities” (p. 149).

However, a critical review of Dann’s (2014) and Torrance’s (2007) studies indicate the practical challenges encountered by most teachers in the effective implementation and use of assessment as learning: to enhance students’ self-assessment skills. Furthermore, Aydeniz (2007) argued that policy developers believe few teachers have the capacity to explicitly use assessment

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to develop students' metacognitive skills; if that is indeed the case, then professional development initiatives should focus on equipping teachers with the tools needed to effectively develop and implement assessment as learning in their classrooms.

Over the last couple of decades, researchers have documented advances in assessment to include performance assessment, alternative assessment, authentic assessment, sound assessment, and non-traditional assessment (Bell, 2007; Butler & McMunn, 2006; Manitoba Education and Training, 1997; Ruiz-Primo, 2011; Wiliam & Thompson, 2008). For example, while exploring paradigms of assessment, Wiliam and Thompson (2008) argued that assessment has advanced from conventional (i.e., traditional pencil and paper tests, multiple choice tests) to modern forms (i.e., performance assessments, authentic assessments). In traditional assessments, teachers expect students to identify the best choice of answer from a given list (selected response) or are asked to list responses to a question (constructed response). Authentic assessments are “meaningful, challenging, performance driven, integrate rather than fragment knowledge for students, realistic, and relevant to the needs of students” (Butler & McMunn, 2006, p. 6); and “occur in real life contexts” (Manitoba Education and Training, 1997, p. 15.4). A wide variety of assessment formats come under the authentic and alternative forms of assessment, including performance assessments, portfolios, concept maps, interviews, observations, reports and self-assessments (Bell, 2007).

In many educational contexts, science educators use performance assessment more than they use other forms of assessment due to its practical and holistic applicability (Bell, 2007). This assessment format allows teachers to assess many curricular goals including laboratory demonstration of knowledge and skills, design processes and products, and tasks related to real-

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life contexts (Bell, 2007). Debates, demonstrations, oral presentations, and panel discussions are some examples of performance assessment (Butler & McMunn, 2006).

A combination of assessment formats can be used for the same purpose. For example, while performance assessments, portfolios, and reports can be used for summative purposes, these, or a combination of these with others, could also serve formative assessment purposes (Liu, 2010). Indeed, some educational researchers have argued that the purpose for assessing students' learning should determine the assessment format(s) that teachers use in their classrooms (Earl, 2006). To date, the literature has it that assessment as learning is taking the centre stage in discourses of assessment in contemporary times, while formative assessment continues to receive the attention of researchers (William & Thompson, 2008; Zeng et al., 2018). As Delandshere (2002) contended, while few educators still hold the belief that assessment is meant to evaluate, grade, and classify students, the majority of them are of the opinion that it should be used as an enhancement to educational outcomes and students' performance.

In our current educational system, teachers employ a variety of assessment instruments to assess the level of knowledge and skills of students, including: "standardized tests, district-developed assessments, textbook tests and quizzes, commercially developed tests and quizzes, and informal classroom assessment strategies" (Calveric, 2010, p. 29). More often than not, assessment is used for "supporting learning (formative), certifying the achievement or potential of individuals (summative), and in evaluating the quality of educational institutions or programs (evaluative)" (William & Thompson, 2008, p. 59). While distinguishing between testing and assessment, Birenbaum (2003) identified testing culture as mainly defined by its focus on memorization of facts, while assessment culture is characterized mostly by its understanding and application to real-life conditions or settings. Birenbaum (2003) stressed that assessment and

instruction should be integrated to provide adequate learning experiences for students. Similarly, Gulikers, Bastiaens, Kirschner, and Kester (2006) offered that the use of contemporary perspectives such as authentic assessment tasks in classrooms result in deep learning for students. The arguments and positions presented by contemporary researchers point to the fact that assessment should be used for the purpose of integration with instruction for better educational outcomes.

Assessment in Manitoba

In Canada, educational policies for Grades K through 12, including those for assessment, are developed and implemented by each jurisdiction, with the exception of education for Indigenous students. In Manitoba, the Assessment and Evaluation unit of the Manitoba Education, Citizenship and Youth Department is responsible for developing assessment policies with a focus on enhancing teaching and learning through the '*Provincial Assessment Program*' (PAP) and '*Provincial Assessment Initiative*' (PAI) (Manitoba Education, Citizenship and Youth, 2006a). However, there are specific policy and initiative documents on classroom assessment recommended for use by teachers in Manitoba.

Manitoba Education and Training recommends that teachers and students should identify and establish goals for student learning and assessment criteria in correspondence with the province's student learning outcomes. Assessment, in the context of Manitoba education "is a process of collaborative communication in which information about learning flows between teacher and student" (Manitoba Education, Citizenship and Youth, 2008, p. 10). Given the importance of assessment in classrooms nowadays, and the significance of assessment to students' learning, an assessment initiative was developed in Manitoba—*Rethinking Classroom Assessment with Purpose in Mind* (from now on referred to as RCAPM) (Manitoba Education,

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Citizenship and Youth, 2006a). The aim of the classroom assessment initiative is to provide a model for students to engage in deep thinking, to affirm, offer, and direct effective changes in their assessment procedures, as well as for teachers to engage in classroom assessment practices that will improve students' learning and to promote the growth of professional learning for teachers.

Assessment has been found to improve students' learning outcomes especially when teachers' intent in assessing is to promote learning (Black & Wiliam, 2009). Similarly, it has been emphasized that to bring about positive learning outcomes, assessment should be utilized for the purpose of gathering data on changes in skills, knowledge, and students' views of learning at the beginning, during, and after instruction (Manitoba Education, Citizenship and Youth, 2006a). In the case of Manitoba classroom learning, educational processes draw on a constructivist pedagogy (Manitoba Education, Citizenship and Youth, 2006a), which, as Aydeniz (2007) argues, occur when students are actively involved in knowledge formation. Building upon constructivist learning views, Manitoba Education envisions that enhanced learning occurs "when students are encouraged to think about their own learning, to review their experiences of learning ... and to apply what they have learned to their future learning" (Manitoba Education, Citizenship and Youth, 2006a, p. 5).

Consistent with Manitoba assessment initiatives, purpose defines the type(s) of assessment that are constructed and used in classrooms, therefore "it is important for educators to understand the three assessment purposes, recognize the need to balance among them, know which one they are using and why, and use them all wisely" (Manitoba Education, Citizenship and Youth, 2006a, p. 14). Practically, Manitoba teachers are expected to have knowledge of the three purposes of assessment and be capable of using each one for different assessment practices.

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In addition, teachers must have reasons for using particular assessment(s) and be able to utilize the information gathered from each purposefully and effectively (Manitoba Education, Citizenship and Youth, 2006a).

In the context of Manitoba Education, assessment of learning is intended “to confirm what students know, demonstrate whether or not they have met curriculum outcomes or the goals of their individualized programs, or to certify proficiency and make decisions about students’ future programs or placements” (Manitoba Education, Citizenship and Youth, 2006a, p. 55). In addition, it is used as a source of evidence of success or failure to students, parents, employers and educational institutions; its results are usually publicized; and it is an essential contributor to decisions about students’ prospects. Assessment for learning, on the other hand, is aimed at making students’ comprehension, perceptions, and knowledge visible. Teachers utilize assessment for learning “as an investigative tool to find out as much as they can about what their students know and can do, and what confusions, preconceptions, or gaps they might have” (Manitoba Education, Citizenship and Youth, 2006a, p. 29). Teachers also use information gathered through assessment for learning to plan future instruction, provide feedback, and decide on instructional resources that suits the needs of their students.

The third purpose of assessment in Manitoba is assessment as learning, which was designed to develop students’ metacognitive processes. Assessment as learning as described in the RCAPM document, draws from the constructivist learning theory whereby students actively construct and re-construct their own learning processes. It follows then, that “students become adept at personally monitoring what they are learning and use what they discover from the monitoring to make adjustments, adaptations, and even major changes in their thinking” (Manitoba Education, Citizenship and Youth, 2006a, p. 41).

Classroom learning, therefore, must be integrated with classroom assessment for better instructional planning, teaching, and student learning experiences. The integration of assessment and learning forms a cycle whereby teachers utilise their feedback, interaction, and general teaching and assessment skills to fill gaps in the process (Dixon & Haigh, 2009). This cycle, according to Manitoba Education, must be teacher and student centered with higher emphasis on students developing their metacognitive skills along the line as instruction and assessment progresses. To this end, two purposes for which teachers assess students—assessment as and for learning are recommended to be used more often than assessment of learning in Manitoba.

Figure 1 below illustrates the traditional assessment practice whereby more emphasis was placed on assessment of learning— “measuring learning after the fact, using the information to make judgements about students’ performances, and reporting these judgements to others” (Manitoba Education, Citizenship and Youth, 2006a, p. 14). A reconfigured assessment pyramid (Figure 2) illustrates Manitoba Education’s intentional emphasis on the use of contemporary assessment techniques.

Consistent with contemporary assessment discourses, Manitoba assessment recommendations require teachers to develop and use assessment types in the following order, with emphasis from the first to the last: assessment as learning, for learning, and of learning (Figure 2). It is also recommended that teachers critically evaluate and adjust their assessment strategies constantly to align with provincial recommendations. Manitoba assessment programs and policies reflect ongoing discussions that assessment should be focused more on formative types than summative types. Drawing on constructivist learning theory, classroom assessment practice in Manitoba suggests that teachers must identify each student’s level of knowledge and skills prior to instruction, assist students in actively constructing new knowledge, and facilitating

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the processing of such knowledge in a manner that will be appropriate to each student's cognitive level. This is consistent with the views of researchers on the purposes for which assessment should be used in the classroom (Black & Wiliam, 2009; Butler & McMunn, 2006).

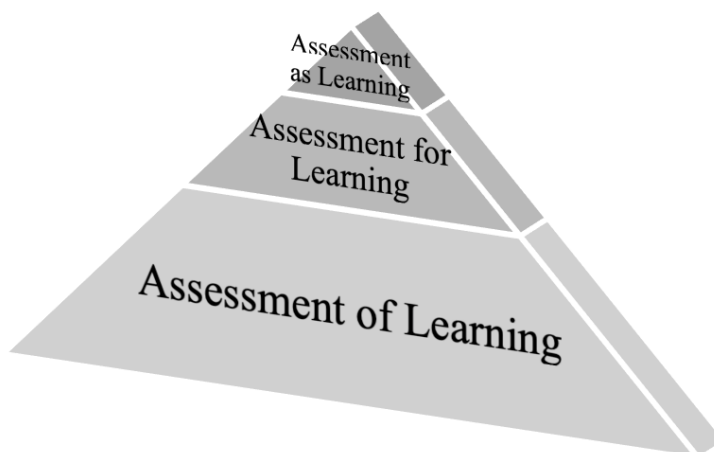


Figure 1. Traditional Assessment Pyramid (Adapted from Manitoba Education, Citizenship and Youth, 2006a, p. 15).

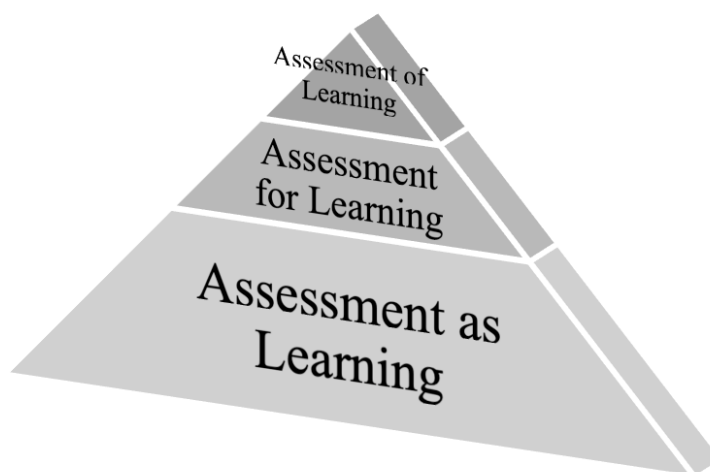


Figure 2. Reconfigured Assessment Pyramid (Adapted from Manitoba Education, Citizenship and Youth, 2006a, p. 15).

Other assessment policy documents provide support to Manitoba teachers' classroom assessment practices. One such policy document is the *Manitoba Provincial Report Card Policy and Guidelines: Partners for learning, grades 1 to 12 (MPRCPG, Manitoba Education and Training, 2018)* aimed at providing teachers with grading principles and practices to effectively communicate information on students' learning to parents and students. Drawing from assessment principles outlined in the *RCAPM* and the *Provincial Assessment Policy, Kindergarten to Grade 12: Academic Responsibility, Honesty, and Promotion/Retention (PAP)* (Manitoba Education and Advanced Learning, 2015) documents, teachers are expected to grade students through a variety of evidence-based assessment forms (Manitoba Education and Training, 2018). To achieve precise, reliable, and meaningful grades through assessment of students' learning in schools, Manitoba teachers are encouraged to focus assessment only on students' understanding of curriculum contents, to report behavioural assessment separately, and should not include non-academic behaviours such as students' attitudes and attendance in assessment and grading processes (ibid). Furthermore, the *MPRCPG* document advocates for teachers' use of differentiated assessment strategies, so that students can demonstrate their learning in ways that makes most meaning to them based on their interests or learning desires (ibid).

According to *PAP* (Manitoba Education and Advanced Learning, 2015), Manitoba “assessment policies must cultivate that sense of responsibility early on by providing appropriate and challenging expectations and ensuring that students rise to these challenges” (Manitoba Education and Advanced Learning, 2015, p. 5). This document provides specific recommendations for using assessment of learning (or summative assessment) in classrooms, which is defined as “the process of judging the quality of student learning on the basis of

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established criteria and assigning a value to represent that quality” (Manitoba Education and Advanced Learning, 2015, p. 6). It further states, “evidence of student achievement is collected over time from three different sources— observations, conversations, and student products. Using multiple sources of evidence increases the reliability and validity of the assessment of student achievement” (ibid). In terms of types of assessment tasks or instruments, the document suggests a variety of assignments that can be also used as summative assessment, including “rich performance tasks, demonstrations, projects, and/or essays as well as tests or exams” (ibid).

Assessment in science in Manitoba. Science, a means through which we learn about the universe, involves activities such as predicting, defining, understanding, and finding meanings for natural and human-made processes and developments (Manitoba Education and Training, 2000). Science education has been identified as an important factor to consider in efforts geared towards developing scientifically literate citizens and working at developing Canadian youth towards creating a good Canadian future; these are the premises upon which the Pan-Canadian Science Framework was developed. This framework was the result of collaborative efforts of “educators from Alberta, British Columbia, Manitoba, Ontario, Saskatchewan, the Northwest Territories, the Yukon Territory, and the Atlantic Provinces” (Manitoba Education, Citizenship and Youth, 2006b, p. 1).

The *Pan-Canadian Science Framework*, known as the *Common Framework of Science Learning Outcomes K to 12*, is the framework from which the Manitoba science general and specific learning outcomes are drawn. Therefore, in Manitoba, the *Science Framework* “provides the basis for teaching, learning, and assessing science, and is mandated for use in all schools” (Manitoba Education and Training, 2000, p. 1.1). In Manitoba, the science curriculum is based on five foundations for scientific literacy: Nature of Science and Technology; Science,

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Technology, Society, and the Environment (STSE); Scientific and Technological Skills and Attitudes; Essential Science Knowledge; and Unifying Concepts (Manitoba Education, Citizenship and Youth, 2006b, p. 3). Development of scientific literacy for Manitoba students involves three processes:

Scientific inquiry: students address questions about natural phenomena, involving broad explorations as well as focussed investigations; Technological problem solving (design process): students seek answers to practical problems requiring the application of their science knowledge in various ways; Decision making: students identify issues and pursue science knowledge that will inform the issues. (Manitoba Education and Training 2000, p. 4)

Advancement towards developing scientific literacy in individuals has been the focus of 21st century science education reforms in Canada (Manitoba Education and Training, 2000). Accordingly, a science education reform in Manitoba was initiated through the Action Plan for Science Education in Manitoba, a reform process focused at improving the engagement of students in science and supporting science teachers' professional learning. The goals for science education as reflected in this initiative are to:

Encourage students at all grades to develop a critical sense of wonder and curiosity about scientific and technological endeavours; enable students to use science and technology to acquire new knowledge and solve problems, so that they may improve the quality of their own lives and the lives of others; prepare students to critically address science-related societal, economic, ethical and environmental issues; provide students with a proficiency in science that creates opportunities for them to pursue progressively higher levels of study, prepares

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them for science-related occupations, and engages them in science-related hobbies appropriate to their interests and abilities; and develop in students of varying aptitudes and interests a knowledge of the wide variety of careers related to science, technology, and the environment. (Manitoba Education and Training, n.d., *Action Plan for Science Education in Manitoba*).

The five foundations for scientific literacy are described in the Manitoba curriculum documents alongside their general learning outcomes, which serve as expectations and goals for learning science in Manitoba from Kindergarten to Senior 4. These general learning outcomes are presented in connection to specific learning outcomes in the grade-specific curriculum documents for science. For example, the Senior 1 Science curriculum document presents the following specific learning outcome: “Define element and identify symbols of some common elements. Include: the first 18 elements and K, Ca, Fe, Ni, Cu, Zn, I, Ag, Sn, Au, W, Hg, Pb, U. GLO: C2, D3” (Manitoba Education and Training, 2000, p. 2.10) (See Figure 3).

| PRESCRIBED LEARNING OUTCOMES |
|--|
| <i>Students will...</i> |
| SI-2-03 Define element and identify symbols of some common elements. Include: the first 18 elements and K, Ca, Fe, Ni, Cu, Zn, I, Ag, Sn, Au, W, Hg, Pb, U. GLO: C2, D3 |

Figure 3. Extract from the Manitoba *Senior 1 Science: A Foundation for Implementation* document (Manitoba Education and Training, 2000, p. 2.10), showing a specific learning outcome (SLO) and the applicable general learning outcomes (GLO).

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In this example, GLO C2: “Demonstrate appropriate scientific inquiry skills when seeking answers to questions,” refers to the third foundation of scientific literacy, “C: Scientific and Technological skills and attitudes,” while D3: “understand the properties and structures of matter as well as various common manifestations and applications of the actions and interactions of matter,” refers to the fourth foundation of scientific literacy, “D: Essential Science Knowledge” (Manitoba Education and Training, 2000, p. 12).

While each unit or cluster in the senior years science curriculum documents presents specific learning outcomes related to conceptual knowledge in that unit, an overarching unit, referred to as Cluster Zero, presents learning outcomes related to skills and attitudes students should develop as part of learning science in the senior years. For example, in connection to the specific learning outcome presented above (Figure 3), the following Cluster Zero specific learning outcomes are listed (Figure 4): “Select and use appropriate methods and tools for collecting data or information” and “Record, organize, and display data using an appropriate format. Include: labelled diagrams, graphs, multimedia” (Manitoba Education and Training, 2000, p. 12). Each of the specific learning outcomes for Cluster Zero also include associated general learning outcomes, related to the five foundations for scientific literacy, as well as cross-curricular specific learning outcomes (in Figure 4, these include learning outcomes from TFS: Technology as a Foundation Skill Area and ELA: English Language Arts).

| Skills and Attitudes Outcomes |
|--|
| <p>S1-0-5a. Select and use appropriate methods and tools for collecting data or information. GLO: C2; TFS: 1.3.1</p> <p>S1-0-5c. Record, organize, and display data using an appropriate format. Include: labelled diagrams, graphs, multimedia (ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2</p> |

Figure 4. Extract from the Manitoba *Senior 1 Science: A Foundation for Implementation* document (Manitoba Education and Training, 2000, p. 2.10), showing specific learning outcomes (SLO) from Cluster Zero: Skills and Attitudes Outcomes, as well as applicable GLO and cross-curricular connections (TFS, ELA).

In the Foundation for Implementation grade-specific curriculum documents for science, recommendations are also provided for teachers to assist them in instruction as well as assessment of learning outcomes, while staying within the province's constructivist approach to teaching and learning. In response to, and aligned with, changes in emphases on science education across Canada and other regions of the world, Manitoba Education views effective assessment in science as:

- an integral part of instruction and learning
- continuous and ongoing
- authentic and reflective of meaningful science-learning processes and contexts
- a collaborative and reflective process
- multi-dimensional, incorporating a variety of tasks
- developmentally and culturally appropriate
- focussed on students' strengths
- based on how students learn

- supportive of learning by offering clear performance targets to students. (Manitoba Education and Training, 2000, p. 23).

Recommendations on how to effectively assess students in science are also documented in the *Senior Years Science Teachers' Handbook* (Manitoba Education and Training, 1997). This handbook suggests that teachers should: design and select assessment instruments with purpose in mind, while adopting a wide variety of strategies; design assessment tools that will cater for their students' learning styles, and those that will provide students with opportunity of demonstrating their learning through various means; and establish mechanisms of reporting students' results to reflect learning goals and outcomes. Also, teachers, administrators and students have been charged with thinking and doing assessment in new ways and ensuring the ultimate goal for assessing is met—enhancing students' learning experiences.

In a study of the implementation of assessment policy documents and initiatives by high school science teachers in the United States, Aydeniz (2007), documented the low level of interest demonstrated by most students towards scientific literacy in contrast with the goals of science reform initiatives. Similarly, science education researchers have commented on the failure of teachers and students in meeting reform initiative expectations (e.g., Aydeniz, 2007; Brickhouse, 2006; Haney, Lumpe, Czerniak, & Egan, 2002). Such failures in students' science learning and assessment are partially due to implementation processes that favour the development of exhaustive contents and standardized assessment practices (Aydeniz, 2007).

The literature affirms the important role that assessment plays in initiatives geared towards improvement in teaching and learning and in education generally. Assessment serves such roles as supporting teaching and learning, monitoring the effectiveness of the curriculum, evaluating the validity and reliability of instructional pedagogies, and enhancing school system

efficiency (Aydeniz, 2007; Shepard, 2000). Nevertheless, there is a call for improvement by science educators on the calibre of science teaching and learning, as well as assessment practices adopted in science classrooms which are not up to the standards recommended by science reform policies (Aydeniz, 2007; Brickhouse, 2006). It has also been argued that, “although some teachers have incorporated self-assessment into their programs, few have systematically or explicitly used assessment to develop students’ capacity to evaluate and adapt their own learning” (Manitoba Education, Citizenship and Youth, 2006a, p. 14).

Classroom Assessment Implementation

Not surprisingly, classroom assessment varies by school districts/regions, educational level, teachers’ experiences, and the curriculum (McNair, Bhargava, Adams, Edgerton, & Kypros, 2003). In using classroom assessment to design, administer and support students’ learning, teachers engage in a variety of assessment practices ranging from conventional to contemporary (DeLuca et al., 2016). Indeed, a study of Canadian teachers’ assessment practices confirmed variations in assessment types teachers adopt in their classrooms across ten Canadian provinces (Chu & Fung, 2018). Also, in their study of 404 teachers in Canada and the United States, DeLuca et al. (2016) investigated teachers’ approaches to assessment, their skill in using contemporary assessments and their priorities regarding professional development. These authors explored one of the assessment literacy themes—assessment processes (administration, communication, design, and scoring) through the *Approaches to Classroom Assessment Inventory (ACAI)* (DeLuca et al., 2016). Using the *ACAI*, teachers self-assessed how they practice assessments in their classrooms. The study reported teachers’ stating they provide useful feedback, and in a timely manner, to improve students’ learning. However, teachers also reported

their inability to engage students (especially in developing their metacognitive skills) and parents in their classroom assessment practices.

Along similar lines, assessment procedures of 157 elementary teachers in Michigan, US, were investigated through open-ended interview protocols to analyze the assessment types and frequencies of use in their classrooms (McNair et al., 2003). Results from the study revealed that Michigan teachers use observations, portfolios, paper and pencil tests, and checklists in their classrooms. In addition, though participants used both formative and summative assessment types, their classroom assessment practices aligned more towards summative assessment. The study focused on elementary teachers only, and it did not provide any insights into possible differential assessment practices discipline-wise.

In Canada, experiences of five secondary school mathematics teachers in Ontario were explored through case studies to determine their use of authentic assessments in their classrooms (Suurtamm, 2004). To provide in-depth information on mathematics teachers' assessment practices, Suurtamm elicited data through individual interviews with each teacher and focus groups. Moreover, to substantiate information teachers provided during interviews and focus groups, the researcher also conducted two classroom observations. All five teachers in this study held the belief that authentic assessment should be used in mathematics to develop students' problem solving and metacognitive skills, and to solve mathematical problems following real life examples and solutions. These teachers endeavoured to relate contemporary assessments with inquiry-based mathematics instructional practices in their classrooms. Some of the assessment practices the mathematics teachers used to assess students' problem-solving skills as found in the study were:

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Written submissions with full justification for their answers and presentations of the solutions to the class, often using visuals or demonstrations. The teachers assessed these problem-solving situations through observation checklists while students worked, rubrics to determine levels of performance of a written submission, and teacher or peer assessment of classroom presentations. (Suurtamm, 2004, p. 501)

Furthermore, the participant mathematics teachers developed and implemented assessment instruments such as performance tasks, group projects, journals, and portfolios. This study concluded that, more often, these teachers were “torn between delivering a curriculum that listed content topics and assumed a traditional teaching style and offering a problems-rich curriculum with a variety of teaching styles” (Suurtamm, 2004, p. 510). Therefore, for teachers to effectively implement authentic assessments, a curriculum that promotes such assessment activities should be designed and effected (Suurtamm, 2004). This study refers to an Ontario curriculum which has since been redesigned and now promotes these forms of assessment (Suurtamm, Koch, & Arden, 2010).

Classroom assessment practices teachers engage in to find information about what students know and are able to do was the focus of a study of grades seven to ten Ontario mathematics teachers (Suurtamm et al., 2010). As part of a large-scale project, these authors investigated teachers' perceived comfort using varieties of assessment techniques in their classrooms. Results of questionnaire data revealed that 91% of participants in the study indicated their ease of using varieties of assessment to enhance student learning. An analysis of the specific tools these teachers used in their practice to assess students' understanding revealed the

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teachers relied mostly on quizzes and tests. Frequency distribution shows that, of the 1,019 teachers investigated,

96% used paper-and-pencil tests; Quizzes (89%); Performance tasks (83%); Responses of students in class (76%); Homework performance (71%); Observations of students (notes/checklists) (66%); Projects (38%); Interviews/conferencing with students (35%); Student presentations to other students (20%); Portfolios/dated work samples (19%); Students' journals (18%); and Self assessment (16%). (Suurtamm et al., 2010, p. 404)

These results indicate that, though teachers in Suurtamm et al.'s (2010) study relied more on traditional mathematics assessments methods (quizzes and tests) for report cards, they used diverse assessment tools, including contemporary forms of assessment in their classroom practices to get a sense of students' understanding. As this result is peculiar to teaching and learning in mathematics, and focused on advancing teachers' assessment pedagogies in this subject area, the need remains to explore teachers' assessment practices in science, given the distinctive teaching and learning disciplinary context, which, in Manitoba, include not only content knowledge but also skills and attitudes related to scientific literacy (Manitoba Education and Training, 2000).

Classroom assessment implementation in science. Some recommended assessment instruments provided for science teachers' use in the engagement of their students, promotion of their inquiry skills, and in assisting students with low levels of scientific interest are: "portfolios, performance-based tests and examinations, and teacher observations and anecdotal records" (Manitoba Education and Training, 1997, p. 15.9). In addition to these, essays, projects, presentations, and demonstrations have been named as effective assessment instruments teachers

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can utilize in ensuring that students develop the requisite skills and knowledge recommended by the science education curriculum (Abell & Siegel, 2011).

Other developments in the use of assessment in science education include those of computer-based tests; in these, science teachers tend to choose open-ended questions over closed-ended ones, because of the development of higher order thinking skills attributed to the former type of questions (Chu & Fung, 2018). Computer-based assessment types also include performance tasks using computers, text-based responses, and those that require the use of a mouse such as drag and connect, drag and drop, and pull-down menu assessment items (Zenisky & Sireci, 2002).

Classroom assessment practices of 155 secondary school science teachers in Israel were explored using the *What Is Happening In This Class (WIHIC)* survey to identify teachers' use of formative assessment types as stipulated in the country's science education curriculum (Alt, 2018, p. 394). Science teachers in this study were found to use traditional tests and quizzes mostly in their classrooms, with very minimal formative assessment practices. Overall, science teachers in Alt's study relied more on teacher-centered teaching, learning and assessment approaches; however, they mentioned some barriers to the effective implementation of teaching and assessment as prescribed in their science curriculum.

In a quantitative study that examined assessment practices of 297 science teachers in the US through the *Assessment Practices Inventory* (Zhang & Burry-Stock, 2003), researchers found differences in the assessment practices across subject areas. Their findings revealed that science, language arts and social studies teachers utilized paper and pencil tests more often than mathematics teachers. In terms of grading practices, they found that science and mathematics

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teachers reported grading non-achievement factors, such as, student's ability, effort, motivation, and attitude.

Teachers' elicitation practices of students' level of knowledge about scientific concepts was the focus of Ateh's (2015) study, which took place in California, US. Through video recordings of a teacher-identified 50-minute science class, followed by an interview with the teachers, Ateh found a mismatch between science teachers' assessment practices and effective formative assessment practices. The two science teachers essentially practiced low-level elicitation of information about their students' learning, going against their indicated notion of the purpose of assessment—to improve instruction:

The teachers did not create opportunities to engage students in divergent thinking that would elicit their conceptual understandings. Within the moment-to-moment interactions, teachers typically asked convergent questions, requiring responses that were based on memorized knowledge and/or cues from the teachers. (Ateh, 2015, p. 128)

In Canada, classroom assessment practices of 1,680 grade eight science teachers were investigated to find out the assessment types they adopted in their science classrooms and their correlation to science achievement (Chu & Fung, 2018). Science teachers responded to survey questionnaire items on assessment item formats, assessment types, and performance tasks that the teachers used in understanding scientific competencies of their students. Results indicated that science teachers across ten Canadian provinces mostly utilized teacher-developed classroom tests (tests and quizzes). Rated next in order of use by the teachers in this study were individual assignment/ projects and group assignment/ projects (homework and portfolios), respectively. The fourth most frequently used assessment type was performance assessments, while the least

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used were common school-wide assessments such as standardized tests. Chu and Fung's (2018) study also recorded significant differences among the ten Canadian provinces in terms of frequency of use of assessment types, formats and performance assessment tasks in science classrooms. For example, teachers from the Western provinces rated using homework assignments higher than teachers from the Eastern provinces.

As seen, literature on assessment practices document various methods employed by teachers across different contexts, in their effort to assess students' achievement in schools. Despite the volume of research on assessment documenting the usage of various assessment instruments across educational levels and subjects, there remains a lack of studies on subject areas such as the sciences in Canada and, especially, in Manitoba. While reports of teachers' assessment practices in Ontario (Suurtamm, 2004; Suurtamm et al., 2010) and British Columbia (Fu, Hopper, & Sanford, 2018) have been documented, studies focused on Manitoba science teachers' assessment practices remain modest.

Challenges to Assessment Implementation

Assessment has the potential to enhance students' learning if utilized appropriately (Black & Wiliam, 2009; Mussawy, 2009); it is considered as an essential part of teaching and student learning, and also as a useful resource. Researchers have found that several factors affect implementation of effective assessment practices in schools. With regards to implementing quality assessment processes in the classroom, DeLuca et al. (2012) asserted that, although formative assessment has been identified in the literature as a promising pedagogical approach to teaching and learning, several barriers contribute towards its full implementation: "misalignment in educational and assessment priorities, conceptual confusions, teachers' perception of assessment, and practical/contextual barriers to its integration" (p. 7).

Similarly, it has been emphasized that while teachers attempt to integrate new classroom assessment practices and apply inquiry-based methodologies to teaching and learning, there will be possibilities of facing a wide range of challenges (Suurtamm & Koch, 2014). These authors explored the experiences and dilemmas of 42 mathematics teachers in Ontario as they incorporated new assessment practices in their classrooms through discussion in their communities of practice. Results of this study revealed four dilemmas the mathematics teachers encountered in their assessment practices: conceptual; pedagogical; cultural, and political dilemmas. Suurtamm and Koch (2014) identified that these dilemmas are interconnected and discussed the importance of teachers' engagement in communities of practice to the advancement of their professional learning. To them, by engaging in communities of practice, teachers would learn new assessment strategies and critically assess their notions about what assessment means and how to take proper assessment decisions (Suurtamm & Koch, 2014).

These research studies suggest that teachers have experienced difficulty in implementing contemporary assessments. It follows then that integration of assessment for learning in classrooms can be a daunting task for teachers when educational systems prioritize summative assessment, as evident in most system's assessment priorities—sorting students and for certification purposes (DeLuca et al., 2012). Teachers may not be inclined to use contemporary assessments because of time constraints (Alt, 2018; DeLuca et al., 2012), and lack of clarity, as exemplified by a teacher's quote referring to formative assessment: "the structure of the method is not clear enough. I do not understand what assignment is needed to be graded and how should it be graded. ... I do not have enough time to assess each student using these methods" (Alt, 2018, p. 400).

Based on teachers' misconceptions about the link between assessment for and assessment of learning, their perceptions of the value of assessment for learning may be negative, leading to implementation problems (DeLuca et al., 2012; Widiastuti, 2018). Negative perceptions could be a result of teachers' past experiences with assessment, either as students or during their teaching careers. Teachers' challenges in effectively implementing assessment for learning in classrooms may be a result of their lack of adequate training and familiarity with the assessment method (Alt, 2018). In a study that examined factors influencing teachers' assessment practices of 10 junior high school teachers in Bali, Indonesia through classroom observations and interviews, teachers' conceptions of assessment were identified as the most influential internal factor towards their decisions to implement effective assessment practices (Widiastuti, 2018).

Other barriers to effective implementation of student-centred assessment types are practical and contextual factors such as large class sizes, inadequate human resources, and accessibility to resources, such as technology and funding (Alt, 2018; DeLuca et al., 2012), covering subject content, feeling of isolation/ alienation, lack of administrative support and professional development (Suurtamm, 2004). Furthermore, when teachers have a negative view or a misconceived understanding of effective assessment practices, they usually adopt a behaviourist approach to teaching, learning and assessment (DeLuca et al., 2012).

Conceptions of Assessment and Their Connection to Classroom Assessment Practices

The significant changes recorded over the years in education and the society at large have also been observed in studies about views, beliefs, conceptions, and policies influencing assessment principles and methods. Brown (2002; 2004) claimed that teachers' conceptions of assessment have made the most particular impact on assessment studies. The term *conception* was introduced by Thompson (1992, as cited in Aydeniz, 2007) as "a general mental structure

defining teachers' conceptual ecology which encompasses teachers' beliefs, knowledge and dispositions" (p. 8). Consistent with Aydeniz (2007), the process through which teachers scaffold instruction is based on their conceptions of teaching and learning. Hence, this author argued that conceptions are mental structures or "frameworks through which a teacher views, interprets, and interacts with various aspects of classroom practice" (ibid). Similarly, to Pratt, conceptions are a "lens through which a teacher views, interprets and interacts with his/her understanding of the world" (1992, as cited in Azis, 2015, p. 130).

To disambiguate the terms 'beliefs' and 'conceptions,' Remesal contended that beliefs usually refer to "those basic statements about different aspects of reality that any person might take for true at different times of his/her life, although they do not have to constitute an objective truth at all" (Remesal, 2011, p. 474). This author added that, though beliefs are usually immune to change, they could change through the course of living and they are responsive to influences within an individual's social environment. Remesal further argued that beliefs just do not exist loosely in an individual's mind; instead, they build up to form conceptions. Thus, conceptions are groups or clusters of beliefs we hold that account for our decisions and actions (Remesal, 2011).

Another way of differentiating these terms contends that beliefs represent how knowledge is acquired, while conceptions refer to understanding of that knowledge and a change in our personal views (Chan, 2011). For Yilmaz and Sahin (2011), beliefs are akin to having preference for doing something based on previous experiences. An illustration of this argument offered by these authors is the idea that teachers who believe teaching and assessment to be student-centred were perhaps taught by educators who propagated these same views about teaching and assessment. These authors argued that, though beliefs and conceptions are related

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constructs, conceptions provide a framework for understanding beliefs. The dominant argument here is that conceptions are driven by beliefs (Chan, 2007; Yilmaz & Sahin, 2011); there is a relationship between teachers' epistemological beliefs and their conceptions of teaching and learning. Sometimes, this relationship may indicate incoherence between teachers' thoughts about assessment and their classroom assessment practices, as reported by Suurtamm and Koch (2014, p. 278): although teachers "appeared to have progressive ideas and practices with respect to assessment, many shared their practice of preparing students for province-wide assessments by practicing multiple-choice questions".

Despite efforts to define these terms, beliefs and conceptions have sometimes been used interchangeably to assume similar meanings in assessment studies (Opre, 2015). Nonetheless, while it is true that beliefs have been used in the literature to refer to educational themes in studies exploring teaching and learning, curricula, and philosophical theories of knowledge, Opre (2015) argued for the use of the term 'conceptions' for assessment-related studies. In his views, beliefs are a sub-category of conceptions, and the variable used by researchers in the field of assessment is 'conceptions' (Brown, 2002; 2004). Although both constructs are widely used to connote similar interpretations, in line with the accepted construct established in models on conceptions of assessment adopted in my study, I use the term conceptions. In this study, conceptions are defined as the representations and ideas people hold regarding how an action or behaviour ought to be; that is, teachers' conceptions of assessment are those ideas and representations teachers have about what assessment is and how and why it should be used in classrooms (Opre, 2015).

Conceptions of Assessment

Social and cultural processes affect the conceptions that people build, and these are important factors contributing towards the type of actions, behaviours, and practices they display (Azis, 2015). In the exploration of teachers' understanding and commitment to quality teaching in Australia, Griffiths, Gore, and Ladwig (2006) reported that teachers' deep understanding, commitment to students' learning, and beliefs accounted for quality teaching. In addition, these authors found teachers' beliefs as a significant factor in changing their classroom practices.

Wolf, Bixby, Glenn and Gardner's (1991) study was one of the first research studies on teachers' conceptions of assessment, where a distinction between assessment culture and testing culture was presented. These authors asserted teachers' conceptions of students, instruction, and assessment processes influence their classroom assessment practices. Furthermore, Wolf et al. contended that, "in stepping away from the 19th-century notion of a single chain of being, we are opening up the possibility of multiple paths to excellence" (Wolf et. al, 1991, p. 63). Such paths, according to these authors, are teachers' conceptions and use of assessment practices such as, performance-based assessments, exhibitions, and portfolio-based assessments.

In another study on teachers' conceptions of assessment, Delandshere and Jones (1999) suggested three dimensions with which to establish teachers' conceptions of assessment. Mathematics teachers in their study conceived of assessment as an externally defined process (for purposes of grading, student placement, and mandated tests), which is contingent upon how teachers view the curriculum and their professional abilities, and also dependent on teachers' perceptions of learning and the learners. From these three dimensions, teachers were found to be in a state of "assessment paralysis" (Delandshere & Jones, 1999, p. 238), produced by the conflicting expectations between curriculum and pedagogy reform calls and the simplistic

notions reflected through mandated tests. Relatedly, mathematics teachers in Ontario were found to experience conceptual dilemmas as they attempted to “understand the conceptual underpinnings of inquiry-based mathematics teaching and learning and of current views of assessment” (Suurtamm & Koch, 2014, p. 272). Notwithstanding, the mathematics teachers in Suurtamm and Koch’s study developed deeper conceptual understanding of current assessment approaches as they participated in communities of practice where they engaged in conversation and dialogue.

Other studies have made important contributions to research on teachers’ conceptions of assessment. For instance, Brown (2004) examined conceptions of assessment of New Zealand elementary school teachers through a 50-item survey. Brown found that teachers believed assessment renders students accountable for their learning and that assessment is relevant to teachers’ work. Another important study on teachers’ conceptions of assessment was an earlier model developed by Brown in 2002, while exploring conceptions of assessment of New Zealand teachers, which led the author to develop the Teachers’ Conceptions of Assessment, TCoA model. This model espouses four statements about teachers’ conceptions of assessment: “A focus on improvement (teachers’ views of assessment as a tool to improve teaching and learning); assessment as driven by school and teacher accountability purposes; assessment for student accountability; and perceptions of assessment as irrelevant or a meaningless practice in daily school life” (Brown, 2002, p. 184). Brown’s model has been tested and confirmed in other studies (e.g., Brown, 2004; 2006; Brown, Lake & Matters, 2011; Calveric, 2010).

However, when Brown’s model was tested in a study on conceptions of assessment in Spain, Remesal (2009) discovered that the model failed to fit Spanish pre-service teachers. Based on this inconsistency, the author concluded that conceptions of assessment of pre- and in-service

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teachers are complex and require further investigation (Remesal, 2009). Therefore, in 2011, she explored in-service teachers' conceptions of assessment through a qualitative and interpretive approach to reformulate Brown's model. Remesal used content analysis and a progressive categorization process to arrive at four conceptions for why teachers assess students: "assessment influence on teaching; on learning; on the accreditation of achievement; and on the teachers' accountability to different audiences" (Remesal, 2011, p. 480). The ensuing categories derived from data placed teachers' responses into two poles: pedagogical conceptions (assessment based on teaching and learning); and societal conceptions (assessment based on accountability and certification). Notwithstanding the differences in the conceptions held by teachers in the Brown and Remesal studies, the two models presented teachers' conceptions of assessment as either accountability or teaching and learning focused.

Azis (2015) argued that teachers' conceptions of assessment may be a combination of one or more conceptions described in the models above. To document the conflicting nature of teachers' conceptions of assessment, Azis (2015) examined 107 Indonesian English language junior high school teachers. He employed a mixed methods approach to examine English teachers' understanding of assessment and how their conception relates to the assessment method they practice. His study revealed that participants' purposes for assessment were to improve teaching and learning, and to be answerable to students' performance and the school. He further concluded that cultural expectations and government policies accounted for conflicting conceptions of Indonesian teachers.

Other researchers also have indicated that personal ideals, thoughts, and conceptions with regard to assessment account for teachers' choice of assessment methods (Azis, 2015; Brown & Remesal, 2017; Opre, 2015). For example, Azis (2015) argued that, teachers who conceive that

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assessment is for student accountability or have pedagogical conceptions of assessment mostly utilize formative assessment in their classrooms. In similar lines, Calveric (2010) argued that, teachers who conceptualize assessment as an improvement technique for teaching and learning processes often adopted formative assessment strategies. When teachers hold accountability conceptions, they tend to concentrate more on institutional ideas, communal and societal goals and interests, while also prioritizing summative assessment over formative assessment types (Chan, 2007).

The strong connection between teachers' conceptions of assessment and classroom practices is well established by researchers (Brown, 2002; Brown & Remesal, 2017; Calveric, 2010; Remesal, 2011; Opre, 2015). Indeed, other studies have indicated that, in making classroom decisions, teachers' conceptions act as one, if not the most important factor to consider (Brown & Hirschfeld, 2008; Stipek, Givvin, Salmon & MacGyvers, 2001). In their study of fourth to sixth grade mathematics teachers in Los Angeles County, California, Stipek et al. (2001) found that teacher assessment decisions were affected by their beliefs about assessment. These authors concluded that "beliefs and practices are linked, and emphasis of teacher professional development on either one without considering the other is likely to fail" (p. 225). Most studies on teachers' conceptions of assessment described above have focused on teachers' conceptions and its relationship to classroom practices. How teachers conceive of assessment and their assessment practices relationship is a complex process; and is affected by the societal, cultural and political systems where they practice their profession (Opre, 2015).

Indeed, Opre (2015) argued that the complex relationship between assessment conceptions and practices is influenced by several key factors, such as the context of the teaching and learning environment. This is exemplified in a study with 15 fourth to seventh grade teachers

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in the United States that explored participants' experiences of self-regulated learning and assessment through classroom observation and interviews (Davis & Neitzel, 2011). Through an analysis of the conceptions of assessment they hold and the assessment practices they employ in classrooms, this study revealed that teachers did not prioritize self-regulated learning. Teachers reported that imposition of assessment strategies by policy makers accounted for the conceptions and assessment strategies they adopted in teaching.

In another study of 558 teachers in England, James and Pedder (2006) identified a gap between teacher-narrated practices and their conceptions of assessment. Drawing on results from a 30-item questionnaire, the authors reported that though teachers placed and preferred "promoting learning autonomy" above "performance orientation" (p. 125), they mostly practiced performance-oriented activities and assessments with their students, leading to a conception-practice gap. This gap as described in their study is a result of pressure and influences that context can have on teachers' conceptions and practices of assessment. Consequently, they contended that "in the current climate in England, the performativity dimension is inescapable, and teachers are willing to acknowledge its legitimacy in the policy context" (James & Pedder, 2006, p. 129).

Researchers have identified that cultural and social factors are key issues affecting the discourse on conceptions of assessment (Brown & Michaelides, 2011; Gebril, 2017). Studies from different cultural backgrounds have thus been conducted and support this claim. An illustration of this are studies conducted in the United States (Calveric, 2010; Hamilton et al., 2007), New Zealand (Brown 2002; 2004), Cyprus (Brown & Michaelides, 2011), Egypt (Gebril, 2017; Gebril & Brown, 2014), and Australia (Brown et al., 2011). In a survey of Egyptian pre-service and in-service teachers' conceptions and practices of assessment, it was found that both

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in-service and pre-service teachers have the conviction that assessment is for school accountability purposes; however, a difference was recorded on the improvement purposes of assessment (Gebril, 2017); in-service teachers in this study held better improvement conceptions and utilized formative and summative assessments, while pre-service teachers held low improvement conceptions and reported using more summative assessment practices.

Other studies carried out on teachers' conceptions of assessment examined teachers in China (Brown & Gao, 2015), Hong Kong (Brown, Kennedy, Fok, Chan, & Yu, 2009), Spain (Brown & Remesal, 2012), Ecuador (Brown & Remesal, 2017), as well as Canada (Earl, Volante & DeLuca, 2015). Comparatively, Gebril argued that researchers have recorded similar results in educational systems that operate through evidence obtained from high-stakes examinations. To Gebril, "in such test-orientated contexts, accountability receives more attention while low-stakes assessment context espouses a different model that promotes the improvement function of assessment" (Gebril, 2017, p. 84). A case in point is the Brown et al. (2011) study, where these researchers found similar patterns in the assessment conceptions of Australia and New Zealand teachers. These authors contended that low-stakes assessment policies in both contexts accounted for the similarities recorded in their results. Likewise, Hamilton et al. (2007) found similar attitudes in the US states of California, Georgia, and Pennsylvania regarding teachers' purposes for assessing students. Their research revealed that teachers in these three states conceived assessment to be for accountability purposes and engaged in standards-based assessment processes.

In Canada, Earl et al. (2015) contended that, from the beginning of the last decade, movements in support of accountability purposes of assessment have increased across Canadian education systems. These researchers assert that, presently, the major conception Canadian

teachers have about assessment is for monitoring and reporting students' learning and achievement. Because of provincial specificity in educational policies and curriculum in Canada, it is important, therefore, to investigate the relations between teachers' conceptions of assessment and their practices and perceived self-efficacy of assessment within the particular educational context in which they work. Furthermore, subject specificity may also be a compounding factor influencing teachers' conceptions, practices and perceived self-efficacy of assessment.

Research on teachers' conceptions of assessment in science education. In the science education context, Lin, Lee and Tsai (2014) claimed that teachers' conceptions of assessment in science education are different from those of their students. Results from a quantitative study of Taiwanese high-school students and their science teachers indicated that teachers held improvement conceptions of science learning through their assessment practices, while their students conceived science learning and assessment as for knowledge reproduction. Through a sociocultural perspective, the authors explained this dissonance to be related to national and school high-stakes tests that Taiwanese students often prepare to take and must pass.

In their research on science assessment, Pellegrino (2016) argued that teachers' values and principles extend to the formation of their belief systems, which accounts for the assessment decisions they make in their classrooms. Assessment decisions, according to Shepard (2000), are grounded in the views teachers have of students' learning and how best to practice assessment procedures; the value science teachers assign to one assessment type over another depends largely on the views the teacher has of science learning (Pellegrino, 2016). For example, if the views of the teacher are about learning of science by sense-making, assessment choice would likely support students in their application of knowledge to solve problems rather than multiple-choice assessment techniques (Abell & Siegel, 2011; Pellegrino, 2016).

Similarly, Abell and Siegel (2011) highlighted the different forms of assessment knowledge and skills they perceived teachers require in order to provide students with an assessment-focused classroom. These authors argued that, “if a teacher values developing scientific understanding over learning the facts of science, she will use different assessment strategies” (Abell & Siegel, 2011, p. 215). They identified that teachers’ awareness of assessment strategies is connected to their assessment purposes, knowledge of what to assess, interpretation, and actions. Specifically, their model reflected the fact that science teachers’ assessment values and their awareness of what is relevant to assess accounts for assessment tasks that they design and implement in classrooms. Studies on science teachers’ conceptions of assessment and their practices have been relatively few; this notwithstanding, as noted, the existence of a relationship between teacher’s assessment conceptions and practices has been identified in other subject areas (Brown, 2002; 2004; Brown & Hirschfeld, 2008; Stipek et al., 2001).

To adequately develop, implement and use assessment for improving teaching and learning in science education, it is important to examine science teachers’ views, what they know and what they are able to do with regard to assessment (Abell & Siegel, 2011). However, most studies on teachers’ conceptions of assessment did not explore and/or link assessment to the science curriculum. Teachers’ assessment views and practices are dependent upon the content, instructional approach and intensity requirements of each subject area (Zhang & Burry-Stock, 2003).

Teachers’ Self-Efficacy of Assessment

Researching how teachers conceptualize the purposes of assessment and assessment strategies they are able to develop and use is fascinating, as it provides a clearer picture into the

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choices teachers make while engaging in assessment-based decisions (Abell & Siegel, 2011). In the literature, teachers' effective development and use of assessment have been termed assessment competencies (Alkharusi, 2011a; Brookhart, 2011), assessment knowledge and skills (Alkharusi et al., 2012), and assessment literacy (DeLuca & Klinger, 2010). Alkharusi (2011a) claimed that the latter involves teachers' capabilities of "knowing what is being assessed, why it is assessed, how best to assess it, how to make a representative sample of the assessment, what problems can occur within the assessment process, and how to prevent them from occurring" (p. 281). Another term used in the literature is assessment self-efficacy, defined as "teachers' conviction or belief in their own ability to influence how well students learn or perform" (Brown, 2002, p. 22). For the purpose of this study, teachers' self-efficacy refers to their perceived ability to perform certain actions effectively, leading to specific intended results; that is, in this study, teachers' assessment efficacy refers to how teachers perceived their ability and confidence to execute effectively the goals they intend for assessment to play in their classrooms.

Research into self-efficacy has mostly relied upon the social cognitive theory by Bandura (1977), a four-part self-efficacy model. According to Bandura, self-efficacy is the conviction and certainty in an individual's personal ability to establish, coordinate and act to achieve a specific goal. Put more explicitly, "it is a conviction that one can successfully do what is necessary to achieve or produce a desired set of outcomes" (Brown, 2002, p. 22). The four sources of self-efficacy as highlighted in Bandura's social cognitive theory are: mastery, vicarious, verbal, and affective experiences.

Mastery experiences: those experiences which teachers believe to have achieved success in performing a teaching task.

Vicarious experiences: those experiences in which a teacher observes another teacher successfully completing the teaching task; these experiences are most impactful on self-efficacy beliefs when the teacher both trusts the person performing the task and feels that they possess similar characteristics to that person.

Verbal persuasion: the feeling by a teacher that the person providing positive feedback is trusted or seen as more capable than the teacher.

Affective experiences: teacher's feelings of anxiety, joy, pride, and despair which can impact how individuals judge their capabilities. (Kuusinen, 2016, p. 5)

Research on teachers' assessment shows that teachers generally have low levels of assessment knowledge and skills, regardless of the widespread call for assessment capable teachers (MacLellan, 2004). This assertion is corroborated by results revealing the contradictions that exist between recommendations of assessment experts and what teachers actually do with assessments in their classrooms (Alkharusi et al., 2012; Aydeniz, 2007).

Specific training of teachers on assessment appears to result in significant improvement of teachers' competence and self-efficacy of assessment. In a study with 288 teacher candidates enrolled in a teacher preparation course in Canada, DeLuca and Klinger (2010) found that enrolment of teacher candidates in an educational assessment course boosted their confidence in the effective development and use of assessment in classrooms. This result was also found in a study of 516 Oman in-service teachers; in this case, assessment training and teaching experiences of teachers were found to be highly correlated with their assessment self-efficacy (Alkharusi, 2011a). An examination of 46 Turkish pre-service physics teachers found that teachers valued and reported high self-efficacy in using performance assessments (Ogan-Bekiroglu, 2009). This

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study utilized a parallel mixed method design to explore pre-service physics teachers' attitudes and self-efficacy of assessment after the completion of an assessment course. Generally, participants in this study regarded their self-efficacy to be high in the development and use of assessment types, especially diagnostic and formative types. The author acknowledged that the teachers' high self-efficacy of assessment could be because of the assessment course they recently completed at the time of the study.

The relationship between teacher self-efficacy and their assessment practices have been substantiated in previous studies. For example, in a study of 246 Oman in-service teachers Alkharusi et al. (2014) analyzed factors that predicted in-service teachers' use of assessment (gender, self-efficacy, teaching load, and teaching experience) and found teachers' perceived self-efficacy of assessment to be a strong influence on how teachers use assessment in their classrooms. However, findings from their study did not reflect any causal inference and, as such, specific relationship between teacher self-efficacy and the actual assessment types teachers used could not be identified.

Grade level and content area have been proposed to justify the disparities observed in teachers' classroom assessment competencies in their research with 297 elementary, middle, and high school teachers in a south-eastern state in the United States (Zhang & Burry-Stock, 2003). Zhang and Burry-Stock's (2003) research on teachers' self-perceived assessment skills and their assessment practices revealed that science teachers recorded higher competencies in using and developing paper and pencil tests than using performance assessments in their classrooms. This result, though in line with perceived skills of language arts and social studies teachers, contradicts perceived assessment skills of mathematics teachers, who reported higher skill developing and using performance assessments (Zhang & Burry-Stock, 2003). In a similar study

of 516 middle school science teachers' in Oman on their perceived assessment skills, results of the quantitative analysis revealed that science teachers were more competent in developing and using performance assessments and in the analysis of assessment results than their counterparts in Fine Arts and English Language (Alkharusi, 2011b).

Glackin and Hohenstein (2018) argued for the use of qualitative approaches as a means to deeply understand teachers' self-efficacy of assessment. They highlighted losing data richness and concerns with instrument validity and reliability as shortcomings of exploring teacher self-efficacy through quantitative approaches.

Models of Teachers' Conceptions of Assessment and Assessment Types

As described in the previous section on teachers' conceptions of assessment, quite a number of models have been developed to define how teachers conceptualize assessment (e.g., Brown, 2002; Delandshere & Jones, 1999; Remesal, 2011; Wolf et al., 1991). Brown's (2002) model of teachers' conceptions of assessment served as a framework through which data collected for this study were analyzed for Manitoba science teachers' conceptions of assessment. This model has been used to explore teachers' views about assessment in different contexts. Moreover, Brown's categories offer a broad and explicit view on teachers' conceptions of assessment. Brown (2002) identified four conceptions teachers may have on assessment: Improvement of teaching and learning, accountability of teachers and schools, accountability of students, and irrelevant conceptions.

“Improvement of teaching and learning” conception. This conception is grounded on the “assumption that the duty of teachers is to improve the learning of their students and that assessment is a process for obtaining information to assist in this process” (Brown, 2002, p. 29). Teachers holding this conception will typically have a constructivist view of learning and utilize

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a range of assessment instruments to collect information about students' understanding of concepts, design of instruction, and barriers to effective classroom teaching.

“Accountability of teachers and schools” conception. There are two bases for school and teachers' accountability conceptions: “one rationale emphasises demonstrating publicly that schools and teachers deliver quality instruction, and the second emphasises improving the quality of instruction” (Brown, 2002, p. 33). Teachers holding this conception view assessment as a means by which to openly defend their classroom teaching and assessment practices to stakeholders. Also, teachers in this category view assessment as a compelling task that they must perform under guiding principles to improve the quality of teaching and learning in schools (Brown, 2002). Consequently, Brown argued that the use of rewards or consequence for systems, schools and teachers based on students' achievement from assessment is the principle of accountability structures.

“Accountability of students” conception. Teachers holding this conception view assessment as the responsibility of students: “students are individually accountable for their learning through their performance on assessments” (Brown, 2002, p. 40). This is usually the case in senior years when students have to write high stakes examinations for entry into higher education institutions, to earn a final grade, obtain a certificate, or for employment purposes. When teachers view assessment in this way, they believe students should be made accountable for their inputs (hard work, resilience, attendance, laziness, etc.) towards achieving educational goals (Brown, 2002).

“Assessment as irrelevant” conception. This conception of assessment is grounded on the view that assessment as a formal, rigid process has no valid identity in the teaching and learning of students (Brown, 2002). Therefore, Brown argued that teachers who hold this conception about assessment believe that “assessment equates to testing, and, by corollary, that testing is bad for

education, or that assessment makes teachers, schools, and students accountable for their work” (Brown, 2002, p. 43), hence irrelevant to them.

Another model of assessment that is used in this study of Manitoba science teachers as an analytical framework is Abell and Siegel’s (2011) classification of assessment according to their types. This model is preferred because it was developed within the context of science education, and its categories encompass different purposes from those described in the Manitoba science curriculum and assessment document (i.e., assessment of, for and as learning), which are widely used in the currently literature on assessment. Accordingly, assessment can be categorized as diagnostic, formative, summative, or metacognitive.

Diagnostic assessment: Assessment used at the start of instruction or course to provide information on pre-existing beliefs and knowledge that students have about science.

Formative assessment: Usually used as instruction proceeds to elicit information on students’ learning progress. Teachers benefit from this assessment as it allows them to guide the teaching and learning process.

Summative assessment: Usually known to be a one-shot, end of instruction or course assessment type. Focus of this type of assessment is on providing grades.

Metacognitive assessment: This form of assessment encourages students to take charge of their learning experiences. Metacognitive assessment can be used in combination with any of the three types mentioned above. (Abell & Siegel, 2011 pp. 213–214)

Chapter III: Methodology

This chapter includes an overview of the research paradigm adopted in this study, the methodological approach, and data collection and analytic methods used to explore research questions in this study. First, I briefly discuss the constructivist paradigm and its nature, followed by case study research as the methodological approach suitable to gather information about science teachers' conceptions and self-efficacy of assessment in this study. Participant recruitment and data collection procedures are then discussed, followed by data analysis, validation methods and limitations to this study.

Theoretical Framework

To effectively conduct qualitative research, a clear and concise reference must be made to the theoretical framework guiding the research (Denzin & Lincoln, 2000). Similarly, making explicit the research paradigm, explains a researcher's choice of research approach and data collection methods (Creswell, 2014). Consistent with Denzin and Lincoln, paradigms are "the net that contains the researcher's epistemological, ontological, and methodological premises" (as cited in Lincoln & Guba, 2013, p. 85).

The Constructivist Paradigm. The constructivist theory is the theoretical paradigm that guides many interpretive and naturalistic investigations and analyses (Creswell, 2014; Lincoln & Guba, 2013). In this study, I adopted the constructivist paradigm, which seeks to understand an individual's view of the world in which they work and live (Creswell, 2014). In constructivist studies, researchers depend majorly on participants' interpretations and notions of the research problem being explored by way of historical and cultural ideals that operate in their lives (Creswell, 2014).

Methodological Framework

This research employs a qualitative research approach to explore science teacher's conceptions of assessment and their perceived self-efficacy in developing and using assessment strategies. Thus, in line with Lincoln and Guba (2013), methodologically, the intent of this study is to capture the individual meanings and interpretations that science teachers have of assessment and their perceived ability to develop and use classroom assessment. In doing this, some assumptions have been identified that researchers must hold with regards to developing meanings while drawing on the constructivist approach:

1. Meanings are constructed as human beings interact with their worlds and thus open-ended questions are an appropriate way to allow participants to share their views;
2. Historical and social perceptions account for how human beings make sense of their world, hence qualitative researchers must seek to understand participants' contexts, visit those contexts, and interpret their findings based on the information collected and their personal background and experiences.
(Crotty, 1998 as cited in Creswell, 2014)

The assumptions above point to the distinct feature of case study research, which involves the desire of researchers to inductively understand a social event, issue, process, or individual(s) (Yin, 2009). Case studies also allow for the specificity of the sociocultural context to be taken into consideration, as I focus on the specific cases of three high school science teachers in Manitoba. Thus, within a constructivist paradigm, I utilize in this study theoretical lenses that align with sociocultural and interpretivist perspectives, while adhering to case study design and teacher's conceptions of assessment models as analytical frameworks.

Research Design: Case Study. A case study research design is adopted in this study to describe how science teachers conceive of assessment and what strategies they employ to assess their students and to get a sense of their self-efficacy. Case study research has been described as “particularistic, descriptive and heuristic” to justify its suitability for any research focused on exploring a phenomenon or situation, that provides insights into a situation, and describes any existing relationship amongst participants (Gay et al., 2009, p. 427). In addition, McMillan (2016) emphasized the unique characteristics of case study research. He described the research design as useful in understanding, exploring and describing a phenomenon.

In the literature, different types of case study designs have been described (Creswell & Poth, 2018; Gay et al., 2009; McMillan, 2016; Yin, 2009). McMillan (2016) highlighted seven approaches to case studies; however, this author contended that only three are commonly used in educational research: “intrinsic, instrumental and collective” (p. 316). In the views of another researcher, “single case, single case embedded, multiple case, multiple case embedded” are the four case studies design types (Yin, 2009, p. 46). Other researchers classified case studies into: instrumental, intrinsic, and multiple designs (Creswell & Poth, 2018; Gay et al., 2009). By and large, researchers agreed that the choice of any design depends on the focus or intent of the research, number of participants, number of sites, focus on contemporary or historical events, and the degree of researcher control over behavioural cases.

For this study, a multiple case study design (Creswell & Poth, 2018; Gay et al., 2009) was employed to explore three Manitoba high school science teachers' conceptions of assessment and its relation to their perceived self-efficacy to develop and use assessment in their classrooms. Consistent with Creswell and Poth (2018), a multiple case study approach involves the recruitment of participants from different sites to show different perspectives they have of an

issue. In addition, a multiple case study design is appropriate for use in this study based on its ability to avail the researcher the opportunity to explore differences within and among cases (Yin, 2014). In this study, each participant's narrative is considered as a single case and their interviews are analyzed on a case-by-case basis.

Participants. To delimit the cases in this study, participants were purposefully recruited by identifying science teachers who have been teaching science (exclusively or with other subjects) in Winnipeg high schools for at least the past two years and who self-identified as passionate and innovative in the use of assessment. As noted earlier, the decision to seek teachers who see themselves as passionate is important as they will have adequate information needed to explore the research problem. Yin (2009) cautioned against using power analysis to determine the number of cases to be investigated in a multiple case study research. Yin commented that on the one hand, two to three cases are adequate for a straightforward theory or issue that does not require excessive certainty or generalization, and on the other hand it ensures manageability by the researcher. In keeping with this view, I decided to include three teachers in this study.

The process of recruiting participants followed the approval of the University of Manitoba Education and Nursing Research Ethics Board (ENREB) (see Appendix A). Approval to conduct this research was sought and granted by two school divisions in Winnipeg and details of the research were shared with all high school principals in the two school divisions. School principals shared details of this study with science teachers in their schools. Teachers who self-identified as innovative and passionate about assessment, or that self-identified as being interested in advancing their classroom assessment practices were invited to participate in this study. Other inclusion criteria were having at least two years of teaching experience and having taught a natural science discipline specifically. Participant recruitment followed a first-come,

first-served basis; the first three teachers who volunteered to participate in this study and who fitted the inclusion criteria described above (i.e., self-identified as passionate, innovative and/or interested in advancing their classroom assessment practices, with minimum of two years of experience teaching, and teaching a natural science discipline) were contacted and a meeting was arranged with each science teacher to discuss the study in detail, to attend to any questions each teacher had and to confirm their consent to participate in the study.

Data Collection. Data for this study was collected through two forms: interviews and artifacts. In qualitative case study research, researchers identified the importance of adopting multiple data collection techniques as a means to ensuring validity of data, and to present a clearer picture of the phenomenon under study (Creswell, 2014; Gay et al., 2009). In addition, collecting data from two or more sources is one of the major characteristics of case study research (Yin, 2009).

Artifacts are useful physical evidence collected or observed as part of research studies. However, they should be used with another source of evidence in data collection for case study purposes (Yin, 2014). In this study, past year's assessment instruments were sourced from participants to satisfy two purposes. First, to portray some of the types of assessments science teachers employed in their classrooms; and secondly, to provide a concrete background for conversations during interviews. Only artifacts shared by a teacher were used during the interview with that same teacher.

Although artifacts are good sources of information for case study research, Yin (2014) claimed that interviews are an important and reliable source through which adequate information needed for case studies can be elicited. In the views of Brinkmann and Kvale, interviews represent a process whereby "knowledge is constructed in the interaction between the

interviewer and the interviewee” (as cited in Creswell & Poth, 2018, p. 163). These authors further described interviews as “attempts to understand the world from the subjects’ point of view, to unfold the meaning of their experiences, to uncover their lived world” (Creswell & Poth, 2018, p. 164). Accordingly, interviews were scheduled with each participant to discuss their use of assessment in their science classroom, grounding the conversation on the artifacts teachers provided, and the provincial curriculum documents.

Interviews were conducted following an un-structured protocol, which allows participants to freely discuss their experiences of the research problem without being confined within the boundaries of set questions (McMillan, 2016). However, the use of prompts has been suggested to guide interview conversations and to stay focused on the research problem (Gay et al., 2009). The interview protocol is available in Appendix B.

A discussion session was held with participants before the interview to explain, and define concepts such as assessment, conception, efficacy, assessment types, assessment development, and assessment use. A one-time, face-to-face interview was conducted one-on-one with each teacher, in a quiet space in their schools, during school hours, and lasted approximately sixty minutes for each participant. The interview with each teacher began with gathering contextual information about each participant’s school, subject(s) taught presently and prior to participating in this research, years of teaching, qualification(s), involvement and participation in any professional development organization/program. Interviews were digitally audio-recorded with a handheld recording device, with the permission of the interviewee. Participants were allowed to have control on the flow of information and did most of the talking, while I was flexible in my involvement and kept the overall focus of the discussion on the research problem being explored.

Data Analysis. The analytic process in qualitative studies goes beyond analyzing data from texts and images; it includes organizing and condensing the amount or forms of data gathered during data collection, connecting and classifying categories and searching for some interpretation of it (Creswell & Poth, 2018). Many analytic processes have been identified in the literature as suitable for analyzing qualitative data, for example, hermeneutics, phenomenology, grounded theory, thematic analysis, discourse analysis, and content analysis (Bengtsson, 2016).

According to Bengtsson (2016), an important consideration in choosing an analytic method is for researchers to follow a rigorous and credible means to achieve trustworthy results and draw accurate conclusions. Bengtsson further emphasized that content analysis is an analytical process that is reliable, learnable, and limits researchers' personal influence on the data. Content analysis is "a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use" (Krippendorff, 2004, p. 18).

Researchers have identified two forms of content analysis: quantitative and qualitative (Bengtsson, 2016; Bos & Tarnai, 1999). These two forms differ in terms of analytic purposes and data presentation: while quantitative content analysis seeks to provide answers to the number of times a concept is mentioned, qualitative content analysis seeks to provide a reflection of participants' statements about a topic. Moreover, qualitative content analysis presents data in themes and categories, which allows the researcher to draw interpretations of the data collected (Bengtsson, 2016; Bos & Tarnai, 1999). As the choice of data collection may have an effect on the depth of analysis, interview remains the preferred data elicitation method for qualitative content analysis (Bengtsson, 2016). In this study, data was gathered through interviews and analyzed using qualitative content analysis.

Crowe, Inder and Porter (2015, p. 617) defined qualitative content analysis “as a process of description of qualitative data in order to represent clusters of responses”. Qualitative content analysis may follow a latent or manifest analytic procedure contingent upon how close to the text the researcher wants to stay. Manifest analysis permits the researcher to describe participants’ actual words, to utilize those words themselves, and communicate with readers all visible and apparent data in the text. On the other hand, latent analysis enables the researcher to analyze data on an interpretive level and to find underlying meanings to the text (Bengtsson, 2016). Both manifest and latent analysis can be used together, with the latter providing some inductive and interpretive meanings from interview transcripts (Erlingsson & Brysiewicz, 2017).

Four analytic stages have been identified as procedure and interpretation processes in qualitative content analysis: decontextualization, recontextualization, categorization and compilation (Bengtsson, 2016). In addition, an iterative, continuous process of data coding and categorization has been emphasized as peculiar to qualitative content analysis (Bengtsson, 2016; Erlingsson & Brysiewicz, 2017). Decontextualization involves familiarization with data and creating “meaning units” (Bengtsson, 2016, p. 11) or open coding. During the recontextualization phase, researchers re-engage with the text to identify consonance between the meaning units and the text and to identify unmarked texts. The process of categorization follows, by condensing the meaning units or codes to form categories; then the compilation phase follows, where the researcher provides deep meanings to the text (Bengtsson, 2016; Erlingsson & Brysiewicz, 2017).

I listened to the audio recordings of interviews repeatedly in the early stage of data analysis to gain a better understanding of the data. I tried to gain a sense of the text as a whole, as I searched for meaning units (Bengtsson, 2016). Consistent with Bengtsson, a meaning unit is the

“smallest unit that contains some of the insights the researcher needs, and it is the constellation of sentences or paragraphs containing aspects related to each other, answering the question set out in the aim” (Bengtsson, 2016, p. 11). After I got immersed in the data, I created a list of codes and an explanation or meaning of each code to minimize changes in my reasoning of the codes (Bengtsson, 2016). As this study follows an inductive analytic design, I developed codes following an iterative process to increase the reliability and stability of the codes. This decontextualization process produced over fifty codes from each interview; some of which include: *improving teaching, reporting, school accountability, mastery, engagement, system demands, confidence*, among others. Codes were paired with timeframes from the original audio recordings as a means to organize this first stage of data analysis.

I then engaged in a recontextualization process to condense the codes for each interview datum while ensuring that the meanings were kept intact. Also, I ensured that all the texts were adequately analyzed, and non-relevant texts were kept for further analysis to minimize data loss. A continuous process of code development, checking and cohesion was adopted to form sub-categories. Examples of sub-categories derived from analysis includes: *assessment is used to guide teaching; adequate knowledge of assessment; making better choices for students; relying on formal education; uniquely mine; creativity; regular conversations; flexibility in assessment; scaffolding students' learning; time constraints*. Each case study was analyzed following this technique to produce manifest statements from each interview. Because research on teachers' conceptions of assessment, assessment practices and perceived self-efficacy has been conducted extensively and because this study does not aim to generate new theories or models, I aligned the final categories for each participant with corresponding categories in models already published in the research literature in this field, which served as analytical framework for this study.

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Therefore, the sub-categories informed the final categories for each participant, which is equivalent to the final category as per the analytical/theoretical model used to interpret the data; that is, for teachers' conceptions of assessment, final categories are equivalent to one or more of the conceptions outlined in Brown's model. Final categories for each participant for their assessment practices and perceived self-efficacy data also correspond to categories in the models used to analyze these datasets (for example, *diagnostic assessment* or *metacognitive assessment* for assessment practices and *mastery experiences*; *verbal persuasion* for self-efficacy). I then gave a descriptive latent analysis of the data to bring forth hidden meanings in the text and to interpret participant's statements about views on assessment, perceived assessment self-efficacy and assessment practices.

To provide a latent analysis of the data, I relied on theoretical propositions that shaped my review of the literature, research questions, and study design (Yin, 2009). A theoretical proposition is the "theoretical orientation guiding a case studies research" (Yin, 2009. p. 130), helps in the organization of case studies, and in the definition of other explanations to be investigated. The theoretical propositions adopted in this study were described earlier in the literature review section and are as follows: participants' meanings of assessment practices were viewed through the assessment types detailed in Abell and Siegel's (2011) study; teachers' assessment purposes were described in this study given those recommended by Manitoba Education, Citizenship and Youth (2006a); analysis of teachers' perceived self-efficacy follows Bandura's (1977) four sources of self-efficacy, that is, mastery experiences, vicarious experiences, verbal persuasion, and affective experiences; while teachers' conceptions of assessment were categorized using the conceptions of assessment model by Brown (2002).

Analysis of assessment artifacts. In this study, assessment types discussed in Abell and Siegel's (2011) study were used as an analytical framework to categorize assessment types that Manitoba science teachers utilize in their classrooms, based on the assessment artifacts they shared with the researcher. Even though artifacts were used to contextualize the conversations during interviews, and as such, they were also described and discussed in the interview data, they were further analyzed to explore participants' assessment practices (conceptions and self-efficacy are concepts that cannot be explored through the artifacts, but these concepts can and were related to the artifacts analyzed). Accordingly, artifacts were classified following Abell and Siegel' model: diagnostic, formative, summative, or metacognitive assessment.

Furthermore, teachers' purposes for assessing students have been identified as critical to the choices they make before, during, and after assessment practices (Bell, 2007). The purpose for assessing students' understanding and skills have been discussed to include assessing for the purpose of learning, for learning, and as learning (Manitoba Education, Citizenship and Youth, 2006a). As this document is provincially-based and recommended for teachers' use, this study drew on these three purposes (assessment of, for, and as learning) to identify Manitoba science teachers' purposes of assessment as available through the artifacts they shared with the researcher and through interview data. Beyond a classification of the artifacts based on their purpose and type, this data source also allowed me to validate descriptions of assessment practices teachers provided during the interview.

Quality Measures in this Study

Trustworthiness in a study is an integral part of its design and analytical processes; it avails the reader an opportunity to look for alternative means to data interpretation if the study failed to adequately present this evidence, and it ensures that appropriate measures have been

followed by the researcher in providing answers to the research questions (Bengtsson, 2016). In qualitative research, some concepts have been considered as evaluative criteria towards achieving trustworthiness in studies. While some researchers regard these criteria as validity, reliability, generalizability and objectivity; others view them as credibility, dependability, transferability and confirmability; however, these terms have similar meanings but differ in use depending on a study's research approach (Bengtsson, 2016; Creswell, 2014; Creswell & Poth, 2018).

The ability of a study to investigate what it was designed for; to explicitly discuss data collection and analytic procedures remain the focus of the research credibility criteria (Bengtsson, 2016). First, in this study, I clearly highlighted two data collection procedures: interviews and artifacts, to enhance credibility of the data collected. Furthermore, I sent a follow-up email to each teacher to confirm some of the discussions we had during interviews; as well as a summary of their specific case interpretations. However, after requesting their comments on these documents twice within a four-week period, one teacher responded and confirmed he was satisfied with the case interpretation while two other teachers chose not to respond to the emails. Through peer-debriefing, my supervisor reviewed this study's data collection and analytic procedures and techniques and provided a second view of these processes. Determination of the reliability, consistency, and stability of research processes and procedures are what the term dependability entails (Creswell, 2014). A description of the procedures I followed in this case study research has been provided above and a description of each case context is presented in the next chapter.

Research confirmability refers to auditing the research process by an external member to confirm trustworthiness of the process (Creswell & Poth, 2018). This procedure was enacted

through the participation of my thesis advisor in careful and repeated readings and discussion of earlier versions of my thesis. To ensure confirmability, a criterion to look for is the researcher's neutrality or objectivity (Bengtsson, 2016). In my role as researcher and interviewer, I ensured I did not know any of the participants prior to their involvement in this research, which contributed to my neutrality and objectivity in analyzing the data. Furthermore, I am not a teacher in Canada, and I do not hold any other role or position that may conflict with my role as a researcher. I also shared with participants the purpose of this research and the definitions of terms I was using in this study, hoping to establish a common ground for the conversation and ensuring transparency. Ultimately, the use of quotes directly from the data will allow readers to participate in the process of data analysis and confirmability.

Finally, application of research findings to other contexts and groups is the focus of the transferability criterion (Bengtsson, 2016). Also known as generalizability, this criterion lay weak claims in qualitative research approach since its major emphasis is on finding the depth of a small sample, which affects the ability to generalize findings. Drawing on applicable theories and previous, contemporary research in this area, indicates a connection to relevant bodies of knowledge that have shaped the study's research questions, data collection and analytic frameworks; by so doing, future related studies can apply results from this study to contribute a broader understanding of the issue investigated here.

Chapter IV: Findings and Discussion

This chapter presents the three science teachers' cases that constitute the data corpus for this study. In describing each case, I articulate each science teacher's conceptions of assessment, their general views of the purposes of assessment in science education, the assessment types they use in their classrooms, their assessment practices, and their perceived self-efficacy to develop and use assessment strategies. In keeping with methodological parameters in case studies, according to which findings should reflect a description of the case and its context, issues found in the case, and an interpretation of the case[s] (Creswell & Poth, 2018), in this chapter I present each case individually, and proceed to further discuss and draw connections between the three cases in the next chapter. Thus, in this chapter, I present first a description of each case, that is, the science teachers in the context of the science classes they are teaching, as well as their school context; second, I present findings from data analysis of artifacts and interviews.

The names of teachers and the schools where they work were replaced by pseudonyms. The pseudonyms given to the three teachers, Mr. Ade, Mr. Olu (a short form of Oluwa), and Mrs. Temi are Nigerian words that mean, respectively, crown, lord, and mine. All three words together form the word Temiladeoluwa, which means mine is the Lord's crown. The pseudonyms given to the schools where the teachers work are Ibadan and Ilorin, which are the names of two cities in Nigeria.

Case Study I: Mr. Ade

Mr. Ade, a middle-aged male, teaches physics at Ibadan High School in the city of Winnipeg, Manitoba. Ibadan High School promotes and supports student's learning through specialized programs in science, mathematics and English language arts. Located in a residential community, with a student population of about 800 from various socio-economic backgrounds,

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Ibadan High School is a publicly funded English-speaking school and a multi-cultural learning institution with about 50 international students. The serenity of the school environment caught my attention as I walked into the school to check in with the secretary at the school office.

During my two visits to the school, teachers were either teaching in classrooms or in laboratories; some were in their offices, while the hallways were as quiet as expected given that I was at the school during class time.

During Mr. Ade's 16-year teaching career, he has taught science, mathematics, and French in middle and high schools. Mr. Ade has taught grades seven, eight, nine, eleven and twelve; but for the most part, he has taught grades seven and eight science. Mr. Ade currently teaches grade 11 and 12 physics classes, which he has been doing for about four years, and also the honours and advanced placement physics in grades 11 and 12. After his Bachelor of Science degree, he earned a Bachelor of Education degree, a Post-Baccalaureate in Education degree, and he is currently enrolled in a Master of Education degree program. In his professional education trajectory, Mr. Ade believes he has gained a sound understanding of student assessment, even though he did not specialize on assessment in any of his educational degrees. Mr. Ade published his first research paper on students' assessment choices a few months prior to participating in the interview for this study. As a teacher who is passionate about classroom assessment, Mr. Ade belongs to a professional organization that focuses on student access to student-centered assessments in schools.

From my interaction with Mr. Ade, I found him to be a pro-active teacher who is passionate about student's learning and understanding of concepts, who values student-teacher relationships and aims to improve the learning experiences of students in an inclusive school environment. For example, Mr. Ade mentioned, "my teaching and assessment is about students'

learning ... I think it is easy for me to think of different ways students can do assessment.” Also, he is an advocate for the use of contemporary classroom assessments with students and teachers alike. He mentioned, “convincing everybody else that the environment I am creating by looking at inquiry and all these project-based learning experiences rather than tests, it just takes work.” Moreover, Mr. Ade’s confidence in the value of further education was evident not only in his professional education trajectory, but also in several of his statements during our interview, as provided below.

Mr. Ade’s conception of assessment: Improvement of teaching and learning. After going through the data repeatedly while developing first codes during the decontextualization stage and second codes during the recontextualization stage of the content analysis, I generated three sub-categories from grouping of these second codes: assessment is used to guide teaching; adequate knowledge of assessment; and making better choices for students. These sub-categories informed the final category, pertaining to Mr. Ade’s conception of assessment: Assessment for improvement of learning.

Mr. Ade described his personal conception of assessment as encompassing the three purposes of assessment (i.e., assessment for, as and of learning), involving the integration of assessment within instruction, and being about frequently checking students’ understanding throughout a lesson. To him, assessment should be designed to improve teaching and learning in classrooms. Thus, Mr. Ade described assessment based on what he believes it means to him and his practice:

Getting an understanding of where the student is at, so you teach and then you have to figure out if they are learning from the teaching, and involves the assessment of, as and for learning ... So, you are always assessing, there is never

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a time in your class that you are not assessing, you have to guide your teaching based on the assessment.

As evidenced in the quote above, while providing an explanation of what assessment means to him, Mr. Ade referred also to assessment as a continuous process used to guide instruction and to identify where students are at in their learning. Of particular importance is his mention that he thinks assessment is for identifying students' learning, primarily as a way to plan his instruction. This relates to an improvement of teaching and learning conception of assessment: "so you teach and then you have to figure out if they are learning from the teaching, you have to guide your teaching based on the assessment."

For Mr. Ade, assessment does not include just tests, but also those interactions that occur in classrooms that lead to students' better understanding of content. Accordingly, he does not believe he has to be at a certain lesson at any given time, as might be prescribed by the school and curriculum documents; rather what matters most is how his students engage with, process, and understand the content of lessons. In his words:

I have come to know that [assessments] are even simple prompting questions ... I still stop and ask students if what I have done on the board makes sense, do you have any questions? Is there some way that I can change what's on the board?

I do get my students to do a thumbs-up or a thumbs-down just to let me know if they are with me ... I do not care if I am supposed to be on a certain lesson by tomorrow if they are not getting what I am doing right now, I have to spend more time on it.

From the quotes above, we can interpret Mr. Ade's commitment to assessment for learning, and his preoccupation with using assessment to find out whether students are following,

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so he can plan his lessons accordingly, which is in line with some aspects of formative assessment (Abell & Siegel, 2011). The link between assessment and instruction planning, for Mr. Ade, seems to be well established, which is further evidence of the assessment as improvement of teaching and learning conception.

Mr. Ade further discussed his ideas of assessment as being student-centered. He believes his students should take charge of their learning experiences and indicate when they have and can demonstrate their learning: "I am not the one that is going to decide when students are ready for assessment or when they are ready to share their learning ... I would say totally a hundred percent assessment guides my instruction."

It is interesting to notice how Mr. Ade shifts the control about decision-making related to assessment practices to students, as indicated in the quote above; even though he is the pedagogical expert in the classroom, and, as part of his tasks as teacher, he is the one responsible for assessment-related decisions, he allows students to choose when they are ready to demonstrate their learning. Thus, at least on a conceptual level, Mr. Ade espouses the notion of assessment as learning.

When talking specifically about the purposes of assessing, Mr. Ade mentioned what he looks for in assessment and why he looks for such skills in his students. In the categorization stage, I developed three sub-categories related to Mr. Ade's notions of purposes of assessment: *Assessment for challenging students; assessment for informing my teaching and students' learning; and using assessment for and as learning*. These informed the final category pertaining to Mr. Ade's conceptualization of the main purposes of assessment: *Assessment for and as learning*. For the most part, Mr. Ade assesses his students to figure out if they are learning from his teaching and also to develop their thinking and creativity skills. "I challenge them to see how

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they can show me the most learning possible without just regurgitating what I've already done with them." As noted earlier in the review of the literature, learning from teacher's teaching, engaging in feedback, and assisting students in critically assessing their learning and creative skills are characteristics of formative and metacognitive assessments.

Furthermore, Mr. Ade explores students' prior knowledge of scientific concepts, which indicates the use of diagnostic assessment in his practice. This type of assessment is intended to identify students' level of understanding at the beginning of a lesson to assist in tailoring instruction and assessment practices. For example, he mentioned that, "students should know about what we are going to talk about in this lesson, now before we go, what have you learned, even if it's a sub-piece of the big unit."

In terms of his purposes for assessment, in consonance with his definition of assessment as a means to gauge students' understanding to plan his teaching, it appears that Mr. Ade engages mostly in assessment for learning, with some aspects of assessment as learning also present. His discussion indicated a constructivist view of learning coupled with an assessment as learning approach by encouraging students to take charge of their learning. He noted, "I think the purpose really is to see, this could be a couple, to see how much the students are learning, but also to see how I am teaching." This further substantiates the assessment as improvement of teaching and learning conception, as Mr. Ade believes assessment can be used to calibrate his teaching.

During our interview, I presented the *Rethinking Classroom Assessment with Purpose in Mind* document (Manitoba Education, Citizenship and Youth, 2006a) to Mr. Ade, briefly informing him about contents of the document and to ask him to comment on the pyramids in Figures 1 and 2, which were coded B and A, respectively, and presented without captions. Mr.

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Ade selected A, the re-configured assessment pyramid (Figure 2) as a representation of his assessment practices. This pyramid advocates for greater use of assessment as learning, followed by assessment for learning, and finally, assessment of learning. However, Mr. Ade mentioned that, from his experience of teaching and assessment, teachers' purposes for assessment vary by the grade level they teach.

I personally, is A, but high school science classes is mostly B. Yeah, because I taught in other schools before coming here, I know early years is very much focusing on assessment as learning, very much, and middle years, 'cause I was a grade seven and eight teacher, I began to and became more of that kind of teacher as well.

Furthermore, Mr. Ade reiterated that, of the three purposes of assessment, the most used in his classes is assessment for learning:

The one that would probably show up the least in my class would be the assessment of learning. Most of my time would be spent on assessment for learning and making sure that I know where they're at ... And I guess every individual lesson should have those three pieces too.

Thus, the pyramids represented in Figures 1 and 2 are not quite an accurate representation of Mr. Ade's preferences when it comes to assessment purposes in his classes. Rather, his pyramid would have assessment for learning at the base, comprising most of the assessment practices and processes in class, with assessment as learning as the second most common, and followed by assessment of learning as less used approach. This view may be connected to his ideas about some of the assessment practices and instruments used traditionally for summative purposes, as discussed further on.

Teachers' thinking about assessment is not only influenced by the skills acquired through professional development, but also by the number of years they have been involved in the teaching profession (Alkharusi, 2011a; Alkharusi et al., 2014). In the case of Mr. Ade, after more than a decade as a science teacher, he can perceive changes in his conceptions of assessment:

I certainly started off my career focusing on getting students ready for the test and that was a big piece taking in lots of marks, but nowadays I don't, I focus on a reconfigured assessment ... I think it is super important to not focus on the way that it was before, right?

When discussing his practices, it also became evident how Mr. Ade attempts to distance himself from assessment types he considers out-dated and not in line with his current conceptions of assessment as improvement of teaching and learning, formative, and student-centered. One interesting aspect of Mr. Ade's assessment development and use was his description of the *RCAPM* document. Having mentioned his unfamiliarity with the document, after I engaged in a brief discussion about it and stated its purpose to him, he described the document as dated. To him, since student population characteristics keep changing, there is the need to also develop educational policies that can cater to these changes. He further discussed the reasons why he does not agree with using the provincial assessment document as a reference point when developing and practicing assessment with his students.

When you think about schools ten to twelve years ago, you are talking about a totally different population and so to always fall back to the same routine and habits doesn't help. Like even the grade nines and tens we are having in school, fourteen to fifteen years old today have lived their whole lives with either a device or a phone in their hand, so I think referring to a document that is twelve years old

is not current enough to meet the needs of the new generation of students that we teach in our schools just the way that teaching is changing.

Despite considering the document too old and probably not aligned to the reality of the digital world in which students live today, Mr. Ade's conceptions of assessment were, to a greater extent, aligned to the recommendations in this document, as discussed further on and evidenced by some of his assessment practices.

Mr. Ade's perceived self-efficacy in developing and using assessment: Verbal persuasion self-efficacy of assessment. During the interview, I asked Mr. Ade how he develops the assessment instruments he uses in his classroom to evaluate students' knowledge and skills, and his self-reported efficacy of developing those instruments and utilizing them in class. From our conversation, three sub-categories were developed from second codes generated during the recontextualization stage: relying on formal education, uniquely mine, and creativity, resulting in the formation of the final category, verbal persuasion. One of the unique characteristics of Mr. Ade is his connection with his background, especially his education. During our interview, he continually drew on his education background as a means through which he developed his assessment conception and practices, and, especially, his self-efficacy to develop and use assessment.

Mr. Ade appeared confident in the development and use of assessment instruments with his students. In our discussion on the sources for his assessment instruments, Mr. Ade mentioned, "I have used a lot of textbooks and notes I have from my university classes, and I would refer to those ones, I feel they are a bit updated." His confidence to develop and use assessment instruments was further validated in the way in which he appears to be proud of his ability to develop assessment himself, rather than using pre-made or other teachers' assessment

instruments: "I do it [development of assessment instruments] by myself, I follow some templates from some of the classes that I took, but everything that I have is definitely, uniquely mine."

Mr. Ade also pointed out how his creative skills contributed towards his assessment self-efficacy and ease of implementation. He mentioned,

I feel like I have good strategies for doing assessment, I feel like my nature is to be a creative person, I think it's easy for me to think of different ways students can do assessment. And I just think if you are more open-minded and more creative, then it's easier to do that.

When sharing with me how he developed his personal assessment conception, Mr. Ade mentioned the knowledge he derived from his professional development and how this has assisted in shaping his thinking towards student assessment, and also inspired him to assess the way he does in his classroom. This drew my attention to the significance teachers can derive from engaging in additional qualifications in education and how this could have an influence on how teachers develop assessment conceptions and practices, as noticed by Alkharusi (2011a), DeLuca and Klinger (2010), and Ogan-Bekiroglu (2009). Mr. Ade mentioned,

When I did my post-bac, I took a few pretty awesome courses that taught me a lot about not just teaching in general and assessment and instruction, so it inspired me to look critically at the way I have my classes set up and to think about how I can make better choices for students.

Mr. Ade's high regard for his education in terms of a source of his perceived self-efficacy of assessment aligns with Bandura's (1977) verbal persuasion category. That is, according to Mr. Ade, his course instructors succeeded in planting a seed of confidence in him, which provoked

him to think about his practices and promoted self-efficacy in relation to instructional and assessment practices. Even though he also mentioned relying on textbooks, these were resources shared with him during formal educational courses; thus, in addition to a personality trait, namely, his creativity, he mostly considers his educational experiences as the source of his ability and confidence in developing and using contemporary forms of assessment in his classrooms.

Mr. Ade's assessment practices: Diagnostic, formative and metacognitive assessments. This section describes how Mr. Ade practices assessment with his students. Five sub-categories were derived from second codes: Guided inquiry; I plan assessment ahead; students' freedom of expression of learning; time constraints; and hands-on & real-world problems. These sub-categories informed the final categorization of Mr. Ade's assessment practices, following Abell and Siegel's model (2011): Diagnostic, formative and metacognitive assessments.

Before assessing students' understanding of scientific contents, Mr. Ade mentioned giving students enough time to process the contents of a lesson and then discuss with them their knowledge about it:

I do a checking with the whole class towards the end of the class to see everyone's okay, I always give them time to apply their learning, my class will never be a sixty-minute lecture, it will be twenty, thirty minutes of learning and the rest of the class is applying what they've learned to try to develop those skills. So, I will definitely check in with the students at that time, most of my time will be spent on assessment for learning, making sure that I know where they are at,

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because if we are not on the same page, I can't go further if there are pieces that they are missing.

Here, Mr. Ade reinstates the importance of diagnostic and formative assessment in his pedagogy. Moreover, allowing time for students to apply their knowledge while he checks on their understanding is aligned with a constructivist approach to learning, as emphasized in the Manitoba science curriculum documents. As Mr. Ade mentioned elsewhere, he is not concerned about covering content within a certain particular timeline; indeed, as indicated here, he "can't go further if there are pieces that they [students] are missing." Thus, Mr. Ade demonstrates awareness of the importance of diagnostic assessment, even though he does not refer to the practice in these terms.

An example of how Mr. Ade integrates assessment with teaching during physics labs with his students is highlighted below. His assessment practices support the development of procedural and critical thinking skills in students, with an originality of ideas, procedures, and designs as an alternative to a repetition of existing laboratory procedures.

What I do is, I start with this guided inquiry where I give my students the whole lab, and all they have to do is collect their own data and come up with their own conclusion, so that's the only part I'll mark the first time through, then the next lab, I'll take away the procedure, so this time, I'll give them the question, then I'll say "here's the material, how are you going to make this lab happen?" So, come up with your own procedure, collect your own data, and draw conclusions. Other times, I say, "we have done a lesson on this topic, I want you to do a lab for me on this topic, come up with your question, hypothesis, design your own procedure" so gradually releasing the responsibility there, so that now every lab, I

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am not marking the whole lab, I am just always highlighting every piece of it, so that by the end of my course, they've had feedback on each section of a lab. So that they are ready to do an open inquiry lab where they have nothing but their own knowledge to go on.

Through scaffolding, Mr. Ade enacts precepts of constructivism in the way in which he progressively allows his students to take increased responsibility for designing and conducting science inquiries. As students develop the skills necessary to, eventually, take charge of the entire inquiry project, Mr. Ade assesses different skills and aspects of the projects each time, so that he is not focusing always on the same set of skills and abilities; rather, his assessment aligns with the expectations of students rising to the challenge of engaging in student-centered, open inquiry. In science education literature, this is one of the types of authentic, performance-based assessment tasks teachers are encouraged to implement in their classrooms.

Further into how Mr. Ade practices assessment, one of his assessment instruments suggests he engages his students in performance assessment. In this assessment instrument, he asked students to build a rollercoaster. In this project, building materials were provided for students to demonstrate their knowledge of kinematics, energy, forces, and circular motion as covered in a just-concluded unit. Students were to measure, calculate, analyze, demonstrate, and provide conclusions based on their observations throughout the project. This assessment instrument revealed how Mr. Ade assessed students' skills and procedural competencies. In the artifact he shared, Mr. Ade assessed students' ability to calculate acceleration, kinetic, and potential energy as part of the project, and demonstrate Newton's 1st, 2nd and 3rd laws. Lending verbal support to the assessment instrument, his discussion further strengthens the claim that

practicing performance assessment with students could develop their creativity, collaboration, and originality.

So, this is rollercoaster project, where I assess their understanding of momentum and energy and forces, but they built their own rollercoaster and they have to analyze it in groups of two, three or four, also to collaborate and talk.

The hands-on project where students build a rollercoaster provides opportunities for the development of several of the skills listed as learning objectives in Cluster Zero of the Manitoba science curriculum documents. Moreover, the group analysis aspect of the project provides opportunities for collaboration and for some forms of metacognitive learning to occur, as students engage in evaluation of each other's and their own project. In relation to this particular assignment, Mr. Ade mentioned how students are challenged but how he believes this is what may push students to succeed:

I mean, the only time you are ever going to make a name for yourself is when you come up with an idea that is original and unique, or you find a different way to approach something ... This practice, students find it challenging.

Further analysis of Mr. Ade's discussion on his assessment practices supports the above claim that he engages students in real-life inquiry projects and that he plans assessment ahead of instruction. He explained how he would use a real-life project to assess his students' skills and understanding of the effects of weather on the design of external building entrances and the appropriate angle necessary for such entrances. This kind of assessment instrument shows that Mr. Ade engages students in authentic assessment; indeed, authentic assessment has been identified as the assessment of students' understanding of concepts and ability to process

information in real-life situations; and in line with contemporary assessment practices (Butler & McMunn, 2006).

In the advanced placement classes I will take [i.e., teach] next term, I am looking to say, okay, find me a real-world problem that we need to do, improve it ... Or if we're going to design a building feature, like wheelchair accessible ramps suitable for Winnipeg winters. What type of materials should we use, what kind of angle should it be at?

Developing assessment strategies to be utilized in a unit along with the sequential structure of it has been another approach through which Mr. Ade integrates assessment with instruction. To him, assessment should be planned, purposefully designed, and used concurrently with each unit lesson. This practice could benefit teachers to appropriately assess relevant skills in a timely manner. In planning for assessment in his class, Mr. Ade discussed a process he adopts that makes his practice easy and effective.

This is what I do and its very front heavy, like its backwards design, so I am doing all the planning ahead of time and then as the unit unfolds, there is less and less of work for me to do, other than of course marking the final project and all the feedback in-between, but its really front heavy, but once you do it once, like, if I have four units in a course, I will not have to make all four units like this the first time through, I can focus on one unit this time, and another unit the next time I teach it, and after three or four years, I'll have my course the way that I was hoping it would be, that respects all the different learners in the classroom.

Here, Mr. Ade makes evident his preoccupation with planning assessment ahead of time and managing the often referred to barrier to implementing non-traditional, student-centered

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performance assessment: time constraints. By parsing out the development of assessment for each unit of a science course in multiple years when he is teaching this same course, Mr. Ade could build a repertoire of assessment instruments and practices that are performance-based and can be implemented in subsequent years when he is teaching the same course. This demonstrates careful thought given to the development of assessment and is a practice aligned to his conception of assessment as improvement of teaching and learning.

Another means by which Mr. Ade practices assessment is by allowing students to demonstrate learning in whatever format they prefer and feel most comfortable with. "If they are good at working with their hands, then there is an opportunity to construct a model where that represents what they have learned." By so doing, students are provided with flexibility in their choices of assessments and means through which they can express knowledge and skills of content learned in his course. This practice is indicative of developing metacognition in students as they tend to critically assess their understanding and differential skills of presenting what they have learned while learning from this process as well. For example, Mr. Ade's assessment practices with his grade 12 physics class shows a process he adopts while practicing differentiation in assessment through some instruments and types of assessment he mentioned:

If I explained to my students that we've learned all of this, now its your chance to share with me or to me what you have learnt, like, any means that's helpful for you, through verbal presentations, through tests, through hands-on stuff ... I would give, at the end of a unit, a really broad question, a summative question that encompasses all what we've learned, and I will just say to them, "using your preferred skills of expressing your understanding, tell what you know, what you have learned, or show me."

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Mr. Ade's consideration in allowing students to choose the format of the assignment to be assessed can be seen as indicative of his attempts to implement assessment as learning. Students in his course need to think about what they have learned, but also reflect on their preferred ways to demonstrate this knowledge.

Another interesting dimension of Mr. Ade's assessment practices in addition to allowing students' flexibility in displaying scientific knowledge and engaging students in a creative and real-life inquiry, is his use of different formats of assessment in evaluating students' engagement with lessons and its contents. Mr. Ade indicated his preferences in terms of practices he engages in and those he finds less fascinating.

I am not really into portfolios, but I do it sometimes, somehow, I just like unique interesting little daily activities, hands-on things ... What I really like to focus on are the end-projects, I challenge myself to get away from the tests.

I mean I'll be honest it's less interesting for me, just giving a test, right? Like it's boring, they are fast marks, but they are not interesting to mark. So, I just don't see that cramming for a test actually allows them to deal with that of real-world practical thinking.

Mr. Ade's views on traditional paper and pencil tests further corroborate his assessment as improvement of teaching and learning conception and is aligned with his commitment towards formative assessment and assessment for and as learning. His interest in developing end-of-unit projects, which are hands-on and include practical, real-life problems, is further evidence of his ideas of how authentic and performance assessment can be used to foster students' learning.

Based on the constructivist learning approach, teachers are encouraged to support students in thinking and reviewing their learning experiences and then applying these to their

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future learning (Manitoba Education, Citizenship and Youth, 2006a). At the same time, metacognitive assessment falls under this category of learning by assisting students in the active construction and reconstruction of their own learning processes. To achieve these purposes, teachers must engage students in assessment practices such as presentations, which have been identified as effective assessment practices teachers can utilize in ensuring that students develop the requisite skills and knowledge recommended by the science education curriculum (Delandshere, 2002). In agreement with this notion, Mr. Ade assessed students' comprehension of lessons on the ecosystem through a presentation on how to promote positive sustainable environmental choices. In this project, students were asked to make a presentation following their own thoughts and ideas of representation to discuss a specific ecosystem in a country of their choice. Mr. Ade assessed students' skills in defending and explaining theoretical stances on changes in the earth's crust, formulation of plans to address the impact of natural, physical, and human aspects on the ecosystem; and designing a plan to reduce the effects of these consequences on the planet. Assessment rubrics for this project were designed in a way for students to design, process, and present information as opposed to memorization of content.

Mr. Ade discussed some impediments and the support available towards his notions of assessment and assessment implementation strategies. The influence of political, structural, and institutional policies and reform processes has been identified as a contributor towards teachers' assessment practices and implementation (Aydeniz, 2007). From our discussion, it appears that Mr. Ade's school division has contributed positively to his assessment advancement, implementation, and practices. Mr. Ade shared with me the efforts of the school division in ensuring that teachers implement contemporary assessments in their teaching and classrooms generally:

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Within the division, there is always a push for assessment practices, certainly in the last year and the past we've had in-school workshops, we've had divisional workshop opportunities on assessment, but there is a constant push from the division to be progressive.

However, he shared his physics students' reactions to his teaching and assessment practices, especially concerning awarding of marks to assessment tasks. He discussed students' preference for summative assessment and assignment of marks because they believe grades are required for their certification and higher education purposes.

I think it's hard for the students to realize that not everything is necessarily worth marks. In my classroom, if I just give a comment on something that they wrote, and I give it back to them and they don't see a mark on it, they are like, "what did I get?" I am like, "it doesn't matter, I just wanted to see what you do." So, I think it takes some education for the students to understand that the feedback is helping them to progress in their learning.

I don't know what happens but when I get students in grade twelve, that's what the bulk of their focus comes down to, so it's hard to recondition them to get away from that.

I am struggling with the fact that my grade twelve's are coming with, to me in a certain way, they want their worksheet and lectures and tests and exams, and I don't want to do that. So, it's a struggle for me because it's easy to teach that way too, it's easy.

Another issue mentioned by Mr. Ade which could be a setback towards effectively implementing assessment that he believes caters to students' learning, is time constraints in

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implementing formative assessment. Despite having identified feedback as a means through which teachers recognize the level at which students are learning and to modify teaching and assessment to suit the needs of their students, Mr. Ade perceives feedback as time-consuming. To him, written feedback, especially with large class sizes, is more time-consuming and this could have an effect on the frequency with which teachers provide students with feedback on their learning. According to him,

I think for me if it's verbal, that's so much faster, if I have to write it out, I mean that's just by its nature time consuming, so if I have a class of thirty plus students, when it's written out, all that feedback, it's extremely time consuming. And I can see why people would be hesitant to give that much feedback that indicates pieces that they [students] still need to work on.

Furthermore, the need for colleagues' engagement in a community of practice about classroom assessment was observed from Mr. Ade's discussion about his colleagues' reaction to his teaching and assessment practices.

Convincing everybody else that the environment I am creating by looking at inquiry and all these project-based learning experiences rather than tests, it just takes work getting everybody else to realize that this is just as if more rich learning and application is going on, so, that part is a struggle.

Thus, Mr. Ade perceives his practices to be progressive and grounded on updated notions on assessment as presented in some of the courses he took as part of his formal education. Nonetheless, he is cognisant of the potential barriers to development and implementation of authentic, performance assessment of the kind he is using in his classes. Some of these barriers include resistance from students and from teachers alike, alongside others that are well

documented in the literature, including time constraints and macro-structural forces, such as school division mandates and policies, even though Mr. Ade does not consider the latter to be an impediment in his case; quite the contrary.

Overall, Mr. Ade indicated that he conceives assessment as student-centered and non-traditional; which aligns with an improvement of teaching and learning conception. Furthermore, his perceived self-efficacy is primarily in line with the verbal persuasion source of self-efficacy. Through our interview and from the artifacts he shared, it can be established that he engages students in performance and authentic assessments, integrates assessment with instruction, provides on-going feedback and carefully and strategically plans his assessment ahead of time. The purpose for assessing students, for Mr. Ade, involves assessment for learning most of all, and assessment as learning, configured as the opportunities given to students to evaluate their own learning and choose the best way to demonstrate this learning. With a clear conception of assessment as improvement of teaching and learning, Mr. Ade believes he developed his conception and self-efficacy of assessment from academic programs, also benefiting from working in a progressive school division when it comes to assessment.

Case Study II: Mr. Olu

Mr. Olu is a male, middle-aged, Chemistry teacher at Ibadan High School in the city of Winnipeg, Manitoba, the same school where Mr. Ade (case I) teaches. Over his twenty-year career, Mr. Olu taught grades nine to twelve science and chemistry, grade nine mathematics and grade nine biology. Presently, he teaches grade 11 and 12 chemistry classes and the advanced placement and honours chemistry in grades 11 and 12. As an experienced teacher, Mr. Olu has over the years added several teaching and administrative degrees and certificates to his C.V. After his Bachelor of Science degree in biochemistry, he completed a Bachelor of Education and

a Post-Baccalaureate Degree programs in addition to a Master of Educational Administration degree. Mr. Olu is also certified as teacher of English as a second language. As a teacher who is passionate about assessment, he was a member of an assessment committee focused on the Pan-Canadian science curriculum and a member of a committee that overlooks the province's report cards and teacher's comments on them.

Mr. Olu's conception of assessment: Accountability of teachers and schools and improvement of teaching and learning. After the recontextualization stage of the content analysis, I developed four sub-categories as part of the categorization phase: communicating and reporting information, supporting learning, teacher accountability, and political pressures. These sub-categories were grouped into the category describing Mr. Olu's conceptions of assessment: Accountability of teachers and schools and improvement of teaching and learning.

To Mr. Olu assessment means, "communicating information about students' learning to people." This definition of assessment aligns with an accountability of teachers and schools' conception of assessment. It places the importance of reporting on students' achievement at the forefront of the role played by assessment in schools. It is interesting to notice that this reporting is done "to people" rather than to the students themselves. Thus, there seems to be a clear focus on the evaluative aspect of assessment of learners, with emphasis on communicating or reporting this to other stakeholders in the educational system. This view is further validated in other comments offered by Mr. Olu. Communicating evidence of student's learning to the public reflects his thinking that teachers need to be accountable for students' learning through assessment. As he stated:

Assessment must also have a transparency that can transcend the classroom in the relationship that you have between teacher and student, so, like, students that are

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not legally of age, so, as a result, they have parent representatives, so, we need to be their parent representative also, because there is an entire support system and an entire community that is involved in the learning of students and so, if we communicate the information we get through assessment, then the idea is, along with the team, like parents, guardians, student support services, anyone in the student advisory team, within our division or outside our division, other agencies, then the idea is to support their learning.

In this statement, Mr. Olu made evident that he also considers assessment to be a broader task that ultimately can be used to support students' learning. He mentioned here the connections between several people and agencies involved in the well being of students, and how teachers, through assessment, can fulfil this role of supporting students beyond a classroom relationship. Having a degree in Educational Administration and having been involved in committees that examine issues related to reporting students' achievement, it is not surprising that accountability of teachers and schools' is part of Mr. Olu's conceptions about assessment and that he is able to "see the big picture" of assessment as transcending the classroom and as a means to, ultimately, support student learning. As exemplified in the quotes above, Mr. Olu's conceptions of assessment includes more than the classroom assessment aspects to encompass assessment as reported student achievement and as accountability in the larger educational system, while also presenting evidence of a conception of assessment as improvement of teaching and learning, particularly in regard to the role of the educational community in supporting learners.

His experiences with reporting on students' achievement and learning are further embedded in his comment, "we can pass assessment further in terms of when we get it, why we get it, what are we looking for, and where is it going, right? It is reporting, 'cause assessment and

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reporting aren't necessarily the same." Further into his description of how he thinks of assessment, which also relates to accountability on the part of teachers, Mr. Olu described assessment as a complex process that has a political undertone.

Oh! Absolutely, a huge amount of accountability. And the difference is based on the school, based on the school division, based on the administration. The other piece too, is there are political pressures that are created beneath the way we assess.

To clarify his point, he offered the example of summative assessment: "How much summative assessment is required and the answer to that is a political one, right? How much of summative assessment do the people who are reading reports expect." Mr. Olu consistently discoursed on assessment in view of the larger systemic context, where reporting of student achievement becomes the driving purpose of assessment practices. His mention about politics influencing these practices further emphasizes his awareness of the connection between classroom assessment and broader assessment contexts and the social-political influences on assessment, as well as the influence of assessment broadly conceived on student learning.

This connection continues through his comments about his personal feelings towards summative assessment: "Summative assessment is just plain easier, but it sucks, it's not as fun, right? I don't have time, I am too busy doing traditional assessment to look at more work." In reference to the two pyramids representing purposes of assessment (Figures 1 and 2), he also mentioned, "I would prefer to use A [Figure 2] for sure because that would be more empowering to students" and added: "They don't care and depending on the level of student engagement, we can be limited in what we apply." Mr. Olu is keenly aware of the forces constraining assessment choices of teachers, while at the same time, he concedes that perhaps other ways of assessing, as

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alternatives to assessment of learning, may be more fun and more empowering to students, but he is not ready to undertake these alternative forms because he is busy doing what he considers to be required of him, and also because he feels limited in what he can do.

Further into the discussion about his conceptions of assessment, Mr. Olu mentioned that he conceives assessment in other ways, too. It is not surprising to find teachers having multiple conceptions of assessment, as this has been reported in earlier studies on teachers' conceptions of assessment (Azis, 2015; Brown, 2002). According to Mr. Olu, assessment "also could be collecting information or just thinking about what it is that you want kids to get out of learning." He further described assessment as "collecting information so that you can assess what students know". His thinking of assessment as a process of collecting information about what students know and are able to do as well as what a teacher wants students to learn, reflect another aspect of his improvement of teaching and learning conception of assessment. When teachers hold this conception, according to Brown (2002), they engage in processes to identify the level at which students are learning and think of assessment as a process to obtain this information. The first quote is aligned with the idea of backwards design, where the ends (outcomes in terms of student learning) are used to design your instruction. The second quote defines assessment more broadly, as any assessment can be said to be "getting to know what students know." In this sense, Mr. Olu demonstrated a broad understanding of assessment, from the more immediate teacher-student interactions that happen daily in classroom to a system-wide structure that influences how teachers assess in their classrooms and is a part of available support for student learning.

I engaged Mr. Olu in a discussion about his awareness of the provincial assessment document, the *RCAPM*, to find out if his conceptions of assessment were influenced by recommendations from this provincial document on how teachers should design and implement

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assessment. He noted: “No, the information isn’t fashionable, no. Because, I don’t see that, because it’s old. The document does not have any implication on how I assess, ‘cause I am not using it.” Similarly, to Mr. Ade in Case I, Mr. Olu indicated he is not familiar with the document and does not use it in his planning and implementing of assessment in class. He also aligns with Mr. Ade in thinking that the document, published in 2006, is too old to be “fashionable.” It is an interesting point of view considering that policy guidelines may take a long time to get created, revised, and published, and even longer to be enacted, points that both Mr. Ade and Mr. Olu do not seem to consider in their evaluation of the utility of the document based solely on its date of publication.

Mr. Olu’s comment about the recommendations in this document makes it clearer that he is indeed unfamiliar with its content. For example, he mentioned that, “no, the document does not have any implication on how I assess, ‘cause I am not using it.” Also, he added: “I don’t remember assessment as learning, it is a little bit awkward, I just kind of settle on the formative and the summative assessment.”

To provide insights into how Mr. Olu assesses students and his understanding of the purposes for assessment, especially as stated by Manitoba Education, three sub-categories, *students’ mastery of content; assessment for learning is not summative assessment; and demonstration of learning outcomes* were developed in Mr. Olu’s case. These informed the final category pertaining to Mr. Olu’s dominant views on assessment purpose: *Assessment of and for learning*. In the case of Mr. Olu, his expectations or purposes of assessment are to determine the extent to which students have mastered content and met the stated curricular outcomes. He stated:

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What we are looking for is, we are looking for their level of mastery based on the outcomes that are part of the curriculum, so the Manitoba Education has curriculum documents that have all of the outcomes that we are required to teach students. So, what we do is we decide how we want to collect information to determine whether or not a student knows these outcomes or is able to demonstrate these outcomes.

This purpose relates to the assessment of and for learning purposes as stated in the *RCAPM* document. Further analysis into Mr. Olu's description of his purposes for assessment indicates that he designs and collects assessment information to know how much of the lesson's content students have learned. Indeed, it is highly important that students deeply understand content to prevent superficial learning; students' demonstration of deep understanding of content should be one of the purposes why teachers assess (Brown, 2002).

Further to his views on the purpose of assessment in science education, it can be stated that Mr. Olu's purposes for assessing students also involves the assessment of their procedural and laboratory skills. He clarified that: "in science, we are looking for, can a student engage in a process that leads them to draw conclusions or demonstrate these outcomes?" He added:

They are able to do it safely, they will be able to collect data, and a demonstrative competence of that it's not so much the results they obtain, it's interpretation of the results that is really important as is the conclusions that they are drawing.

Here, Mr. Olu expands his description of the purposes of assessment to include not only the content in science but also the skills and attitudes, which are part of the curriculum mandated general and specific learning outcomes for students in science. When articulating his

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understanding of the three purposes of assessment and how often he utilizes each one with his students, Mr. Olu stated:

My understanding is assessment for learning and assessment of learning. So, assessment of learning is typically what we call summative, and the summative is basically the end game, so what do they know at the point when we are stopping, we are no longer teaching those particular concepts, what do they know and what can they do with that part? And assessment for learning is gathering information so we can garner, teach them so that they might be able to school well, or perform well or reach mastery level in the outcomes. Philosophically, information that we gather as for learning is not something that should show up as summative.

Mr. Olu's definitions of assessment of learning and for learning align with the definitions provided in the curriculum documents. He clarified his views by stating, "summative assessment is collecting information where you are going to report, versus formative assessment where you are just gathering data based on where your students are at that point, that's less formal." Here, Mr. Olu reiterates his view of summative assessment main purpose of reporting on students' achievement, and therefore, more formal, versus a more informal process of gathering information throughout the course, which is not used for reporting. This statement helped clarify his previous one, where he indicated that data gathered for formative assessment purposes should not be used as summative assessment.

Mr. Olu demonstrated expertise in defining assessment of learning and for learning, while confessing to have little knowledge about assessment as learning: "I don't remember assessment as learning, it is a little bit awkward, and I just kind of settled on the summative and formative assessment. I used to know but I don't remember." Assessment as learning is the main purpose

of assessment recommended by the provincial assessment document *RCAPM* (see reconfigured pyramid, in Figure 2), and a lack of clarity about what this means certainly influences assessment practices, as discussed later on.

Mr. Olu's perceived self-efficacy in developing and using assessment: Mastery self-efficacy of assessment. This category encompasses Mr. Olu's description of his perceived self-efficacy and information about the development and use of assessment instruments. I developed two sub-categories during the categorization stage, confidence and ownership of assessments and advancing classroom assessment practice, which resulted in the final category pertaining to Mr. Olu's perceived self-assessment, mastery self-efficacy.

Mr. Olu appeared confident in developing and using assessment instruments: "Often times I develop them, I don't really fully like using others.' I pretty much have done my assessments." And further, "every form of assessment that I use, I developed, so I'm fine using the materials I developed. And anything that I would use that came from another source, would be customized in a way that I'll be comfortable with." Mr. Olu's confidence in personally developing and using assessment instruments along with an indication of his perceived achievement in doing so aligns with Bandura's (1977) mastery source of self-efficacy.

Mr. Olu, similarly to Mr. Ade, holds post-baccalaureate and graduate level educational degrees, but differently from Mr. Ade, Mr. Olu did not mention relying on his educational background to develop his assessment instruments, although he did mention doing research when he needs to refine his assessment:

That's what I do, I don't need anyone's extra input to be able to develop my assessment instruments. If I am looking to refine my assessments, maybe I will do some research. Unless, if I have to do it for an entire course, then I would do it

differently than I do it now, and so it tends to be piecemeal, then it tends to be global.

However, when it comes to enacting substantial changes to his assessment practices to be able to include all three purposes as stated in the provincial curriculum document, Mr. Olu spoke of the need to be involved in a team. This statement points to the value teachers could derive through belonging to communities of practice — to enhance their classroom pedagogies (Suurtamm & Koch, 2014). According to Mr. Olu:

Oh, if I want to re-do all of my assessment and make it consistent with of, for and as, how are we going to do it, that's a bigger project. Usually, that would be best done as a team. So, if there was a team project for that, I would be really excited to do that because at the other end I know there would be support. The other thing is once you have your assessment practice established, it then tends to be very difficult to change them in a major way, personally.

Thus, although Mr. Olu expressed high self-efficacy in developing and implementing assessment in his classes, he does so mostly with assessment of learning and assessment for learning, having demonstrated unfamiliarity with assessment as learning and the perception that he would need the help of a team to effect changes he is not confident he would be able to do it alone, as well as bigger changes that are to impact entire courses and would require support from other stakeholders.

Furthermore, Mr. Olu's low self-efficacy in terms of assessment as learning seems evident in his discussion: "My understanding is assessment for learning and assessment of learning... I don't remember assessment as learning, it is a little bit awkward, I just kind of settle on the formative and the summative assessment". Here, he mentioned his unfamiliarity with

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assessment as learning and appeared to justify his reasons for doing so and for being more confident in using assessment of and for learning. Mr. Olu further made points about his understanding of metacognitive assessment and why it is important for students' learning experiences: "Assessing their metacognitive skills is a discussion that we should have with students because accessing their metacognitive would allow students to develop the skills necessary to become independent learners". He further stated:

It doesn't come up as much as I would like to and so not too much, that's something we try and activate within students but in terms of collecting information about that, that doesn't happen as often as I would like. And I haven't put the system in place to assess that.

The quotes above provide evidence of Mr. Olu's awareness of metacognitive assessment, at the same time offering a possible interpretation for his only occasional use of this form of assessment and expressed low self-efficacy in developing assessment instruments to advance metacognition in his classroom.

Mr. Olu's assessment practices: Summative and formative assessments. In the categorization stage of the content analysis for Case II, I developed five sub-categories: student and system demands, assessment preferences, political pressures, performance-based assessments; and test and quizzes, which informed the final category pertaining to Mr. Olu's assessment practices: Summative and formative assessments.

Mr. Olu's discussion of the types of assessments he practices with his students indicates the use of more summative and less formative, diagnostic and metacognitive assessments. As emphasized in recent assessment discourses, teachers are expected to engage in assessment practices that will bring about improvement in students' learning and assist in the development

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of their metacognition. Such efforts were not found in Mr. Olu's description of his classroom assessment practices. However, he expressed a desire to engage students in metacognitive assessment:

It doesn't come up as much as I would like to and so not too much, that's something we try and activate within students but in terms of collecting information about that, that doesn't happen as often as I would like. And I haven't put the system in place to assess that.

The type of assessment instruments (artifacts) Mr. Olu shared with me were in accordance with his more traditional approach to assessment; most were paper and pencil tests, multiple choice tests and questions asking students to list responses. However, he mentioned again that the reason behind his traditional assessment practice was the system and student demands. To him, there is a need for teachers to respond to the type of assessment preferred by students, even though it may not be valuable to their learning. When asked about what influences his choices of assessment, he stated thus: "It would be student and system demand, yeah, and it would be the fact of the inertia that's present in the system, yeah. I would prefer to use A [Figure 2] because it is more empowering to students." He further explained empowerment in these terms:

Assessing their metacognitive skills is a discussion that we should have with students because accessing their metacognitive would allow students to develop the skills necessary to become independent learners, and what I found is summative assessment taking a greater part and even the formative assessment it doesn't assess their metacognitive skills and as a result, students find that they look to the teacher as they don't feel empowered.

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Mr. Olu admitted he is not confident in discoursing about assessment as learning, and in the above quote, his uncertainty becomes evident, as he struggled to articulate his views on metacognition and the role of assessment in providing opportunities for students to develop self-regulation and skills related to meta-learning.

Continuing his narrative about what influences his assessment practices, Mr. Olu described the situation as school-system related. To him, school systems account for what classroom practices teachers have time to execute, how they report students' results and reporting periods, and the type of information (grades or feedback) required by educational stakeholders, including students and parents. Several times throughout our discussion on assessment, Mr. Olu expressed the belief that policy-related pressures influence teachers' classroom teaching and assessment practices. He commented:

We are a semester system and based on the fact that it's a semester system, we see students for sixty minutes a day, we have to think about what do we have the time for? We have a constraint we have to think about, reporting periods, so when do we have to have summative assessment information, we also have to think about the way in which we report, so what types of information do people require, so if it's a grade, if it's a percentage, if it's a comment-based, so the other piece, too, is political pressures that are created beneath the way we assess.

There is a very large influence, yeah because there is an expectation as to what things need to look like and if they don't look like that, then questions are asked about why they don't look like that, and they are asked not necessarily in an open way.

Mr. Olu clearly framed his practices within structural constraints that he perceived as barriers to the implementation of forms of assessment that are more in line with curriculum recommendations, such as assessment as learning. Even though he reiterated his desire to use more contemporary forms of assessment, and despite mentioning a dislike for summative assessment, he does not envision himself as being able to change his practices on his own and seems to be paralyzed by factors he believes impede his purported will to use different forms of assessment. His preoccupation with reporting also surfaces again in the above quote, reinforcing his conception of assessment as accountability of schools and teachers.

When talking about the feedback he provides to students, Mr. Olu reiterated the view expressed by Mr. Ade that students oftentimes are only interested in grades:

Students often say to me, “why is, why do I have a code here? Why don’t I get a mark for that?” and I will say, “it’s because it is a formative assessment piece” and usually students don’t care about it because it doesn’t impact them, right? ... Yeah, yeah, if it’s a mark, I’ll do it, if it’s not with a mark, then why are you recording it and why would I do it? For them, the reward is the mark.

However, he mentioned how this attitude may change according to grade level:

Grade nine, you can still capture the students’ interest in some respect where they would do stuff regardless of what the purpose is. I find that grade nine is different from grade ten, which is different from grade eleven and grade twelve. In terms of grade differences, grade twelve students are focused on getting perfect marks because they think they need to.

In terms of providing feedback to students, Mr. Olu does this through reports on students’ progress, although this may be done through several media, as stated below. Here, he mentioned

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another view he has about summative assessment—to drive student's behaviour. To him, when other parties are involved in the process of feedback, students tend to respond to such feedback, which renders them to be accountable for their learning. This thinking about assessment feedback relates to the accountability of students' conception of assessment (Brown, 2002).

There is feedback that we have in the form of providing them the evidence that we collected as summative assessment through progress reports. Also, I have feedback through conversations with students and questioning them, through online data collection like Google forms. Also, I send home progress reports too via email and also to their student support liaison, and usually providing that information will elicit a response from some students, but again it's like using summative assessment to drive behaviour.

Mr. Olu is also careful to encourage students through positive feedback, which seems to take the form of generic and brief words or signs of encouragement, rather than specific feedback aimed at improving student learning.

I'll help students, I am very conscious of making evaluations on their learning other than maybe comments that will encourage them. Yeah, lots of thumbs up, lots of smiles and encouragement for them to continue in the direction that they are going 'cause it's a good direction.

At times, Mr. Olu collects feedback from students via online tasks that also work as reviews for major summative assessment:

The other thing is that our students have access to some online resources where they need to input data, might be a Google form, quiz, which is a form of review

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for learning, so they are providing feedback to me on what they know, they have the freedom to do it outside of class or inside the class.

Mr. Olu's use of digital and online technologies, which students are quite familiar with nowadays, reflects assessment practices described in studies on science assessment (Chu & Fung, 2018). Particularly in relation to science, he enunciated the types of assessment he uses:

Students will have quizzes, they will have tests. In science we also have labs and there may not be a lab report, it could be a lab experience where they're just submitting some aspects of a lab where there are calculations, where there is a conclusion, where there is a procedure they need to perform.

However, Mr. Olu also noted in relation to labs, "generally speaking, in terms of what I feel of the confines of the curriculum, in terms of the breadth and the scope of it, I don't feel like I have time for students to develop labs inside the class." Thus, time constraint also constitutes a factor precluding Mr. Olu from implementing more authentic, hands-on inquiry types of assessment practices in his science classes. Continuing listing types of assessment he uses in his science classes, Mr. Olu added:

Yeah, so there are also performance-based tests that may typically be called projects that they will be doing, like a research presentation, it could be an experiment they did at home and provide information on the results of that experiment. Sometimes it's a student-initiated project, so if a student says, "I would prefer to show you what you are asking for using this as a tool," then I am happy having a discussion with students about that. A lot of the assessments have rubrics, so students have some communication of the expectations on what they need to know.

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Although attempting to implement different forms of assessment in his science classes, Mr. Olu seems more comfortable keeping to the traditional formats. However, his assignment artifact on physical properties of matter indicates an attempt to incorporate student choice and assessment as learning. The preamble of the assignment read:

The purpose of this assignment is to give you the opportunity to explain your understanding of some of the physical properties of matter in your own words. Be creative. You will also have to assess your own writing piece and submit your self-assessment.

Thus, Mr. Olu's conception of assessment as accountability of schools and teachers grounds his assessment practices, mostly utilizing traditional formats of summative assessment reflective of his concern with reporting student achievement at determined points in time, according to constraints he assigns to the broader educational system, and to students' preferences for marks, as well as his recognition of his own limitations. Although he engages in a variety assessment approaches, he feels that consistency is important in the approaches used in schools. His unfamiliarity with the provincial assessment document (RCAPM) and his low self-efficacy of assessment regarding assessment as learning resulted in a traditional approach to assessment and very limited attempts to incorporate student choice and student self-reflection in his assessment instruments. Nonetheless, Mr. Olu expressed a broader view on assessment, which also encompasses a conception of assessment as improvement of teaching and learning, particularly regarding his responsibility as stakeholder in the educational system to use results of summative assessments to drive changes needed for supporting student learning. An aspect of a third category of conception of assessment, assessment as student accountability of learning, was also present in at least one of Mr. Olu's comment, thus clearly indicating Mr. Olu's multiple

conceptions of assessment, which may be a reflection of his “big picture” approach to education due to his experience and professional educational background.

Case Study III: Mrs. Temi

Mrs. Temi is a biology/science teacher at Ilorin High School in Winnipeg, Manitoba. Ilorin High School has a student population of over a thousand, with students from various ethnic backgrounds. Ilorin High School prides itself in the dynamism and capabilities brought to the learning institution by its staff members. This dual-track school provides learning to students from various socio-economic and cultural backgrounds in English and French languages. The school is located on a busy street, with several business establishments, and surrounded by residential houses. My two visits to the school were at the start of the lunch recess, and I found students loitering in the hallways and chatting with teachers who swung past students hurriedly. Office staff chatted away, forgetting I was standing in their midst while waiting to meet the teacher. In my experience with school staff members, the staff members of this school were exceedingly friendly and accommodating.

Mrs. Temi had worked for over 12 years as an athletic therapist before starting a career in teaching four years ago. In her four years of teaching, she has taught essential mathematics, pre- and applied calculus, science, photography, social studies and biology in grades nine, ten, eleven and twelve. Currently, Mrs. Temi teaches grades 11 and 12 biology, grade 10 essential mathematics and grade 10 science. With an athletic therapy degree, Mrs. Temi completed her Bachelor of Education degree, majoring in physical education with a minor in biology. Mrs. Temi constantly referred to herself as new to teaching and that she is continuously working on improving her teaching and assessment practices.

Mrs. Temi's conception of assessment: Accountability of teachers and schools. After carefully going through the data I developed three sub-categories as part of the categorization stage of the content analysis: assessment is used to organize instruction and evaluate students, grading and pressure to teach to the test. These sub-categories informed the final category pertaining to Mrs. Temi's conception of assessment: Accountability of teachers and schools.

Mrs. Temi described her personal conception of assessment as identifying students' level of understanding of subject content, to provide a quantitative measure of their learning and to help organize instruction.

Assessment allows you to evaluate where your students' knowledge of the outcomes of the subject area that you are teaching, every subject has a curriculum, there is outcomes to that curriculum, there're general outcomes and specific outcomes. So, assessment just gives you this sort of quantitative analysis of your students' comprehension of those outcomes, in my mind.

It allows you to organize, so if you divide your course into a unit, assessment sort of allows you to look at an individual's improvement in learning throughout that unit, so it sort of allows you to see if they have taken in any information that you've been teaching them over the past couple of weeks. So, if you do assessment along the way or assessment at the end, it sort of gives you an idea of where their comprehension is.

This definition aligns with an accountability of teachers and schools' conception of assessment (Brown, 2002), according to which teachers conceive of assessment as a means to collect and report student achievement. Mrs. Temi's reference to quantitative measurement and end-of-the-unit assessment further corroborates this conception. Furthermore, Mrs. Temi

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mentioned how exams represent a high percentage of the final grade a student gets in the course, and how performing exams may work as practice for students who may enter university, where they will likely have to take exams as well. This resonates with her conception of assessment as being for the purpose of quantitatively evaluating student learning at the end of a unit.

I mean, our exams here are thirty percent of a student's final mark, so you have to think, that's a lot, so that means seventy percent of the work that you do in class sets up your mark and then thirty percent is the exam. So, students kind of learn that to pass, right? So, I don't know. It's tough, exams definitely prepare students for, I think, the future, like, if they go to university, you have to prepare them in some way 'cause that's the way universities would test, if they go into the workforce, assessment is different in the work industry. Sometimes I feel like we are more preparing them for the society anyways, sometimes, too, with assessment.

Mrs. Temi seems to ground her understanding of assessment on structured processes that are used to evaluate students at the end of a set period of instruction. This aligns with the purpose of assessment of learning, and summative assessment type. However, she also seems to think of assessment as a way to practice skills she believes students may need in the future. During our conversation about the provincial assessment document (*RCAPM*), Mrs. Temi indicated she was not familiar with the document: "I have never seen it and I don't think I read it, unless excerpts of it that we were given in education [B.Ed. program], but I can't recall." And then she added, "I mean, I am still new, right? So, yes, that vocabulary I have heard but..."

When commenting on the purposes of assessment present in the curriculum document, she stated:

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The as and for learning is definitely something you are taught at university but beyond that, I would say the words are not necessarily within the work setting, you will see it in PD days, but within the work setting it's not a vocabulary that we normally use.

Here, Mrs. Temi acknowledged her lack of familiarity with the vocabulary used in the provincial document to refer to the purposes of assessment. She also mentioned this may be because of her being a novice teacher, as well as the fact that these terms are not necessarily used in the school setting, albeit she encountered them in her teacher preparation courses and professional development days.

Mrs. Temi's perceived self-efficacy in developing and using assessment: Verbal persuasion self-efficacy of assessment. During the interview, I asked Mrs. Temi how she develops the assessment instruments she uses in her classroom, and her perceived self-efficacy of developing those instruments and utilizing the instruments in the classroom. From our conversation, the category that seemed the best fit is – verbal persuasion self-efficacy of assessment as informed by three sub-categories: can't take the credit, new to teaching and work in progress.

During our discussion, Mrs. Temi recurrently mentioned that she is new to teaching and how this has influenced her perceived self-efficacy of developing and using assessment. She had depended mostly on colleagues and her education programs to develop the assessment instruments she uses in her classroom. She mentioned: "It [her assessment practice] would be based on what I experienced in the university, right? It would sort of fall back on that;" and she added:

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Well, all the ideas would come from people that I worked with or worked underneath in the past, as well as specifically what you are taught in education, right? ... Basically, these have given me ideas on how I can approach assessment.

As a novice teacher, Mrs. Temi relies on what she has learned during her teacher preparation program as well as colleagues she has worked with, presumably more experienced teachers (“work with or worked underneath in the past”), as sources of ideas on how to design and use assessment. This reflects a verbal persuasion source of self-efficacy (Bandura, 1977). Further on, Mrs. Temi acknowledged the assessment instruments she uses are not of her own creation, even though she may adapt them to use in her classrooms.

I mean, you come in here and you work with a team of teachers, so everybody is very open and shares their assessment instruments and then you sort of manipulate it to tailor yours. But, I mean, you are constantly being given instruments by your colleagues, but the baseline foundation is not something that I created, I can't take credit for that, right? It's handed to me down from the teachers.

Sharing resources is common practice among many teachers, and Mrs. Temi acknowledged her reliance on her colleagues to procure ideas and instruments to use in her classroom assessment practices. However, she does not feel entitled to take credit for these assessment instruments, but seems to trust the source, which aligns with the verbal persuasion category of self-efficacy. This may also be related to her being a novice teacher, thus substantiating the claim that teachers' perceived self-efficacy of assessment is influenced by their years of teaching experience (Alkharusi et al., 2014). As Mrs. Temi offered,

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It's a work in progress for me, it's a continuous work in progress, it's not where I want to be, especially only being in my fourth year of teaching, it's a constant work in progress, and I am changing it every year still.

The continuous mention of not being where she wants to be is an indication that Mrs. Temi is aware of the improvements to be made to how she practices assessment and a range of other possibilities of assessments. Also, her acknowledgement that she is yet to develop assessment instruments and the fact that she seemed to use the assessment instruments she receives from colleagues for assessment of learning purposes leads me to interpret Mrs. Temi's low self-efficacy in the use of contemporary assessment.

Mrs. Temi's assessment practices: Summative assessment. From the codes generated during recontextualization, I developed five sub-categories during the categorization stage of the content analysis: use of various assessments, unfamiliarity with assessment document terminology, summative and formative assessments, time constraints, and pressure from policymakers. These sub-categories informed the category about Mrs. Temi's assessment practices: Summative assessment.

When discussing the provincial document on assessment, Mrs. Temi indicated she was unfamiliar with the document and with the terminology used to classify assessment according to its purpose. After I briefly explained to her the terms assessment of learning, for learning, and as learning, she used this classification to describe the specific assessment practices she enacts in her class:

So, my own practice is going to encompass all three, okay? But, because we have to foster exams, exams is going to always be assessment of learning, so, if you going to do a basic exam, it's going to be a multiple choice, short answer, long

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answer, you could have assessment as learning within those developmental questions within the exams, right? And then your multiple choice is going to be more of the of, those developmental questions the as. So, for example in my bio 40S, yes, it's multiple choice, but at the end I have an article for them to read and they have to read the article and it's about a theme that we talked about in class and I am going to provide opinion-based questions based on their learning and understanding of the themes, and then, reading the article, can they provide an opinion-based answer and then defend what they are saying using terminology and things they have learned, right?

Although Mrs. Temi relies on exams and tests, she attempts to incorporate open-ended questions that encourage students to express their own opinion. These attempts reflect her willingness to provide opportunities for students to demonstrate their knowledge in different ways and to foster higher order cognitive skills (following Bloom's taxonomy [1956]), while also being a more authentic form for students to apply knowledge. However, these do not constitute assessment as learning *per se*. Other comments Mrs. Temi provided during her interview further indicate her naïve notion of assessment as learning:

Then the projects we do in class, the big projects, are assessment as learning. So, for example in the bio 30S, they have to design their own experiment within the circulatory system. So, all I say is your experiment has to have an effect on the heart rate. So, some students would choose, okay, "I am going to research the effects of caffeine on heart rate if taken in the morning." Another student, maybe, "I am going to use music, different types of music to see the effect on heart rate." ... So, they go out, they have to design their own experiment and then they have to

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do a presentation and present a poster, so we are constantly using both assessment for and as learning. But the projects will have a heavier weight on their mark.

In this latter quote, she provides another example of practices she believes encompass assessment as learning. The project is described as more student-centered and open-ended, although she still chooses the topic of the inquiry, that is, the dependent variable in the experiment, while students are given the choice of independent variable and procedures. However, she mentioned this project will be graded, and it will account for a larger portion of their mark, which indicates the project is used as assessment of learning. According to the *RCAPM* document, assessment as learning should foster the development of metacognitive skills, where students are increasingly capable of reflecting on their own learning trajectories and adjusting strategies to augment their chances of achieving learning outcomes. Neither of the two approaches Mrs. Temi mentioned in this and in the previous page reflects these elements of assessment as learning.

Mrs. Temi's understanding of assessment for learning is better aligned to the definition provided in the assessment document (*RCAPM*):

Within the classroom, classwork associated with each lesson is going to be more of assessment for learning. So, you sort of teach something and then you do some sort of activity, which allows them to practice and then dig a little deeper into that knowledge and gives me an idea of what they know and what they still need to know.

Mrs. Temi mentioned using a variety of assessment instruments to evaluate students' knowledge of scientific concepts, both for summative and formative purposes.

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That can be in various forms, right, so that can be anything from oral presentations, science-related, it can be a project with a presentation, it could be a model of something, they have to design a model, it could be tests and quizzes, it can be a lab exam, right? There are so many varieties in science that I use.

Ok, so, like, exams is for sure going to be summative, which is going to cover everything, and then the test at the end of every unit is summative. Formative is going to be your projects and your little in-class worksheets. At the end of the day, I would say I have a lot more of the formative because I have got these little mini worksheets and the projects, yeah, so I would say maybe in the end it's like sixty forty.

As discussed above, her classroom assessment practices focus mostly on formative and summative assessments, with a clear indication that she uses larger end-of-the-unit assignments as summative assessment. Even though she mentions using more formative assessment, earlier on she referred to the final exam representing 30% of the final grade, and the remaining 70% coming from other activities done in class. It is possible that the mini worksheets and projects she alludes to as formative assessment practices in the above quote are also used as assessment of learning. In terms of the information she collects through the various forms of assessment she employs in her class, Mrs. Temi recognizes the usefulness of the feedback she is able to get from projects and overarching questions that encourage students to provide more elaboration on their understanding. She stated:

Sometimes I find that the best feedback is, you know, some of those projects, right? In a way, are they enjoying what they are doing? Have they learned? Are

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they able to take what they learned and apply it to design a project? That's kind of my feedback up to date.

Once again, you're not just ever testing on basic facts, right? You are trying to, you do have some basic fact questions, but then that brings you all the way to the end when you have also overarching theme questions where you have to tie in various themes and be able to say, "read an article and answer questions about that article," with the knowledge that they have gained throughout the course.

Mrs. Temi also indicated an attempt to incorporate metacognitive assessment in her class, through student self-evaluation and peer-evaluations, which she remarked she uses less often than she would like.

I sometimes have peer-evaluations where students would evaluate other students, and I use that, and that's another approach, a different way to take it, sometimes I will have the students do a self-evaluation with projects and I will accompany that with mine, and then I have an understanding of where do they see themselves. I don't use it all the time, I'd like to use it more.

Mrs. Temi also provided evidence of being confused about what summative and formative assessments mean; she seems to equal summative assessment to tests and exams, and formative assessment to other types of assessment instruments still used for assessment of learning.

Because some kids do really well in summative and some kids do really well with the formative, so you try to divide that. I mean not everyone is going to be a good test-taker, right? So, if you are a very good multiple-choice person and you are

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not very good at the developmental questions, I will try and divide my points within the exam. So, if you are good at one and not on the other, you will still pass, you are trying to cater for all types of learners in that sense.

Despite her confusion about the purposes of assessment, Mrs. Temi expressed the willingness to differentiate her assessment practices to provide diverse opportunities for students with different abilities and preferences, as suggested in the above quote. Mrs. Temi also talked about the barriers to the implementation of assessment. Having acknowledged that science is different from mathematics when it comes to provincial assessment, as science is not included in province-wide standardized tests, she mentioned that, generally, provincial policies affect teachers' implementation of contemporary classroom assessment. Her experience of teaching multiple subjects gave Mrs. Temi information about how teachers teach to the test to satisfy systemic demands. Her discussion suggests that some teachers teach to the test because of pressure from policymakers for students' positive results in standardized exams.

And a provincial exam, you kind of then put in something that you have to teach for that standardized test because you have no choice but to administer it. So, then you are even more tied that way, right? The nice thing is, in science there is no provincial exam, so it's really open.

Another perceived barrier to implementation of alternative forms of assessment relates to the time required to practice meaningful assessment. To her: "as a teacher, marking takes up so much time, so much time and if you truly want to get to the nitty-gritty and really breakdown every single thing, you are marking the whole of your free time. So, it's tough." In addition to time constraints, her discussion also indicated that students' reaction to teacher's assessment

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practices can be another factor limiting how teachers integrate contemporary assessment practices in their classes:

Comments help a lot, although they are time-consuming, if you provide comments with a mark, you will find students, a lot of times, won't read them, they just look at the number, that's all they care about. Whereas the comment is truly the most important feedback.

Similar to the comments provided by Mr. Ade and Mr. Olu, Mrs. Temi also perceives students' attitudes to assessment as discouraging when approaches that are not solely focused on grades are utilized. However, despite the barriers to implementing assessment, Mrs. Temi seems desirous of changing her assessment practices to use less test-based assessments.

So, although my current exam is a written exam, I would like to prepare a more practical lab exam to accompany that written exam and that is something that I am working on. To sort of foster hands-on learning as well as hands-off learning, yeah.

Like I said, I am looking to ways to change the way I assess in biology a little bit by applying that lab exam, similar, like, they would see in the university, and I am curious to see the feedback on that. You know, students, it may not be something they are used to but, if they, like, say, I teach in grades eleven and twelve, it's something they would sort of get used to. So, students are definitely capable of doing more than what they believe they can do.

She also expressed her interest in implementing different practices to include diagnostic assessment and assessment for learning, such as exit slips or exit meetings with students, which

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would provide her with information about how students are doing in the course, while at the same time giving her a chance to provide students with feedback on their learning.

I have never asked for feedback from students in that sense. It's one of those on my to-do list, I would love to get into the habit of doing exit slips. I would love to get into the habit of doing a teacher evaluation at the end of the unit. But I would like to get into a habit of doing some feedback, yes, absolutely. And the idea of exit meetings, I mean individual exit meetings with each student to provide them with some of those verbal feedback, that could go a long way too, I don't know, it's something I would want to explore.

Overall, Mrs. Temi's discussion on assessment indicated that she conceives assessment as for grading and evaluation of students for future academic and career advancements, which aligns with the accountability of teachers and schools' conception of assessment (Brown, 2002). Although she indicated practicing formative and summative assessment types in her classroom, her practices revealed a confusion of assessment types with assessment instruments. Furthermore, there was little to no indication that she engages students in metacognitive and diagnostic assessment types. Although she reported a seemingly low perceived self-efficacy, she appeared passionate at improving her assessment practices to develop and use contemporary classroom assessments.

Chapter V: Conclusion

In this chapter I suggest some meanings for the findings presented in chapter four and I address the research questions guiding this study. First, I discuss the findings as a cross-case analysis organized by sections pertinent to each research sub-question. Second, I discuss my findings in terms of the overarching research question in this study. Subsequently, I draw implications of this study for further research in science education, for science teachers' classroom assessment practices, and for policymakers. Finally, drawing from lessons learned in this study, some concluding thoughts are presented.

This study is guided by the research question: *What is the relationship, if any, among conceptions, perceived self-efficacy, and practices as these relate to classroom assessment in the cases of three Manitoban high school science teachers?* Additionally, the following sub-questions provide further direction to this study: *What are the conceptions of assessment of these three Manitoban high school science teachers? How efficacious do these three Manitoban high school science teachers perceive themselves to be in the development and use of assessment strategies in their science classrooms? What are these three Manitoban high school science teachers' classroom assessment practices?*

What are the conceptions of assessment of these three Manitoban high school science teachers?

Findings from this study indicate that the three Manitoban science teacher participants held different conceptions of assessment, at times, simultaneously, which is referenced in the literature as a possibility, as categories in Brown's model are not necessarily mutually exclusive (Azis, 2015; Brown, 2002; 2004; Remesal. 2011). For instance, Mr. Olu viewed assessment as accountability of teachers and schools and, at the same time, as an improvement of teaching and

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learning activity actively influenced by broader, systemic educational demands. Mr. Olu appeared to have a “big picture” view of assessment as transcending the classroom, with the involvement of various stakeholders in the provision of evidence of teaching and learning and in supporting students’ learning. In his view, providing evidence of students’ learning and his teaching to external parties such as parents and school support staff are important facets of assessment practices.

Mrs. Temi also primarily conceived assessment as an accountability process whereby teachers and schools evaluate and grade students and— similar to Mr. Olu—she placed a greater emphasis on the macro-structural aspects of the educational system that constrain teachers’ classroom assessment practices. Differently from Mr. Olu, however, Mrs. Temi’s view of assessment as accountability of teachers and schools did not expand to include the political aspects of reporting student achievement, even though she did mention the high stakes provincial tests in mathematics and how these tend to limit her assessment practices in this discipline, especially in terms of students’ focus on grades.

In fact, the three teachers mentioned how students can resist formative assessment; participants mentioned that students expect to receive grades and pay little attention to written feedback teachers may spend much time adding to their assessment. Mr. Olu and Mrs. Temi remarked students require to be trained so as to think and engage with assessment in a more contemporary manner, valuing feedback and taking advantage of opportunities to reflect on their own learning. Literature on teachers’ conceptions of assessment have also discussed the constraint in implementing these types of assessment due to students’ low interest in them (Brown, 2002). All three teachers in this study mentioned that students were not fully engaged with formative and metacognitive assessment. Mr. Olu and Mrs. Temi mentioned having low

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self-efficacy in conducting metacognitive assessment and therefore these two teachers did not implement this form of assessment as much as they would like to in their classes. However, the fact that both teachers recognized the importance of this type of assessment and expressed a desire to implement it more often in their classes is a hopeful sign that, given the proper conditions and training, teachers will design and implement assessment as learning in their classrooms.

Among the three teachers, Mr. Ade was clearly the one who engaged the most with assessment for learning and as learning. Mr. Ade held a conception of assessment that was more fully focused on improvement of teaching and learning, which, according to Brown (2002), includes viewing teaching, learning and assessment from a constructivist approach. This constructivist approach to assessment is explicit in the case of Mr. Ade. Although Mr. Ade engaged in the provision of marks, he used these to construct and re-construct his classroom teaching and assessment practices with his students, practices he believed would lead to better student learning outcomes and engagement. His constructivist approach was evident from practicing different methods of assessment and engaging in timely and on-going feedback to students, which he utilized to scaffold students' learning and plan for future teaching. Not only did Mr. Ade provide opportunities for his students to gradually build up their skills and knowledge through different assessment tasks, often times in a collaborative manner, but he also gradually and progressively improved his own assessment practices, planning in a way that allowed him to develop through the years assessment instruments and teaching materials that more closely reflected his understanding of progressive, contemporary assessment practices. In doing so, Mr. Ade also coped effectively with one of the most cited barriers to implementing authentic, performance-based assessment in science classrooms: time constraints.

The literature on conceptions of assessment mentions political, societal and school systems as important factors in the development of teachers' conceptions of assessment (e.g., Azis, 2015; Pellegrino, 2016). Indeed, in this study, science teachers' assessment conceptions were affected by several factors, including educational background. For instance, Mr. Ade and Mrs. Temi mentioned university courses they took as sources for information regarding assessment practices; Mr. Ade explicitly identified some of these courses as providing him ideas about effective assessment, while Mrs. Temi recognized that some of her university courses discussed assessment purposes and she would use some assessment instruments from these courses. Mr. Olu, who, like Mr. Ade, also presented further professional and educational experience, did not mention this experience as a source of his conceptions of assessment or otherwise as a factor influencing his assessment practices. Mr. Olu's graduate studies were in Educational Administration, which could partially account for his view of assessment as accountability of teachers and school and his preoccupation with reporting, as well as his "big picture" view of assessment beyond the classroom.

Opre (2015) recognizes the complexity inherent in exploring teachers' conceptions of assessment and she mentions teachers' years of experience, years of education and the socio-economic status (SES) of the school where they teach do not constitute influencing factors. This study, however, found that years of experience and further professional education were influential in teachers' views and practices of assessment, although their influence was quite different in each teacher's case. In the case of Mrs. Temi, her perceived inexperience provided justification for her lack of knowledge of and limited attempts to implement formative and metacognitive assessment in her classes. Mrs. Temi considered that, being new in the teaching profession has not afforded her enough opportunities to adequately explore and enact assessment

in the ways she would have liked to. Mr. Ade and Mr. Olu, on the other hand, believed their many years of teaching experience influenced them in thinking about assessment. Mr. Olu seemed quite confident on the tried and true methods of assessment he had been using in his classes, thus making evident how years of practice influenced his self-efficacy and conceptions of assessment. Mr. Ade also discussed how his years of teaching helped him, particularly in terms of overcoming personal challenges and gradually improving his practice. The scope of this study did not allow for any conclusions regarding school SES as an influencing factor on teachers' conceptions of assessment.

How efficacious do the three Manitoban high school science teachers perceive themselves to be in the development and use of assessment strategies in their science classrooms?

Efficacy belief “is a conviction that one can successfully do what is necessary to achieve or produce a desired set of outcomes” (Brown, 2002, p. 22). The three teachers in this study indicated different types of self-efficacy beliefs, ranging from mastery experiences to verbal persuasion in Bandura’s classification scheme. It is important to understand teachers’ confidence levels with regards to the development and use of assessment instruments they mentioned in the discussion of their assessment practices. The inclusion of teachers’ perceived self-efficacy in this study is expected to provide an understanding of teachers’ efficacy levels and a background for designing opportunities to assist individual teachers in advancing their classroom assessment practices towards more contemporary forms.

Interestingly, only one of the more experienced teachers, Mr. Ade, referred to his professional education background as a source of knowledge connected to his self-efficacy of assessment, whereas the more novice teacher, Mrs. Temi, despite her low self-efficacy of assessment, referred to educational courses as sources of ideas for her assessment practices. Mr.

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Olu appeared confident in doing the types of assessment he is used to implementing in his classes, but he also mentioned he would require help to change his assessment practices and to use more assessment as learning in his classes. His mentioning of a low self-efficacy of assessment as learning could be influenced by how he thinks of assessment as politically affected and student- and system-directed, as well as by his participation in assessment committees where the focus was mostly on formative and summative assessment. Furthermore, as mentioned earlier, his graduate studies in Educational Administration may have fostered a view of assessment as accountability, rather than providing him with opportunities, as in the case of Mr. Ade, to entertain innovative approaches to classroom assessment, particularly as these apply to formative and metacognitive assessment strategies.

For Mrs. Temi and Mr. Ade, their self-efficacy can also be linked to how they think about assessment and the support they received from education and colleagues. Mr. Ade mentioned how being in graduate studies education prepared him to practice innovative assessment. Mrs. Temi, on the other hand, provided evidence of low-self efficacy and depended more on her colleagues when designing and implementing assessment.

The science teachers' teaching experience seems to be related to their perceived self-efficacy in developing and using assessment instruments in their classrooms. In the cases of Mr. Ade and Mr. Olu, the teachers mentioned they had been teaching and practicing classroom assessment for over 10 years and they felt confident developing and using assessment instruments in their classrooms. Having taught for many years afforded them opportunities to try and to validate these practices, as in the case of Mr. Olu, or, alternatively, as in Mr. Ade's case, to feel confident enough to experiment with innovative practices deemed effective and learned through professional education (a form of verbal persuasion). However, as indicated by Mr. Olu,

changing assessment practices could be difficult once established over time. In Mrs. Temi's case, inexperience clearly played a center role on her low self-efficacy of assessment, as she believed more years of teaching would influence the enactment of changes in her classroom. Presently, she indicated her willingness to improve on her assessment practices, but she seems to believe neither her formal education nor her opportunities so far in teaching have allowed her to build the confidence needed to try new forms and types of assessment.

What are these three Manitoban high school science teachers' classroom assessment practices?

Classroom assessment can be described from the perspective of its purpose, the types of methods and processes adopted, its validity and reliability, use of results, and its relationship to external school activities (Butler & McMunn, 2006); and involves the gathering and interpretation of data following a systematic, multistage, and multiform process (Liu, 2010). Consistent with the Manitoba assessment initiative document, purpose defines the type(s) of assessment that are constructed and used in classrooms, therefore "it is important for educators to understand the three assessment purposes, recognize the need to balance among them, know which one they are using and why, and use them all wisely" (Manitoba Education, Citizenship and Youth, 2006a, p. 14).

The three science teachers who participated in this study indicated they do not consult provincial assessment guidelines in their assessment design and implementation practices. Indeed, the three teachers were unfamiliar with the contents of the *RCAPM* document (Manitoba Education, Citizenship and Youth, 2006a), however, they could be familiar with other formal curriculum policy documents. Even in the case of Mr. Ade and Mr. Olu, who completed further graduate education, their unfamiliarity with the assessment guideline document was evident.

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Interestingly, the teachers enacted some of the assessment practices and purposes recommended in the Manitoba assessment document (*RCAPM*), especially Mr. Ade, despite considering the document out-dated. This is in agreement with previous findings that suggest that, although teachers habitually do not consult policy documents in the design of assessment they perform activities recommended by education and assessment experts (Alkharusi et al., 2012; Aydeniz, 2007). The document mentioned to participants (i.e., *RCAPM*) is not a policy document, but a guideline; however, it does present information that could be useful to these teachers, particularly in terms of elucidating assessment as learning and validating some of the contemporary assessment formats that are recommended by the province.

The teachers in this study understood and engaged differently with the three purposes for assessment (assessment of learning, for learning, and as learning). Only Mr. Ade could adequately articulate a definition for all three purposes of assessment, whereas Mr. Olu and Mrs. Temi struggled to define assessment as learning. Mr. Olu mentioned metacognitive assessment and how, in his view, it works better to empower students, but he failed to connect it explicitly to assessment as learning, which he admitted not to understand as well as the other purposes of assessment. Mrs. Temi mentioned assessment of learning, but clearly interpreted it very differently from the definition provided in the provincial documents — she used the term to convey different formats of assessment instruments other than tests and quizzes, while still using them as assessment of learning. While Mrs. Temi did not have a clear sense of assessment as learning, she does want to move toward more self-assessment and so she sees some of the value in metacognitive assessment but waiting to develop her knowledge and skills to try it out. Limited understanding of assessment as learning in the case of Mr. Olu and Mrs. Temi could have an association with the fact that they did not engage in it as often as Mr. Ade did. However,

Mr. Olu mentioned he would like to do more metacognitive assessment while Mrs. Temi also signified interest in learning more about assessment as learning and implementing it in her classroom.

Mr. Ade indicated permitting students to express their learning through whichever means comfortable to them and encouraged them to develop their inquiry skills to perform authentic inquiry projects and experiments through performance assessment tasks. He mostly used assessment for learning, but he also used assessment of learning and as learning. This is different for Mr. Olu and Mrs. Temi, both of whom used assessment of learning most often. Although Mr. Ade mentioned using end-of-unit projects, he used these as assessment for learning and as learning purposes. This finding tallies with results from other studies that indicate that what teachers know about assessment as learning is primarily conceptual, and that in the actual classroom setting, teachers frequently do not implement such practices (Dann, 2014; Torrance, 2007). Furthermore, this finding is synonymous to those found in the study of over four hundred Canadian teachers' assessment practices, where teachers provided useful and timely feedback to students but could not provide support for metacognitive development and skills (DeLuca et al., 2016).

The three teachers used different formats of assessment instruments in their practices. All three mentioned using projects; however, how they used these, as well as their use of presentations, portfolios, student self-assessment and peer-assessment differed amongst them. For instance, Mr. Ade seemed to use more projects, presentations and student self-assessment and avoided the use of tests and quizzes. Mr. Olu, on the other hand, seemed to depend more heavily on the use of tests and quizzes, while Mrs. Temi felt she had to an exam for at least 30% of the final grades of students. Mr. Olu and Mrs. Temi mentioned using portfolios and peer-

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assessment; however, it was found that they used these assessment instruments primarily for assessment of learning purposes. Other studies have also found that teachers tend to use assessment of learning more often than assessment for and as learning (Ateh, 2015; McNair et al., 2003). These findings also fit into Canadian science teachers' assessment practices more broadly, as reported by Chu and Fung (2018).

Participants used formative, summative and metacognitive assessment types (Abell & Siegel, 2011) to varying degrees, while only one teacher mentioned enacting diagnostic assessment. Mr. Ade, for example, mentioned his attempts at knowing what his students already knew so he could plan his instruction accordingly, which is congruent with his constructivist approach to teaching and learning. Mr. Olu mentioned how he briefly requested students to show a thumbs up or thumbs down to indicate whether they are following his teaching, which is a way of quickly gauging where students are at to adjust the pace of his lessons and is a form of assessment "as" since it requires metacognitive processes. However, this strategy lacks the sophistication to provide specific information about students' prior knowledge on a topic, or to specify what students may be struggling with; presumably, further action and different strategies would need to be employed for students who indicate a thumbs down during classes.

Mr. Ade performed mostly formative assessment and his use of summative assessment was such that it would improve his teaching and students' learning. Ideally, summative assessment should be used for the improvement of teaching and learning in the classroom and not for ranking, categorization or certification purposes (Brown, 2002). Mr. Olu used summative assessment more often than formative assessment, but of the three participants, he seemed to be the most closely aligned to the view of summative assessment as a means to take required actions to improve students' learning; this was particularly evident in his comments about support

systems available to students beyond the classroom environment and how assessment and reporting on student achievement were means of supporting their learning. Mrs. Temi expressed using both summative and formative assessment, but upon further discussion, it seemed evident that she relied mostly on summative assessment in her classes.

All three teachers in this study mentioned that students resist new forms of assessment and indicated that students' engagement with assessment is part of their assessment decision-making. For Mr. Olu, students are partly responsible for the type of assessment he practices, as to keep students engaged he tends to abide by the assessment preferences of his students, which he perceived as being focused on grades. Differently, Mr. Ade, whose assessment is primarily student-centered, stated that, when introducing new forms of assessment, he ensured students get used to the new assessments by persevering until they get a good understanding of it. Mr. Ade also mentioned the need to clarify classroom assessment strategies with students before assessing them and to explore students' views of assessment, providing alternatives for students to demonstrate their learning; this is in line with recommendations proffered by Aydeniz (2007) that teachers can engage students in discussions on the best assessment practices.

The participating teachers also mentioned the observed differential engagement with assessment among elementary, middle, and high school science students, which they also saw as a factor in how they practised assessment. Although interview questions for this study were not designed to inform this discussion, the teachers in this study mentioned that, as students move up the education ladder, they tend to prefer traditional and summative assessment tasks. This is in line with the literature on assessment practices (e.g., Zhang & Burry-Stock, 2003). This perceived preference on the part of students for summative assessment can be as much a result of students being used to certain types of assessment as of their conceptions on assessment, which

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could be influenced by the practices they have been exposed to. More importantly, it could be to the fact that they know that their grades would also be used for post-secondary entrance decisions and for scholarships – as they move to the senior grades.

In any case, the provincial documents on assessment clearly recommend prioritizing metacognitive assessment, which, when implemented effectively, would allow students to regulate their own learning and value feedback as equally or more useful to their learning than final grades. However, it is important to notice the systemic and structural forces shaping assessment practices, as students, parents, administrators and teachers alike may respond to perceived differential values placed on summative, formative and metacognitive assessment. As Mr. Olu and Mrs. Temi pointed out, teachers' practices are constrained by what the school and division expect in terms of how to report student achievement.

Also of notice is the unfamiliarity of these three teachers with one of the provincial documents on assessment and how this may have influenced their practices. The *RCAPM* document (Manitoba Education, Citizenship and Youth, 2006a) clearly emphasizes assessment as learning (as illustrated in Figure 2), but the three teachers in this study did not consult the document and expressed concerns in following the document because of how long ago it was published. Perhaps if they had had deeper knowledge of this document and others pertaining to assessment in the province, they could have found validation or at least inspiration to more consistently pursue the practices they mentioned they would like to implement more often in their classes, especially in the cases of Mr. Olu and Mrs. Temi.

What is the relationship, if any, among conceptions, perceived self-efficacy, and practices as these relate to classroom assessment in the cases of three Manitoban high school science teachers?

Findings from this study indicate that the science teachers' assessment practices are influenced by their conceptions of assessment, in line with existing literature on this topic (for example, Brown, 2002; Brown & Remesal, 2017; Calveric, 2010; Remesal, 2011; Opre, 2015). From my findings, Mr. Ade, who mostly holds an improvement of teaching and learning conception, utilized more formative and metacognitive assessment tasks than summative assessment tasks; and even his summative assessment often relied on innovative, authentic and performance-based instruments as often as possible, rather than traditional paper and pencil tests. He clearly espoused a constructivist view of teaching and learning, and firmly placed his assessment practices on assessment for learning, guiding all aspects of his teaching.

Conversely, although Mr. Olu seemed to hold multiple conceptions of assessment, he and Mrs. Temi held an accountability of teachers and schools' conception, which cohere with their employing more summative assessment tasks, which were also more traditional (quizzes and tests). Mr. Olu mentioned he is yet to put in place strategies to assess students' metacognitive skills in his classroom; while Mrs. Temi indicated that providing useful feedback to students to develop their metacognitive skills is still a work in progress.

Consistent with Abell and Siegel (2011), "the types of assessment tasks that a science teacher designs and implements reflect the assessment values the teacher holds and his/her knowledge of assessment, as well as her knowledge of assessment purposes and what is important to assess (p. 215)." I believe that the three science teachers demonstrated coherence among their conceptions, knowledge, and purposes for assessing students and the assessment

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tasks they were comfortable with and thus practiced. In case I, Mr. Ade, who believed assessment is primarily for improving teaching and learning, designed and implemented assessment for learning often in his classes. His practices were guided by experiences he had in his graduate education, and his knowledge of the three different purposes of assessment (of, for and as learning), which facilitated his design and implementation of all three purposes of assessment in his classes, even though he claimed to be unfamiliar with one of the provincial documents on assessment and he evaluated this document as out-dated.

For Mr. Olu, his multiple conceptions of assessment as being an accountability of teachers and schools coupled with an improvement of teaching and learning conception seemed to be related to his frequent implementation of assessment of learning and occasional use of assessment for learning. In addition, his knowledge that assessment practices primarily, should be consistent and often difficult to change after prolonged use, are mostly based on system and student demands, and mostly used for reporting students' grades facilitated his purpose for assessment which seemed related to assessment of learning purposes with minimal employment of assessment as learning practices.

Mrs. Temi conceptualized assessment mostly as accountability of teachers and schools, which seemed to be quite consistent with her practices, focusing mostly on summative assessment and referring to the constraints imposed by the school as well as students' own preferences when it comes to purposes of assessment. Her lack of knowledge about assessment as learning precluded her from effectively designing and implementing this type of assessment, even though she remarked on her desire to include more of it in her classes. Her views on assessment were primarily related to grades and summative evaluations of student learning, and

consequently, most of the instruments she used in her classes were for the purpose of assessment of learning.

Teachers' perceived self-efficacy of assessment has been found to be a strong influence on how teachers use assessments in their classrooms (Alkharusi et al., 2014); the results from the three teachers in my study corroborate this conclusion. Perceiving to be highly or poorly skilful in designing certain assessment tasks afforded or constrained implementation of these tasks. For example, Mr. Ade, who demonstrated high skills in designing and implementing formative assessment with students, enacted and used more projects, portfolios, in-class interactions, and timely and constructive feedback in his classroom, while explicitly commenting about how he disliked and avoided using quizzes and pencil and paper tests. Conversely, even though Mr. Olu stated mastery in doing the assessment he has been doing with students, he mentioned his low self-efficacy in the effective use of formative assessment tasks; he stated that most of his assessment is assessment of learning and that he would require assistance to enact innovative assessment, especially assessment as learning. Mrs. Temi's low self-efficacy also influenced her assessment practices, which she considered to be still a work in progress. Relying mostly on her colleagues for sources of assessment instruments, she stated several barriers to implementing different purposes of assessment in her classes, despite her desire to do so. Chief among these were her inexperience as teacher and her lack of knowledge about what assessment for learning and as learning meant. She confounded purposes with formats of assessment, a confusion that clearly impacted her practices.

Mr. Ade used formative assessment to verify students' progress constantly and often, with the intention of planning his teaching accordingly. He is a firm believer that assessment must be integrated with instruction and that the latter depends on the former. Indeed, he planned

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assessment carefully and ahead of time, putting quite a lot of work into the design of assessment instruments that involved real-world problem solving and that were flexible enough to meet students' needs and abilities. These assessment practices relate to how he thinks of assessment as an improvement of teaching and learning process. Moreover, in Mr. Ade's case, professional learning opportunities seem to be directly related to his perceived high self-efficacy of assessment, which in turn influenced his assessment practices. His conception of assessment as improvement of learning is congruent with his classroom assessment practices, albeit in his case there seem to be a clear preference and tendency for formative assessment and assessment for learning. Unfamiliarity with one of the provincial assessment documents seemed not to deter Mr. Ade from doing many of the things recommended in that document, and the verbal persuasion type of self-efficacy most evident in Mr. Ade's case may have a relation to his conception of assessment, as he was inspired to try innovative assessment practices from courses he took in his formal educational training, especially at the graduate level.

In case II, Mr. Olu acknowledged a low self-efficacy to advance his assessment practices from what he currently does with his students, even though he reported mastery in doing assessment. Mr. Olu's high perceived self-efficacy influenced his assessment practices because, on the one hand, he was confident in what he already did and he believed it is difficult to change practices once someone is used to them; on the other hand, his low-self efficacy in developing innovative assessment, especially assessment as learning, meant that he would continue doing traditional assessment tasks. Thus, it can be said that Mr. Olu's low self-efficacy in developing and using formative and metacognitive assessments and the fact that he conceives assessment also as accountability of teachers and schools are related to how he practices assessment, which were found to be primarily summative in nature.

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Mrs. Temi held an accountability of teachers and school conception and perceived her assessment self-efficacy as low while explicitly justifying her low self-efficacy on how young she is in the teaching profession. This teacher mentioned her strong reliance on assessments passed from colleagues she works with or had worked with in the past. Her conception of assessment relates assessment to grading, marking, and evaluating; to her, a key role of classroom assessment is to prepare students for the types of examinations they will encounter in university and, in this sense, it prepares students for the world. Mrs. Temi believed as well that teachers are confined to certain assessment practices due to recommendations from the educational system where she works. Her reliance on ready-made assessment and her conception that assessment should be for grading limited the forms of assessment she enacted in her classroom. Perhaps with more years of experience she will find ways to advance her practice within the requirements of that education system.

Overall, the analysis of these three Manitoban high school science teachers' conceptions, perceived self-efficacy and practices in terms of classroom assessment indicate that these three factors are intertwined—teachers' practices relate not only to how they conceive of assessment, but also on how much they perceive themselves to be able to effectively design and implement the types of assessment they believe to be most helpful for whatever purposes assessment plays in their classrooms. Lack of knowledge of one of the provincial documents on assessment and its recommendations regarding assessment practices seem to contribute to the difficulty Mr. Olu and Mrs. Temi presented in designing and implementing assessment as learning. Confronted with the often cited barriers and challenges to implementation of authentic, performance-based assessment, especially time and resistance from students, these teachers reacted differently from each other, but quite coherently with their own conceptions of assessment and perceived self-

efficacy: Mr. Ade put extra effort and time to plan assessment very carefully and ahead of time, relying on resources from his graduate education, which reinforced his perceived self-efficacy on practicing this type of assessment. Mr. Olu and Mrs. Temi, on the other hand, indicated a desire to vary the types of assessment and increase the frequency with which they use assessment as learning in their classrooms, but did not feel capable of doing so on their own and mentioned various barriers to successfully implementing these practices. Their position is aligned with their own lack of understanding of assessment as learning and their conception of assessment as mostly focused on accountability of teachers and schools.

Limitations of the Study

In the conduct of this study and through my appraisal of the literature, it is pertinent to state that most if not all studies, regardless of efficiency in the adoption and utilization of research design, are liable to limitations. For this reason, all study limitations must be adequately presented and considered. Since this study elicited data from only two sources, interviews and artifacts, and only three cases, through a single interview with each participant, its findings “cannot provide a conclusion that could lead to the development of converging lines of inquiry” (Yin, 2009, p. 115). Engaging in two or more interviews with the teachers would have provided a deeper sense into how the teachers discussed their conceptions, practices and perceived self-efficacy of classroom assessment, thus, providing a more robust data.

Another limitation to this study is the data collection time frame. Spending more time collecting data through multiple interviews and including classroom observations would improve the depth of findings and conclusions in this study. In addition, classroom observations could have provided first-hand, experiential information about the actual classroom assessment practices of the three teachers who participated in this study; this could also reveal further

relationship among the concepts explored in this study. Secondly, since this study relied on interviews, engaging in multiple interviews and classroom observations would prevent any possibility whereby teachers' discourse could intentionally be aligned to expected researcher's goals.

Lastly, interviews with the teachers in this study were conducted towards the end of the term when teachers were preparing to engage in end of the term assessments. Conducting interviews towards the end of the school term or examination periods could have an effect on how teachers discuss their assessment practices.

Study Implications

Results from this study contributes to the existing literature that recognizes the complexities inherent in teachers' conceptions of assessment and their assessment practices and has also made significant contributions towards the understanding of three Manitoban science teachers' classroom assessment practices. Below, I expound on the implications of this study to various audiences involved in teachers' classroom assessment practices and in the teaching and learning of science in K-12 education. This study corroborates previous research findings (for example, Brown, 2002; Brown & Michaelides, 2011; Remesal, 2011).

The three high school science teachers acknowledged that their participation in this research, in the form of having a conversation about assessment, availed them the opportunity to critically assess their teaching, learning and assessment philosophies and to further their thoughts and approaches towards classroom assessment. Specifically, Mr. Olu and Mrs. Temi mentioned that, by participating in this study, they have been provided with opportunities to advance their classroom assessment practices in alignment with contemporary assessment practices and provincial recommendations.

A recommendation that can be made based on this study's results is that science teachers should be involved in professional learning communities or communities of practice. Professional learning and development programs would assist teachers in the continuous evaluation of their classroom practices and in the practical development of their assessment pedagogies. Moreover, the use of communities of practice to improve teachers' assessment practices have been endorsed by researchers; for instance, Suurtamm and Koch (2014) stated that "we suspect that such an approach may result in more meaningful changes in teachers' classroom assessment practice than would result from an approach where assessment experts transmit theoretical ideas to teachers" (p. 283). In a similar view, the establishment of professional learning frameworks will provide grounds for articulating assessment learning programs for developing teachers' assessment pedagogies (DeLuca et al., 2012).

Another recommendation from this study's result is grounded upon the unfamiliarity of the three teachers with the provincial assessment guidelines (*RCAPM*) and their mention that it is out-dated. Insofar as this document contains guidelines for contemporary assessment practices, it should be made more visible on the Manitoba Education webpage for ease of accessibility by the intended audience, that is, teachers. It is also highly recommended that these guidelines be revised often and updated as needed, to reflect societal and cultural changes in schools.

As implied from findings from this study, understanding teachers' classroom assessment practices could provide insights to their pertinent needs where future policies can draw on to bring about improvement in students' and teachers' engagement in science education which could contribute towards the effective implementation of the *Action Plan for Science Education in Manitoba* (Manitoba Education and Training, n.d.). It is important that further research be conducted on students' conceptions of assessment to provide insights and accounts of their views

and engagement with assessment especially in a low-stakes educational system as obtained in Manitoba. Further to this, narrowing the scope of study to explore science students' conceptions and engagement with assessment by grade level will explicitly provide further insights into the issues discussed in this thesis, as participants in this study believed that students' engagement with assessments varies by grade level.

Similarly, it is pertinent that future research be conducted on participants' mention that senior students believe assessment for grades matters the most. This kind of proposed research is expected to offer insights to why senior students most especially, view assessment as for grading and also provide an understanding of ways to better assist them to be more supportive of assessment for and as learning alongside their teachers. Given the findings from this study that the teachers' years of teaching, teacher education, and involvement in professional education programs contributed towards their perceived self-efficacy and assessment practices and conceptions of assessment, it would be beneficial to conduct similar studies with Manitoba pre-service teachers and those in graduate education programs to investigate a possible relationship among these concepts.

Future studies conducted on teachers' conceptions of assessment and classroom assessment practices should expand on data collection techniques to include multiple interviews and classroom observations, as well as different periods during the school year when interviews and observations were to take place, to reduce the possibility of teachers' discourse and practices being influenced by factors such as examination periods.

Concluding Thoughts

This study described the conceptions, assessment practices, and perceived assessment self-efficacy of three high school science teachers in two schools in Manitoba; results

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corroborate the strong connection between assessment conceptions, perceived self-efficacy and classroom practices, and suggest an interesting link to formal post-degree education, as well as alignment to provincial assessment recommendations. I found it worthy to conduct this study which provides insights from science teachers' perspectives on assessment and assessment decisions—which is what educational stakeholders require to adequately understand teachers' classroom practices for future professional development designs and educational policy developments.

Indeed, I have learned quite a great deal from conducting this study. First, it availed me opportunities to learn how to research for literature specific to my research area; expanded my scope on assessment, conceptions, and self-efficacy literature, the works of relevant researchers in these fields, and how assessment plays out in different classrooms and educational contexts. On another level, I was able to gain first-hand information on how science teachers assess the way they do from my “ever ready to assist” participants—surely, without their interest in my research, I would not be able to complete this interesting project.

Through this research, I learned that although science disciplines are all referred to as “the sciences,” teachers that teach these subjects have different notions of assessment and adopt different assessment strategies towards developing scientific literacy in students. Similarly, this research informed me that on the one hand, science teachers have different conceptions of assessment, and on the other hand, it was interesting to find out that these conceptions were developed through various means which seemed to include each teacher's personality.

Finally, this research has improved my level of reasoning about research methodologies appropriate for conducting studies and in examining to research problems. The constructive feedback I received from my professors, committee members and my supervisor went a great

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length in shaping my focus towards what is essential to look for in aspects of research – especially case study research. Lastly, it is my desire to focus my inquiry towards research on how science teachers' classroom assessment practices can be improved to bring about improved student learning outcomes, especially in the current accountability frameworks existing in most educational systems of the world.

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Appendix A: ENREB Approval Certificate



Human Ethics
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PROTOCOL APPROVAL

TO: **Monsurat Omobola Raji** (Advisor: Richard Hechter)
Principal Investigator

FROM: **Sarah Teetzel, Vice Chair**
Education/Nursing Research Ethics Board (ENREB)

Re: **Protocol #E2018:088 (HS22297)**
Exploring Science Teachers' Conceptions and Efficacy of Assessment
in Manitoba Schools: A Case Study

Effective: November 13, 2018

Expiry: November 13, 2019

Education/Nursing Research Ethics Board (ENREB) has reviewed and approved the above research. ENREB is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*.

This approval is subject to the following conditions:

1. Approval is granted only for the research and purposes described in the application.
2. Any modification to the research must be submitted to ENREB for approval before implementation.
3. Any deviations to the research or adverse events must be submitted to ENREB as soon as possible.
4. This approval is valid for one year only and a Renewal Request must be submitted and approved by the above expiry date.
5. A Study Closure form must be submitted to ENREB when the research is complete or terminated.
6. The University of Manitoba may request to review research documentation from this project to demonstrate compliance with this approved protocol and the University of Manitoba *Ethics of Research Involving Humans*.

Funded Protocols:

- Please mail/e-mail a copy of this Approval, identifying the related UM Project Number, to the Research Grants Officer in ORS.

Research Ethics and Compliance is a part of the Office of the Vice-President (Research and International)

umanitoba.ca/research

Appendix B: Interview Prompts

Note: As this research is inductive, it is expected that some other interview questions could emerge and develop as the interview advances. The unstructured interview will be framed as a conversation, where participants will be encouraged to engage in free narratives about the artifacts at hand and the topic of the study: assessment. Accordingly, the following questions are prompts only, which will be used in no particular order and may be framed slightly differently and/or rephrased as needed to encourage conversation and ensure comprehension.

Interview Prompts

- What does assessment mean to you? Like when you think of assessment, what ideas come to your mind?
- In terms of your thinking of assessment, what would you say accounts for your choice of assessment types and forms as reflected by this artifact?
- Explain how you understand the purpose, and strategies for assessment in science education?
- What are the purposes for which you assess your students? Or what do you look for in your assessment strategies?
- Manitoba Education has identified three purposes for assessment: of, as, and for learning. What do these mean to you in general, and how do they manifest in your science classes?
- Assessment pyramid from the rethinking document? Any idea of this document? which one represents your practice the most?
- Does this have any implication for how you evaluate students' learning of content and acquiring of relevant skills?
- How would you describe stakeholders' influence on education (parents, superintendents, policy makers etc.)?
- Looking at the present Manitoba curriculum on science education, do you envision other purposes for which teachers should assess science learning?
- How do you source for assessment tools that you use with your students?

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- Can you discuss the purposes for assessment that you use in your classroom: as, of, and for learning?
- How about feed back? How do you provide feedback to your students?
- How confident are you in developing the assessments that you just described?
- How confident are you in using the assessments that you just described?