Exploring Professional Identity in Response to Curriculum Reform and Professional Development: The Teaching Life Stories of Chemistry Teachers

by

Gayle D. Peters

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Advisor: Dr. Brian Lewthwaite

Department of Curriculum, Teaching and Learning

University of Manitoba

Winnipeg, Manitoba, Canada

Abstract

This study contributes to the existing literature in teacher education on teacher professional identity (Beijaard, Meijer & Verloop, 2004; Lamote & Engels, 2010; Rots, 2007), particularly in response to curriculum change and professional development. It proposes to offer a much better understanding of how chemistry teachers' professional identities have evolved through their school and work experiences, and the tensions they experience associated with their beliefs about teaching and learning and their actual practice. Specifically, this study aims to identify how teachers' professional identities have evolved following the introduction of the latest chemistry curricula in Manitoba. These latest chemistry curricula advocate for a more learner focused 'tetrahedral orientation' (Mahaffy, 2004) teaching practice that supports chemistry learning through the use of Johnstone's (1991) three modes of representation – the symbolic, macroscopic and molecular levels – as well as a human element dimension. This study also aims to identify how teachers' professional identities have evolved following their participation in long-term professional development offered by teacher educators at the University of Manitoba. Additionally, this study aims to determine whether teachers feel they have experienced tensions associated with their beliefs about teaching and learning and their current teaching practices as a result of sustained professional development. Finally, this study aims to determine whether the curriculum changes and associated professional development have led teachers to think about and reflect more on their teaching practice and whether this has led to a change in their beliefs about teaching and learning and their teaching practice. Urie Bronfenbrenner's (1979) Model of the Ecology of Human Development was used as a theoretical framework for this study. This study was informed by semi-structured interviews involving 32 teachers of chemistry that were

conducted during the fourth phase of a five-year research and development project supported by the University of Manitoba's Centres for Research in Youth, Science Teaching and Learning (CRYSTAL). These interviews suggested that teachers have experienced some tensions associated with their beliefs about teaching and learning and their current teaching practices. The study further elicited data from eight of these 32 teachers via a qualitative narrative inquiry study employing narrative interviews to reveal teachers' perceptions of their evolving professional identities and chemistry teaching practices. Teaching life stories constructed from the narrative interview data revealed that these teachers feel that their professional identities have evolved through their school and work experiences, and that a change in curricula followed by supportive professional development has caused these teachers to reflect more on their teaching practices. Furthermore, though these teachers indicated that they have experienced tensions associated with how they want to teach and their actual teaching practices, they feel they have experienced a shift in their beliefs about teaching and learning such that they feel their teaching practices have improved through their more consistent use of the four modes of representation in chemistry learning. The qualitative data show, however, that these teachers still feel that they have a long way to go to achieve a truly learner focused classroom practice where these four modes of chemistry learning are being used the majority of the time. The study closes by recommending that a much broader study be undertaken to include more teachers of chemistry in Manitoba to verify and add to the findings of this study, among other suggestions.

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1.1: Introduction

When a new school curriculum is being implemented, such as the recently released Grade 11 and 12 chemistry curricula in Manitoba, do teachers' professional identities align with what is being proposed? If so, does the intention of the curriculum become the enacted curriculum in their classrooms? If not, how do teachers respond to the intentions of a new curriculum? How do they negotiate the potential tension that is created by incongruence between what is anticipated and their actual practice? As a result of a new curriculum introduction, are teachers reconsidering and reflecting on their practice and, ultimately, trying to improve their practice? Does ongoing professional development associated with a new curriculum introduction assist in altering teachers' professional identities, their reflective practice and, ultimately, their teaching? I ask these questions quite sceptically because I query the influence of a new curriculum introduction since, as Cuban (1990) asserts, "few reforms aimed at the classroom make it past the door permanently" (p. 11).

I wonder if the introduction of the latest chemistry curricula in Manitoba (MECY, 2006-7), which has shifted from more traditional, content focused curricula to curricula which are rooted in constructivist ideologies and promote a more learner focused classroom environment, has caused tensions between teachers' beliefs about teaching and learning and their actual teaching practice. The preface to the latest chemistry curricula suggests that teachers place less emphasis on the transmission of content knowledge and that they modify their instructional practices so as to create a more learner focused classroom environment that will increase the

motivation of students and their engagement in learning (MECY, 2006-7, p. 3). To highlight this more constructivist, or learner focused approach, the preface to the latest chemistry curricula employs terminology such as 'construction of meaning,' 'hands-on,' 'prior knowledge,' 'applications,' 'large-context problems,' 'small groups,' 'experiential learning,' 'inquiry,' and 'critical thinking' to illustrate how the teaching of chemistry should be approached. To emphasize teaching within a more constructivist methodology, the preface to the current chemistry curricula states:

> Students learn most effectively—in a Piagetian sense—when their study of science is rooted in concrete learning experiences related to a particular context or situation, and applied to their world of experiences where appropriate. (MECY, 2006-7, p. 3)

The preface to the latest chemistry curricula also suggests that teachers consider the interrelatedness of Science Technology Society and the Environment (STSE) in their teaching – that is, teaching science in a social-technological or human context – and that they concentrate on developing the scientific literacy of students within this more constructivist, or learner focused, environment. Researchers agree that science should not be portrayed as a "value-free, abstract and objective pursuit" (Pedretti and Solomon, as cited in Pedretti, 1999, p. 174), but rather should be presented as a human activity, which acknowledges both the strengths and limitations of science and technology (Pedretti, 1999). Emphasizing the humanistic component or human element of science also aligns with current research into teaching and learning in chemistry by Mahaffy (2004) who suggests that chemistry concepts in particular be taught utilizing multiple modes of representation, which includes the three modes first proposed by

Johnstone (1991) – the symbolic, macroscopic and molecular levels – in concert with this fourth human element.

In the wake of such assertions and curriculum mandates, I am wondering if teachers are illustrating chemistry concepts using mainly a symbolic level approach, or if they have pursued the teaching of chemistry using the multiple modes of representation that might lead to greater student understanding. While the latest chemistry curricula in Manitoba drew some of its influence from the work of Johnstone (1991), it was primarily the beliefs of the curriculum writing team that this multi-dimensional approach to instruction in chemistry, including a human element component, was essential if students were to achieve a much greater understanding of chemistry concepts.

The research literature has revealed that the manner in which teachers approach their instruction of a given subject matter depends largely on their beliefs about teaching and learning. For example, there have been a number of studies in the area of conceptions of teaching (see Kember, 1998), which have revealed a continuum of teaching approaches which range from a traditional teacher/content oriented approach which aims to fill the student or 'empty vessel' with knowledge, to a more constructivist student centred/learning approach which, amongst other things, focuses on fostering student understanding. One such study by Samuelowicz and Bain (as cited in Boulton-Lewis, Smith, McCrindle, Burnett & Campbell, 2001) in which 13 academic teachers were interviewed, resulted in five conceptions of teaching emerging through the process of constant comparative analysis: (1) imparting information, (2) transmission of knowledge and attitudes in a discipline, (3) facilitating student understanding of course content,

(4) developing concepts and principles through interaction with students and (5) supporting students' learning. I am wondering if a similar continuum of conceptions of teaching exists among Manitoba chemistry teachers, and if perhaps they are making their way towards becoming a supporter of student learning and away from being an imparter of information, as the preface to the latest chemistry curricula suggests they do.

Despite the recommendations in the preface to the latest chemistry curricula that teachers aim to develop student understanding using more constructivist and humanistic methodologies in their classrooms, the student learning outcomes (SLOs) portion of the documents still largely reflect a teacher/content oriented curriculum. It is this 'disconnect' between the preface and the SLOs that may pose a serious barrier to this latest curricula's successful implementation. If the latest chemistry curricula are to be implemented as intended in the preface, it suggests that teachers will need to practice more constructivist and humanistic methodologies throughout their coverage of the SLOs. My interpretation, then, of what the latest chemistry curricula are suggesting, is that content knowledge should still be given importance so as to provide students with basic background knowledge to prepare for future study in chemistry, but rather than content knowledge being at the forefront of the latest curricula, that base knowledge is intended to simply provide a foundation for the understanding of humanistic STSE issues. Furthermore, the multi-dimensional approach to the teaching of chemistry concepts suggested by Johnstone (1991) allows for a greater understanding of chemistry concepts than would normally be obtained through sole use of the symbolic level approach. Thus, if the curricula are implemented as intended, students will still be provided with basic knowledge in chemistry, in a much more

meaningful multi-dimensional manner to allow for greater student understanding, and will also be given exposure to chemistry in a human context.

After searching for concise meanings of the term 'learner focused' I encountered one definition which seemed to resonate well with my understanding of what the term means. Terry Doyle, who is an author, educational consultant and professor of reading at Ferris State University, notes that "learner centred teaching means subjecting every teaching activity (method, assignment or assessment) to the test of a single question: 'Given the context of my students, course and classroom, will this teaching action optimize my students' opportunity to learn?'" (*Learner Centered Teaching*, n.d.). In my understanding then, any classroom approach which optimizes students' opportunities to learn is considered to be learner focused and is contrasted with a teacher/content focused approach, which, in my view, is characterized by the direct transmission of information from a teacher to a relatively passive student. In the context of this study then, the term *learner focused* will be used to signify the instructional approach suggested in the preface to the latest chemistry curricula; that is, a classroom learning approach that is more constructivist in nature and that focuses on generating student understanding of chemistry concepts through the incorporation of humanistic STSE issues and multiple modes of representation as the curricula suggests. I am aware that in using this definition of the term *learner focused* that some theorists, such as Dewey, may not agree with its use, however, my reference to the learner focused approach simply refers to an approach which leads students to a greater conceptual understanding of chemistry concepts.

Also, since this study focuses on understanding teacher beliefs and teacher professional identity with respect to the implementation of these latest chemistry curricula, it is worthwhile to

define these terms as they will be used in this study. In the context of this study, then, the term *teacher beliefs*, or more broadly, *teacher professional identity*, is the evolving belief system or identity of a teacher which has been shaped by their childhood experiences in education, the knowledge and learning they obtained in teacher education, and their experiences in teaching practice (Lamote & Engels, 2010). In the context of this study, then, a teacher's professional identity may determine whether they approach the teaching of chemistry with a traditional approach which is more teacher directed and which focuses on the transmission of content knowledge, or with a more constructivist and humanistic approach which has more of a learner focus and which emphasizes student understanding. So, I wonder if teachers are buying into the latest chemistry curricula and implementing the curricula as intended. I also wonder what some of the obstacles to this implementation are. Do teachers feel that they are experiencing an alteration or, possibly, a transformation in their beliefs about teaching and learning following their participation in long-term professional development which has encouraged teachers to use more constructivist and humanistic methodologies and multiple modes of representation in their teaching of chemistry? And have their teaching practices been transformed as well so that the intended curriculum becomes the achieved curriculum for their students and their learning interests and goals? These questions posed guide this research inquiry.

If this inquiry is focused on understanding teacher professional identity and what motivates a teacher's teaching, especially within the context of chemistry education, I feel it is best to introduce myself and the influences on my professional identity that have transformed my orientation to the teaching of chemistry concepts from being more content focused to an orientation which is more focused on the learner. I introduce myself because, potentially, my

story may be similar to many, even the participants in this research; that is, I may bring scepticism to the idea of teacher change when, in fact, it is a common lived experience for teachers. Change, at least in thinking, may be, contrary to Cuban's (1990) assertions, a common lived experience for teachers. Maybe teachers live with a tension between their aspirations and their classroom lived experience. Maybe they are making it to the door (as Cuban suggests) or, even further, into the classroom practice. Perhaps this tension that teachers may be experiencing is a good thing; perhaps it encourages a transformation in their beliefs as they wrestle with the idea of living out their classroom goals. Thus, prior to seeking answers to these and many further questions, and outlining the structure of this thesis, I believe it is worthwhile to introduce you to me; professionally at least. I will begin by looking back at my own journey and how my professional identity has evolved from the time I was a student to my current role as a teacher. Below is my teaching story, to which there are five parts: My life as a student; my life as a teacher candidate; my life as a novice teacher; my life as a more experienced teacher; and my further education.

1.2: My Teaching Story

1.2.1: My Life as a Student

I recall from my own experience as a secondary student in chemistry that the course was taught in a very traditional, content focused manner. The majority of the time our apathetic teacher sat at his desk with a textbook and told our class what pages to read and what questions to answer afterwards. We occasionally did class experiments, but they were uninteresting 'cookbook' style labs, and we subsequently wrote lab reports based on our results with very little

understanding of what it was we were supposed to learn from the experiments. I also remember working, rather mechanically, through algorithmic problems and writing chemical equation after chemical equation, and then balancing them afterwards for what appeared to be no intended purpose. Everything I learned was at the algorithmic and symbolic level (Johnstone, 1991). I didn't really understand the relevance of what I studied during this chemistry course, but rather I just learned by rote the course material for tests and exams. And so, what my A^+ in chemistry showed, in my opinion, was that I had a great ability to memorize course material, not that I understood chemistry concepts at all or the relevance of chemistry to my life.

My secondary school experience was not all comprised of traditional learning and disinterested teachers, however. I was inspired by two teachers in particular, that had a love of their subject matter and an enthusiasm for teaching that far prevailed over all of the others. The first was my Grade 8 mathematics teacher. If I were to describe this teacher as a person, I would say that he was by far one of the most caring of all of my teachers. He truly wanted the best for me and I felt that, without a doubt, he was sincere. And this was despite my less-than-stellar attitude and poor class performance. As a professional, I would describe him as a very good teacher and an 'extended professional' (Lamote & Engels, 2010) of sorts who was involved in all things student related in the school. With regards to the quality of his teaching, I felt that, for the day and age (the 1980s), he made every effort to make mathematics exciting and relevant. I wouldn't say that he was entirely on the learner focused end of the traditional to learner focused continuum of classroom instruction, but I feel that he was somewhere in the middle and was certainly striving to improve his practice. In addition, his efforts in student related activities more than made up for what he lacked, if anything, in the classroom. He coached sports, he

supervised the yearly canoe trips, and he was head of the Mathematics Club. And, he was one of those all around good teachers.

The second teacher that inspired me was my Grade 9 mathematics teacher. He also saw potential in me despite my lackadaisical approach to schooling. This teacher was also a very good teacher. He was not so much of an 'extended professional' (Lamote & Engels, 2010) in that he 'lived' in his classroom, but he was extremely passionate about his subject area, which always made me wonder what all the fuss was about. I remember that as he taught his face would get all red from all of his excitement. He loved mathematics, and he wanted everyone else to love it as well. As one might expect from being amongst someone so passionate about his subject, his love of mathematics eventually wore off on everyone in his class. You could not, NOT love mathematics after being in his class for even a short time. As much as I resisted, his encouragement and his passion for numbers somehow drew me in. Again, I wouldn't say that he was entirely on the learner focused end of the traditional to learner focused continuum of classroom instruction, but I feel that he was somewhere in the middle and, as far as teachers went in those days (mainly traditional and content focused), he was one of the better ones for sure, and seemingly striving to improve his practice. When you consider that most of my other teachers taught from a textbook while sitting behind their desks, this man, who almost danced as he taught, was, in my view, far superior to the others. And, had it not been for his persistence and for his refusal to let me drop to the non-university entrance mathematics course as per my request, I would not have become the studious and high-achieving high school student that I eventually became. Also, my career would have likely taken a much different and bleaker path, and so I give him much credit for the path I eventually took in becoming a teacher.

My university educational experience was not much different from what I had experienced in secondary school. With great marks in everything by the end of high school, my decision to take science courses, in particular chemistry, in university was the direct result of having had an effective and interesting teacher candidate in my high school chemistry class. Because my regular secondary school science teachers were exceedingly content focused, all it took was the fresh, new face of a teacher candidate – wearing a shirt with benzene rings on it no less – to add some relevance and context to the content he was teaching and to pique my interest in the field of chemistry. And so, from secondary school, I studied chemistry and environmental studies at the University of Winnipeg for 5 years, obtaining my 4-year Bachelor of Science degree, and was part of a co-operative program where I obtained research experience in the field of chemistry.

Now, while I thoroughly enjoyed doing research and working in the field of chemistry, I later discovered that I also really loved teaching. I found that I enjoyed working with kids and that for some reason or another, they liked me. My love for teaching science began after a short stint as a chemistry lab demonstrator, while studying in the chemistry department at the University of Winnipeg. It was during this time that I realized that I wanted to become a teacher. I have been passionate about teaching ever since. Having treated some of my school teachers in a less-than-respectful manner, it was shocking to many that I was about to enter a faculty of education.

1.2.2: My Life as a Teacher Candidate

Following my Bachelor's degree in Science, I enrolled in the Bachelor of Education After-Degree Program at the University of Winnipeg, and for the next 2 years, I studied all things related to science and chemistry and the teaching of science and chemistry. While I found the theory I learned in my education courses to be equally valuable to my practicum experience, I feel it is worthwhile to describe the latter in detail as it really illustrates my evolving professional identity.

My practicum experiences can be described as three entirely unique experiences in three different secondary schools. My first practicum experience was at my former secondary school – a middle class school in a large school division, known more for its football team than for its academics. Interestingly, I ended up as a teacher candidate in my former chemistry teacher's classroom. You may recall that this particular teacher was exceedingly content focused and added little relevance or context to the course material. For the first few weeks of my practicum, I sat and watched this teacher teach the class in exactly the same manner as he once taught me, using the same old worksheets and tests that he used when I was a student in his class. Interestingly, when it was my turn to begin teaching the class, I don't think I did a much better job of actually teaching than my former chemistry teacher did. The students maybe responded better to me, as I was slightly more animated and interesting than what the students were used to, but I am sure that the students *understood* as little as I did when I was a student there. So, here I was, teaching the way that I had been taught – in the traditional content focused way – and modelling my teaching after that of my former chemistry teacher using mainly symbolic level references to chemistry and rarely adding relevance or context to the course material. My grades

in this first year of the education program were great, however, – all A's and A^+'s – but this only reflected that I was a good student, and not necessarily a good teacher.

My second practicum experience was eye-opening. In this next placement – a similar type of school to the first, but a bit more diverse in terms of student class and ability – I worked with a remarkable teacher. He was in the same demographic as my three high school science teachers – an over 55 male – but not nearly as traditional in his teaching style. I would describe this teacher as more of a learner focused teacher who focused more on problem solving and helping students construct their own knowledge than on content. After observing this teacher for a few weeks, I was beginning to understand how to make science relevant for the students and how to help them *understand* the content, as opposed to just having them memorize facts and concepts that would later be forgotten. Thus, when I began teaching in his class, I was more conscious of *how* I was teaching rather than just *what* I was teaching, and I was more intentional about bringing relevance and context into my teaching of science. In addition, this teacher and I engaged in a lot of dialogue and reflection after each lesson that either he or I taught which greatly enhanced the experience and also my teaching practice, I believe. The constant dialoguing after each lesson helped us both to understand the thinking underlying our practices. I didn't realize it at the time, but this is exactly what Dewey meant when he referred to becoming more 'knowing' and not to just observe others' teaching but also understand the thinking underlying others' teaching practices, as only then can one begin to become an effective practitioner (as cited in Loughran, 2002). In addition, when we reflected upon the events of each lesson, it clarified some of the issues with the lesson so that we could problem solve together and use that knowledge and understanding for future lessons. This teacher made a significant impact

on me during my Faculty of Education experience, and I felt that my professional identity was evolving such that my teaching orientation was becoming more learner focused.

My final practicum experience was also an 'eye-opener,' but for different reasons. For the final year of my practicum, I was placed in an upper-middle class academic school with a great group of science teachers. I had the opportunity to learn from and teach with three fantastic science teachers at this school, and it was there that I can say that I really became passionate about teaching. I made some great connections with the students at this school and really got into my 'groove' of teaching. Also, in this placement, there were several teacher candidates together in one building, which meant less isolation and the increased ability to dialogue and problem solve with one another. Thus, this was a better collaborative experience overall than at my other practicum placements where I was more isolated as the only teacher candidate in the building. Now despite the fact that I would view these teachers I worked with as 'fantastic,' they were forced to be a bit more content focused than at my previous practicum placement. This was likely due to the more academic type of school and the major focus on exams. Covering the content was a huge priority, although the teachers at this school made every effort to create a more learner focused environment. And so, this was an eye-opener in the sense that it showed me how easy it is to fall into the trap of content focused teaching. When there is pressure to cover the content and teach to the exam, you have to make a decision as to what kind of teacher you are going to be – one who caters to the exam, or one who caters to the students. What I observed from the teachers at this school is that this was a constant source of tension for them as it was their belief that a more learner focused classroom environment was essential if they wanted their students to understand science, but that they were being pulled in the opposite

direction because of a ‘top-down’ push to cover the content. I was determined after observing this that this same ‘tension’ would not be a factor in my career. Though I may not have realized it at the time, I recognize now that perhaps this ‘tension’ can be a good thing in that it can bring about awareness of the issues we are faced with as teachers, and may potentially cause us to re-evaluate our teaching and bring us a few steps closer towards change.

Finally, in addition to three great eye-opening practicum experiences, the course component of the Bachelor of Education degree was becoming more relevant and beneficial to me, and I felt in this year that all of the information and experience I obtained over the previous 2 years was all coming together. And so, when I got the calls about job offers – I had three to choose from – I felt confident and excited and was ready to embark upon my teaching career. I was determined and ready to become a great teacher, and I was going to create a more learner focused environment in my classroom and to make science relevant and interesting for the students, despite any push from ‘above’ to focus on covering the content.

1.2.3: My Life as a Novice Teacher

Following my Bachelor of Education degree, I immediately obtained a job working in a large school division in the Western portion of Winnipeg, Manitoba, Canada. In the time that I taught there, I was responsible for teaching Grades 9 and 10 science and Grades 11 and 12 chemistry and also International Baccalaureate (IB) chemistry. My first year of teaching was difficult, as it is for many teachers. There was not a lot of support for new teachers and I felt as though I was ‘left to the wolves,’ so to speak. I managed to push through this first year, however, I felt a bit ‘spread thin’ as I was trying to teach the content, connect with the students,

and keep up with the administrative details inherent in the job – never mind attempting to create a learner focused environment in my classroom, as was my goal. My biggest challenge in this year was adapting to the process of preparing students for divisional exams, while still trying to accomplish all that I wanted to achieve with the students. I felt that the divisional exams forced me to teach in a more traditional, content focused manner than I otherwise would have, and I felt that, since class grades on the exam were published, that I had to compete against other teachers for the best marks on the divisional exams. And, with a push from the province of Manitoba to teach an STSE-based curriculum and produce more scientifically literate students, I felt pulled in two different directions – in one way towards getting the content covered, and in the other way towards making science relevant for students. Despite being pulled in different directions, though, I would say that at this point in my career I perceived myself as a fairly competent teacher with a strong commitment to the teaching profession. And, I was striving to become more of an 'extended professional' (Lamote & Engels, 2010) – working collaboratively with my peers and taking part in many school activities. In terms of my beliefs, I would say that at this point I was caught up in more traditional views of teaching – due in part to divisional exams – but I desired to create a more learner focused environment in my classroom, and this was my goal in my next few years of teaching.

My next two years of teaching fared far better as I had more confidence and definitely more ability to 'stay afloat,' while also having enough time and energy to connect with the students. I also became more involved in extracurricular activities which helped a lot with those student relationships. In addition, I was attempting some more constructivist methodologies in my teaching and worked at creating a more learner focused environment in my classroom,

despite the divisional exam pressures I faced. I kind of enjoyed the business of it all – teaching, marking, planning and coaching. My life was my work and I loved every minute of it. During the summer between these two teaching years, I was also fortunate enough to be able to attend the 'ChemEd' conference in Toronto, where I was given the opportunity to collaborate with others and obtain new teaching ideas and strategies to try out in my classroom. I especially appreciated the opportunity to dialogue with others as this is where I feel that I learn the most. Although, it wasn't extended professional development, I still felt as though I took a lot of ideas away from the conference, and as professional development often does, it motivated me to improve my teaching practices.

1.2.4: My Life as a more Experienced Teacher

It was at this point in my teaching career that I began to put a little more flair into my teaching. I felt that I had my job under control in that I was able to adequately cover the course material in a more learner focused manner and at the same time prepare students for their divisional exams. While I often used demonstrations to connect with the content I was teaching, I 'stepped it up' a little by trying new demonstrations, incorporating some chemistry songs, showing computer simulations, and using relevant stories, history and contexts to supplement my teaching. The students responded really well to these new initiatives in my class, and for many students, it was their favourite class. I think that the students appreciated these more fun components to the class as it took some of the pressure off of divisional exams. These exams were the focus of our school division for years, and it seemed that from the start of each course, exams were all the students worried about. By making the course fun and interesting, it meant

that the students didn't realize how much they were learning. So, from this point on I was the 'demo lady,' which meant that I also got the call for putting on science shows during our school open houses, instructing 'science camp' for the Grade 8 students, and putting on magic shows for the elementary school students. I also got more involved in school-wide science fairs and all things science related in our school. It felt good to be involved in an area that I enjoyed, and I felt that I was truly en-route to becoming a more 'extended professional'(Lamote & Engels, 2010) as well. I also had the opportunity in this year to attend an IB training session in New Mexico, where again, I could collaborate with other chemistry teachers and share ideas and strategize with teachers from around the globe. This week-long session provided me with valuable resources, great networking opportunities and, like most professional development does, it motivated me to improve my teaching practices.

Also, during this time in the school division in which I taught, there were more initiatives put in place in our division to help novice teachers. In this year, I was asked to be a mentor teacher to a new chemistry teacher. This 'Mentor Teacher Program' was a program whereby a more experienced teacher was assigned to a new teacher in the building to mentor them for the school year. This included, among other things, classroom visits to give the new teacher feedback on their teaching and to dialogue with them, identify problems and seek resolutions to their problems. Recognizing the success of this initiative, the school division then created a 'Coordinator of Instruction' position, which employed a coordinator level teacher to assist new teachers to the school for the first 2 to 3 years of their teaching. Their role was to essentially provide judgement-free feedback on their teaching and more involved reflection, dialogue, problem identification, and resolution. While I was not able to be on the receiving end of these

great initiatives as they were implemented a few years after I began my teaching career there, I was able to take part in an initiative unique to our science department (headed up by my then department head) to make more of a commitment to reflective practice. My science department head offered to use his extra preparation time to cover our classes while we observed other teachers' classes and met with other teachers to dialogue and reflect on our teaching practices. Not many teachers get this opportunity for reflective practice and, therefore, don't get that opportunity to grow and develop their pedagogy. Having been given this opportunity, it allowed me to practice the process of reflection and dialoguing, followed by problem seeking and resolution, so that I could work at redefining my professional identity (Lamote & Engels, 2010), or specifically, reorienting my classroom practice towards a more progressive constructivist approach with a focus on the learner.

I felt at this time that I was in a good place in my career. I felt good doing what I was doing, and I was far more confident in my teaching role than I had been before. Also, I was learning and growing constantly – often spending my summer vacation and other holidays developing and revising materials and finding new ideas to try out in the classroom. I would say that at this point in my career I was fairly confident in my teaching ability and was very committed to the teaching profession. I also considered myself an 'extended professional' (Lamote & Engels, 2010) of sorts in that I made it a priority to work collaboratively with my peers and take part in many school activities. In terms of my beliefs, I would say that at this point I was shifting away from traditional views of teaching – despite the pressure of divisional exams – and more towards a learner focused, constructivist and humanistic view of classroom

practice. These qualities and beliefs held fairly constant throughout my next 2 years of teaching as well.

In my next 2 years of my teaching, I felt extremely competent and confident in my teaching abilities. Curricula and my course loads were almost constantly changing, but it never fazed me. I was connecting well with the students, I was able to teach the content well, and I was able to bring relevance and context to the content I was teaching. However, in these 2 years I taught many IB courses, which allowed me slightly less time for the 'frills' due to the greater content load in these courses. I did not enjoy teaching these IB courses as much as the regular science courses since it afforded me less time for demonstrations and the learner focused classroom environment I strived to create. Also, I found that many of these IB students just wanted to learn and did not want to make time for fun or to understand the relevance of what they were learning; they simply wanted the important testable information and that was it. They were very traditional learners wanting a focus on content acquisition.

The following year, I took a one-year leave of absence from teaching. I chose to stay home with my two children to avoid the complicated logistics associated with my children being in half-day kindergarten and preschool programs and trying to find appropriate child care to accommodate the half days. And so, I decided to tutor from my home and also obtained a job as a chemistry education assistant for the University of Manitoba. In this job I was developing chemistry teaching resources for a chemistry teacher professional development initiative supported by the University of Manitoba's Centre for Research in Youth, Science Teaching and Learning (CRYSTAL). I also had the opportunity to present some of these resources at the SAG

conference for science teachers. As well as assisting in the development of resources, I was also conducting interviews with chemistry teachers that pertained to how they taught and, more importantly, *why* they taught the way they did. About this time, I had been thinking about completing a Master's degree in Education.

1.2.5: My Further Education

I began my Master's program the following fall while expecting my third child. I was also continuing with my chemistry education assistant job since I would be off of teaching for another year, and I had committed to return to teaching the following year. The course work in this Master's program began to challenge my views on the purpose of teaching and how teacher beliefs about their perceived role as teachers influence their actual teaching. I was now beginning to question teaching, especially in regards to professional identity.

Interestingly, I feel as though I have learned more in my, now three years, away from teaching than I would have learned had I been teaching all along. My job as a chemistry education assistant enabled me to see that I was missing a huge component to my everyday teaching – the 'molecular level.' Though I feel that I was very adept at incorporating the symbolic, the macroscopic and the human element (Mahaffy, 2004) into my teaching, I did not always integrate the molecular level, with the exception of some instances where I showed a computer simulation or animation. I wonder now if students really *understood* everything I was teaching them. Also, while completing graduate level courses, I have had some great exposure to the research literature, which has really expanded my views about teaching, learning and science. Furthering my education has been the best decision I have ever made.

As it turns out, an out-of-province move forced me to resign from my teaching position at the school division in which I worked. And so, I am presently working on this Master's thesis and I plan to return to teaching once my Master's degree has been completed. As I reflect on my years as a teacher, I have seen myself transform through various methods of teaching – from more traditional and content focused, towards a more progressive constructivist and humanistic style of classroom practice which is more focused on the learner – while still maintaining my passion for connecting with students. I see great value in a learner focused way of approaching the teaching practice. I was striving for this in my last few years of teaching – even with the previous chemistry curricula that were more content focused. With a new set of chemistry curricula now in Manitoba that advocates for more of a learner focus, and with supportive professional development, it would be even easier to approach instructional tasks in a more constructivist and humanistic manner as the latest curricula suggests. However, I wonder if other teachers in Manitoba are equally responsive to the current chemistry curricula. Perhaps teachers are experiencing some tensions associated with their beliefs and their actual classroom practice. It would be interesting to see where teachers are at with their approach to the latest chemistry curricula, especially after involvement in long-term professional development and its associated reflection component.

1.3: Context of the Study

A committee of chemistry educators in the United States of America headed by Professor Armstrong got together in 1889 to inquire into and report on present methods of teaching chemistry. The Committee's recommendations were published in *Nature* in 1889 and strongly

emphasized that science should not be taught mainly as useful knowledge. The Committee suggested that learners ought to be discovering and inquiring and that when learning some particular content, illustrations should be referenced to that which is familiar to the students in everyday life. Armstrong (1889) remarks,

> chemistry as usually taught loses greatly in educational value because pupils are told, more often than not, that "so and so is the case," instead of being taught *how it has been found out* that such is the case; indeed that which has been proved is usually taken for granted. (p. 600)

I think this committee may have been on to something! As I read this article in *Nature*, I wondered what ever happened to these recommendations and the many other proposals for a more progressive education of our children. In his combined book, *The School and Society and the Child and the Curriculum*, Dewey (1991) emphasizes that learning must be *active*. Dewey asserts that "the logically formulated material of a science or branch of learning, of a study, is no substitute for the having of individual experiences" (p. 12). Thus, he feels that curricula should not just be presented to children as 'finished abstractions' (*Curriculum theory*, n.d.), but rather should include the child's preconceptions and should build upon the child's own sense of the world around them. Dewey states that curriculum material that is not relevant to a child's life actually becomes a substitute for the child's life, and he speaks of three evils associated with this: (1) If the curriculum has no connection to the child then the material is simply symbolic; (2) Children will lack motivation to learn material that has no real-life connection; (3) Curriculum material loses its quality when presented in an "external, ready-made fashion by the time it gets

to the child" (p. 14). Dewey argued throughout his life that schools did not provide genuine learning experiences for students – only an 'endless amassing of facts', which were fed to the students and soon forgotten (*John Dewey*, n.d.). So, why was I being taught school subject matter, in particular chemistry, in a very traditional, content focused manner nearly 100 years after these recommendations for a more progressive education?

As it turns out, many in the field of chemistry education are on board with solving the problems of a traditional, content focused chemistry education. In fact, over 40 years of chemistry education research has been devoted to this very problem. Johnstone (2010) states that many of the problems in chemistry teaching that were identified over 40 years ago are still of concern today. Johnstone (as cited in Lewthwaite & R. Wiebe, 2010), in response to the need for chemistry education renewal, proposed a 'triangular planar modes of representation' model (Figure 1) which correspond to three elements that students require exposure to in the learning of chemistry: the symbolic, the molecular and the macroscopic levels. This more learner focused three-dimensional exposure to chemistry, he thought, would give students a much greater conceptual understanding of chemistry, rather than just the facts.

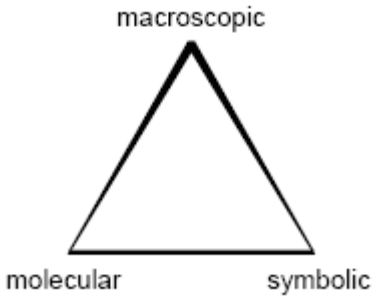

Figure 1: Johnstone's Triangular Planar Model of Chemistry Learning

Sometime later, Mahaffy (2004) elaborated on this model to include a fourth element – the human element – which would include relevant applications, social and environmental issues and historical references in the teaching of chemistry. Mahaffy refers to this model as a 'tetrahedral orientation' to the teaching of chemistry (Figure 2). It is thought that teachers spend much of their time presenting students with the symbolic level in chemistry, while the other modes are less often represented (Lewthwaite & R. Wiebe, 2010).

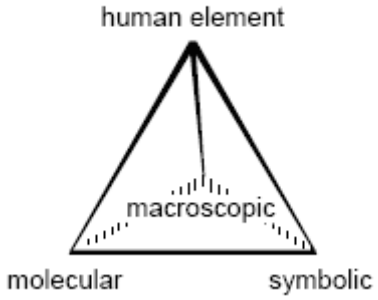

Figure 2: Mahaffy's Tetrahedral Model of Chemistry Learning

Chemistry curricula in Manitoba have apparently evolved over the past 20 years from more traditional, content focused curricula to curricula which advocate for a more constructivist and humanistic, or learner focused, approach that focuses on student understanding. In the latest chemistry curricula, the preface to the documents suggest that teachers incorporate humanistic STSE content and include multiple modes of representation in their teaching of chemistry concepts such that the focus is on student understanding rather than on the presentation of content and facts. While Mahaffy's work did not directly influence the curriculum writing team, the writers, already influenced by Johnstone (1991), were of the belief that students should be

experiencing, thinking and communicating in multiple modes of representation similar to what Mahaffy had suggested; in other words, they already believed in the importance of incorporating a humanistic or human element approach when representing chemistry concepts as they felt that it would give students a more complete understanding of chemistry concepts. Now, while the total number of outcomes in the latest chemistry curricula have been decreased allowing for, potentially, a deeper understanding of fewer concepts, and while the outcomes have evolved from the previous documents to include more STSE issues and multiple modes of representation, there are still a large number of knowledge-based outcomes. As a result of this, I am wondering if what has been suggested in the preface to the chemistry curricula is actually occurring in chemistry classrooms in Manitoba. In other words, are teachers following the recommendations in the preface of the curricula for a more constructivist and humanistic, or learner focused approach, in their classrooms, or are they simply teaching the SLOs as prescribed in the 'outcomes' portion of the documents with little consideration of what learning theory suggests leads to student understanding? Consequently, are Manitoba teachers implementing these latest chemistry curricula with an awareness of what the preface and what learning theory suggests in terms of 'construction of meaning,' 'hands-on,' 'prior knowledge,' 'applications,' 'large-context problems,' 'small groups,' 'experiential learning,' 'inquiry,' and 'critical thinking?'

Although chemistry teachers in Manitoba have been faced with the daunting task of implementing these latest curricula in their classrooms, it has not been without the offer of support. The University of Manitoba's CRYSTAL developed a five-year research and development project to support the latest chemistry curricula and to improve the teaching and learning of chemistry in Manitoba chemistry classrooms (Lewthwaite & R. Wiebe, 2010). As

part of this project, approximately 120 hours of face-to-face professional development was offered to Manitoba chemistry teachers that saw all ten clusters from the *Grades 11 and 12 Chemistry* (Manitoba Education, Citizenship and Youth (MECY), 2006-7) curricula addressed by the end of the five-year period consistent with a more constructivist and humanistic, or learner focused approach, which utilizes multiple modes of representation in chemistry (Lewthwaite & R. Wiebe, 2010). Although I was the research assistant conducting the preliminary interviews during phase four of the professional development, I was interested in how teachers were responding to these latest curricula and what was transpiring in their classrooms after the project ended. I was also interested in knowing what was motivating their teaching and whether their motivations had changed and remained secured as a result of the professional development.

And so with the recommendations over 100 years ago for a more progressive chemistry education, and with all of the research over the last 40 years that went attempted to solve problems associated with chemistry teaching, are Manitoba chemistry teachers implementing the latest chemistry curricula as intended by the developers? Specifically, I wonder if, with the intent of the latest chemistry curricula in Manitoba to promote a more learner focused environment in classrooms, and with the offer of professional development support from teacher educators at the University of Manitoba, teachers feel that they are implementing these curricula in their classrooms in the manner suggested in the preface to the curriculum documents. And, I wonder if teachers' feel that their professional identities (that is, their beliefs about teaching and learning) are aligned with such a proposal. Research suggests that teachers' beliefs are difficult to change (Kagan as cited in Roehrig, Kruse & Kern, 2007) and that effective long-term professional development and support (Krajcik et al. as cited in Roehrig et al., 2007) and

ongoing reflection on their teaching practice (Mezirow, 1981) might be required to enact such a change in their beliefs. I also wonder if teachers have experienced some tensions associated with how they want to teach and how they are actually teaching and whether they feel that their teaching practices have improved following the introduction of the latest chemistry curricula and their involvement in the CRYSTAL professional development.

Prior to seeking answers to these questions, it is necessary to conduct and present a literature review to fully understand the evolution of the chemistry curricula in Manitoba and to more fully understand its underlying intentions. Also, it will be necessary to analyze the research literature in the area of curriculum implementation to more fully understand the factors which affect the implementation of school curricula. In addition, it will be important to examine the research literature in the area of teacher professional identity and professional development and reflective practice to more fully understand what obstacles teachers are faced with in regards to their own professional identities and also how professional development and reflective practice might shift their teaching orientations and, ultimately, improve their teaching practice. This overview of the chemistry curricula in Manitoba and a review of the literature in the areas of curriculum implementation, teacher professional identity, professional development and reflective practice will be addressed in detail in Chapter 2 of this thesis.

1.4: Purpose of the Study

This study involves an examination of the teaching life stories from eight teachers of chemistry who have been a part of implementing the latest chemistry curricula in Manitoba and who have participated in ongoing professional development designed to support the latest

curricula. By obtaining some key information from teachers' life stories, this study aims to gain some insight into their evolving professional identities by determining what motivated them to enter the teaching profession, what their experiences in teacher education were like, what their experiences as teachers of chemistry have been like and what motivates them to teach the way they do now. Specific questions were asked of the teachers so as to determine how they responded to the orientation of the latest chemistry curricula in Manitoba with its more constructivist and humanistic, or learner focused approach, and emphasis on multiple modes of representation, and whether they feel that their participation in the CRYSTAL professional development workshops has caused them to reflect more on their practice, and if the workshops have assisted with any changes in their teaching practice, both during the sessions and after the sessions have ended. Finally, this study aims to determine what might be some the tensions associated with a potential change in teachers' beliefs and teaching practice as a result of a new curriculum introduction.

1.5: Research Questions

Because the research literature suggests that teacher professional identity, or more specifically teacher beliefs, are formed as a result of early childhood experiences in school, I was initially interested in what motivated teachers to enter the profession. This led me to my first research question:

1. What were some of the influences/motivations on teachers' decision to enter the teaching profession?

Also, it was my belief that teacher professional identity is a major factor affecting how teachers have conducted their classrooms early on in their teaching career and how they respond to a new curriculum introduction, so the goal in the second research question was to determine what teachers initially believed about teaching and learning and whether teachers feel that they have changed their beliefs as a result of the new chemistry curriculum introduction, and if they feel that this change has impacted their teaching practices. This led me to my second research question:

2. What were teachers' perceptions of their changing professional identities and teaching practice prior to and as a result of the introduction of the latest Manitoba chemistry curricula?

When the latest chemistry curricula in Manitoba were proposed and implemented in schools, professional development workshops were offered to teachers of the new curricula to improve teaching and learning in chemistry according to what the preface to the documents were suggesting. Several teachers took part in these workshops over a five-year period, and I am wondering if these professional development workshops impacted these teachers of the latest chemistry curricula such that they felt it modified their professional identities and teaching practices. This led me to the third research question:

3. What were teachers' perceptions of their changing professional identities and teaching practice as a result of their participation in the CRYSTAL professional development workshops?

Previous interviews with several of the participants in this study revealed that teachers are often conflicted about their beliefs about teaching and learning and their actual teaching practices. I am also wondering what some of these tensions are that teachers have experienced throughout their teaching career and especially in response to the latest curriculum introduction. This led me to the fourth research question:

4. What were some of the tensions teachers have experienced throughout their teaching career associated with a potential conflict between their own beliefs and their current teaching practice, especially in response to the latest curriculum introduction?

Having taken part in several of the professional development workshops offered over a five-year period, I am wondering if teachers are satisfied with their teaching practices even after the professional development has ended, and also how their teaching practices have changed over the years and what they attribute these changes to. This led me to the fifth research question:

5. Are teachers satisfied with their current teaching practices? And what are some of the ways their teaching practices have changed over the years and what factors do they attribute the changes to?

Finally, after hearing the teaching life stories of the participants, I am wondering how their stories, and my consideration of their stories, have influenced my own professional learning. This led me to the sixth research question:

6. How do the personal stories of the teachers participating in the study influence my own professional learning?

1.6: Significance of the Study

Research suggests that classroom reforms are rarely ever implemented as they were intended (Cuban, 1990), largely due to teachers' professional identities, or beliefs about teaching and learning (Fullan, 1981). Although, research also suggests that long-term professional development can aid in shifting teachers' beliefs and teaching practices (Krajcik et al., as cited in Roehrig et al. p. 886). The preface in latest chemistry curricula in Manitoba suggest a more constructivist approach to teaching and learning with a focus on using multiple modes of representation in the teaching of chemistry concepts and teaching chemistry in a human context. With the recent introduction of these curricula, and with associated professional development to support the latest curricula, it is worthwhile to determine whether teachers feel that their beliefs about teaching and learning and their chemistry teaching practices have evolved in such a way that they complement what is suggested in the latest curricula. It is suggested that teacher professional identity is shaped by teachers' childhood experiences in education, the knowledge and learning they obtained in teacher education, and their experiences in teaching practice (Lamote & Engels, 2010), so it may be valuable to query teachers regarding their response to the latest chemistry curricula, their chemistry teaching practices and the impact of the professional development sessions on their teaching practices, so as to understand their evolving professional identities and what might be some of the tensions associated with how they want to teach and

how they are actually teaching. This may provide some insight into the degree to which teachers are implementing the latest chemistry curricula as intended by the developers.

Specifically, this study aims to gain some insight into teachers' evolving professional identities by determining what motivated them to enter the teaching profession, what their experiences were like in teacher education, what their experiences have been like as teachers of chemistry and what motivates them to teach the way they do now. In addition, this study aims to determine how teachers are responding to the orientation of the latest chemistry curricula in Manitoba with its more learner focused approach and emphasis on multiple modes of representation, and whether they feel that their participation in the CRYSTAL professional development workshops have assisted with any changes in their teaching practice, both during the sessions and after the sessions had ended. Finally, this study aims to determine what might be some the tensions associated with a potential change in teachers' beliefs and teaching practice as a result of a new curriculum introduction.

By examining teachers' evolving professional identities as they journey through school, teacher education and their teaching careers, this study contributes to the current research and to teachers' own understandings of what has shaped their professional identities, how they negotiate the tensions associated with how they want to teach and how they are actually teaching, and how their teaching practice continues to be impacted as their professional identities continue to evolve through factors such as curriculum changes and professional development and reflective practice. Thus, the major implication of this study is that if teachers' professional identities are evolving and they are changing their teaching practices as a result of exposure to

long-term professional development opportunities where reflection on teaching practice is enhanced and encouraged, then teacher support in the form of long-term professional development is an important and necessary component of the curriculum implementation process.

Thus, this study will be especially significant to chemistry teachers in Manitoba concerned with implementing the latest chemistry curricula in the manner intended by its developers, which includes a more constructivist and humanistic, or learner focused, approach incorporating multiple modes of representation and human context. In addition, this study will be of importance to those chemistry teachers who want to work at re-defining their professional identities and chemistry teaching practice through ongoing reflective practice and professional development, and by incorporating research-based best practice (Awenowicz, 2009) into their teaching. Finally, the understanding gained from this research will inform my future teaching practice and will contribute to a greater understanding of professional identity and teaching and learning in chemistry for all chemistry educators.

Only three other recent studies that I am aware of have looked at some aspect of improving teaching and learning in chemistry in Manitoba. Teller (2006) researched the use of interactive vignettes in the study of the mole concept, Straub (2010) examined teacher use of computer simulations in the teaching of chemistry and Lewthwaite and R. Wiebe (2010) examined teacher progress towards a tetrahedral orientation to the teaching of chemistry. To date, there have been no other studies (as far as I am aware) on teacher professional identity shifts following a change in the Manitoba chemistry curricula and professional development

support. In fact, although there are several studies regarding the concept of teacher professional identity, there is a paucity of information in the literature regarding secondary science teacher professional identity. Thus, this study will serve fill a gap in the literature in this area.

1.7: Limitations of the Study

A general limitation of this study is that due to the focus on a small number of teachers with a chemistry specialty who attended the CRYSTAL professional development workshops, only a small number of teachers were initially considered for the study (N=32). Of these 32 participants who had been interviewed for a previous research and development project with CRYSTAL, only eight final participants were purposefully selected for this particular study. Thus this is not a representative group of chemistry teachers in the province. Views of some of the remaining 24 chemistry teachers would have contributed to this study. However, although the number of participants in this study is small, there was enough diversity among the participants in the different genders, the range in years of teaching experience and the types of schools and school divisions in which they teach to consider it a representative sample of all chemistry teachers in Manitoba. Although this study focused on a specialized group of individuals, the outcomes could be applied to other settings and individuals as well.

1.8: Overview of the Thesis

This thesis is organized into six chapters. Chapter 1 of this thesis included my personal teaching story, the context of the study, the purpose of the study, the specific research questions that define the study, and the significance and limitations of the study. Chapter 2 includes a look

at the development of chemistry curricula in Manitoba from 1998 to the present and an extensive review of the literature in the areas of factors affecting the implementation of curricula in schools, and professional development and reflective practice as key factors which may contribute to professional identity shifts and teacher change. Chapter 3 outlines the methodology used in this research study and includes a re-statement of the research questions, an introduction to the participants, the limitations of the method of data collection and the specific research design. Chapter 4 outlines the method of data analysis which includes the teaching life stories of the eight participants in the study, while Chapter 5 follows with the results and discussion and implications of the study. Finally, the thesis concludes in Chapter 6 with a review of the study, a summary of the major findings and oopportunities for further research. References and Appendices follow.

1.9: Chapter Summary

Following the introduction to this thesis, my teaching life story was presented to professionally introduce myself and to illustrate my evolving professional identity through my school and work experiences. Additionally, the context and purpose of the study were presented, followed by the six research questions posed. Finally, Chapter 1 concludes by outlining the significance of the study, the general limitations of the study and an overview of the thesis.

Chapter 2: Background of the Study and Review of the Literature

2.1: Introduction

"Nothing in education is so astonishing as the amount of ignorance it accumulates in the form of inert facts" (Henry Adams, as cited in Wintermute, 1997, para. 24).

Creating a more learner focused environment in today's chemistry classrooms can pose a genuine challenge to teachers. But, this is just what the latest chemistry curricula in Manitoba have proposed. These curricula are founded upon the *Pan-Canadian Protocol for Collaboration on School Curriculum: The Common Framework of Science Outcomes K-12* (Council of Ministers of Education Canada (CMEC), 1997), which proposes in its preface that teachers employ constructivist teaching methodologies which focus on student understanding as opposed to factual knowledge of the essential learning outcomes (ELOs). The preface further proposes that teachers incorporate humanistic STSE issues in their coverage of the ELOs and maintain a focus on improving the scientific literacy of students. To facilitate students' understanding of chemistry concepts, the latest chemistry curricula in Manitoba proposes in its preface that teachers employ a multi-dimensional approach to the teaching of chemistry by incorporating not only the symbolic level, but also the macroscopic and the molecular levels, based on the research contributions of Johnstone (2010). This proposal to create a more constructivist and humanistic, or learner focused, environment in chemistry classrooms in Manitoba may not resonate well with some teachers – particularly those who believe that the transmission of 'inert facts' at the symbolic level is sufficient in the coverage of chemistry concepts. The implementation of any new curriculum innovation is often fraught with issues and a change such as this may also

require a change in teachers' beliefs about teaching and learning. In this chapter, the development of the chemistry curricula in Manitoba from 1998 to the present will be examined so as to better understand the foundations upon which the latest chemistry curricula in Manitoba have been built, and to see how it has apparently evolved to suggest more of a focus on the learner. Understanding the development of these curricula may assist in the understanding of some of the issues regarding its implementation. Following a look at the development of the chemistry curricula in Manitoba, the literature will be examined in terms of the factors influencing the implementation of curricula in schools, and how certain aspects of teacher professional identity and reflective practice may contribute to more effective teaching practice.

2.2: The Development of Chemistry Curricula in Manitoba from 1998 to the Present

2.2.1: Introduction

Imagine a future where not only potential scientists, but also average everyday citizens are scientifically literate. This is the future envisioned for Canadian people by science curriculum developers across the country, all inspired by the *Pan-Canadian Protocol for Collaboration on School Curriculum: The Common Framework of Science Outcomes K-12* (CMEC, 1997). This *Pan Canadian Science Framework*, or *Framework* (CMEC, 1997), which was a project initiated under the *Pan-Canadian Protocol for Collaboration on School Curriculum* (CMEC, 1997), stresses the importance of 'scientific literacy for all,' achievable through an STSE perspective, so that all people may understand and use scientific concepts in a common sense way in their everyday lives. The province of Manitoba emphatically accepted this

curriculum framework as a foundation upon which all of their science curricula would be built. Science curricula in Manitoba have evolved since the introduction of the *Framework* (CMEC, 1997) to a proclaimed emphasis on more of a constructivist and humanistic, or learner focused, curricula in the hopes of producing this scientifically literate citizenry. Specifically, in the context of the chemistry curricula in Manitoba, both the *Transitional Chemistry 30S and 40S* (Manitoba Education and Training (MET), 1998) and the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula were, in principle, based on The *Framework* (CMEC, 1997).

According to the preface of both the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula, and the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula, the SLOs have progressed from outcomes in the previous curriculum documents that required learners to memorize facts and definitions to curricula with more of a constructivist and humanistic focus, again, in the hopes of creating a scientifically literate public. It is the purpose of this overview of the chemistry curricula in Manitoba to examine what progress has been made since the introduction of the *Framework* (CMEC, 1997). Specifically, this overview focuses on the development of the chemistry curricula in Manitoba from 1998 to the present, beginning with the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula, followed by the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula. In particular, the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula and the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula will each be described with a specific look at the main ideas that informed the development of each set of curricula and their supposed curriculum orientations as portrayed in the introductory pages of each set of documents. Because the *Framework* (CMEC, 1997) was a major influence on both sets of curricula, it will be described in detail in advance. Secondly,

each set of curricula will be compared and contrasted to examine how the main ideas and orientations initially described are manifest in the actual learning outcomes in each set of curricula. Finally, the implications of the curriculum orientations to teachers of the latest chemistry curricula will be addressed.

2.2.2: The Pan-Canadian Science Framework

Fundamental to the post-1998 chemistry curricula is the influence of the *Pan-Canadian Science Framework* (CMEC, 1997). The *Framework* (CMEC, 1997) was adopted by the CMEC in 1995. The main vision of the *Framework* (CMEC, 1997) was to improve scientific literacy in Canada using a more constructivist and humanistic approach. Scientific literacy is defined in the *Framework* (CMEC, 1997) as "an evolving combination of science-related attitudes, skills and knowledge students need to develop inquiry, problem solving, and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them" (CMEC, 1997, p. 4). The *Framework* (CMEC, 1997) is guided by the vision that scientific literacy should be accessible to all Canadian students, regardless of gender or cultural background (CMEC, 1997). STSE refers to the nature of science and technology; the relationships between science and technology; and the social and environmental contexts of science and technology and is the driving force of the *Framework* (CMEC, 1997). It is in teaching through this more constructivist and humanistic, or learner focused, approach that it is hoped that scientific literacy will improve in Canada.

A set of goals for Canadian science education were developed in the *Framework* (CMEC, 1997) in response to the vision for scientific literacy, which in turn led to a set of four foundation

statements, upon which the learning outcomes in the *Framework* (CMEC, 1997) are based. These four foundation statements are listed below:

Foundation 1: Science, Technology, Society, and the Environment (STSE)

Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology. (p. 9)

Foundation 2: Skills

Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions. (p. 12)

Foundation 3: Knowledge

Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge. (p. 15)

Foundation 4: Attitudes

Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment. (p. 17)

(CMEC, 1997)

These foundation statements are for science education in general and are not specific to chemistry, but one would expect them to appear throughout all of the science-related curricula. Thus, with respect to the chemistry curricula in Manitoba, one would expect to see a more progressive constructivist and humanistic, or learner focused, curricula evolving as a result of this thrust for a scientifically literate society. A comparison of the two sets of curricula will note whether this has been achieved or not.

2.2.3: The Transitional Chemistry 30S and 40S Curriculum: A Foundation for Implementation

The preface to the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula suggest there were two major influences on the development of these curricula. The first was based on a plan for general educational renewal in Manitoba called *Renewing Education: New Directions* (MET, 1998). The *New Directions* policy documents essentially addressed the gap between current curriculum topics and what students need to know and be able to do in order to lead meaningful and productive lives (MET, 1998). The development of these documents included input from various education stakeholders including teachers, parents, post-secondary representatives and members of business and professional organizations. These *New Directions* documents informed all Manitoba curricula in general. The second influence on the development of the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula was the *Pan-Canadian Science Framework* (CMEC, 1997), which has informed all science curricula in Manitoba. Manitoba was a participating partner in the CMEC's decision to adopt the *Framework* (CMEC, 1997).

The *Transitional Chemistry 30S and 40S* (MET, 1998) curricula are said to reflect current trends in science education (scientific literacy, learning theory, and curriculum design and implementation) and have been designed according to the four main foundations – knowledge, STSE, skills and attitudes – as stated in the *Framework* (CMEC, as cited in MET, 1998). As in the *Framework* (CMEC, 1997), the outcomes in the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula were considered to be developed with the primary goal of developing scientific literacy in students, achieved through the development of the four ideologies stated above – knowledge, STSE, skills and attitudes. The current trends in science education as discussed in the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula include scientific literacy, learning theory, and curriculum design and implementation. The drive for a scientifically literate public is central to the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula. The introductory pages of these documents state that developing scientific literacy in students is best accomplished by "defining clearly what students should know and be able to do in science, relating the science content to real-world contexts, and incorporating Science, Technology, Society and the Environment issues in science teaching and learning" (MET, 1998, p. 4). Equally important in providing insight into the developing foundations of the document is learning theory (MET, 1998). Learning theory is an understanding of how children learn, which should be important because understanding how children learn science is fundamental to the ability to teach science (MET, 1998). The *Transitional Chemistry 30S and 40S* (MET, 1998) curricula are said to support a constructivist model of learning, which is dependent on prior knowledge, context, and whereby students construct their own meaning. Many educators believe that science education should be concerned with not only learning science (knowledge), but also

learning about science (processes), and the doing of science (skills). This is because investigative tasks in science allow students to explore the relationships between these three types of learning (MET, 1998). Another current trend in science education, as discussed in the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula, has been in examining the way curricula are designed and delivered. The design and implementation of any new curricula are critical if essential learning is to take place. The chemistry curricula state that previous science curricula did little to teach students "science for meeting personal needs, resolving society issues and assisting with career choices" (MET, 1998, p. 12). This is because the previous science curricula were very content and textbook focused where terms and facts were memorized and rarely given in context (MET, 1998). The *Transitional Chemistry 30S and 40S* (MET, 1998) curricula were designed as more outcomes-based which has required changes in the way that teachers implement these curricula, particularly in their selection of learning resources. Textbooks cannot solely provide an STSE-based chemistry experience and therefore the *Transitional* curricula recommend that teachers also incorporate various multi-media to make for a more valuable learning experience for the students. Thomas S. Kuhn, in his book *The Essential Tension*, said of the textbook:

> The objective of a textbook is to provide the reader, in the most economical and easily assimilable form, with a statement of what the contemporary community believes it knows and of the principal uses to which that knowledge is put. Information about how that knowledge was acquired (discovery) and about why it was accepted by the profession (confirmation) would at best be excess baggage. Though including that information would almost certainly increase the humanistic

> values of the text and might conceivably breed more flexible and creative scientists, it would inevitably detract from the ease of learning the contemporary scientific language (as cited in Akeroyd, 2007, p. 767).

The preface to the *Transitional Chemistry 30S and 40S* (MET, 1998) chemistry curricula suggests a curriculum orientation that is departing from an 'academic' view of curriculum in favour of a more humanistic view (as described in McNeil, 1985). An examination of the SLOs in these curricula will confirm whether this humanistic orientation holds true throughout the entire documents or not. McNeil (1985) describes an academic curriculum as one which focuses on the mastery of knowledge and that is used to "develop the mind." George Baldwin, Principal Writer of the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula, justifies an academic orientation to curriculum by stating that "if you want 'scientifically literate citizens they must know the basics and not just the jargon of the time" (personal communication, March 27, 2009). Theorists opposed to the academic orientation of curriculum consider an academic curriculum as "rote learning at the expense of critical thinking" (McNeil, 1985). A humanistic curriculum is based on the notion that the curriculum should focus on the growth of the individual and provide them with intrinsically rewarding experiences. This implies that curricula should be relevant or 'brought to life' for the learner. McNeil (1985) states that,

> The humanistic curriculum goes a long way toward solving a fundamental problem facing educators today: that much of what is taught is not learned and much of what is presented and tested is not assimilated. Critics who think that greater learning results by pouring more facts into children's minds are mistaken. (p. 4)

Opponents of the humanistic curriculum accuse the humanists of being too focused on the individual and not enough on society, but as Cuban (1992) suggests, “schools should not feel obliged to scratch the back of society every time society has an itch” (as cited in van den Akker, 2003). The more humanistic, STSE approach that has emerged as the primary vehicle through which scientific literacy will be achieved in students also implies a ‘social reconstructionist’ view of curriculum in the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula to some extent, although the humanistic orientation dominates. Social Reconstructionists, according to McNeil (1985), believe that curricula should focus on the needs of society first, although naysayers doubt the ability of the curriculum to effect social change.

Many in the field of chemistry education research would agree that as long as the chemistry curricula in Manitoba are moving away from an academic orientation, that the curricula are headed in the right direction. In fact, if one looks at the change from the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula to the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curriculum, the academic orientation appears to be even less emphasized in that the preface to the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula which promote an even greater emphasis on approaching the curricula in a more constructivist and humanistic, or learner focused, manner, with its greater emphasis on linking science to students’ lives, encouraging teachers to use multiple modes of representation in their teaching of chemistry concepts, and using more varied instructional approaches.

2.2.4: Grades 11 and 12 Chemistry Curriculum: A Foundation for Implementation

The preface to the current chemistry curricula in Manitoba, *Grades 11 and 12 Chemistry: A Foundation for Implementation* (MECY, 2006-7), implies that the significant influences on these curricula are the *Pan-Canadian Science Framework* (CMEC, 1997) and, the curricula's precursor, the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula. Manitoba has elaborated on the *Framework* (CMEC, 1997) in this new document in that it has been built upon five foundations for scientific literacy rather than four (MECY, 2006-7). The five foundations are: Nature of Science and Technology; Science, Technology, Society and the Environment (STSE); Scientific and Technological Skills and Attitudes; Essential Science Knowledge; and Unifying Concepts (MECY, 2006-7). In addition to the influence of the *Transitional Chemistry 30S and 40S Curricula* (MET, 1998) and the *Framework* (CMEC, 1997), all science curricula in Manitoba, including the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) documents, are said to be influenced by a document titled *Education for a Sustainable Future* (MET as cited in MECY, 2006-7). The purpose of this document is to outline ways to promote sustainability in the various science learning environments (MECY, 2006-7). Also highly influential in the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula is the *National Science Education Standards* (National Research Council (USA), 1996, as cited in MECY, 2006-7) where there is a changing emphasis on science education content delivery and a changing emphasis to promote inquiry (MECY, 2006-7). For example, in terms of content delivery, these latest chemistry curricula in Manitoba are said to emphasize the understanding of science concepts and the development of inquiry, and put less emphasis on the knowledge of scientific facts and information (MECY, 2006-7). In terms of promoting inquiry, these latest curricula are said to put more emphasis on using multiple process skills – manipulation, cognitive and

procedural – rather than just individual process skills such as observation or inference (MECY, 2006-7). At the heart of this new focus is Piagetian learning theory which is founded on the belief that learning is most effective when the topic of study is rooted in concrete learning experiences related to a particular context or situation, and applied to students' experiences (MECY, 2006-7). A similar 'context-based' approach has been widely promoted in the literature (see Gilbert, Justi, van Driel, de Jong & Treagust, 2004; King, 2007).

The preface to the *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula indicate a curriculum orientation that is departing from an academic view of curriculum towards an even greater emphasis on a humanistic view of curriculum (as described in McNeil, 1985) as compared with the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula. It is important to note that the social reconstructionist orientation comes through in the STSE approach in the *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula as well to some extent, although again, the humanistic orientation dominates. An examination of the SLOs in these curricula will confirm whether this humanistic orientation holds true throughout the entire documents or not.

Each set of chemistry curricula described above will now be compared, including their similarities, and progressions, and the way in which the main ideas and orientations initially described in the preface are manifest in the SLOs in each curriculum will be examined.

2.2.5: Comparison of each set of Curricula: Similarities and Progressions

Some similarities are obvious among the two sets of chemistry curricula described above. First, the influence of the *Framework* (CMEC, 1997) is evident in both. From the primary vision

for scientific literacy among Canadians to the foundation statements and goals for science education, the *Framework* (CMEC, 1997) has had noticeable authority over both the *Transitional Chemistry 30S and 40S* (MET, 1998) and the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula. Both sets of curricula also provide support in terms of suggestions for assessment and instruction, not unlike the *Framework* (CMEC, 1997). As well, both sets of curricula reinforce the importance of learning theories in the development of their curricula. Both curricula acknowledge that "learning involves the process linking newly constructed understandings with prior knowledge, and then adding new contexts and experiences to current understandings" (MECY, 2006-7, Intro. p. 3).

Although both sets of curricula have been founded upon the same *Framework* (CMEC, 1997) for science education, there appear to be some progressions between the two sets of chemistry curricula described previously. One progression is the major influence of the *National Science Education Standards* (National Research Council, as cited in MECY, 2006-7) in the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula. As well, there is a sustainable development focus in the current chemistry curricula with the explicit reference to *Education for a Sustainable Future* (MET, as cited in MECY, 2006-7). Also in the latest chemistry curricula, the emphasis is on processes that engage students in science learning, including science inquiry, problem solving, decision-making, the nature of science, science-related skills and science content knowledge (MECY, 2006-7). It is important to note that science content knowledge is stated last in this list of processes that engage students in science learning, whereas in the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula it was listed as a first priority. The current chemistry curricula also stress the importance of involving students in the planning,

development and evaluation of their own learning experiences, and in including peer review (MECY, 2006-7). Finally, in the latest chemistry curricula, there has been a shifting emphasis in assessment which is supported by the *National Science Education Standards* (National Research Council, as cited in MECY, 2006-7). For example, in the current chemistry curricula, the suggestion for teachers is to focus more on assessing understanding as opposed to just knowledge (MECY, 2006-7).

So, upon assessment of the preface to both sets of chemistry documents described previously, Manitoba appears to be quite progressive in science, and specifically chemistry curriculum development. The vision for scientific literacy is explicitly stated and many progressions from the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula to the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula are evident. Again, according to the preface in the current chemistry curricula, content knowledge is emphasized less than in the previous chemistry curricula. The current documents state that "transmission of science content is no longer considered to be the primary outcome of science teaching" (MECY, 2006-7, Intro., p. 5). This decreasing emphasis on the presentation of scientific facts is echoed in the following quote by De Vecchi and Giordan from the *Framework*:

> Presenting a body of knowledge to students (whether it is in telling them more or showing them better) will not suffice in order for students to understand, memorize and internalize that knowledge. Every student must individually and personally construct each bit of understanding, using tools at her or his disposal, namely her or

his own ideas and thought processes. (De Vecchi, G. & Giordan, A., 1990, as cited in CMEC, 1997, p. 8)

Other progressions from the former to the current chemistry curricula include a greater STSE focus, the importance of creating a more stimulating learning environment, an emphasis on using multiple learning resources to teach, and a focus on linking science to experiential life. In addition, the latest chemistry curricula appear to include a greater emphasis on learning theories and have provided suggestions for effective teaching in chemistry which has been supported by current research in teaching and learning (MECY, 2006-7).

Another significant progression from the former to the current chemistry curricula has been the emphasis on using 'modes of representation' in chemistry which include relationships between the macroscopic, molecular and symbolic levels in the study of chemistry concepts. The idea of connecting these three levels in the teaching of chemistry concepts was first proposed by Johnstone (1991), in the hopes of generating a greater conceptual understanding of chemistry in students, such that they would be able to experience, think and communicate on these three levels (Lewthwaite & R. Wiebe, 2010). The latest curricula also reinforce the use of the numerical and graphical modes of representation in addition to these three modes proposed by Johnstone (1991). This focus on the different modes of representation in chemistry in the current chemistry curricula is supported in more recent research by Mahaffy (2004) which has emphasized the importance of making connections between these levels when studying chemistry concepts. Mahaffy later enhanced the model proposed by Johnstone (as cited in Lewthwaite & R. Wiebe, 2010) by including another dimension to the learning of chemistry

concepts – the human element – in response to the need "to address concerns about scientific literacy and limited public understanding of the role of chemistry in everyday life" (Mahaffy, 2004, p. 231). To Mahaffy, these four representations – the macroscopic, microscopic, the symbolic and the human element – when placed "in the authentic contexts of the human beings who create the substances, the culture that uses them and the students who try to understand them," may help to integrate content and context (Mahaffy, 2004, p. 232). Now while the current chemistry curricula were not directly influenced by Mahaffy (2004), the curriculum writers already believed in the importance of multiple representations in chemistry and promoted chemistry learning in a human context. In fact, many chemistry educators (for example Cook, 2006, and Lewthwaite & R. Wiebe, 2010) are now affirming the move towards the inclusion of multiple representations in chemistry. Cook states that visual presentations in particular "provide a means for making visible phenomena that are too small, large, fast or slow to see with the unaided eye" (p. 1074). And, by including the historical development of models and theories in chemistry, students gain an understanding of how models and theories have developed over time. This idea of using the human 'stories' of science has been supported in the literature recently (R. Wiebe & Stinner, 2010).

Another noted progression in the latest chemistry curricula is that there is a greater emphasis on using varied instructional approaches in the teaching of chemistry. So, in addition to direct instruction such as didactic questioning and lecture, the latest curricula also suggest: Indirect instruction such as inquiry and reflective discussion; experiential learning such as simulations and field trips; independent study such as computer-assisted instruction and research projects; and interactive instruction such as debates, brainstorming and collaborative learning

groups. And finally, another progression is that the latest curricula explicitly promote the use of research-based effective teaching in chemistry which is based on the National Research Council report *How People learn: Brain Mind, Experience, and School: Expanded Edition* (Bransford et al., as cited in MECY, 2006-7), and cites the four following implications for effective chemistry instruction: Drawing out students' current understandings; addressing students' metacognitive skills, habits, and epistemologies; being good diagnosticians of student knowledge, reasoning, and participation; and teaching a smaller number of topics in greater depth, providing many examples in which the same concept is at work.

After analyzing the developments from the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula to the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula, as cited in the preface to each set of curricula, one would also expect to observe a significant change in the SLOs between the two sets of curricula, especially in terms of knowledge-based outcomes, which should be emphasized less according to the apparent progressions between the two. An evaluation of the SLOs in each set of chemistry curricula will confirm that the ideas informing each set of curricula are actually evident in these outcomes.

2.2.6: Comparison of the Outcomes between the Transitional Chemistry 30S and the Current Grade 11 Chemistry Curricula

Upon analysis of each set of curricula, it was surprising to see that content knowledge-based outcomes are still heavily weighted in both sets of curricula, despite the declared progressions between the two. As summarized in Table 1, in the *Transitional Chemistry 30S* (MET, 1998) curriculum, there are 90 knowledge-based outcomes out of a total of 134 outcomes,

with 20 outcomes devoted to skills and 38 outcomes devoted to applications (with some outcomes falling into two or more categories). In the current *Grade 11 Chemistry* (MECY, 2006) curriculum, there are 76 total outcomes, 47 of which are knowledge-based, 18 that are skills-based, 19 of them application-based and four outcomes dedicated to the historical development of models and theories (with some outcomes falling into two or more categories).

Table 1: Summary of the Comparison of Outcomes between the *Transitional Chemistry 30S* and the Current *Grade 11 Chemistry* Curricula

Type of learning outcomes	**Total of learning outcomes*** *Transitional Chemistry 30S*		**Total of learning outcomes*** Current *Grade 11 Chemistry*	
	Number	**%**	**Number**	**%**
Content Knowledge	90	67	47	63
Skills	20	14	18	24
Applications	38	28	19	25
Historical Development of Models and theories	0	0	4	5
Total Outcomes	134		74	

* The number of individual outcomes does not equal the total number of outcomes due to the fact that some outcomes fall into two or more categories.

The only significant changes noted between these two documents is the decrease in the total number of SLOs, a greater emphasis on skills (which could include manipulative, cognitive

and/or experimental skills) and a greater emphasis on the historical development of models and theories, but it appears that not much improvement has been made in decreasing the knowledge-based outcomes or focusing on applications of chemistry. One promising trend is that there were some SLOs dedicated to the modes of representation in chemistry suggested by Johnstone (1991). In the latest *Grade 11 Chemistry* document, for example, outcome C11-2-06 states: "Experiment to develop the relationship between the volume and temperature of a gas using visual, numeric and graphical representations" (MECY, 2006). Also, in outcome C11-4-03 it states: "Explain the solution process of simple ionic and covalent compounds using visual, particulate representations and chemical equations" (MECY, 2006).

2.2.7: Comparison of the Outcomes between the Transitional Chemistry 40S and the Current Grade 12 Chemistry Curricula

As summarized in Table 2, in the *Transitional Chemistry 40S* (MET, 1998) document there are 95 knowledge-based outcomes out of a total of 133 outcomes, with 18 outcomes devoted to skills and 22 outcomes devoted to applications (with some outcomes falling into two or more categories). In the current *Grade 12 Chemistry* (MECY, 2007) curriculum, there are 65 total outcomes, 40 of which are knowledge-based, 20 that are skills-based, only 5 of them application-based and 3 outcomes dedicated to historical development of models and theories (with some outcomes falling into two or more categories). Again, the only noteworthy changes noted between these two documents is the decrease in the total number of SLOs, a greater emphasis on skills (which could include manipulative, cognitive and/or experimental skills) and a greater emphasis on the historical development of models and theories, but a substantial

decrease in application-based outcomes and, again, it appears that not much improvement has been made in decreasing the knowledge-based outcomes. Again, a promising trend has been the increase, although slight, in SLOs dedicated to the modes of representation in chemistry suggested by Johnstone (1991). In the current *Grade 12 Chemistry* curriculum, for example, outcome C12-1-01 states: "Explain examples of solubility and precipitation at the particulate and symbolic levels" (MECY, 2007).

Table 2: Summary of the Comparison of Outcomes between the *Transitional Chemistry 40S* and the Current *Grade 12 Chemistry* Curricula

Type of learning outcomes	**Total of learning outcomes*** *Transitional Chemistry 40S*		**Total of learning outcomes*** Current *Grade 12 Chemistry*	
	Number		**%**	
Content Knowledge	95	71	40	61
Skills	18	13	20	30
Applications	22	16	5	7
Historical Development of Models and theories	0	3	3	4
Total Outcomes	133		65	

* The number of individual outcomes does not equal the total number of outcomes due to the fact that some outcomes fall into two or more categories.

In general, it seems that the modes of representation in the teaching of chemistry as outlined by Johnstone (1991), which had some influence on the current chemistry curricula, is apparent in the SLOs of the current chemistry curricula to some extent, albeit greater in the *Grade 11 Chemistry* (MECY, 2006) curriculum than in the *Grade 12 Chemistry* (MECY, 2007) curriculum. Also, the current chemistry curricula boast a greater emphasis on STSE, however, most of the STSE-references are stated in the general learning outcomes (GLOs), and very little in the SLOs. The few exceptions are the SLOs dedicated to the historical development of models and theories and a few environmental issues such as outcome C11-2-02: "Research Canadian and Global initiatives to improve air quality" (MECY, 2006).

So, what progress has been made in the transition from the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula to the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula? Despite the fact that the preface to the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula conveys the notion that the curricula are oriented towards more constructivist and humanistic, or learner focused, curricula, it seems as though little progress has actually been made in terms of orienting the SLOs to reflect this progress. Although, it is likely that the intentions are that teachers are to digest the recommendations put forth in the preface and GLOs in the current chemistry curricula and change the ways that they are delivering the SLOs to students. According to John Murray, Science Consultant with MECY, this apparent 'disconnect' between the SLOs and the intentions as outlined in the preface to the curricula is likely a result of the fact that much of the introduction to the current chemistry curricula, including the GLOs, were created for science curricula in general and, with the exception of the specific chemistry references, were written a few years ago with the development of other science curricula in

Manitoba. The chemistry curriculum development team had little input into the preface of the document and were mainly responsible for developing the SLOs. Murray recommends, however, that teachers should make every effort to see the document as a whole and to link all components of the document together to achieve what the document intends (personal communication, April 17, 2009).

2.2.8: Conclusion

This overview has focused on the development of chemistry curricula in Manitoba from 1998 to the present, beginning with the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula, followed by the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula. Both sets of chemistry curricula were, in principle, based on the *Framework* (CMEC, 1997) which was created in response to a vision set forth by the CMEC to improve scientific literacy in Canada. It was suggested in the preface to each set of documents that both sets of curricula had moved away from an academic oriented curriculum to a more humanistic oriented curriculum. However, it was determined that the SLOs are still very knowledge-based in the current chemistry curricula, despite the documents proclaiming to have shifted their focus away from content knowledge and towards a more constructivist and humanistic, and, consequently, learner focused, approach. It was concluded that this had to do with the GLOs that enforced the STSE approach being disconnected from the SLOs.

Research would suggest that there will be little change in what teachers are doing in their classrooms, despite the best efforts of the current chemistry curricula to change the way that chemistry content is delivered in the classroom. I wonder if chemistry teachers in Manitoba have

read and applied the information in the introduction to the latest chemistry curricula. Or, are they simply teaching the content only as it appears in the SLOs. I also wonder if the GLOs, which are to deal with many of the STSE issues and improve scientific literacy, are being addressed in many Manitoba chemistry classrooms. A modification of the SLOs to directly address some of the STSE issues, rather than separating the issues as vague GLOs might orient chemistry teachers towards a change in the way they deliver their course material. And, I question whether the Manitoba chemistry curricula will ever fully depart from an emphasis on knowledge and content-based outcomes, as the post-secondary chemistry institutions seem to be focused more on the production of future scientists rather than a scientifically literate public.

So, on paper, Manitoba looks really good in its thrust for STSE and scientific literacy as outlined in the preface to the current chemistry curricula. Practically though, not much progress appears to have been made in the SLOs. Perhaps what will occur is that there will not be a noticeable change in the way that students are learning chemistry, and this will drive the need for further change in the chemistry curriculum. According to Murray, the entire chemistry curriculum should be eradicated in favour of a more 'integrated' approach. He states:

> In my opinion, chemistry, physics and biology as disciplines should be dissolved from the secondary science curriculum in favour of a more 'systems oriented' science curriculum that demands far fewer points of algorithmic memorization and much more integration that is truly integrated science – not four clusters with one being chemistry etc. I mean a radical restructuring of the science curriculum so that it looks more like a modern ELA (English Language Arts) curriculum, with

teachers being more empowered to work in the necessary content and context (John Murray, personal communication, January 27, 2009).

Murray feels that although it is likely that Manitoba will encourage more of an emphasis on STSE in the future, that "history shows that these influences are cyclic and always reach a dead end" (Personal communication, January 27, 2009). It will be interesting to see where Manitoba science curricula, and in particular the chemistry curricula, are headed in the future.

This analysis of the chemistry curricula in Manitoba has left me with several questions: Are teachers applying the latest chemistry curricula in their classrooms as intended? If not, then why not? Is it because they are not aware of the implicit expectations outlined in the preface of the current chemistry curricula that they are to create a more learner focused environment in their classrooms? Or, is it because they feel that a more humanistic approach to the teaching of chemistry concepts is less important than giving students a solid foundation in chemistry knowledge and content? Or do teachers feel that they don't have the background knowledge to apply some of these more humanistic applications in their chemistry classrooms? Or is it simply that development like this takes time and that they are starting to think about it but not yet changing their teaching practices to reflect what is presented in the latest chemistry curricula? Or, are their beliefs about teaching and learning holding them back? Perhaps a look at some of the current research on the factors that affect the implementation of curricula in schools would provide some insight into why teachers may not be applying the intended chemistry curricula in their classrooms.

2.3: Factors Affecting the Implementation of Curricula in Schools

2.3.1: Introduction

> It is no wonder teaching is such a hard thing ... it's such a complex job ... there is so much to it ... that just imagine we sit around and we say we are going to change pedagogy well ... why don't we just level Mt. Everest or something? (Teacher 4, as cited in King, 2007, p. 2)

Over the past 40 years, much research into science teaching has focused on deserting a de-contextualized approach to instruction in favour of pedagogical advances that are more humanistic in nature. Researchers in favour of the humanistic approach (for examples, King, Bellocchi & Ritchie, 2008; Mahaffy, 2005) argue that the learning of science should be a human enterprise which encourages connecting science concepts with everyday life so that the learner sees science as relevant and the learning of science to be a rewarding experience, and that ways of conveying a more humanistic approach to science is to teach it with a more constructivist and humanistic STSE orientation built on the interests and experiences of students. A modification in teaching approach may be a daunting task for many teachers, however, as it could involve not only changes in curriculum materials and resources, but also changes in their own beliefs about teaching and learning. It is believed that any change in pedagogical approach would require a "complete paradigm shift in teachers' thinking, content knowledge and praxis" (Beasley & Butler, as cited in King, Bellocchi & Ritchie, 2008, p. 7).

In Manitoba, in fact in all of Canada, science curricula have been influenced by the *Pan-Canadian Science Framework* (CMEC, 1997). The main goal of this *Framework* (CMEC, 1997) is to improve scientific literacy among Canadians by encouraging the teaching of science with a

focus on STSE. This STSE approach has become quite evident in the preface to the more recent chemistry curricula in Manitoba. The chemistry curricula in Manitoba has apparently seen a shift from the traditional knowledge-based focus in the former chemistry curricula (ca. 1990) towards a more constructivist and humanistic approach in the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula, and in the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula. However, while this more constructivist and humanistic orientation is quite implicit in the preface and GLOs, it is not explicitly stated in the SLOs of the current chemistry curricula in Manitoba. My question is this then: "Is the implementation of the current chemistry curricula in Manitoba aligned with what has been intended?" Upon examination of the SLOs in the current chemistry curricula in Manitoba, it was observed that these outcomes are still largely content-based. There are very few links to applications, history, or STSE issues. However, it is implicit in the preface to the documents that teachers are to use contexts – applications, historical references, and STSE connections – and link them to the concepts they are teaching. The importance of relating concept with context can be summed up in the following quote by humanistic scholar John A. Moore:

> There must be an acceptance that science courses have to make that major step to relevance. There is quite a gap between understanding the chemistry of combustion and understanding how human societies will solve their needs for energy now and in the future. Students need to know both. (in Bardeen & Lederman, as cited in Bybee, 2003, p. 349)

Some other questions that arise are: "If teachers are not applying the intended Manitoba chemistry curricula in their classrooms, then why not?" Or, more specifically, "what factors

might influence the delivery of these more constructivist and humanistic, or learner focused, chemistry curricula in the classroom?"

The main objective of this review of the literature then is to examine the factors that might influence curriculum implementation with specific reference to the literature pertaining to the implementation of chemistry curricula with a humanistic orientation. Thus, this review will examine the factors influencing the general implementation of curricula in schools, including a specific look at the implementation of science and chemistry curricula that emphasize a more constructivist and humanistic, or learner focused, orientation[1]. An examination of the recent literature in these areas may show some common contributors and constraints to curriculum implementation. In particular, factors external to the teacher such as time, curriculum materials, resources, professional development, the role of administration and teacher-teacher relations, and teacher characteristics such as values and beliefs, and knowledge will be examined. In the discussion of these factors, Bronfenbrenner's Ecological Systems Theory (Bronfenbrenner, 1979) will be used to show how many of these factors are interrelated.

2.3.2: Bronfenbrenner's Model of the Ecology of Human Development

[1] With regards to terminology, Bennett (as cited in King, Bellocchi & Ritchie, 2008) suggests that the context-based and STSE-based approaches, which are more constructivist and humanistic in nature, are indistinguishable from one another since both approaches are more learner focused and are seen as alternatives to traditional or conceptually-based science programs. He implies that at the centre of the more context-based and STSE-based programs are the application of science in students' everyday lives. As such, these terms will be used interchangeably throughout this review and factors that affect the implementation of a constructivist and humanistic approach to the teaching of chemistry will be viewed as having similar relevance to the context-based and STSE-based orientation to the teaching of chemistry, specifically in the context of the latest chemistry curricula in Manitoba.

Since Bronfenbrenner's (1979) Model of the Ecology of Human Development will be used to assist in understanding the factors affecting curriculum implementation in schools, this model will be examined first. This model will be used to compare the interactions of the teacher, as the individual, and his or her interconnections with a multitude of external factors and how this might impact the ability of the teacher to implement the current chemistry curricula in Manitoba.

Bronfenbrenner's Model of the Ecology of Human Development involves the study of human beings and their environments (Bronfenbrenner, 1979). Bronfenbrenner saw the individual's experience "as a set of nested structures, each inside the next, like a set of Russian dolls" (Bronfenbrenner 1979, p. 3). In his book, *The Ecology of Human Development* (1979), Bronfenbrenner describes the unique interaction between the developing person and all levels of their environment. Bronfenbrenner (1979) suggests that there are several levels at which the individual and the environmental structures interact. This interaction is pictured on the next page in Figure 3 as concentric circles which represent the intricate layers of environment, each having an effect on the development of the individual. Although they are represented as discrete levels, they do not influence development as discrete entities.

Bronfenbrenner's (1979) model can be used to illustrate the unique interaction between a teacher and his or her environment, with each level representing a different connection with the teacher, whether direct or indirect. In the center of the model is the individual (that is, the teacher). The individual is surrounded by the microsystem. Microsystems are the immediate interactions and relationships of the individual, such as with close colleagues. In this sphere,

there are also many components of the individual, including psychological and cognitive factors, like personality, knowledge and beliefs. The individual in his or her own microsystem is constantly shaped by both the environment and by any personal interactions (Bronfenbrenner 1979). Microsystems are surrounded by the mesosystem, the relationships between two or more settings in which the individual participates that shape the environment within which the individual and interpersonal relations occur (Bronfenbrenner 1979). In the school context, the mesosystem would include the school and the interrelations between the teacher in the classroom with all colleagues and the principal and other in-school administration.

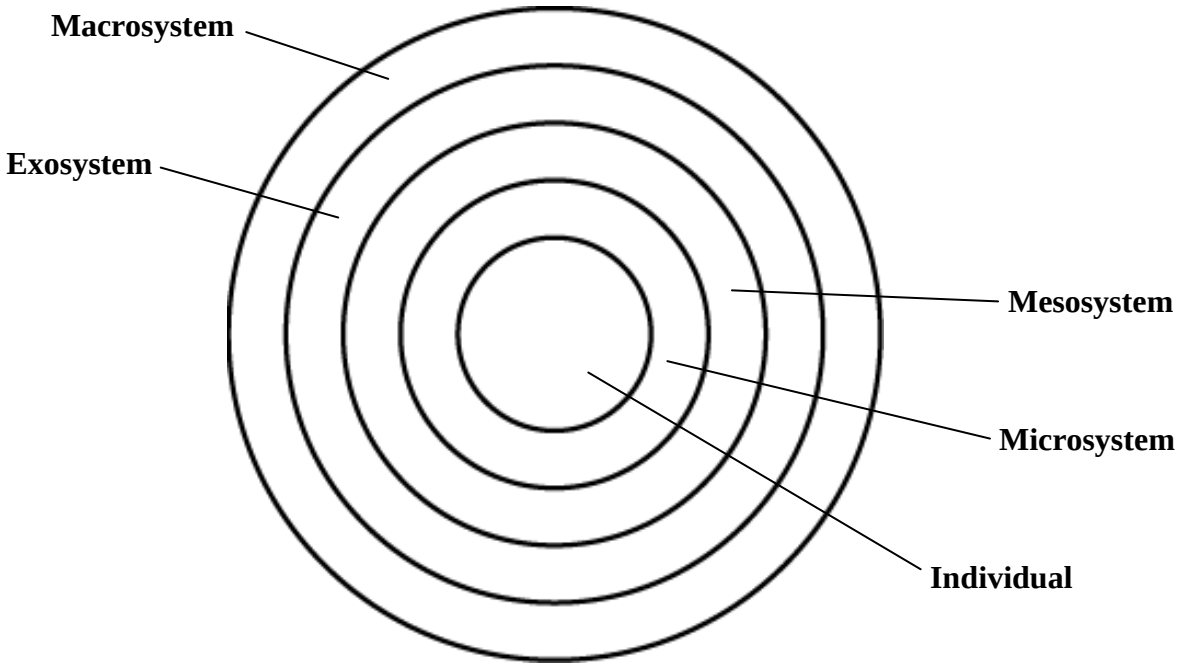

Figure 3: Bronfenbrenner's (1979) Model of the Ecology of Human Development

Bronfenbrenner (1979) also claimed that the greater the intensity of the communication in this system, the more influential it is on the microsystem. Mesosystems exist within exosystems, which are community level environments which indirectly influence the development of the individual, which in the school context would include the school division/school board. Exosystems are essentially any setting which affects the individual, although the individual is not required to be an active participant (Bronfenbrenner, 1979). Finally, the outermost ring of the model represents macrosystems, the larger socio-cultural context. In the school context, this would include the Minister of Education who is responsible for national curricula. Each system contains roles, norms and rules that can powerfully shape the development of the individual (Bronfenbrenner, 1979).

In Manitoba, core curricula in public schools are prescribed by Manitoba Education, Citizenship and Youth and enforced by the Minister of Education. The province of Manitoba is divided into several school divisions, each of which is administered by a locally-elected Board of Trustees. Each school division has a Superintendent and several Assistant Superintendents (one of whom is in charge of curriculum). In many school divisions, there are also Coordinators for many of the core subject areas (for example, Science Coordinator). Each school has a Principal and one or more Vice-Principals (depending on school size). For the core subjects there is usually a Department Head, for example the Science Department Head who oversees all teachers of science courses. These different levels of influence in the education system might impact the teacher to some degree – with closer structures providing more direct impact than those structures which are further away. So essentially, in the teacher context, Bronfenbrenner's (1979) model looks at the interrelatedness between the teacher and their environment. It is in

examining these connections that one might understand the factors that affect the implementation of curricula in schools.

2.3.3: Factors Affecting Curriculum Implementation in Schools

Those who conduct research in the field of curriculum change know very well that for every implementation effort that succeeds, there are many more that do not. But, as Goodlad notes, "often innovations that are thought to have failed really have not; they really were never implemented" (in Basch & Sliepcevish, as cited in Snyder, Bolin & Zumwalt, 1992, p. 403). Curriculum change has often relied on the simplistic assumption that a developed curriculum will be implemented as intended. So much effort goes in to producing such intricate documents that little attention is often given to how an intended curriculum will actually pan out in the classroom. If successful implementation is to be achieved, the intended and implemented curricula need to be more fully connected. So, what factors affect the implementation of a proposed curriculum in schools? And, more specifically, what factors might affect the implementation of the latest chemistry curricula in Manitoba as intended – with a more constructivist and humanistic, or learner focused approach? A look at the meaning of the terms 'curriculum' and 'implementation' will provide necessary background for this discussion.

"Curriculum is the way content is organized and emphasized; it includes structure, organization, balance, and presentation of content in the classroom" (National Research Council, as cited in Bybee, 2003, p. 348). Van den Akker (2003) defines curriculum more simply as 'a plan for learning.' Van den Akker (2003) also states that there are four main levels of curriculum, which correspond closely to Bronfenbrenner's (1979) model:

1. Individual/personal level
2. Classroom (micro) level
3. School/institution (meso) level
4. System/society/nation/state (macro) level

Van den Akker (2003) uses three curriculum representations when discussing problems relating to curricula: The intended, the implemented, and the attained curriculum. The intended curriculum refers to the basic philosophy at the core of a curriculum and its overt intentions as specified in the curricula. As Cuban (1992) states, "the intended curriculum is a map of theories, beliefs, and intentions about schooling, teaching, learning and knowledge" (p. 222). The implemented curriculum is the curriculum in action. It is the actual curriculum that is delivered and presented by each teacher. Cuban (1992) refers to this as the taught curriculum where teacher beliefs begin to correspond to a specific curriculum/teaching style. The attained curriculum refers to the resulting learning outcomes of students – the concepts and content that are in fact learned and remembered. Cuban (1992) calls this the learned curriculum. He states that "the gap between what is taught and what is learned – both intended and unintended – is large" (Cuban, 1992, p. 223). So, in the Manitoba school context, Manitoba Education, Citizenship and Youth is the department responsible for the underlying STSE and humanistic theme present in the preface to the latest chemistry curricula – the intended curricula. The chemistry curriculum writers, then, have supposedly prepared the SLOs in the current chemistry curricula to reflect this theme. The teachers, then, are somewhat bound to implementing these objectives, and, being that the curricula are policy documents, ought to teach according to these prescribed learning outcomes. The specific manner in which a teacher interprets these outcomes,

however, may depend on several factors – some central the teachers themselves, and others which are external to the teacher. This review looks specifically at the implementation phase of curriculum, with reference to general, science and chemistry curriculum implementation with a humanistic orientation.

Implementation refers to "the process of altering existing practice in order to achieve more effectively certain desired learning outcomes for students" (Fullan, 1981, p. 6). It is essentially 'changing practice' (Fullan & Steigelbauer, as cited in Altrichter, 2005). As Fullan (2007) states, "implementation is critical for the simple reason that it is the *means* of accomplishing desired objectives" (p. 85). Fullan (1981) states that the implementation of a new program, in this context the latest chemistry curricula, will likely require changes in materials, approaches and beliefs and that without these changes, implementation will not occur. Fullan (1981) states that beliefs may be the hardest of the three factors to change since beliefs are based on the core values a person holds. For example, a teacher who believes in a more traditional content focused approach to instruction may find it difficult to modify their beliefs and deliver the curriculum using more of a learner focused approach. The specific approach used by the teacher, that is based on their beliefs or professional identity, can greatly impact the learning experiences of students. If the implementation of a new curriculum that necessitates a modification in teaching approach occurs and the teaching approach actually improves, then the outcome will likely be improved student understanding. But, if only the materials change and the teaching approach does not, then it is unlikely that the desired outcome will be achieved. Fullan (1981) states,

> The implementation process has frequently overlooked people (behaviour, beliefs, skills) in favour of things (e.g., regulations, materials) and this is essentially why it fails more times than not. Although people are much more difficult to deal with than things, they are also much more necessary for success. (p. 13)

Again, this review will look specifically at external factors that affect curriculum implementation as well as certain teacher characteristics that may play a role in the implementation process, and relate these findings to the implementation of the current chemistry curricula in Manitoba.

2.3.4: Curriculum Implementation in the Literature

Curriculum implementation has been the topic of many recent studies. While few studies relating to science and chemistry curriculum implementation at the secondary level exist, there have been several studies (for example, Lewthwaite, 2005), and a few dissertations on the subject of science curriculum implementation at the elementary school level (for example, Arnott, 1994, and Lewthwaite, 2001). Arnott (1994) examined factors affecting the implementation of an elementary science curriculum in three northern Saskatchewan schools, while Lewthwaite (2001) studied the factors affecting science curriculum delivery at the primary school level in New Zealand and at an elementary school in north-western Canada (2005). Although results may differ in different implementation localities, different levels and different fields of study, there seems to be some convergence of research findings about key factors that affect the implementation of curricula in schools.

Fullan and Park (1981) group the factors that affect the implementation of reform initiatives into four main areas: characteristics of the change itself (the need for change, clarity and complexity of the change, and the quality and availability of the materials); characteristics at the school system level (history of innovative attempts, expectations and training for principals, teacher input and professional development, board and community support, time-line and monitoring, and overload); characteristics at the school level (principals' actions, teacher/teacher relations and actions; and factors external to the school system (role of the ministry of education and other educational agencies). Fullan (1981) states that the more factors supporting implementation, the more effective it will be. Fullan (2007) also stresses that these factors are not in isolation from one another but that they form a "*system of variables* that interact to determine success or failure" (p. 86). While Fullan and Park's (1981) exhaustive list of factors are important in determining the success or failure of an implementation project, this review will focus on a few local school/school system factors, which I will refer to as external factors, and some teacher characteristics, that can act as impediments or supports to implementation, with particular regard for the latest chemistry curricula in Manitoba. In Bronfenbrenner's (1979) model, the components examined in this paper will include predominantly the microsystem and the mesosystem levels since these two systems would exert the most influence on the individual.

2.3.5: External factors that affect Curriculum Implementation

So, what type of external factors at the mesosystem level in Bronfenbrenner's (1979) model might affect the implementation of the latest chemistry curricula in Manitoba as intended – with a more constructivist and humanistic, or learner focused, approach? The following

discussion, with reference to the literature, will include a look at time, curriculum materials, resources, professional development, the role of administration and teacher-teacher relations.

2.3.5.1: Time as a Factor that affects Curriculum Implementation

Lack of time was a major factor identified by many researchers as a barrier to the implementation of an innovation in an extensive review of the literature by Fullan and Pomfret (1977). "The need for time for teachers to familiarize themselves with new materials and methods, and to reflect and work on problems of implementation both individually and collectively" was strongly emphasized in some studies (Hamingson, as cited in Fullan & Pomfret, 1977, p. 373). In the context of the Manitoba chemistry curricula, coverage of the essential SLOs may be, first and foremost, on the minds of chemistry teachers, particularly in those school divisions with standard exams. To include applications of chemistry and historical contexts – more humanistic STSE content – may take time away from the SLOs. Also, for many teachers in Manitoba, time to read and digest the implicit intentions of the latest chemistry curricula, time to research and learn humanistic content, and time to prepare resources could be key impediments to the implementation of the latest chemistry curricula as intended. And so, although the total number of learning outcomes has been reduced from the *Transitional Chemistry 30S and 40S* (MET, 1998) to the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula, the incorporation of more humanistic content may increase the time-load in these chemistry classes – in terms of both teacher preparation and class time – and may therefore be a barrier to the curricula's successful implementation.

Time is only one factor, however, that might prevent chemistry teachers in Manitoba from applying the latest intended curricula in their classrooms. In his book *Successful School Improvement*, Fullan (1992) describes a study in which an Environmental Studies program was implemented. Of all of the factors that were presented as possible factors affecting the implementation of this program, the teachers identified the following as being among the most significant: curriculum materials, resources, ongoing professional development, the principal, and teacher-teacher contact. A review of the literature in these areas will illustrate the significance of these factors in the implementation of curricula, especially as it pertains to the latest chemistry curricula in Manitoba.

2.3.5.2: Curriculum Materials as a Factor that affects Curriculum Implementation

Those in the business of school reform have commonly relied on curriculum materials as a means of influencing the practices of teachers, but with limited success (Ball & Cohen, as cited in Brown & Edelson, 2003). Curriculum materials have probably the most direct influence on what teachers do each day with their students, however, the use of curriculum materials provides no guarantees of instructional transformation (Brown & Edelson, 2003). Teachers must "perceive and interpret" existing curricula if they are to teach with the intentions of the specific curriculum document in mind (Brown & Edelson, 2003). In the current chemistry curricula in Manitoba, for example, the intentions as outlined in the preface of the documents and the GLOs suggest that the teaching of chemistry should include a more constructivist and humanistic, or learner focused, approach. Teachers' practices may not change if they focus solely on the SLOs and pay little attention to the rest of the curricula. It is questionable, then, if the current

chemistry curricula are designed appropriately. Perhaps the more constructivist and humanistic applications should be more reflected in the SLOs.

Some teachers may even rely solely on a given textbook in their attempt to cover the SLOs in a given curricula, but as Fullan (1981) asserts, "an approved textbook may easily become *the* curriculum in the classroom, yet fail to incorporate significant features of the curriculum guideline on which it is based" (p. 16). This assertion may be true of the latest chemistry curricula in Manitoba due to the apparent disconnect between the SLOs and the main intentions of the curricula to approach learning goals with a more constructivist and humanistic, or learner focused, approach. Fullan (2001), in an extensive review of universal change, concludes that "to achieve large scale reform, you cannot depend on people's capacity to bring about substantial change in the short run, so you need to propel the process with high quality teaching and training materials" (as cited in Roehrig et al., 2007, p. 884). Thus, if the latest chemistry curricula in Manitoba are not designed appropriately, and are without high quality training materials, teacher change to support the latest curricula will be less likely.

2.3.5.3: Professional Development as a Factor that affects Curriculum Implementation

The professional development of teachers is another factor that may affect the outcome of an implementation effort. Davies is cited in Guskey as concluding that "in-service education is the slum of American education – disadvantaged, poverty stricken, neglected, psychologically isolated, riddled with exploitation, broken promises, and conflict" (as quoted in Arnott, 1994, p. 28). However, professional development is seen by many (for example, Supovitz and Turner, 2000) as the best bet for changing teaching practices. One-time professional development

sessions may not significantly change the ways that teachers teach, but when professional development is offered on a continuous basis, some studies have shown a significant change in teaching practices (for example Coenders, Terlouw & Dijkstra, 2008). Arnott (1994) agrees that while pre-implementation in-services are important and are usually provided, follow-up staff development initiatives are less regularly available. He cites three main obstacles to follow-up plans for staff development – expense, disruption and time. As Fullan and Pomfret assert, there needs to be training "during, not just prior to, implementation" (as cited in Arnott, 1994, p. 28). In a 1984 study of Manitoba teachers implementing a new Grade 10 science curriculum, for example, the degree of implementation was closely related to attendance at in-services or workshops. The study showed that 83% of teachers who had a higher degree of implementation had attended in-services or workshops, as compared to about 65% at other levels of implementation (Manitoba Education, Planning and Research, 1984). Supovitz and Turner (2000) have reported that one of the critical components of science professional development is that it must be both "intensive and sustained." An example of a more recent study that has investigated the relationship between professional development and teaching practice is a study of teachers who participated in Ohio's State-Wide Systemic Initiative in science and mathematics. Supovitz, Mayer, and Kahle found that,

> Highly intensive (160 h), inquiry-based professional development changed teachers' attitudes towards reform, their preparation to use reform-based practices, and their use of inquiry-based teaching practices. Further, they found that these changes persisted several years after teachers concluded their experience (as cited in Supovitz & Turner, 2000, p. 965).

While the latest chemistry curricula in Manitoba do not solely emphasize inquiry-based instruction, it is seen as a more learner focused classroom approach and thus it is likely that this finding would translate to the context of the Manitoba chemistry curricula.

In support of the latest chemistry curricula in Manitoba, the University of Manitoba's Centre for Research in Youth, Science Teaching and Learning (CRYSTAL) developed a five-year research and development project to improve the teaching and learning of chemistry in Manitoba chemistry classrooms (Lewthwaite & R. Wiebe, 2010). As part of this project, approximately 120 hours of face-to-face professional development was offered to Manitoba chemistry teachers that saw all ten clusters from the *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula addressed by the end of the five-year period consistent with a more constructivist and humanistic, or learner focused, approach utilizing multiple modes of representation (Lewthwaite & R. Wiebe, 2010). In conversation with the director of the professional development, Dr. Brian Lewthwaite, the purpose of this professional development project was two-fold: The first purpose, based on Mezirow's (1981) adult learning theory, was to try to create tensions in teachers regarding their beliefs and teaching practices so that they might recognize the need for change; and the second purpose, based on constructivist learning theory, was to suggest to teachers that they deliver the latest chemistry curricula in a manner that supports the learning styles and interests of students (personal communication, March 5, 2012). The study indicated that although teacher change was gradual, the professional development sessions impacted teachers of the latest chemistry curricula such that they became more inclined to teach chemistry using the different modes of representation in chemistry more often in their lessons.

In an implementation study of a new chemistry curriculum in the Netherlands, Coenders et al. (2008) agreed that any reform attempts must include continuous professional development. They state that 'one-shot' workshops often fail and they encourage the constant training and supporting of teachers implementing a new curriculum.

These studies demonstrate a significant relationship between professional development and teachers' practices. And in some studies, more dramatic results emerged when the experiences were sustained over longer periods of time. For example, it was found in a more recent science program implementation study (Penuel, Fishman, Yamaguchi & Gallagher, 2011) that follow up and support even long after the initial professional development is necessary if teacher knowledge and teaching practices are to change according to the new program.

Thus in the context of the latest Manitoba chemistry curricula, it can be assumed that long-term professional development might improve the implementation efforts of teachers.

2.3.5.4: Teacher Resources as a Factor that affects Curriculum Implementation

Closely tied to the issue of professional development is that of resource support (Arnott, 1994). Arnott (1994) argues that the availability of resources is important in any implementation effort, especially in a science program, which is "resource-based and activity-oriented" (p. 30). In the Manitoba chemistry context then, it can be assumed that resource support might be significant in the current implementation effort as well. With such a demanding job, few teachers have the time or energy to develop their own quality teaching materials. Along with the introduction of the latest chemistry curricula in Manitoba, a study as part of the University of

Manitoba CRYSTAL initiative saw new teacher resources for chemistry developed to support the latest curricula. These online resources were created to specifically compliment the learning outcomes presented in the curriculum. Ready-made resources can be a great asset to teachers since teachers often lack required resource development expertise (Brown & Edelson, 2003). One project in this CRYSTAL initiative was developed to improve the teaching and learning of chemistry by combining quality, long-term professional development sessions with these 'ready-to-deliver' resources that support the latest chemistry curricula (Lewthwaite & R. Wiebe, 2010). To date, over 200 resources have been developed. The function of the resources and professional development sessions were to challenge more orthodox views of teaching and learning and expose teachers to methods of instruction and resources that include molecular level and visual representations and some human element approaches using applications of chemistry and historical contexts. Thus far, student survey data collected have shown that teachers are using visual images, historical contexts, manipulatives, and explaining chemistry ideas at the molecular level more often, and are starting to abandon, to some extent, their more textbook-focused teaching style (Peltz & Lewthwaite, 2008).

In the study of chemistry curriculum implementation in the Netherlands by Coenders et al. (2008), the authors found that there were far fewer implementation problems when resource materials were developed to support the new curriculum. All teachers in the study expressed that there was insufficient time to develop learning materials. Interestingly though, while some teachers felt that the development of learning materials should be left to professionals, many argued that teachers should be involved in resource development for the new chemistry curriculum (Coenders et al.). As Coenders et al. attest, the development of resource materials

can create ownership, and can strengthen and develop teachers' pedagogical content knowledge. Although, regardless of who develops the resources, it is likely that resource support of any kind could be helpful to teachers implementing the latest chemistry curricula in Manitoba.

2.3.5.5: The Principal/School Administration and the Science Coordinator as Factors that affect Curriculum Implementation

Many studies have recorded the importance of the school and senior administration in the implementation of curricula. "All major research on innovation and school effectiveness shows that the principal strongly influences the likelihood of change, but it also indicates that most principals do not play instructional or change leadership roles" (Fullan as cited in Arnott, 1994, p. 32). However, as Fullan states "teachers and others know enough not to take change seriously unless local administrators demonstrate through actions that they should" (as quoted in Altrichter, 2005, p. 46). As an example, case studies of four school districts in Ontario known for a curriculum focus estimate that only about 10% of their principals were performing as effective curriculum leaders (Arnott, 1994). Arnott states that studies show that principals give priority to maintenance rather than change and that "implementation often succeeded when administrators exerted strong and continuous pressure on teachers and that such pressure must be combined with effective and sustained support" (Fullan, as cited in Arnott, 1994, p. 33). Another study explored the role of the principal in influencing science program delivery at an elementary school in New Zealand. This study, using a validated science program delivery evaluation tool, the *Science Curriculum Implementation Questionnaire* (SCIQ), as a basis for data collection, discussion among staff and decision-making, determined that one of the major obstacles to the

vision for instructional improvement in a particular school was the lack of leadership, a role typically attributed to the principal (Lewthwaite, 2004).

Some studies have indicated the importance of principals attending professional development sessions. The actions of the principal indicate whether a proposed innovation is to be taken seriously. "One of the best indicators of active involvement is whether the principal attends workshop training sessions" (Fullan, as cited in Arnott, 1994, p. 33). In a 1984 study of Manitoba teachers implementing a new Grade 10 science curriculum, 81% of teachers but only 23% of principals attended in-services on the new curriculum. In elementary social studies, however, 68% of teachers and 76% of principles attended in-service on the new curriculum. This finding might indicate a stronger propensity for elementary school principals to be involved in the implementation process than secondary school principals (Manitoba Education, Planning and Research, 1984).

As Arnott (1994) states, some teachers cannot take change seriously unless the support of the principal is both powerful and visible and that real change takes place only when principals are active participants in the innovation and support it in a noticeable and useful way (Arnott, 1994). However, Cuban (as cited in Larson, 1995) describes the principal as both "boss and bureaucrat," which Larson (1995) concludes leaves the principal with little time or motivation to promote curriculum reforms.

In a study of a chemistry teacher and his class in a high school in the United States, the principal said that the way he monitors whether the curriculum is being covered as intended is by checking the failure percentages of each teacher's classes (Larson, 1995). His role is obviously

not one of support and active involvement. He does offer, however, that the science curriculum coordinator is more actively involved in 'validating' the curriculum by visiting teachers in their classrooms and ensuring that implementation is occurring as intended in the curriculum guide (Larson, 1995). In the context of the Manitoba chemistry curricula then, if principals and other administration do not see the implementation of the current chemistry curricula as important or do not provide support, it is likely that the implementation process will be hindered.

In a large school division in Winnipeg, Manitoba, the position of 'science coordinator' exists to assist teachers in the implementation of latest chemistry curricula and to provide ongoing support to teachers. With this role in place, perhaps the responsibility of ensuring proper implementation of science curricula lies with the science coordinator rather than with the local school administration. In terms of administrative support, the role of Science Coordinator could be seen as a factor positively affecting the implementation of the latest chemistry curricula. Jason Braun, Science Coordinator for a school division in Manitoba, states that his role in the implementation of any new science curricula is multifaceted (Jason Braun, personal communication, April 8, 2009). He said that his role when the latest chemistry curricula were introduced in Manitoba was, first and foremost, to bring chemistry teachers in the school division together to discuss the content of the curricula and possible resources. At these chemistry meetings, all of the SLOs are discussed and a standard is agreed upon for each one to ensure that teachers are aware of the expectations for each and that students, regardless of the chemistry classroom they are in, will receive the same 'taught' curriculum. Following this, the teachers are brought together a few more times throughout the year to discuss how the implementation of the latest curricula is going, and the coordinator also arranges to visit the

teachers in their classrooms to get feedback from the teachers and identify any implementation concerns. Braun also notifies teachers of any professional development opportunities related to the latest curricula such as MECY in-services, the SAG Conference, Science Teachers Association of Manitoba in-services, and more recently, the CRYSTAL chemistry workshops. Braun states that the best professional development is when the chemistry teachers get together and discuss the curriculum, with him acting as moderator. When asked about how he enforces the STSE component of the curriculum, Braun asserts that:

> ... my role is not to 'police' teachers but to support teachers in their instruction and assessment with respect to the sciences. There are opportunities to discuss the STSE outcomes (divisional in-services) and I encourage their application in instruction and assessment. The school division is currently in the process of identifying 'essential learning outcomes' (ELOs) for all disciplines in the high schools. These ELOs are the 'big picture' outcomes regardless of the nature of the curriculum. One of the proposed ELOs for the sciences is specifically about STSE/Skills/Attitudes. This is just getting underway but it should help teachers by confirming their practice of instruction to continue to include STSE discussions and also help those teachers to adjust their instruction to include STSE discussions/assessments (Jason Braun, personal communication, April 8, 2009).

After discussions with Braun, it was clear that his involvement is critical in the implementation of the latest chemistry curricula in his school division. In many ways, it takes some pressure off

of the local school administration (that is, the principal) in that Braun's involvement with the teachers is more direct and his expertise in science is likely superior to that of the principal or vice-principal in a given school. Whether or not all school divisions in Manitoba employ somebody in a similar role is not known, but in cases where this science specialist is present, the role of local school administration is less likely to be a constraint in the implementation of the latest chemistry curricula in Manitoba.

2.3.5.6: Teacher-Teacher Relations as a Factor that affects Curriculum Implementation

Fullan asserted that "the quality of relationships among teachers is strongly related to implementation" (as cited in Arnott, 1994, p. 34). Arnott (1994) agrees that relationships with other teachers in the implementation process are critical. In particular, the modification of new knowledge, skills and beliefs depend on whether teachers are working on their own or with other colleagues. He labels teaching as a 'collective enterprise,' in which the interaction of teachers with one another is critical to the implementation success of any new initiatives (Arnott, 1994). Altrichter (2005) agrees with this remark, asserting that the quality of working relationships among teachers is essential. In his reasoning, he indicates that some teachers are more 'change-oriented' than others and so can be influential on their colleagues to embrace change. For example, in the implementation of the latest chemistry curricula in Manitoba, if a teacher in one school embraces the teaching of chemistry in a more learner focused manner, he or she is likely to influence other colleagues to do the same by networking with them and providing support. According to Roehrig at al. (2007) it is up to the school administrators to provide structured time for teachers to work and plan together in the first year of any implementation project. They also

believe in the importance of a 'trained teacher leader' to guide the planning sessions. Many schools have a 'department head' (for example a Science Department Head) who could act as this teacher leader. In the context of the Manitoba chemistry curricula, if opportunities are not provided for teachers to interact, it could impede the delivery of the curricula as intended. Ongoing professional development, however, such as the CRYSTAL professional development workshops, provided teachers of chemistry this opportunity for collaboration which may have enhanced the delivery of the latest chemistry curricula.

2.3.6: Teacher Characteristics that affect Curriculum Implementation

There are many references in the literature to specific teacher characteristics (microsystem level in Bronfenbrenner's (1979) model) that might factor in to the degree of implementation of a new curriculum. So, what teacher characteristics might affect the implementation of the latest chemistry curricula in Manitoba as intended – with a more constructivist and humanistic, or learner focused, approach? Values and beliefs, and also knowledge appear most frequently in the literature as factors that might affect the implementation of curricula in schools.

2.3.6.1: Values and Beliefs as Factors that affect Curriculum Implementation

As noted earlier, Fullan (1981) states that teacher characteristics play an important role in the implementation process. Yero (2001-2) states that:

> There is a comforting myth that the curriculum, as set down neatly in a school's handbook, defines what is going on in the school. ... Expecting that teachers will

> implement a curriculum in the same way that it exists in the mind of the designer springs from the flawed assumption that every teacher holds the same beliefs and values as the designer and defines/understands the designer's terms in the same way. (p. 2)

As the previous quote implies, it is not only the external factors as discussed previously that may have an effect on the implementation of curricula in schools, but more importantly, teacher values and beliefs. This makes sense when examining Bronfenbrenner's (1979) model since teacher values and beliefs are closer to the individual than are other external factors (for example, the principal) and thus should have more of an impact on the individual. Current research has shown that teacher values and beliefs do, in fact, affect the implementation process greatly as is described in the following pieces from the current literature.

A study by Roehrig at al. (2007) explored some factors, in particular teacher beliefs, that affected the implementation of an inquiry-based chemistry curriculum. Through interviews and classroom observations it was evident that teacher beliefs were in fact a predominant factor affecting the implementation of this reform in the classroom – results which again could apply in the context of the Manitoba chemistry curricula, despite not being fully 'inquiry-based' curricula. In another study of chemistry curriculum implementation in The Netherlands by Coenders at al. (2008), the authors declared that teachers were reluctant to implement curriculum materials that were contradictory to their beliefs about content and content delivery. Teachers, in fact, would use curriculum materials as they were intended if it matched their beliefs, but modified it or discarded it if it did not (Coenders at al., 2008). In the authors' words, "even when teachers initially subscribe to a reform developed by others, there is no guarantee that the reform is

implemented or sustained" (Coenders et al., 2008, p. 321). Additionally, in a study that examined the different levels (state, district, and local school science curriculum policies, and curriculum developers and teacher) of an intended curriculum for a high school chemistry class, as well as the relative influence of each level on a particular teacher and his subsequent implementation, Larson (1995) established that the teacher's curriculum implementation was based more on the personal goals of the teacher, while the levels further apart from the teacher were largely ignored. In her words, the levels "were based in the theoretic rather than in the realistic" (p. 12). The results of this study correspond to that which is described in Bronfenbrenner's (1979) model, where the layer closest to the individual (personal beliefs and values) has a much stronger influence on the individual than do the outer layers which are far more removed from the teacher. The relationship between teacher beliefs and classroom practices is illustrated nicely in the following quote:

> Beliefs, unlike knowledge, are propositions held to be true by the individual, can be non-evidential, based on personal judgment and evaluation (Pajares, as cited in Roehrig et al., 2007, p.885), and as such, beliefs about teaching and learning will impact how teachers utilize their pedagogical knowledge in the classroom. (Morine-Dershimer & Kent as cited in Roehrig et al., 2007, p. 885)

As Stake & Easley confirm, teachers will pursue their own courses of action in the classroom, and even though two teachers may use the same curriculum or the same textbook, two seemingly identical courses may differ greatly – all because each individual teacher will teach according to their own beliefs and values (as cited in Gehrke, Knapp & Sirotnik, 1992). Interestingly

however, in a study of 14 secondary teachers, Luft found that teacher beliefs and practices relating to curriculum implementation changed differentially depending on the experience of the teacher; apprentice science teachers "changed their beliefs more than their practices, whereas the experienced teachers demonstrated more change in their practices than their beliefs" (as cited in Aitkenhead, 2003, p. 45).

So, in the context of the Manitoba chemistry curricula, it is likely that implementation will only proceed as intended if it aligns with the teacher's values and beliefs. If teachers don't buy into the implicit messages offered in the particular curricula, the incorporation of contexts and STSE – more humanistic content – may not occur. Simply put, "there is no reason to change your pedagogy if you don't want to ... it has to be something you believe in" (Teacher 3 as quoted in King, 2007, p. 9). As well, the literature supports that the degree to which teachers change their beliefs and buy into a new curriculum may depend on several factors, including the degree to which they engage in long-term professional development and their years of teaching experience.

2.3.6.2: Knowledge as a Factor that affects Curriculum Implementation

In a study by Supovitz and Turner (2000), which among other things, investigated the relationship between teacher background characteristics and teaching practices, content preparation was the most significant teacher factor affecting implementation, regardless of the extent of how much teachers engaged in professional development opportunities. This finding, using both teacher and principal survey data from a large scale National Science Foundation initiative, reinforced the rising consensus about the importance of content knowledge in science

teaching (Supovitz & Turner, 2000). On the subject of the importance of content knowledge in relation to teaching and learning, Kennedy concluded that "programs that focus on subject matter knowledge and on student learning of particular subject matter are likely to have larger positive effects on student learning than are programs that focus on teaching behaviours" (as cited in Supovitz & Turner, 2000, p. 964). Welch (1979), who studied 20 years of science curriculum development, comments on the fact that science teachers are often ill-prepared to teach the content required of many science courses and attributes it to the fact that many teachers are teaching outside of their certification area. He considers it to be more of a problem at the elementary and junior high levels but also somewhat at the secondary level – particularly prior to the introduction of some National Science Foundation programs. He feels strongly that the lack of science content background causes teachers to feel insecure and thus they tend to resist the implementation of new curricula. In a study by Kruse and Roehrig, content knowledge was found to have an effect on teacher confidence and the ability to teach chemistry in the way that this new curriculum was intended (as cited in Roehrig et al., 2007).

It is evident that the implementation of any new curriculum depends mostly on classroom teachers since it often requires changes in the way teachers approach subject matter, teaching, and the learning of science (Powell & Anderson, as cited in Roehrig et al., 2007). According to Powell and Anderson, there is a specific interaction between the teacher's knowledge and beliefs about the 'nature of the reform,' with the curriculum that establishes how the curriculum actually pans out in the classroom (as cited in Roehrig et al., 2007, p. 885). Research has shown that content knowledge is critical in the implementation of a new curriculum. In the context of the

Manitoba chemistry curricula then, it is imperative that teachers have the necessary content knowledge otherwise the curricula may not be implemented as intended.

It is noteworthy that, in addition to possessing excellent background knowledge of subject material, such as chemistry, if one is to teach with a more humanistic emphasis, it is also necessary to possess knowledge relating to teaching humanistic content. As Aitkenhead (2003) noted, when a humanistic perspective was introduced in new curricula, the results of several research studies showed that teachers did not have adequate background knowledge to deal with humanistic content. As Barnett and Hodson concluded, "knowledge that enables teachers to feel more comfortable in the classroom and to enhance their sense of self is likely to be embraced; knowledge that increases anxiety or makes teachers feel inadequate will almost certainly be resisted or rejected" (as cited in Aitkenhead, 2003, p. 40). Thus, in the context of the Manitoba chemistry curricula, if teachers are to incorporate humanistic content into their teaching of chemistry concepts, they must have the essential background knowledge to deal with it.

2.3.7: Humanistic Chemistry Curriculum Implementation

The implementation of chemistry curricula that are more humanistic in nature are beginning to surface internationally. These more humanistic approaches involve connecting chemistry knowledge with contexts that are more relevant for the student. This more context-based approach to teaching chemistry is evident in such programs as *ChemCom* in the USA (American Chemical Society, as cited in King, 2007) and *The Salter's Approach* in the UK (University of York science education group as cited in King, 2007). The success of these programs is the main reason the humanistic context-based approach was introduced in

Queensland. King (2007) conducted a study of a context-based chemistry curriculum implementation in Queensland to determine the level of success of the implementation. In the Queensland curriculum, the definition of *context* is stated as "a group of learning experiences that encourages students to transfer their understanding of key concepts to situations that mirror real life" (Queensland Studies Authority, as cited in King, p. 4). This is essentially what the more learner focused approach to chemistry instruction involves in the current chemistry curricula in Manitoba, although with a slightly different approach. Many of the context-based approaches start with a context and apply the content to the context, whereas in Manitoba, the emphasis on STSE is merely to link chemistry content to current STSE issues. The results of the Queensland chemistry implementation study showed that the implementation was successful in making chemistry more relevant regardless of the method used to implement the context-based approach (either beginning with context, or with content as is currently intended in the Manitoba chemistry curricula). Many teachers noticed an increase in student interest in chemistry along with an interest in students to pursue post-secondary education in chemistry. This finding provides further justification for teachers in Manitoba to provide contextual references in their teaching of chemistry and to embrace the teaching of concepts with contexts.

In another recent example, The Chemistry Group in Israel (Hofstein at al., 2008), who have been involved in 40 years of chemistry curriculum development, implementation and research, discuss the more recent chemistry curriculum which is more contextual and relevant in the hopes of enhancing student interest and motivation and producing more scientifically literate citizens. The current chemistry program in Israel has students studying the key concepts in the context of issues relating to health, the environment, nutrition and technology. A training centre

was established in Israel about 10 years ago which was responsible for the development of leadership among chemistry teachers. Two courses (450 hours each) were delivered to approximately 70 chemistry teachers which aimed at enhancing their content knowledge, pedagogical content knowledge and leadership abilities and skills. The role of these teachers was then to assist other teachers in their implementation of the new program. This finding illustrates the need for constant support supplied to teachers in their implementation of humanistic curricula. To implement the Manitoba chemistry curricula as intended, for example, might require intensive sustained professional development to some key teacher leaders who could then mentor other chemistry teachers to assist in their implementation of the latest curricula.

The current literature also presents some studies that zero in on other factors affecting the implementation of humanistic chemistry curricula. King, Bellocchi and Ritchie (2008) note some additional factors affecting the implementation of a context-based chemistry program. They state that one of the challenges that might face teachers is to find new ways to demonstrate that they can connect concept with context. They also state that the pedagogies and assessment customs of the high school versus the university may not be aligned. They state further that "if undergraduate university teaching of chemistry, for example, continues to privilege de-contextualized conceptual learning, there will be greater pressure on school teachers to prepare their best students for university as they themselves were taught chemistry" (King et al., 2008, p. 30). From a similar standpoint, but in the humanistic context, Fensham notes that "the ideologies of pre-professional scientific training, mental training, and screening for college entrance challenge any move to reform school science into a subject that embraces a humanistic

perspective" (as cited in Aitkenhead, 2003, p. 7). That being stated, if there is a misalignment of the high schools and the universities in Manitoba, it could hinder the implementation of the latest chemistry curricula as intended.

In a recent Canadian example, Pedretti, Bencze, Hewitt, Romkey, & Jivraj (2006) reported on five tensions identified by teacher candidates in Ontario with regard to their motivation and self-confidence towards implementing an issues-based, STSE approach to teaching science. These tensions were: control and autonomy; support and belonging; expertise and negotiating curriculum; politicization and action; and biases and ideological bents. These tensions revealed some of the challenges associated with implementing STSE education, in particular, that STSE education represents an image of science teaching and a set of pedagogical challenges that are different from normal patterns of practice (Pedretti, et al., 2006). Pedretti et al. (2006) state, "STSE (with its focus on decision-making, ethics, action, transformation and empowerment) is clearly not the dominant paradigm of science teaching. Its implementation creates, for many teachers, thorny problems of practice, and challenges science teachers' professional identities" (p. 943). The authors feel that this is the main reason that, although STSE education has gained considerable force over the past few years, it has made "fewer strides in practice" (Pedretti et al., 2006, p. 944). I wonder if Manitoba teachers are experiencing some of these same tensions and problems as they are faced with implementing a similar type of curricula.

Since the implementation of more humanistic curricula is rapidly surfacing internationally, it may necessitate further studies to investigate the contributors and constraints to

the implementation of curricula of this kind so that the proper supports may be put in place for teachers. In reference to Bronfenbrenner's (1979) model, these supports may include administrative support, relationships with colleagues, professional development or resources, but, ultimately, it may mostly depend on teacher values or beliefs and content knowledge as to whether a more humanistic curriculum will be delivered as intended. Perhaps, then, efforts that challenge teachers' current beliefs to align with the what the latest chemistry curricula in Manitoba are proposing, might be the best bet in changing teaching practices.

2.3.8: Conclusion

Many in the field of science education would agree that there is a need to improve the way that science is taught in schools so that students are more engaged and see science as relevant and important (King, 2007). Whereas the training of future scientists was once the focus of science education, many educators now agree that the learning of science should be made more engaging for students through the teaching of science with a more constructivist and humanistic learner focus where science is learned in context building upon students' familiarities and experiences. As the research literature suggests, the intended curriculum rarely becomes the implemented curriculum as a result of many complex factors. When referring to the intended versus the implemented versus the attained curriculum, Gehrke et al. (1992) state that,

> The distance between the idealized and the enacted is considerable; between the idealized and the experienced, even more. The curricula under criticism, whether language arts, social studies, mathematics, or science, are characterized as teaching students what they already know while omitting many things they should know, as

> focusing on the transmission of factual knowledge to the near exclusion of conceptual understanding and problem solving, and as being disconnected from real experiences – authentic writing efforts, real problems of citizenship, serious questions about the earth's environment, practical uses of mathematical thinking. (p. 97)

The latest Manitoba chemistry curricula were apparently designed to be more constructivist and humanistic in nature – with their references to human element applications and multiple modes of representation – but have the curricula been implemented in the manner intended? In other words, are teachers reconsidering their roles as chemistry teachers towards a more learner focused pedagogy as result of a new curriculum orientation?

In this review of the literature, some of the factors affecting the implementation of curricula were discussed with reference to a constructivist and humanistic orientation of science and chemistry education in light of the more recent chemistry curricula that has been introduced in Manitoba. Several external factors such as time, curriculum materials, professional development, resources, the role of school administration, and teacher-teacher relations, and some teacher characteristics such as values and beliefs, and knowledge were examined with respect to their possible effects on the implementation of the latest chemistry curricula in Manitoba as intended – with a more constructivist and humanistic, or learner focused, approach. The literature presents a common theme with regards to the implementation of new curricula in schools: That disappointment after disappointment abounds in many curriculum implementation efforts. These disappointments have been attributed to the several factors affecting

implementation discussed in this review. It was suggested that it is likely that similar factors could affect the implementation of the latest chemistry curricula in Manitoba as intended. Could it be true that "the size and prettiness of the planning document are inversely related to the amount and quality of action?" (Reeves, as cited in Fullan, 2007, p. 41). The Manitoba chemistry curricula boast with claims of educational reform, but do the teachers have the tools to change, and are their beliefs getting in the way? According to Bronfenbrenner's (1979) model, structures closest to the individual exert the most influence on an individual. Thus, in the school context, teacher characteristics such as beliefs are likely to have more influence on the teachers' actions than other factors at the local school level.

The literature presents so many barriers to the successful implementation of curricula that it seems unlikely that chemistry classrooms in Manitoba are experiencing and implementing the new and improved chemistry curricula as intended. How can the teachers be encouraged to deliver these latest curricula in a more constructivist and humanistic, or learner focused, manner? Welch (1979), in his study of 20 years of science curriculum development, concluded that the science classroom had really not changed much in the previous 20 years. He stated that an enormous amount of money was spent on curriculum development and implementation with little change in what and how teachers taught and students learned. He asserted that, of the 90 research reviews he examined over a 10 year period, there was very little improvement in the educational system. He stated that "the enthusiasm of the 'new approach' lessens as the number of 'no significant differences' mounts" (Welch, 1979, p. 300). Are Manitoba chemistry teachers going to be among those who make 'no significant differences' in their teaching? It is difficult to be enthusiastic about curriculum change when there are so many obstacles faced in its

implementation. The latest chemistry curricula in Manitoba have emerged with suggestions of more constructivist and humanistic ways to approach the teaching of chemistry, but so many factors affect whether these curricula will be implemented as intended. And, when another new set of chemistry curricula emerge in the future with the same promises of educational reform, I wonder if similar implementation constraints will be faced, causing many teachers to stick to their old familiar methods of teaching. It is these familiar ways of teaching – stemming primarily from teachers' own values and beliefs – that teachers tend to stick with, because despite the best intentions by some teachers, values and beliefs are extremely difficult to change. Thus, it will likely take more than a 'pretty curriculum', a 'one-shot' in-service, or a few ready-made resources to bring about change in teachers, it could take a complete transformation in their beliefs about teaching and learning to implement the current chemistry curricula in a more constructivist and humanistic, or learner focused, manner as intended. As Fullan states, "educational change depends on what teachers do and think – it's as simple and as complex as that" (as quoted in Blackburn-Morrison, 2005, p. 35).

2.4: Professional Development and Reflective Practice as ways to assist in Teacher Professional Identity Shifts and Improvement of Classroom Practice

After looking into the development of the chemistry curricula in Manitoba from 1998 to the present and upon reviewing the factors which affect the successful implementation of curricula in schools, this next review focuses on teacher professional identity – in particular, teachers' teaching orientation – and the factors which support teacher shifts towards a more

constructivist and humanistic approach to classroom instruction which focuses on the learner. According to Bronfenbrenner's Model of the Ecology of Human Development (1979), structures closer to the individual exert the most influence on the individual and thus a teacher's evolving professional identity, which has been shaped by their childhood experiences in education, the knowledge and learning they obtained in teacher education, and their experiences in teaching practice (Lamote & Engels, 2010), has a significant impact on the development of the teacher. Thus, the concept of teacher professional identity, which has been the subject of much educational research, will be presented as it appears in the recent research literature. Since the research literature has pointed to both professional development and reflective practice as key ways to impact teachers and bring about teacher change to support a new curriculum introduction, these two key factors will be discussed as they appear in the research literature and as they pertain to professional identity shifts in teachers faced with implementing the latest chemistry curricula in Manitoba. So, when a new curriculum is being implemented, it may require changes in teachers' beliefs about teaching and learning such that they may experience shifts in their professional identities, and, consequently, improvements in their teaching practice. Recall that Fullan (1981) suggests that for successful implementation of any innovation to occur, changes in beliefs must occur as well.

2.4.1: Professional Identity

Teacher professional identity is a complex construct and has been defined and researched in a variety of ways (Beijaard, Meijer &Verloop, 2004). The current research literature indicates that a teacher's personal and professional identity may strongly affect the way that they perform

as teachers. A teacher's personal identity may refer to their distinct personality, or things which make a person unique, while professional identity refers to how teachers view themselves as teachers (Lamote & Engels, 2010). Lamote and Engels (2010) emphasize that personal and professional identities are strongly interconnected and that these identities are formed as a result of "personal history, social interactions and psychological and cultural factors" (p. 5). In the teaching profession in particular, the specific influencing factors on professional identity formation may include childhood experiences in education, the knowledge and learning obtained in teacher education, and experiences in teaching practice (Lamote & Engels, 2010). It is likely that these influencing factors on a teacher's professional identity may be so deep-rooted within them that trying to change their professional identity may be an extremely difficult task.

Certain aspects of professional identity may determine "the way teachers teach, the way they develop as teachers and their attitudes toward educational changes" (Beijaard, et al., 2004, p. 108). In their study on "The Development of Student Teachers' Professional Identity," Lamote and Engels (2010) identify four such aspects of teacher professional identity, which include:

Professional orientation, task orientation, self-efficacy and commitment to teaching (Figure 4).

Figure 4: Four aspects of teacher professional identity (Lamote & Engels, 2010)

First, with respect to professional orientation, Lamote and Engels (2010) describe the concept of the 'extended professional.' The extended professional, they assert, "is creative, an innovator – a team player who contributes to school development" (p. 4). In addition, extended professionals work collaboratively to expand their knowledge and seek out other theories and methods (Lamote & Engels, 2010). Because the expected roles of teachers have essentially changed from transferor of knowledge to facilitator of learning (Klaassen et. al., as cited in Lamote & Engels, 2010), this concept of the extended professional is an important consideration in redefining teacher professional identity.

The second aspect of teacher professional identity as described by Lamote and Engels (2010) is 'task orientation,' which refers to what teachers want to accomplish with their students and how they want to do it. Denessen believes that teachers come at this idea of task orientation

from one of two angles: the content oriented approach or the student oriented approach (as cited in Lamote & Engels, 2010). Specifically, he notes, the more student oriented approach is described as including involvement as opposed to discipline, personal and social development as opposed to career development, and an emphasis on process as opposed to product (as cited in Lamote and Engels, 2010). However, it doesn't necessarily need to be a dichotomy as Denessen describes it, as one can say that the focus in the student oriented approach is more on developing the learner and less on delivering the content, while still addressing the educational goals in question. In fact, Dewey 'held that the two dimensions could be harmonious' (Shen as cited in van Driel, Bulte &Verloop, 2005). And, it was found that in a study in The Netherlands that many people held to a large extent both 'subject-matter oriented' beliefs and learner centred beliefs (Denessen as cited in van Driel, Bulte &Verloop, 2005).

The third aspect of teacher professional identity, 'self-efficacy,' refers to a teacher's perception of their own competence as a teaching professional and is affected by several things. Among them are: Previous successful experiences, indirect experiences, persuasion by others and emotional feedback (Woolfolk as cited in Lamote & Engels, 2010). As such, in the presence of several positive experiences or regular positive feedback from a mentor, a teacher's self-efficacy would likely increase.

Finally, the fourth aspect of teacher professional identity described in the Lamote and Engels piece is 'commitment to teaching' and refers to "the extent to which teachers feel psychologically connected to the teaching profession" (Van Huizen as cited in Lamote & Engels,

2010, p. 7). It is probable that the more committed a teacher is to their job, the more change-oriented they may become.

In a related professional identity study by Rots (2007), teacher education graduates' professional identity was examined. Rots was interested in how teachers perceive themselves as it was her belief that the way that teachers perceive themselves may affect their judgments and behavior (that is, their thoughts about education and teaching, their professional development as teachers and their attitudes toward teacher education). In her first research question, with respect to teacher education graduates' professional identity, three main indicators were assessed, which correlate with three of the four indicators addressed in the study by Lamote and Engels: Self-efficacy, professional orientation and commitment to teaching (Rots, 2007). Regarding the importance of student teachers' professional identity formation was the following quote in the author's paper by Nias: "Not all teachers incorporate occupational identity into their self-image; those who do not, either leave the profession or lose interest in it" (as cited in Rots, 2007, p. 1). What this quote highlights is the importance of continually redefining one's professional identity through the discovering and re-discovering of one's self as a teacher. Speaking specifically about self-efficacy, Rots (2007) impresses that a teacher's self-efficacy may have a positive impact on a teacher's enthusiasm for, commitment to, and retention in teaching.

Thus, when faced with an innovation, such as the latest chemistry curricula in Manitoba that encourages more of a learner focus, regardless of what professional identity teachers bring to it, they need to be willing to embrace the curriculum change and commit to redefining their professional identity so that it associates better with the latest curricula's implicit and explicit

intentions. This may require teachers of the latest curricula to address the aspects of professional identity discussed above and to seek ways to redefine their particular professional orientation, task orientation, self-efficacy and commitment to teaching. It is these aspects of professional identity that Bronfenbrenner (1979) would suggest might have a great impact on the individual as professional identity is a part of the structure closest to the individual.

2.4.2: Teaching Orientation

Because teaching orientation is such a critical aspect of teacher professional identity, it will be highlighted on its own here. It is also so entrenched within a teacher's beliefs about teaching and learning and is an important area to address as teacher beliefs may be the most difficult aspect of one's professional identity to change.

In the previous section, the aspect or sub-identity of professional orientation known as 'task orientation' specifically refers to whether teachers approach the learning goals in question from a content focused perspective or a learner focused perspective. In an article by Tsai (2002), "Nested Epistemologies: Science Teachers' Beliefs of Teaching, Learning and Science," the author categorized teacher beliefs as being either 'traditional', 'process' or 'constructivist' in nature, which essentially refers to whether teachers adopt a more content or learner focused approach to teaching, learning and the nature of science. The author's interest in teachers' beliefs – specifically in their 'task orientation' – lies in his assumption that teachers' beliefs may affect their instructional practice. In the *traditional* view, Tsai (2002) notes that science is best taught by transferring knowledge from teachers to students, science is best learned by acquiring knowledge from credible sources, and science provides correct answers and thus represents the

truth. In the *process* view, Tsai (2002) states that science is best taught by focusing on processes or problem-solving procedures, science is best learned by focusing on processes or problem-solving procedures, and scientific knowledge is discovered through the scientific method. Finally, in the *constructivist* view, Tsai (2002) notes that science is best taught by helping students construct knowledge, science is best learned by constructing personal understanding, and "science is a way of knowing and it is invented through scientists agreed conventions and paradigms" (Tsai, 2002, p. 776). In his paper, Tsai reveals his particular position as constructivist. The results of Tsai's (2002) study showed that 57% of teachers held traditional views about teaching science, 59% held traditional views for learning science and 57% held traditional views about the nature of science. This result was surprising as it discloses that still over 50% of teachers have very traditional views about the teaching, learning and nature of science. Tsai (2002) notes that the large number of traditionalists in his study may be a result of the traditional view these teachers experienced when they themselves were students. The author feels that the experiences that these teachers had as students likely shapes their current beliefs of teaching, learning and science now as teachers. He concludes then that one issue that teacher educators face is how to change teachers' traditional views of teaching, learning and science and that developing teachers' understanding about constructivist epistemologies is necessary in teacher education programs.

Thus, a teacher's specific 'teaching orientation' may determine the level of implementation of the latest chemistry curricula in Manitoba with a learner focus as suggested in the preface to the document. According to Bronfenbrenner's (1979) model, structures closest to the individual exert the most influence on an individual. Thus, a new curriculum introduction is

not likely to induce teacher change as a mandated document endorsed by the Minister of Education as it is so far removed from the teacher. Teacher change, then, will likely require a change in teaching orientation and beliefs, which may only occur through long-term professional development with colleagues or through the process of individual or collaborative reflective practice. Professional development and reflective practice, which will be addressed below, may have a greater effect on the development of the teacher towards these educational goals since it directly involves the teacher in his or her own microsystem.

2.4.3: Professional Development

It is thought that a change in teacher beliefs may occur more easily through exposure to professional development programs to support a new curriculum, but that the duration of the professional development factors in to the degree of this change. Can a teacher's belief system change at a 'one-shot' in-service? Kagan suggested that teacher beliefs can take close to 3 years to change. "The persistent and non-dynamic nature of belief systems is problematic when considering the duration of most professional development or pre-service programs" (as cited in Roehrig et al., 2007, p. 885). Krajcik et al. reported that teachers were beginning to change their beliefs and accept the new curriculum as intended only after long periods of one-on-one professional development (as cited in Roehrig et al., 2007). In fact, it was determined that "even in the most intensive professional development or pre-service programs, changes in beliefs usually only occur for teachers predisposed to the goals of the professional development program" (Holt-Reynolds; Krajcik et al.; Richardson; as cited in Roehrig et al., 2007, p. 886).

As mentioned previously, teacher educators at the University of Manitoba offered ongoing professional development to teachers of the latest chemistry curricula in Manitoba to encourage teachers to teach the latest curricula in the manner intended – using a more learner focused approach by incorporating more human element applications and multiple modes of representation (as discussed in Lewthwaite & R. Wiebe, 2010). I wonder if many of the teachers who participated in these professional development sessions were originally hesitant to teach in a more learner focused way as the latest Manitoba chemistry curricula suggested – due in large part to their own beliefs about teaching, learning and the nature of science. Perhaps the professional development sessions encouraged teachers to see the benefits of learner focused teaching, but for some teachers, it may be that their own beliefs were holding them back. And, possibly, for some teachers who participated in several of the professional development sessions over the entire 5 year period that the sessions were offered, experienced some kind of 'transformational learning' – a concept described by Mezirow (1981) – that resulted in changes in their original beliefs about teaching and learning and the nature of science. I also wonder if teacher beliefs changed after attending these professional development sessions, and if teaching practices improved as well.

Another way of possibly bringing about a change in teacher beliefs is through the process of reflective practice, which is the subject of the final part of this review.

2.4.4: Reflective Practice

In the article, "Fostering Teacher Development to a Tetrahedral Orientation in the Teaching of Chemistry (Lewthwaite & R. Wiebe, 2010), the authors imply the importance of

critical reflection during the implementation of a new curriculum introduction. In this article, the authors provide an account of a teacher of chemistry in Manitoba responding to the latest chemistry curricula in the manner intended, and allowing his students, in turn, to respond to his teaching of this latest curricula. Interestingly, however, the results showed that his students were not all completely on-board with this latest learner focused approach that the teacher was suggesting. Thus, while the teacher was still in favour of these more learner focused curricula, he also recognized the need to respond to the students' individual learning styles as well. Thus, he was caught between the tension of trying to implement the latest chemistry curricula as intended, and responding to his students' voices as well. This tension, however, can bring about reflection which can lead to 'transformational learning,' as described by Mezirow (1981). Transformational learning can occur for teachers during the process of 'critical reflection' and 'rational discourse' when they realize that some of their old beliefs don't remain functional for them anymore and thus challenges their 'dominant ideologies' and forces them to work towards change (Mezirow, 1994). Lewthwaite and R. Wiebe's article (2010) highlights the importance of critical reflection and discourse, which is another key way in which teacher orientations and beliefs may be transformed.

In his book, *Educating the Reflective Practitioner*, Schön (1987) advocates that professionals should be trained to become 'professional artists,' by practicing regular reflection in- and on- action such that they will be able to solve problems that are 'not in the book.' This would enable the practitioner – in the context of this study a teacher – the ability to make sense of uncertain, unique or problematic situations. Schön (1987) states that this type of reflective practice cannot be taught in schools, but rather must be practiced on an ongoing basis, and may

also require mentoring from those who are more advanced in their own professional artistry. He quotes, "what aspiring practitioners need most to learn, professional schools seem least able to teach" (Schön, 1987, p. 8). Schön (1987) distinguishes two types of reflection: Reflection *on* action and reflection *in* action. The process of reflecting *on* action refers to thinking back on an event to reveal how one's 'knowing-in-action' (our knowledge for solving normal, day-to-day problems, and derived from linking theory with practice) may have contributed to an unexpected outcome. This type of reflection has no direct connection to present action as it occurs only after the encounter. An example of reflection-on-action in a teaching situation might be when a colleague sits in on a class a teacher is conducting and then dialogues with them afterwards about some specific events that occurred during the class. This allows the teacher to reflect on the specific situations and perhaps explore why the teacher acted as he/she did and gain new insights or understandings through the reflection. In reflection *in* action, on the other hand, it is still possible to make a difference to the situation, and think and reform what one is doing *while* one is doing it. This is referred to by Schön (1987) as 'thinking on your feet.' So, in reflection-in-action, a surprise or unexpected event occurs which a teacher must interpret as a problem, and then, in the midst of action, must invent a solution to the problem, which teachers may do using their own repertoire of experiences and theories.

So, reflection-in-action means the constant responses to ongoing situations in the classroom, – 'thinking on your feet' – whereas, reflection-on-action refers to the in-depth reflection that occurs after an event. Thus, reflection, in a teaching situation, means looking at how we, as teachers, teach and intentionally reflecting on our practice so that we may understand and improve our practice. It not only involves just describing what we do or what we have done,

but rather it involves bringing our own unique experiences, beliefs, knowledge and values to a teaching situation so that, when encountered with a surprise situation, we may use these individual qualities to 'reframe' the problem (Loughran, 2002) and devise solutions to these problems. We need to do this because our existing professional knowledge does not fit every case. Also, becoming a reflective practitioner means to reflect in- and on- action as ongoing practice so as to learn and grow in our professional field. Also important, is the role of colleagues and mentors in our reflective practice (Schön, 1987). In order to truly become a reflective practitioner, it is important to be able to dialogue with others about problematic situations that might arise in the classroom.

In the implementation of a new curriculum, for example the latest chemistry curricula in Manitoba, teachers may often find themselves in situations where they need to 'think on their feet,' or reflect on a teaching situation and dialogue with colleagues about a specific problem. When faced with new curricula such as the latest chemistry curricula in Manitoba that has apparently changed significantly from a content focused to a more learner focused approach, teachers may find themselves needing to practice the process of reflection and dialogue on an ongoing basis as they encounter issues with a potentially new style of curriculum delivery. It is likely that it is only in this practice of reflection and dialoguing with colleagues that one can work at redefining their beliefs and teaching orientations. And, as Bronfenbrenner (1979) might suggest, the practice of reflection with close colleagues may have a great effect on the development of the teacher, being that close colleagues are part of the structures nearer the individual.

In a related piece, "Effective Reflective Practice: In Search of Meaning in Learning about Teaching," Loughran (2002) discusses a concept which he refers to as 'effective reflective practice' in the context of teaching and learning in teacher education such that 'learning through experience' may lead to a better understanding of one's teaching and also the development of one's professional knowledge. In his article, Loughran (2002) defines 'effective reflective practice' as the custom of, first, questioning 'taken-for-granted assumptions,' or, identifying that a problem exists. Secondly, Loughran (2002) states that it is necessary to see the problem in different ways, or to 'frame' and 'reframe' the problem. With regards to the 'problem,' Loughran (2002) states that if a problematic situation is not viewed by the practitioner as problematic, then it is not likely to be addressed. Further he quotes, "if the problem is considered to be outside the practitioner's control, there is little incentive for the practitioner to attempt to address the situation" (p. 35), hence the need for practitioners to *effectively* reflect and examine the problem at hand. Finally, Loughran (2002) states that 'effective reflective practice' involves acting on a particular situation (that is, the problem) and then reflecting on those actions. Loughran (2002) further emphasizes that the ability to do this greatly augments the possibilities for future actions as the practitioner's professional knowledge is enhanced. The bottom line then, according to Loughran (2002), is that one can't learn from experience alone, but rather one must reflect on those experiences. Teachers must also see and understand the practice setting from a variety of viewpoints, or through another's eyes, rather than simply justifying or rationalizing the situation, which might hamper one's professional growth and knowledge. Loughran (2002) states that ways in which teachers might obtain other viewpoints include having a teacher come and observe one's teaching, writing reflections in a journal,

asking for student feedback, or conferring with other teachers on a particular situation. Using these strategies, Loughran states, might enable practitioners to exercise 'effective reflective practice.'

Thus, in the implementation of a new curriculum such as the latest chemistry curricula in Manitoba, teachers should be constantly practicing effective reflective practice as a means of transforming their professional identities and improving their instructional practice; by framing and reframing the 'problem' and by seeing their practice through another's eyes. Again, as Bronfenbrenner (1979) might suggest, these relations with close colleagues and the receiving of student feedback might greatly affect their practice.

In yet another article on the importance of reflection, Ethel and McMeniman's "Unlocking the Knowledge in Action of an Expert Practitioner" (2000), speaks to a key way in which teachers can work at redefining their professional identities and improve their classroom practice. In this article, the idea of effective classroom practice involves learning from 'expert' teachers by not only observing their practice but also gaining access to the thinking behind their practice and dialoguing with them regarding their teaching behaviours. In Ethel and McMeniman's (2000) study, by exposing student teachers to an expert teacher's reflections on his thinking and practice, students had an 'aha' revelation after understanding his intentions behind his practice. It enabled them to also discover the *how* and *why* of effective teaching practice. The student teachers realized that merely observing a good teacher teach is not enough for learning how to teach effectively. They also realized that good teaching is not quite as easy as it looks. The expert teacher also revealed the essential link between theory and practice and

how they inform one another, which enabled the student teachers to realize the importance of thinking about 'why we teach the way we teach' (Ethel & McMeniman, 2002, p. 95). In addition, the student teachers observed the expert teacher's personal beliefs being linked with his teaching practice. They noted many instances where his beliefs about teaching and learning were made apparent, showing that these beliefs played an important role in informing his teaching practice. Moreover, the results of this study showed the importance of the reflective inquiry model and how it should be used for future practice. The following quote emphasizes that learning to teach effectively must go beyond mere observation of others' teaching practices: "Learning to teach solely through the observation of master teachers ignores the critical elements of teaching provided by the thinking and intentions behind the observable classroom practice" (Kane; Kennedy, as cited in Ethel & McMeniman, 2002, p. 98).

In the implementation of the latest chemistry curricula in Manitoba, this would be an excellent idea for a professional development opportunity in which novice teachers are exposed to an expert teacher's thinking and reflections on their teaching in a manner similar to this study. Again, Bronfenbrenner's (1979) model would suggest that great teacher development might occur from an opportunity such as this.

2.4.5: Conclusion

In this review of the literature, professional development and reflective practice were presented as ways to assist in teacher professional identity shifts – particularly in their 'task orientation' – and improvement of classroom practice. Task orientation was described as the most significant aspect of teacher professional identity and refers to whether teachers approach

classroom instruction for a more content focused or a more learner focused perspective. The research literature suggests that teacher orientations and beliefs are quite difficult to change and that long-term professional development and reflective practice might be the best bet for changing teacher beliefs and teaching practices.

In the case of the latest chemistry curricula in Manitoba, if teachers fully commit to the intentions and educational goals suggested in the preface to the latest curriculum documents, and if they routinely engage in professional development, and critical reflection and rational discourse with other teaching professionals, that they will possibly experience a shift in their beliefs and teaching orientations and, possibly, improve their classroom practice. Again, it is likely not going to be a mandated curriculum that will bring about change in teachers, but rather, as Bronfenbrenner (1979) suggests, it will be interactions of the teacher in his or her own microsystem that are more likely to bring about teacher change.

2.5: Summary

In this chapter, an outline of the development of chemistry curricula in Manitoba was presented along with a review of the literature on factors affecting the implementation in schools and also factors such as professional identity and reflective practice which may contribute to professional identity shifts and teaching effectiveness.

With respect to the development of chemistry curricula in Manitoba, both the *Transitional Chemistry 30S and 40S* (MET, 1998) curricula and the current *Grades 11 and 12 Chemistry* (MECY, 2006-7) curricula were compared and it appeared as though both curricula

had moved away from an academic-oriented curriculum to a more humanistic-oriented curriculum but that the SLOs were still very knowledge-based in the current chemistry curricula, despite the curricula proclaiming to have shifted their focus away from content knowledge and towards a more constructivist and humanistic, or learner focused, approach. Likely this had to do with the GLOs that enforced an STSE approach being disconnected from the SLOs. And so, although progressions were evident in terms of improving the current chemistry curricula to reflect more of a constructivist and humanistic, or learner focused, approach, it left me to wonder whether Manitoba chemistry teachers were making changes to the way they teach based on what the latest chemistry curricula were suggesting.

In the review of the literature on the factors affecting the implementation of curricula in schools, factors were discussed with reference to the humanistic teaching of science and chemistry in light of the more recent chemistry curricula that has been introduced in Manitoba. Several external factors such as time, curriculum materials, professional development, resources, the role of school administration, and teacher-teacher relations, and some teacher characteristics such as values and beliefs, and knowledge were examined with respect to their possible effects on the implementation of the latest chemistry curricula in Manitoba as intended – with a more constructivist and humanistic, or learner focused, approach. Using Bronfenbrenner's (1979) model as a theoretical framework, where structures closest to the individual exert the most influence on an individual, it was posited that teacher characteristics such as beliefs are likely to have more influence on the teachers' actions than some of the other factors, a presumption which was well-supported by the research literature. The implication for teachers is that, although teacher beliefs are difficult to change, if they are not willing to change their beliefs to better

associate with what the latest curricula are proposing, then it is likely that the curricula will not be implemented as intended. The research literature pointed to support in the form of long-term professional development and reflective practice as ways of assisting with a change in teacher beliefs.

In the review of the literature on teacher professional identity, professional development and reflective practice were presented as ways to assist in teacher professional identity shifts – particularly in their 'task orientation' – and improvement of classroom practice. Task orientation refers to whether teachers approach classroom instruction for a more content focused or a more learner focused perspective, and was presented as the most significant aspect of teacher professional identity. The research literature suggests that teacher orientations and beliefs are extremely difficult to change and that long-term professional development and reflective practice might be the best bet for changing teacher beliefs and teaching practices.

Chapter 3: Methodology

"Stories are at the heart of human and social meaning-making" (Wadham, 2009).

3.1: Introduction

The introduction of the latest chemistry curricula in Manitoba (MECY, 2006-7) has the potential to challenge many teachers' professional identities and their teaching practices as they have been encouraged to promote a more learner focused pedagogy and classroom learning environment. Implicit in the latest chemistry curricula is that teachers are to employ a more learner focused, or constructivist approach in their classrooms which includes a human element application and presenting learning experiences that allow students to experience chemistry through the three modes of representation in chemistry as suggested by Johnstone (1991) – the symbolic level, the macroscopic level and the the molecular level. The research literature has consistently shown that there are many factors that affect the implementation of any new innovation and that, in particular, teacher beliefs are a key factor (for example, Roehrig et al., 2007). Previous research in the area of teacher development in response to these current curricula (Lewthwaite & R. Wiebe, 2010) has shown that teacher change has, in fact, been gradual and that professional development has likely assisted with this change.

As stated in the purpose in Chapter 1, it was the aim of this study to investigate teachers' evolving professional identities in terms of what motivates teachers to teach the way they do and whether teachers feel that the introduction of the latest chemistry curricula in Manitoba and subsequent professional development have assisted with any changes in teaching practice both

during the professional development sessions and after the sessions had ended. This study also aimed to determine what might be some the tensions associated with a potential change in teachers' beliefs and teaching practice as a result of a new curriculum introduction. In response to these objectives, the following specific research questions were developed as outlined in section 1.5. These research questions, which were addressed using a narrative inquiry methodology, represent the purpose of this study and also guided the development of the narrative interview questions during the data collection phase of the study.

1. What were some of the influences/motivations on teachers' decision to enter the teaching profession?

2. What were teachers' perceptions of their changing professional identities and teaching practice prior to and as a result of the introduction of the latest Manitoba chemistry curricula?

3. What were teachers' perceptions of their changing professional identities and teaching practice as a result of their participation in the CRYSTAL professional development workshops?

4. What were some of the tensions teachers have experienced throughout their teaching career associated with a potential conflict between their own beliefs and their current teaching practice, especially in response to the latest curriculum introduction?

5. Are teachers satisfied with their current teaching practices? And, what are some of the ways their teaching practices have changed over the years and what factors do they attribute the changes to?

6. How do the personal stories of the teachers participating in the study influence my own professional learning?

Because the research literature suggests that teacher professional identity, or more specifically teacher beliefs, are formed as a result of early childhood experiences, my goal in the first research question was to initially understand what motivated teachers to enter the teaching profession. Also, it was my belief that teacher professional identity is a major factor affecting how teachers have conducted their classrooms early on in their teaching career and how they respond to a new curriculum introduction, and so the goal in the second research question was to determine what teachers initially believed about teaching and learning and whether teachers feel that they have changed their beliefs as a result of the new chemistry curriculum introduction and if they feel that this change has impacted their teaching practices. The goal of the third research question was to determine whether the extended CRYSTAL professional development impacted these teachers of the latest chemistry curricula such that they felt it modified their professional identities and teaching practices. Also, since previous interviews with several of the participants in this study revealed that teachers are often conflicted about their beliefs about teaching and learning and their actual teaching practices, the goal of the fourth research question was to understand what some of these tensions are that teachers have experienced throughout their teaching career, especially in response to the latest curriculum introduction. The goal of the fifth

research question was to determine whether teachers are satisfied with their current teaching practices, even after the professional development has ended, and what are some of the major ways their teaching has changed over the years and what were the factors in these changes. And finally, the goal of the sixth research question was to determine how the personal stories of the teachers participating in this study have influenced my own professional learning.

In addition to the introduction already presented, Chapter 3 outlines the following: The specific research design for this study; information about ethics approval for this study; how the participants were recruited; brief participant vignettes; the data collection procedure; limitations of the method of data collection; and a brief description of the data analysis.

3.2: Research Design

My role as a research assistant in one of the many CRYSTAL research and development projects at the University of Manitoba involved the collection of semi-structured interview data for the principal researcher of the study, Dr. Brian Lewthwaite. This interview data was collected during Phase Four of the CRYSTAL professional development project (March-April, 2009). The interview questions are listed in Appendix 1. These questions were asked of the participants to get a sense of what their response to the latest chemistry curricula in Manitoba was in terms of its recommendation in the preface for a more constructivist and humanistic, or learner focused approach, in the coverage of essential chemistry concepts and whether or not this approach was evident in their teaching practices. I also asked them how the students were responding when they created a more constructivist and humanistic, or learner focused environment in their classrooms and how it further influenced their teaching. I also asked them

if their teaching practices have changed at all since they have been attending the professional development workshops and how satisfied they are with the degree of change. I also asked them if their thinking about teaching has changed as well. Finally, I asked the participants about the degree to which they exposed students to the human element of chemistry to get a sense of the extent to which they incorporated this critical element recently suggested by Mahaffy (2004) into their teaching. The interviews with these 32 chemistry teachers alerted me to the fact that even with ongoing professional development assisting them with the implementation of the latest chemistry curricula teachers were still finding it difficult to align their current teaching practices with what the latest chemistry curricula were suggesting, and what research (Johnstone, 1991) suggests leads to greater student understanding. The data obtained from these interviews prompted me to want to further probe a selection of these participants as it was my belief that teacher professional identity had much to do with their resistance to changing their teaching practices.

This research study employed a qualitative narrative inquiry methodology to obtain semi-structured narrative interview data as a means of obtaining the teaching life stories of eight participants. The primary line of reasoning for the use of narrative in educational research is, as Connelly and Clandinin (1990) attest, “humans are storytelling organisms who, individually and socially, lead storied lives. The study of narrative, therefore, is the study of the ways humans experience the world” (p. 2). Connelly and Clandinin’s (1990) perception of narrative inquiry arises from a Deweyan view that “life is education” and as such, their interest lies in “lived experience” (as cited in Clandinin, Pushor & Orr, 2007, p. 22). Connelly & Clandinin (1990) assert that “narrative and life go together and so the principal attraction of narrative as method is

its capacity to render life experiences, both personal and social, in relevant and meaningful ways" (p. 10). The 'narrative', then, is essentially, the 'what's', 'why's' and 'how's' of a person's experiences (Sarbin, as cited in Holt, 2010), and it is also a story, with a beginning, middle and end. Thus, I desired to create meaningful stories from my conversations with the teachers participating in this study as a means of providing a window into their beliefs and experiences (Bell, 2002) so that I could better understand teacher professional identity.

This research study specifically entailed collecting semi-structured narrative interview data over the telephone. The participants for my study lived in Manitoba, while I resided in Ontario, and so face-to-face interviews were not possible. Since I was particularly interested in interviewing participants who were chemistry teachers in Manitoba who had experienced a curriculum change and who attended the CRYSTAL professional development sessions, I had no other option than to conduct a telephone interview with them (short of my flying to Winnipeg and staying for the duration of the data collection, which was not possible due to my family commitments in Ontario). However, while I was initially uncertain about using the telephone to collect quality narrative interview data, a research study by Holt (2010) eased my hesitations completely. In her research study, which also involved collecting narrative interview data via the telephone, she discussed a number of positive aspects of the telephone interview that I had not considered. Holt (2010) discovered that interviewing via the telephone meant that participants were more available due to the increased convenience of being able to be interviewed at a time when they would be home, and she also liked the convenience of not having to travel anywhere at a specific time. Also, she found that it was much more convenient to reschedule if necessary, than had she shown up on her participants' doorstep or at a pre-arranged place and time. Also,

Holt (2010) found that telephone interviewing reduced 'the intensity of the surveillant other' and so she thought that the participants opened up more than they otherwise would have. In addition, she noted that the absence of ethnographic information that one might obtain from entering the homes or workplaces of the narrators actually kept the analysis of the data 'at the level of the text' instead of allowing contextual data to inform the analysis as well (Holt, 2010). Finally, Holt (2010) noted that in the absence of non-verbal communication, full articulation was required of both the narrator and the researcher, which produced a much richer text than had the interviews been face-to-face. Participants of her study also noted positive experiences with the telephone interview during a post-interview about their experiences. Thus, she concludes, the use of telephones for narrative interviewing may actually be more favourable than face-to-face interviewing (Holt, 2010). The only limitations of this method that Holt (2010) noted, was letting the participants know she was still present and listening during times of silence without directing the narrative too much – a limitation she compensated for by interjecting with lots of 'umms,' and 'ahh's,' and a technique that I used in my narrative interviews as well. And so, as a result of the information I gathered from this study, and due to the logistics of not being able to conduct face-face interviews with the teachers participating in this study, narrative telephone interviews were selected as the most appropriate method to conduct this research.

The qualitative semi-structured narrative interview was conducted with teachers of chemistry in Manitoba who had been part of the implementation of the latest Grades 11 and 12 chemistry curricula in Manitoba, and who had also been a part of the ongoing CRYSTAL professional development sessions offered by chemistry educators at the University of Manitoba that concluded two years prior to this study. Since that time, teachers have had the opportunity

to reflect on their teaching practices and to employ several of the methods of chemistry instruction they learned and utilize the many resources obtained from the professional development sessions in their classrooms. The narrative interview questions essentially encouraged the participants in this study to reflect on their own teaching life story, from the time they were a student in school, throughout post-secondary teacher education and throughout their teaching careers. The narrative interview was chosen for the collection of the data because it seemed to me the optimal way to get a sense of the participants' evolving professional identities while keeping their individual teaching life stories intact. This method specifically allowed me to get a sense of how the participants' professional identities had evolved and what some of the tensions were associated with how they wanted to teach and how they were actually teaching. It also allowed me to probe deeper into some areas where they may not have thought to share, such as their perceptions as to why they teach the way they do. Finally, the narrative interview was chosen for the collection of the data as it was a means to create a chronological story for each of the participants. I wanted to create a story for the teachers participating in this study because I began this thesis with my own story and so I wanted to know if their stories were similar to mine and to each others' stories.

3.3: Ethics

Prior to contacting potential participants for this study, ethical approval was obtained from the Education/Nursing Research Ethics Board at the University of Manitoba. The approval certificate is shown in Appendix 2. To ensure anonymity of the participants, schools and school divisions in this study, all identifiable information has been changed. Participants were given the

opportunity to choose their own pseudonym, or to have one chosen by me. Also, any information that could be used to identify any schools or school divisions has been omitted.

3.4: Participant Recruitment

My research sample consisted of eight teachers of chemistry in Manitoba who had been a part of implementing the latest chemistry curricula in Manitoba and who attended the CRYSTAL professional development workshops over a five-year period. A letter was sent via email to these eight participants requesting their participation in the study (see Appendix 3) and attached to the email message was a letter of intent and teacher consent form for participants to sign and return to me if they, in fact, consented to participate. This letter of intent and consent form are found in Appendix 4. In addition, the proposed narrative interview questions were attached to the email to give the participants a more specific idea of what would be asked of them. These interview questions are listed in Appendix 5. The participants would essentially be asked questions which probed them about their evolving professional identities from the time they were a student in secondary school, through their time spent in teacher education, and throughout their time as a chemistry teacher.

The eight participants for this study were purposefully selected from a group of chemistry teachers who had implemented the latest chemistry curricula in Manitoba and who were participants in the CRYSTAL professional development sessions offered by teacher educators at the University of Manitoba. Seven of the eight participants also participated in semi-structured interviews during phase four of the CRYSTAL professional development project in March and April of 2009. Of the 32 teachers I interviewed as a research assistant for this project, seven

were selected by both Dr. Lewthwaite and me to participate in this follow-up interview for my thesis. One other teacher, Mike, was selected due to his participation and involvement in the CRYSTAL professional development sessions. So, these particular teachers were chosen as one of the eight participants based on either their responses during the preliminary interviews, or based on Dr. Lewthwaite's perceptions of them as their facilitator during the professional development sessions, or both. In other words, they were a select group of teachers whom we felt would contribute greatly to this research study. We were also pleased that our selection of participants included a good balance of both genders and years of teaching experience.

Of the eight teachers selected, three were female and five were male. There were three participants selected from the same school division, but in three separate schools. This allowed me to get a sense of some, perhaps, division-wide policies that may have been a source of tension for these teachers. Two other participants were from the same school division, but again, in different schools, so as to give me a sense of some of the other tensions associated with being in that particular school division. Finally, the remaining three participants were chosen from three separate school divisions – two public and one private – to allow me to get a sense of the main tensions among different school divisions. Finally, all participants except one were from fairly large urban Manitoba secondary schools in various areas of the City of Winnipeg, and all were at varying stages in their career, with the number of years of teaching ranging from five years to 33 years.

All eight chemistry teachers contacted agreed to be part of the study and subsequently signed and returned consent forms to confirm their participation. The interviews took place

between May and June, 2011. This research study did not involve any risk at all to the participants, and participants were not compensated in any way for their participation as outlined in the letter of intent and consent forms (Appendix 4).

3.5: Participant Vignettes

The following paragraphs describe the participants and their school placements. Note that the following arbitrary scale was used to identify whether a particular school was considered to be small, mid-sized, mid-large sized or large:

School Size	Number of Students
Small	Under 500 Students
Mid-sized	501-700 Students
Mid-large sized	701-900 Students
Large	901+ Students

Teacher A, whose pseudonym is Noah, has taught for a total of 33 years. The majority of his teaching years were spent in three large urban high schools in a large school division in the east and northeast portions of Winnipeg in Manitoba, Canada. He also taught for two years in a junior high school and for one year in New Zealand. Throughout his teaching career he has taught various levels of mathematics, science, and chemistry as well as some Advanced Placement (AP) chemistry, Grade 12 physics and career education/development. He has most recently taught for two years in a large urban academic/vocational high school in the

northeastern portion of Winnipeg in Manitoba, Canada, where he has taught various levels of mathematics and also International Baccalaureate (IB) chemistry. Prior to this, he taught for seven years at a large urban high school in the same school division, teaching mainly chemistry and mathematics. Noah holds a Bachelor of Education degree with teachable majors in chemistry and mathematics. Noah has also completed some pre-Master's training in the area of educational administration and has, since 2003, worked half-time as a senior mathematics and science consultant, supporting teaching, learning and assessment in the school division in which he works, while he has spent the remaining half-time fulfilling his regular teaching duties. Noah was also a regular participant at the CRYSTAL professional development sessions offered by teacher educators at the University of Manitoba from 2004 until 2009.

Teacher B, whose pseudonym is Mike, has been teaching for a total of 19 years. He spent his first 4 years of teaching at various schools on term contracts teaching mainly science and physics. He then taught science and chemistry for 5 years at a large urban vocational high school in the western portion of Winnipeg in Manitoba, Canada. In his current placement, a large urban academic high school in the western portion of Winnipeg in Manitoba, Canada, he has taught various levels of mathematics, science, physics and chemistry, as well as AP chemistry. He has also taught some online sections of Grades 11 and 12 chemistry. Mike holds a Bachelor of Science degree, a Master of Science degree, and a Bachelor of Education degree with a teachable major in chemistry and a minor in biology. Mike was also a member of the latest chemistry curriculum development committee. In addition, Mike is also currently enrolled in a Ph.D. program in the area of curriculum, teaching and learning. Mike was also a regular

leader/participant at the CRYSTAL professional development sessions offered by teacher educators at the University of Manitoba from 2004 until 2009.

Teacher C, whose pseudonym is Kristina, has taught for six years at a mid-large sized urban academic/vocational high school in the eastern portion of Winnipeg in Manitoba, Canada. She has taught at the same school for her entire teaching career and has taught various levels of science, chemistry and biology, as well as some advanced and AP courses in chemistry. She has also taught some online sections of Grade 12 chemistry. Kristina holds a Bachelor's degree in science, and a Bachelor of Education degree with a teachable major in biology and a minor in chemistry. Kristina was also a regular participant at the CRYSTAL professional development sessions offered by teacher educators at the University of Manitoba from 2004 until 2009.

Teacher D, whose pseudonym is Holly, has taught for six years at a large urban academic high school in the south eastern portion of Winnipeg in Manitoba, Canada. She has taught at the same school for her entire teaching career and has taught various levels of science, chemistry and biology, as well as some advanced placement courses in chemistry. Holly holds a Bachelor's degree in science, and a Bachelor of Education degree with a teachable major in chemistry and a minor in biology. Holly was also a regular participant at the CRYSTAL professional development sessions offered by teacher educators at the University of Manitoba from 2004 until 2009.

Teacher E, whose pseudonym is Tom, has taught for nine years at a small urban academic/vocational/technological high school in the western portion of Winnipeg in Manitoba, Canada. He has taught at the same school for his entire teaching career and has taught various

levels of mathematics, science, environmental science and chemistry. He taught mainly mathematics and science in his first two years of teaching before teaching any courses in chemistry. He has also, more recently, taught some online sections of Grades 11 and 12 chemistry. Tom holds a Bachelor of Education degree with a teachable major in general science and minors in mathematics and chemistry. Tom was also a regular participant at the CRYSTAL professional development sessions offered by teacher educators at the University of Manitoba from 2004 until 2009.

Teacher F, whose pseudonym is Kate, has taught for 20 years at a large urban academic high school in the southern portion of Winnipeg in Manitoba, Canada. She has taught at the same school for her entire teaching career (with the exception of a two-month placement teaching physics and math immediately after graduation) and has taught various levels of science, chemistry and physics, and some mathematics. Kate holds a Bachelor's degree in science, a Bachelor of Education degree with a teachable double major in chemistry and biology, and recently completed her Master's in Education in the area of curriculum, teaching and learning. Kate was also a regular participant at the CRYSTAL professional development sessions offered by teacher educators at the University of Manitoba from 2004 until 2009.

Teacher G, whose pseudonym is Dave, initially taught for five years at a large rural high school north of Winnipeg in Manitoba Canada, teaching various levels of science, chemistry and physics. He has since taught for four years in a large urban academic/vocational high school in the western portion of Winnipeg in Manitoba, Canada, where he has taught various levels of science and chemistry and also IB chemistry. Dave holds a Bachelor of Education degree with a

teachable major in general science and a minor in mathematics. Dave was also a regular participant at the CRYSTAL professional development sessions offered by teacher educators at the University of Manitoba from 2004 until 2009.

Teacher H, whose pseudonym is Kevin, began his teaching career in a Post-Secondary Institution in Cairo, Egypt, where he taught mathematics for one year. He has since taught for the last four years at a mid-large sized suburban private academic high school in the south western portion of Winnipeg in Manitoba, Canada, where he has taught various levels of mathematics, science and chemistry. Kevin holds a Bachelor's degree in science and a Bachelor of Education degree with a teachable major in chemistry and a minor in mathematics. Kevin was also a regular participant at the CRYSTAL Professional Development sessions offered by teacher educators at the University of Manitoba from 2004 until 2009.

The participant profiles are summarized on the following page in Table 3. Six of the eight participants of this study were already known to me prior to the interviews I conducted in 2009 as a research assistant in the CRYSTAL research and development project, while the other two participants I had only encountered, by telephone, during the interviews in 2009. I first met Kate during one of my practicum experiences in teacher education as she was one of my cooperating teachers, while both Mike and Tom are former teaching colleagues of mine, having all taught in the same school division together for several years. Kevin was a former student in the school in which I taught for six years, although I never taught him, and I encountered him again when he was a candidate being considered for the teaching position which I left in 2007. I first met Kristina when we presented together at a science conference in Manitoba, and I met

Dave when he was, as well, a candidate for the teaching position I left in 2007. Again, I did not encounter Holly or Noah until the CRYSTAL interviews I conducted in 2009.

Table 3: Participant Profiles

Participants	Gender	Degrees Held	# of years Teaching	Teachable Major/Minor	Subjects Taught	Current Placement
Noah	M	B.Ed.	33	Chemistry/ mathematics	Mathematics, science, chemistry, AP chemistry, physics, careers	Urban public school
Mike	M	B.Sc., M.Sc., B.Ed., Ph.D. (in progress)	19	Chemistry/biology	Mathematics, science, physics, chemistry, AP chemistry	Urban public school
Kristina	F	B.Sc., B.Ed.	6	Biology/chemistry	Science, chemistry, AP chemistry, biology	Urban public school
Holly	F	B.Sc., B.Ed.	6	Chemistry/biology	Science, chemistry, AP chemistry, biology	Urban public school
Tom	M	B.Ed.	9	General science/mathematics & chemistry	Mathematics, science, environmental science, chemistry	Urban public school
Kate	F	B.Sc., B.Ed., M.Ed.	20	Chemistry/biology	Science, chemistry, physics, mathematics	Urban public school
Dave	M	B.Ed.	9	General science/mathematics	Science, chemistry, IB chemistry	Urban public school
Kevin	M	B.Sc., B.Ed.	5	Chemistry/ mathematics	Mathematics, science, chemistry	Urban private school

3.6: Data Collection

Again, previous interviews were conducted with seven of the eight participants of this study in 2009 to gauge their teaching practices during the CRYSTAL professional development

sessions in which they participated. I conducted these interviews while working as a research assistant for a related research and development project conducted by Dr. Lewthwaite. During the interviews I got a sense from many of the teachers that they were struggling; that there were tensions associated with how they wanted to teach and how they were actually teaching. The participants' responses to those interview questions informed the development of the interview questions in this research study as I wanted to probe deeper into their teaching life stories. I wondered if, in fact, their stories were similar to each other, and similar to mine as well. Thus, under the advisement of Dr. Lewthwaite, I selected seven of the 32 participants in Dr. Lewthwaite's study, plus one other regular CRYSTAL professional development participant, to participate in the current research study.

Semi-structured narrative interviews were conducted over the telephone as the main data collection method. This method of data collection allowed me to get a sense of the participants' teaching life stories as they were asked to share about their experiences from the time they were a student in school until their present teaching experiences. The interview questions, which arose out of the specific research questions for the study, were structured enough to maintain consistency between the interviews, while also allowing for participants to elaborate and share their story the way they deemed fit. The seven key parts of my instrument are as outlined below.

Key Components of the Narrative Interview Instrument

1. Teachers' early experiences in school
2. Teachers' experiences in teacher education

3. Teachers' experiences in their early years of teaching
4. Teachers' responses to the latest chemistry curriculum
5. Teachers' perceived impact of the CRYSTAL professional development sessions on their teaching practices
6. Teachers' perceived impact of the CRYSTAL professional development sessions on their teaching 2 years post-professional development
7. Summary of major changes in teaching practices over the years

I specifically asked participants to discuss what brought them into the teaching profession and what their motivations were for becoming a teacher, focusing on any school experiences which might have impacted them. I also asked about their experience in teacher education, about their early years in teaching, and how the latest chemistry curricula and supporting professional development impacted their current teaching practices. I was particularly interested in whether the participants' teaching practices had evolved as the latest curricula had, with more of a proclaimed focus on the learner. Recall that in the context of this study, the term *learner focused* is used to signify the instructional approach suggested in the preface to the latest chemistry curricula; that is, a classroom learning approach that is more constructivist in nature and that focuses on generating student understanding of chemistry concepts through the incorporation of humanistic STSE issues and multiple modes of representation as the curricula suggests. I also wanted to get a sense of some of the tensions the participants had experienced associated with a change in the chemistry curricula, and whether the professional development sessions they attended have continued to impact them today. Finally, I asked the participants to summarize the

major ways their teaching has changed over the years they have been teaching and what the main factors were that contributed to these changes.

A copy of the specific interview questions can be found in Appendix 5. The interview questions were first tested on a former colleague of mine who was not a part of this research study and the questions were deemed appropriate and elicited the responses I was looking for. Thus, no changes in the interview questions were necessary, with the exception of a slight re-wording of the last interview question for clarification purposes. All interviews lasted between 28 and 76 minutes and each interview was digitally recorded using an audio recording device and was transferred to a password-protected computer immediately after each recording. Following each interview, the recordings were transcribed verbatim by me, the principle researcher, and 156 pages of transcribed interview data (1.5 spaced) were generated in total. The transcripts were then sent, via email, to the participants for verification, and all came back as acceptable.

In addition to the primary data source, the narrative interview, I contacted all of the participants via email to ask additional questions and to clarify some biographical information. The additional information obtained, along with the interview transcripts, were then used to create a chronological story for each participant, which is discussed in the data analysis section following the section on 'limitations.'

Finally, as per Narrative Inquiry protocol, I shared snippets of my own teaching story with the participants during the narrative interview and formally sent my personal teaching life story to all eight participants after the member checks were completed for both the interviews

and the stories. I shared my teaching life story not only because it has become standard protocol for narrative inquiry research to share and develop more of a relationship with the participants, but also because I wanted to make myself vulnerable to the participants as they had to me.

3.7: Limitations

Again, a general limitation of this study is that due to the focus on a small number of teachers with a chemistry specialty who attended the CRYSTAL professional development workshops, only a small number of teachers were initially considered for the study (N=32). And, of these 32 participants who had been interviewed for a previous research and development project with CRYSTAL, only seven, plus one additional participant, were purposefully selected for this particular study. Thus this is not a representative group of chemistry teachers in the province. Views of some of the remaining 25 chemistry teachers would have contributed to this study. However, although the number of participants in this study is small, there was enough diversity among the participants in the different genders, the range in years of teaching experience and the types of schools and school divisions in which they teach to consider it a representative sample of all chemistry teachers in Manitoba.

Also, since qualitative data were sought for this research study, there were limitations to this method of data collection. The main limitation was that, again, data were only collected from a small number of individuals (N = 8) which meant that the findings could not be extended to the larger population. Specifically, semi-structured narrative interviews were conducted with eight participants to get a more contextualized sense of how these teachers' professional identities have evolved throughout their school and work experiences. A limitation to the

narrative interview method of data collection is that it is very time consuming and therefore unsuitable for work with a larger number of participants.

Also, participant honesty may be of concern since teachers may be tempted to shed a better light on themselves due to the nature of the interview questions. In order to minimize the limitation of participant honesty, the narrative interviews were held over the phone. It is likely that the study would yield more honest answers "the further away the critical eye of the researcher is" (Questionnaire Design, n.d.).

One of the limitations of interviewing over the telephone, however, was when it was difficult to maintain the silence and not direct the narrative too much, but rather wait for the participant to do most of the sharing. This limitation was compensated for by letting them know of my presence by interjecting with lots of 'umms,' and 'ahh's.'

Another limitation to the narrative inquiry methodology is that because the researcher interprets and imposes meaning on the participants' lived experiences, the participants can never be free of the researcher's interpretation of their lives (Bell, 2002). Also, the data analysis is the researcher's interpretation of the data and others might interpret the same data differently. To increase the credibility of my interpretation and to verify the findings, member checks were performed on both the interview transcripts and the stories with all participants in the study.

Also, one really significant limitation is that teacher *perceptions* are measured in this study, not actual teacher performances. Classroom observations of teachers may have contributed to this study.

Finally, inherent in any type of qualitative research is the issue of researcher bias, which must be acknowledged and is difficult to eliminate completely, yet every effort was made to avoid it as much as possible through careful objective interpretation of the interview data. There was also bias associated with the creation of the participants' stories, as I used only information from the transcript that I deemed to be important (although most of the interview data was used).

3.8: Data Analysis

This section provides a brief discussion of the data analysis which will be described in more detail in Chapter 4: Data Analysis. Qualitative data were collected in this study in the form of semi-structured narrative interviews. The narrative interview data was transcribed verbatim by me, the principle researcher, and then sent to the participants for verification. Once verification was secured, and once additional necessary information was obtained from the participants via email, the interview transcripts were coded by combing the data for participant-specific themes, categories and relationships. The main purpose of the coding in this study was to, first, get a good sense of the data and second, to use the themes, categories and relationships to assist in 're-storying' the narratives. The re-storying of the narrative involved combing through each transcript several more times to get a good sense of each participants' teaching life story and evolving professional identity, and then using the created participant-specific themes and codes to create a story from the narrative interview data. The interview questions did provide the broad themes and categories for the data. However, the coding process really highlighted some of the main tensions each participant was experiencing at various points during their teaching careers. The themes and corresponding codes were also organized more

sequentially for each participant so as to enable me to create a more ordered story out of the narrative. The created themes centred on the participants' teaching life story and included their reasons for entering the teaching profession, their experiences in teacher education, and their early years of teaching practice and whether the latest chemistry curriculum introduction and accompanying professional development impacted their teaching practices. The stories that were created from the data showed more clearly each of the participants' evolving professional identities and changes in teaching practice as a result of the latest chemistry curriculum introduction and their participation in the CRYSTAL professional development sessions. The tensions the participants' experienced were the main focus as they journeyed through their teaching years. After each story was created, they were sent to the participants for verification. No concerns were raised by the participants with respect to how I represented each of the participants in their stories. Following verification of the stories, each story was related to my own teaching journey and my evolving professional identity in my personal response to the participants. I responded to each story to illustrate my own professional growth through the process of preparing and reading the participants transcripts and creating their stories.

3.9: Summary

In this chapter, the specific research design for this study was presented as well as information about ethics approval for this study and how the participants were recruited. In addition, this chapter introduced the participants of the study through brief participant vignettes and outlined the data collection procedure as well as limitations of the study and of the method of data collection. Following these sections, a brief description of the data analysis was

presented. Chapter 4 presents in greater detail the data analysis procedure and the findings obtained from the narrative interviews conducted.

Chapter 4: Data Analysis

4.1: Introduction

This chapter focuses on the analysis of the narrative interview data collected from the eight participants in this study who were introduced through the brief vignettes in section 3.5. The goal of the interview was to get a sense of each of the participants' teaching life stories and to illustrate their evolving professional identities and chemistry teaching practice throughout their journeys. This chapter elaborates on the short vignettes that introduced each participant to include each of the participants' teaching life stories, which were re-created from each narrative interview and that illustrate their evolving professional identities from the time they were a student in school, throughout teacher education and in their current role as a teacher. After each story is presented, commonalities, major tensions and any surprises will be highlighted and discussed and related to my own teaching journey and evolving professional identity through my personal response to the participants.

4.2: Qualitative Narrative Interviews

The eight teachers involved in the narrative interviews were each introduced in brief vignettes in Section 3.5. The narrative interviews conducted over the telephone included questions that focused on the participants' teaching life stories; that is, what brought them into the teaching profession, what their experience in teacher education and their early years of teaching was like, and how their current teaching practices are. I was particularly interested in whether the participants' teaching practices had evolved, as the recent curricula had, with more

of a proclaimed focus on the learner. Recall that in the context of this study the term *learner focused* is used to signify the instructional approach suggested in the preface to the latest chemistry curricula; that is, a classroom learning approach that is more constructivist in nature and that focuses on generating student understanding of chemistry concepts through the incorporation of humanistic STSE issues and multiple modes of representation as the curricula suggests. Finally, participants were also asked to discuss any tensions associated with how they wanted to teach and how they were actually teaching.

Narrative Inquiry is a fairly young methodology and, as such, there is no 'correct' or best approach to the analysis of narrative interview data. The particular approach to narrative analysis that was used in this study was a combination of methods: 'Narrative Representation' and 'Thematic Analysis' (N. Wiebe, 2009). In these approaches, the first level of analysis – the narrative representation – involved creating the participants' stories by unifying the interview data. This was followed by a second-level thematic analysis of the data in which I looked for parallels between each of the participants' stories and my own story and reflected on some of the tensions the participants experienced as it brought about the potential for my own transformational learning (Mezirow, 1981). I called this section: 'My Response to the Participants.' As Mezirow (1981) states, 'transformative learning' can occur when we recognize the reasons for our current knowledge, values and beliefs (or worldview), and then, through critical reflection and discourse, take action to overcome them. Mezirow (1981) also notes that certain life experiences or 'disorienting dilemmas' cause alterations in our worldview which can serve as a trigger for critical reflection leading to a sudden insight into the understanding of self and others. I believe that through my analysis of and reflection on the stories of the participants,

my beliefs about teaching and learning have been challenged and that my professional identity has evolved, as evidenced in my response to them.

Finally, I conclude Chapter 4 with 'My Final Response to the Participants,' in which I make a final response to the participants' illustrating how their stories have impacted my own professional identity.

I chose to analyze my data using the methods of narrative representation and thematic analysis after consulting the research literature on the various methods of narrative inquiry analysis and finding the method that best suited the type of data I collected and how I wanted that data to be represented. After all, I began this thesis by sharing my own story; therefore it only seemed fit that I also share the story of the participants and reflect on and understand some of the commonalities and differences between our stories, and, hopefully, come to some sort of understanding about teacher professional identities – what shapes us, what makes us tick, and how we can possibly negotiate some of the tensions associated with how we want to teach and how we are actually teaching.

The eight participants will be re-introduced through a story created from the narrative interview data. Each story illustrates their teaching life stories – the story of how they were brought into the teaching profession, their experiences in teacher education, and their current role as a teacher. The eight participants had varying years of teaching experience and teach in different environments, but they all had a story to share that illuminated their professional identities and how these identities have evolved throughout their lives. Their stories specifically highlight the tensions they experienced throughout their teaching careers and how they

continually sought to negotiate these tensions as they worked towards shifting their professional identities to better align with the latest chemistry curricula and research-based best practice (Awenowicz, 2009). The stories were constructed chronologically and included most of what the participants shared with a specific emphasis on the tensions the participants experienced through the change in chemistry curricula, and how the professional development sessions they attended assisted in changing their beliefs and teaching practice. Any information from the transcripts that was not included in the participants' stories was irrelevant to the study in that it did not directly relate to the research questions.

Once the participants' teaching life stories have been presented, my response to each of the narratives and then a final summary response, illustrating my own learning, will be shared.

4.3 Participant Teaching Life Stories

The following accounts describe the teaching life stories of the 8 participants that were introduced in section 3.5, and reveal how their professional identities have evolved through their school and work experiences.

4.3.1: Teacher A - Noah

As with all teachers I interviewed, Noah experienced some tensions throughout his teaching career, and how he continues to settle these tensions is a result of years of professional identity formation from the time he was a student in school until his current role as a teacher and consultant. As Noah looked back on his own experiences as a student he was reminded of what eventually brought him into the teaching profession.

Many of Noah's early experiences suggest that a 'people' component in his life would be important – commenting that factory work was unsatisfying, as would be a career in science. His experiences working with kids in a day camp setting and working as teacher's aide in a Grade 12 summer enrichment program were highlights in his early schooling experiences and perhaps pointed him to a career in education. He was comfortable in these leadership roles and was confident in his ability to teach children and found these activities to be both fun and engaging. He also joked that he thought he could do a much better job of teaching than his own teachers did, responding with "of course, what did I know at the time?" He was also aware of the value of education and that these values were important in his family as he was growing up. Perhaps this awareness of the need to further his education combined with some key experiences working with children solidified his eventual decision to enter a faculty of education.

As Noah continued to reflect on those early experiences in school, he remembered a few inspirational teachers. He also had some who were not that good, thinking that "one should be able to offer kids something a little bit better than that." His high school English teacher modelled for him how he thought teachers should be and how he would have liked to become if he were to eventually become a teacher. He highlighted two aspects about her in particular – her caring nature (both in a personal way and for teaching and learning) and her passion for her subject matter – as qualities that rendered her superior to some of the other teachers he had in school. By contrast, while his science teachers were indeed competent, they didn't seem to be enjoying what they were doing and seemed to have little care or concern for the students. Noah observed this apathetic approach to teaching in his early years as "you're torturing yourself, why

are you doing this?" It is likely that these experiences with teachers good and bad shaped Noah's professional identity in some way.

Noah's experience in a faculty of education further contributed to his evolving professional identity. While in a faculty of education, his goal, first and foremost, was to become an expert in the subject areas because, for him, it was important to "understand it enough to help someone else understand it." Secondly, his focus was on pedagogy. Throughout the teacher education program he was continually aware of "what we were doing, how we were thinking about learning and what might be some of the obstacles to learning." He felt that his time in the Faculty well prepared him for his practicum experience and he went into his practicum placements with the primary goal of "helping kids understand." He was also aware that there would be a classroom management piece to contend with as well as many hours of preparation involved so that he would be "knowledgeable enough." He also went into the practicum experience recognizing the importance of fair assessment and not being "rigorous for the sake of being rigorous." Consequently, he began his student teaching experience ready to try on the many different 'hats' he had been exposed to.

Noah was exposed to lots of different kinds of teaching, tried on these different instructional hats (which were mainly teacher centred at that time), and learned from his cooperating teachers how to organize for instruction and how to conduct a classroom. He also aspired to get to know the kids well – "in some sort of personal way" – perhaps still remembering his experiences with his inspirational English teacher. He acknowledged that in the beginning his teaching style was more about emulating his cooperating teachers before eventually finding his own way of doing things. Finally, as Noah concluded his role as a teacher

candidate, he was ready to put into practice all that he had learned as a student and in the teacher education program and was ready to begin his first teaching job.

Noah's experience as a new teacher also contributed to his evolving professional identity. Noah speaks of an incredibly challenging first year of teaching – "it was an awful experience" – much the same as it was for all of the other teachers I interviewed. For Noah, these tensions included a 'dog's breakfast' course load (one science, one mathematics and one physical education course), plus the additional stress of being asked to coach a major sport (Junior Varsity Volleyball in the first term), as well as a struggle familiar to all teachers – classroom management. Noah's first year of teaching was in his view, "the worst way to be inducted into the profession." And this was all in addition to trying to find his way around a big school and connecting with a large staff, while being split between three different departments, which minimized the potential for any collaboration or support from other teachers. In addition, the school in which he worked was a vocational school and that came with some other challenges as well, such as dealing with more 'needy kids' and trying to cope with that extra piece in addition to just getting a hold of the subject matter. At the time, Noah thought "well, everybody has to do this ... everybody has to suffer" and he felt he had to do whatever he needed to do to become a good teacher (which he admits he wasn't in his first year of teaching). But Noah doesn't feel 'hard done by' with regards to this first year teaching experience. He learned a lot from this first year of teaching and reaped the benefits of becoming physically active through his exposure to sport. He also ended up coaching for the next 20 years and recognizes that his first year exposure to coaching "was a good thing." He also wonders if perhaps this experience opened

him up to trying out other things as well, such as his recent switch to teaching mathematics after 30 years of teaching mainly science.

Noah's next few years of teaching were far more positive, as he was teaching mainly science, and he had the benefit of working with a great group of science teachers who had recently won a science teaching recognition award. Thus, he had the opportunity to learn from some great role models and collaborate with these colleagues on matters of curriculum and pedagogy. He referred to his experience as "a really fertile kind of place to learn and teach science" where he was given a lot of freedom to conduct his classroom and deliver his curricula how he saw fit.

Moving forward a number of years, and with several years of teaching under his belt, Noah shared his response to the changes in the Manitoba chemistry curricula from a more content-based set of curricula, to one that advocates for a more multi-dimensional approach to the teaching of chemistry that includes not only the symbolic level, but also the molecular level, the macroscopic level and the human element level. Noah's initial reaction to the new curricula was favourable – especially with respect to the molecular level of representation that was encouraged. His involvement with Dr. Lewthwaite around the time that the new curricula were introduced encouraged him to reflect back on his teaching practice and made him realize that while he was certainly aware of the molecular level representation, he perhaps wasn't emphasizing it as much as he could have. In his words, he was "guilty as the next person of moving on to the symbolic representation too quickly." And, while he notes that the molecular view and the visual representations were available way back when he began teaching, these latest chemistry curricula more deliberately specified the need to include multiple representations in

the teaching of chemistry concepts. This change in the chemistry curricula combined with his association with Dr. Lewthwaite caused him to reflect more on his practice and perhaps attempt to shift his practice so that it was more aligned with instruction using multiple modes of representation in chemistry that the curricula were proposing.

Noah spoke as well of the benefits of being a part of the CRYSTAL professional development sessions that were held between 2004 and 2009 to support teaching and learning in chemistry and that provided resources to support the latest chemistry curricula. He said that it definitely influenced his teaching and that it still surprises him when he sees teachers doing it the "old way." Even in the AP or the IB level chemistry courses, he still feels that everyone needs an opportunity to learn, and the more ways you can show them, the better. He was also insistent on making students aware of their own learning and aware that "this is how we do chemistry, this is how we learn chemistry – that we represent what is happening in many different ways." His role as a consultant in the school division in which he works has alerted him to the fact that many teachers are still not on board with the representing of chemistry in multiple forms. He admits that the latest curricula haven't made a huge, huge change in his own teaching, but he is continually finding little things to tweak and he is certainly more aware of the multiple representations in chemistry. What has helped him the most in the professional development sessions is his understanding of the nature of models in chemistry – something he now has enough knowledge about that he can share it with his students. It appears, then, as though Noah has shifted his thinking about chemistry and is changing his practice to better align with the multi-dimensional approach to teaching chemistry through both the change in the chemistry curricula and also through the professional development sessions that he attended.

When I asked Noah to tell me about his current teaching practices (this is now 2 years since the professional development has ended), he started to reveal a lot of the tensions (or what he originally thought were tensions) but used what he learned from the professional development sessions to resolve them. He spoke of the large number of calculations and the large number of outcomes still present in the Grade 12 chemistry curriculum, but realized through the CRYSTAL professional development that a lot of it is very conceptual and that he could (and should) bring in the conceptual explanation for a topic and focus less on the algebra so that the actual chemistry of it is not left behind. That was something big he took away from the professional development that just surfaced for him recently.

When I asked Noah if he was satisfied with this teaching now, his response was "I think for the most part, yes." He was specifically referring to the teaching and learning part, but he acknowledged he would like to work on the assessment part of things more (due to a push from his school division to make it a priority). He then began to bring up some other tensions, however. He still feels the curricula are a bit heavy – which he feels is indicative of the lack of trust in teachers to be able to come up with something that's good. He says "it's just been filled up and I think, quite frankly, they blew it." Noah feels that the latest chemistry curricula are way over-prescribed in terms of time. He feels that teachers should be given some leeway. "They should be able to take things in a direction that they feel is important for their students at that time."

Continuing to discuss the tensions, Noah also mentioned that he feels that some students and parents still have a very outdated idea of how instruction and assessment should go. He feels they are not willing to see new ways of doing things. "There's this expectation that if it's not for

marks they're not going to do it." Some parents are not as on board with 'assessment *for* learning' – they want all homework and assignments marked. (And, some of his colleagues are still doing that)! He wasn't expecting to have to 'pull students along' as they get prepared for tests. He even has the students doing checklists to keep track of their own learning. And, something that surprises him is that students are enjoying more teacher centred instruction. They want the notes and they want to have everything explained to them rather than investigate and discover for themselves. "They are asking for procedural teaching and learning." But he learned from the professional development sessions to try to help students *understand* the concepts as opposed to just memorizing facts. But his students still press him, "give me the steps. ... What are the steps?" It drives him up the wall. He realizes that you have to have a balance between the two. He describes the "huge anchor" of parents and students who think they know best and want things the way they used to be (in terms of teaching and learning) and are not willing to budge and learn these new ways of doing things. "And who could blame them because the students have done well up until now doing exactly that?" Noah makes a really insightful point that this kind of learning is not going to help them – maybe it will with the knowledge piece – but for trying to figure things out that aren't known yet, "how can that help you?" As Noah remarks, there are different kinds of learners out there and we as teachers need to recognize that and cater to that or we will be doing a real disservice to many of these students.

Finally, I asked Noah what were some of the major ways his chemistry teaching had changed over the years, hoping to get the full picture of his evolving professional identity. His response included being more attentive to multiple representations, helping students through misconceptions (which he feels comes with experience), and essentially trying to 'refine the

craft'. He also noted that he has focused more on helping students become more independent learners and releasing some of the responsibility to them. He has made more effort to focus on assessment – trying to get students to take more of a role in that rather than depending on him for everything, and sharing technology with students and using it more in teaching and learning. When asked about whether he thought he was more teacher or learner focused, he mentioned that although he was much more teacher centred way back when, he is trying to be less teacher centred now. He is also questioning himself a lot more now, although, he states, "a good chunk of what we do is still teacher centred ... because there's an expectation that we will do that." He says he is thinking more now, and he is more unsure. He thinks teachers need to start teacher centred to really understand the concepts being taught – but only as a developmental kind of tool. "But, I think what happens is it becomes the method of choice, or the learning style of choice and that's unfortunate." So, he says that while he has progressed, he can't completely leave the teacher centeredness. "We have not made students independent enough learners to be able to do things on their own." Noah's list of how his teaching has changed over the years was exhaustive, which was a sign to me that indeed he was still evolving as teacher – that he still wrestled with certain tensions and that his professional identity had been impacted by the change in the chemistry curricula and by the professional development sessions he attended. He was reflecting more and changing his practice, not because anyone forced him to, but because of who he is. From his early experiences working with children through teacher education, through those first few difficult years of teaching until now illustrates nearly 40 years of growth into the practitioner he has become today.

My Response to Noah's Story:

During my conversation with Noah, there were several moments where I felt that I could really identify with what he was sharing. First, there were several things that were important to him that I found were also important to me: His need for a 'people' component in his life; the need to feel cared for by his teachers; and a need to be that caring teacher – both in a personal way towards students and also for teaching and learning. It was my conversation with Noah where I first thought about how our professional identities as teachers evolve and how certain events such as a new curriculum introduction and professional development can challenge our beliefs about teaching and learning and bring to the surface some of those tensions that challenge our teaching practices.

In a perfect world, when teachers change their teaching practices to better align with research-based best practice, students and parents would be supportive as well. However, this is exactly the opposite of what Noah has experienced and was a huge source of tension for him. What Noah really struggled with was that "students and parents still have a very outdated idea of how instruction and assessment should go." He feels that they are not willing to see new ways of doing things. So, while Noah was on-board with what the latest curricula were suggesting and with what he had taken away from the CRYSTAL professional development sessions, his students and their parents were not. What surprised Noah was that students were enjoying more teacher centred instruction, and they were of the mind-set that if something wasn't for marks, they were not going to do it. Noah talked about the 'huge anchor' of parents and students who think they know best and want things the way they used to be, and who are not willing to budge and learn these new ways of doing things.

I could really identify with what Noah was sharing in many ways. While I experienced the additional 'anchor' of being bound by the school division I taught in to 'cover the content' in its entirety, I also felt bound by those students who wanted the procedural teaching and learning. I had my own 'anchors' that were preventing me from being the teacher I wanted to become – the pressure of divisional exams, and the pressure from students to just give them the facts rather than teaching for understanding. I was definitely oriented towards using multiple modes of representation in chemistry and towards learner centeredness, but it was always a challenge to be fully engaged in that way of teaching, because as Noah suggests, "a good chunk of what we do is still teacher centred ... because there is an *expectation* [italics added] that we will do that."

Noah's story reminded me of similar tensions that I experienced when I was teaching, and it was comforting to know that I was not alone in my frustrations with students wanting 'just the facts' while I tried to encourage them to understand the concepts using more than just the symbolic mode of representation. His story also reminded me that as educators, we need to confidently teach according to our beliefs and not let those anchors weigh us down, or in the end, we would be doing a real disservice to our students.

Finally, my conversation with Noah helped me to grow professionally as we shared some common struggles and as he shared with me some really insightful pieces from his teaching life story. I felt mentored by him and greatly appreciated the wealth of knowledge and experience he brought to the conversation. Noah's story also inspired me, in the sense that even after 33 years of teaching, he was still looking for opportunities to grow and improve his practice.

4.3.2: Teacher B - Mike

Mike has also experienced some tensions throughout his teaching career that he continues to wrestle with and attempts to settle, resulting in years of professional identity formation from the time he was a student in school until his current role as a teacher. As Mike looked back on his own experiences as a student, he was reminded of what eventually brought him into the teaching profession.

What brought Mike into the teaching profession was primarily his work with various youth organizations after he finished high school. He enjoyed being with youth and talking to youth, and he feels that he "had a knack for it." Thus, he felt that the teaching profession was the natural way to go. He also mentions that he had an inspirational high school chemistry teacher who was "kind of fun, and funny." While he doesn't remember a lot of the chemistry he was taught, he remembered enjoying the class because the teacher had an interesting sense of humour. Perhaps this experience influenced Mike's decision to become a teacher as well. And likely, this teacher has had some influence on how Mike conducts his classroom today – realizing that it is not always about the content and that one can't engage students with content alone. After completing his Bachelor of Science degree and then his Master of Science degree, Mike had a difficult decision to make with regards to whether to enter a faculty of education, or complete his Ph.D. in Science and teach at the university level. He was quite sure he wanted to teach, but was not very sure of the level he wanted to teach at. But, he says, "I didn't like the whole idea of taking a Ph.D. in science after looking around at everybody in that department so I decided to go with the high school route." Consequently, Mike entered the Faculty of Education

at the University of Manitoba – an experience that likely continued to shape his evolving professional identity.

Mike's feels that he went in to a faculty of education program with some really good starting skills. He says, "I figured that I had some skills and that I had experiences and also my ability to interact and communicate ... I figured I had some good starting skills with that." He emphasized the communication piece as he feels that communicating is a "really important part of teaching ... being able to communicate whatever to the students." He says that while he didn't enjoy the course work very much in teacher education, he did find the practicum to be very helpful.

Mike's experiences during his practicum were eye-opening in a number of ways. His first practicum experience was in a Grade 1 classroom and right away he knew he "was not Grade 1 teacher material." It just "wasn't his thing." His next practicum was in a junior high, which was an interesting experience for him since his cooperating teacher was a particularly poor teacher (self-admitted), due, in part, to the fact that he was a Physical Education specialist wanting to teach high school and the only way to get there was to start teaching science. Mike then observed this man teach "from a draft of the textbook that was rife with errors." And, while this was not an example of good teaching, it motivated Mike to be the best science teacher that he could be. Mike's next practicum experience was in a high school and it was "extremely positive." He mentions in particular the amazing staff and the great cooperating teachers who were extremely supportive. Mike remarks, "I learned a whole lot there about myself as a teacher and what it meant to be ... a science teacher. It was an extremely positive experience." Although, he admits that the teaching at that time was largely teacher centred – "didactic ... and

done in the traditional way ... lecture and seatwork, with some activities." He mentions that at that point, people were not talking about learner centred sort of teaching. Although, "for the most part I did believe in ... that learners were supposed to be actively involved ... but not at the same point as we see today. He says that while he definitely believed in the importance of demonstrations and lab activities, "it was still focused on the whole teacher centred mode of teaching." Mike's professional identity was clearly evolving throughout these early experiences.

Mike's early years of teaching further contributed to his evolving professional identity, and like many of the other teachers I interviewed, were primarily about survival. He admits that in his first few teaching years his instruction was very teacher centred, very content focused, and required hours of preparing – just sitting there with a bunch of textbooks and re-learning the information and taking old teachers' notes and "trying to work it into something that was your own." He did try to throw in activities and demonstrations here and there, but again, it was still largely focused on the content.

In his first few years of teaching, however, Mike was given quite a bit of freedom to teach the way he wanted to. There was not a huge push to get all the content covered in the various schools that he taught at. However, when he obtained his first permanent position teaching chemistry, he was hired in a school division that had divisional exams for most subjects, including chemistry. That is where the small bit of freedom he experienced ended. With a common divisional exam, where school marks were published within the division, there was all of a sudden some serious pressure in that there was an expectation to meet every single outcome in the curriculum. "So, for that there was a whole lot of pressure to ... just to focus on the content to make sure students were prepared for an exam." Thus, while there may have been that

desire to do more activities and demonstrations with the students, the pressure of divisional exams forced Mike to have more of a focus on content than he otherwise would have.

Moving forward quite a few years, I was interested in what Mike's response was to the latest chemistry curricula and whether the curricula fit in with how he wanted to teach. And this is what he shared:

> The Grade 11 fit in more according to the way I wanted to teach when it came on board ... As being a part of the development committee it was ... it reflected a lot about what I wanted to see in a chemistry course at the time. The Grade 12 was ... the Grade 12 chemistry course, I think is ... it's a disappointment. It's definitely not ... yeah, I'm not terribly happy with that one. It's not much different than it was before.

When I asked Mike about what was better specifically about the Grade 11 versus the Grade 12 chemistry curriculum he mentioned that he thought the Grade 11 flowed better; that the concepts flowed into each other much better. He also thought that the Grade 11 curriculum had more focus on student learning and understanding and less focus on content and algorithmic problem solving.

Because Mike was a regular participant during the CRYSTAL professional development sessions which was provided to support teachers in this curriculum implementation effort, I wondered in what ways the sessions influenced Mike's teaching. One word that came up several times as we discussed this was 'reflection'. Mike was particularly influenced in these sessions to reflect upon his current teaching practices and question himself as to "why do you do what you do?" and "Why are we doing what we're doing?" Further, he comments "and if we don't have a

really good reason for why we're doing what we're doing, then maybe we should change." These professional development sessions afforded Mike the opportunity to really reflect on and examine his current teaching practices and re-evaluate his teaching practices. Mike was also particularly thankful for the collegiality he experienced during the professional development sessions as it gave the group of teachers the opportunity to look at the curriculum and discuss ways to approach concepts and how to involve students more. He states, "whenever you get people together it's always nice to see concepts from different points of view and how to approach those concepts." He feels it is important for teachers to have the opportunity to bounce ideas off one another and share ideas. Mike also emphasized that,

> The professional development provides the time to sit down and just actually, you know, think about it and reflect. I think it's important that you also have the time to, you know, work through these concepts – and I think the 'time' is the important thing – and then just work through various activities that may help the students to understand the content more.

When asked what the main focus of the sessions were, Mike commented that the main focus was on what is known as the 'chemistry triplet' – the macroscopic, the microscopic, and the symbolic – and making connections between them in the instruction of chemistry concepts and providing teachers with the background and resources to accomplish this. Finally, when I asked Mike what was different about these professional development sessions compared with other professional development he has attended, he commented that these sessions were a little more intimate in the sense that specific groups were meeting more often. He says, "I think the fact that you're meeting several times during the year ... I think that, in many cases, several times in the year

over several years ... so you get to know the people better and, I think there's a greater degree of sharing."

Now that the professional development has ended and it is 2 years after the fact, I was interested in what Mike's teaching was like now – hoping to get a better sense of how his professional identity was evolving. I was wondering if the professional development sessions were still influencing his teaching and what was important to him now as a teacher. Mike then shared about his current teaching practices. He commented specifically that the professional development has definitely benefitted him. He still uses the teaching resources from the CRYSTAL website and also the various different websites and simulations that he was made aware of at the professional development sessions. But, the changes he has seen over time in his teaching were not totally as a result of the professional development sessions as it was also his work on the curriculum development committee and also some graduate work he has done that have contributed to the changes in him as well. He states,

> My graduate studies along with the CRYSTAL sessions and my participation in the curriculum development have all led me to be generally dissatisfied with the way I teach and always asking myself the question "why are we teaching what we are teaching?" So looking at the curriculum and the concepts and that, like "why on Earth do we teach this and why do we teach it this way?" So always asking that question and never really satisfied with the way I teach now mostly because – well, partly because of time – I just don't have enough time to do things the way I want to do things, to plan it, mostly for prep work, for one.

It was obvious to me, without even asking the question, that Mike was still not satisfied with his teaching. But, I asked him, and as I predicted he was not very satisfied. I decided then to probe him further about the 'time' issues he mentioned, wondering how he felt about the curriculum.

> I think the Grade 11 is okay ... It is still heavy. I still think that there's a fair bit of content there. I think that there's room to contextualize the concepts more. I still see the curriculum as being as set of content-based outcomes for the most part. So I still see it that way and I still see ... I think that the new curriculum is definitely leaps and bounds ahead of where we were before. There's still room to take that in though to contextualize the concepts more – maybe reduce down some of the concepts and then take certain concepts and contextualize them. The Grade 12 curriculum ... I'm not a huge fan. I still think it's an older type of curriculum. I think the focus is still ... I mean there is still attempt to provide some contextualization to increase the amount of STSE but I think it is still largely a content-based curriculum. Even though there is an attempt, in the outcomes, to stress the three representations in chemistry knowledge, I think that it's still largely a content-based curriculum and I think there's a lot of room for change in that curriculum.

I didn't think there was any need to probe Mike any further about the curriculum as his words said it all. Although there was an attempt in the curricula to include the multiple representations in chemistry – the symbolic, the molecular and the macroscopic – Mike feels that there is still a lot of room for improvement in the curricula, particularly in the Grade 12 curriculum.

I was then wondering how the students were responding to the instructional method of teaching using the three representations in chemistry and I asked Mike to respond to that. His comments were that students, especially the Grade 12 students, are still focused so much on the marks. 'Tell me the content ... tell me what's going to be on the test,' is what he often hears. And, I found what Mike had to say next was particularly insightful:

> I don't think that the chemistry curriculum by itself can help students to see science as more than just a bunch of facts and knowledge ... I think that has to start earlier. And, I have nothing to base this on outside of my opinion, but ... I think there's a culture developed within science that science is a bunch of facts and then students are not as open to discovering and developing the concepts on their own. As much as I would love for my students to sit there develop the concepts, often times they are sitting there and waiting for me to tell them what the answers are rather than them wanting to find the answers.

Referring to the three modes of representation that he uses to teach chemistry concepts, he mentions that it takes a long time for the students to be on board and "buy into it." He says that some students will buy into it by the end of the Grade 11 course, while, often times some students won't buy into it until he has seen them in Grade 10, 11 and then in 12 again and "suddenly the light goes on and they see it ... they see where I'm coming from. They understand that understanding is a whole lot better than memorizing." Finally, Mike states that within the couple of months of contact he has with them, he doesn't think that he can change 15 years of science culture that they've had.

Finally, I was interested in knowing the major ways in which Mike's teaching had changed over the 20 years he has been a teacher, and his response clearly illustrated to me his evolving professional identity. Over the 20 years that Mike has been a teacher, he believes that he now focuses less on content and more on students understanding concepts – something he emphasizes as being of extreme importance to him. He also says he now focuses less on the answer and more on the process – trying to get his students to focus on what the ideas are and whether it makes sense rather than whether they get the right answer. He feels that his classes are now more activity based – having students develop concepts. He states,

> The order of activities and the order in which I deal with the concepts are more important now, because of the way I see the concepts developing. I think it's important for students to develop those concepts on their own rather than me just telling them what they are ... to see the concepts as they actually work.

In addition, Mike states that he likes to teach chemistry more as a story now and try to connect everything together rather than what the tendency in the curriculum used to be with a bunch of different topics all disconnected from one another. He tries to enable students to see the threads that run through and the common concepts moving from one topic to another, despite the fact that they are moving from unit to unit. He also tries to teach less or try to encourage more discussion, and tries to do less pencil and paper tasks and more activities than he used to in his first few years of teaching. Mike's final comment was, "my teaching has definitely changed, but I also know the stuff a whole lot better than I did back then too." Our conversation ended there as Mike left me with quite a snapshot of his evolving professional identity – over 20 years in the making.

My Response to Mike's Story:

During my conversation with Mike, I felt that I could relate to him on several different levels: The positives being his work with church youth that eventually led him into the teaching profession and his extremely encouraging practicum experiences; and the negatives being the experience of being forced to teach to a divisional exam and the negative effects on our teaching practice associated with that. It seems we both had the experience of wanting to get students to that deeper level of understanding in chemistry, but we had that very real pressure of divisional exams that forced us to focus mainly on the content to make sure that students were prepared for the divisional exam.

Divisional exams were not the only tension that Mike revealed in his story. Mike reminded me during our conversations, that although the curricula have evolved from that which was mainly content focused to the latest curricula which advocates for a more learner focused or multi-dimensional approach to instruction in chemistry, the outcomes are still very content-heavy, showing a disconnect between the outcomes and what is prescribed in the preface to the curriculum documents. Mike also reminded me, though, of the huge, huge value of the CRYSTAL professional development sessions that gave teachers some great resources and some great advice on how to incorporate the multiple modes of representation in their chemistry lessons, despite the more content focused outcomes. It reminded me then that, with the proper supports in place, any curriculum can be taught in a meaningful way to students, regardless of how the outcomes are written.

What I noticed during my conversation with Mike was that now that divisional exams are no longer and now that he has had both exposure to long term professional development and also graduate level experience in education, his professional identity has evolved such that he is now more learner focused and he is really working at using multiple modes of representation in his delivery of chemistry concepts. I was thus surprised at Mike's response when I asked him if he was currently satisfied with his teaching practices. Mike said that the knowledge he has gained during his graduate work in Education along with his participation in the CRYSTAL sessions have all led him to be generally dissatisfied with the way he teaches and always asking the question, "why are we teaching what we are teaching?" He cites 'time' as one of the reasons why he isn't all that satisfied with how he is teaching, but he also attributes his discontent with his teaching to the many students who still want the procedural teaching and learning. He feels that the Grade 12 students are still focused so much on the marks, demanding "tell me the content, tell me what's going to be on the test." In Mike's view, he doesn't think that the chemistry curriculum by itself can help students to see science as more than just a bunch of facts and knowledge. He thinks it has to start earlier than that. "I think there's a culture developed within science that science is a bunch of facts and then students are not as open to discovering and developing the concepts on their own." He says that often times the students are sitting there and waiting for him to tell them what the answers are rather than them wanting to find the answers, and that it takes a long time for them to be on board and buy into it. Mike states, "Within the couple of months of contact with them I don't think I can change 15 years of culture – science culture – that they've had.

I could really identify with what Mike what saying in this regard, as I too feel that many students are still so focused on the 'marks' and are wanting the procedural teaching and learning. What Mike said really struck me as it made me realize that students need to be trained when they are much younger to discover and develop concepts on their own, and that it is too late if we are just starting this when they are in high school.

Mike's story also reminded me that a big part of the change we experience in our professional identities comes from having some years of experience under our belts. As Mike commented, "my teaching has definitely changed, but I also know the stuff a whole lot better than I did back then too." His comment reminded me that while I saw my own teaching transform in a similar way, it was also because I knew the content a whole lot better as the years passed and was confident enough to be able to try new things. With classroom management more under control I was also more willing to try activities that were not so teacher directed as I knew how to keep the class in control during a less controlled activity.

Finally, my conversation with Mike contributed to my own professional growth as I reflected on some of the tensions that were central to our experiences teaching in the same school division, and as I learned, through Mike's story, how these tensions can contribute to teacher development. My conversation with Mike also reinforced the benefits of graduate studies, which brings to the surface many tensions as well, and also leads to teacher growth. In addition, Mike's story inspired me, in that after 20 years of teaching, he is still seeking out new knowledge and is looking for opportunities to grow and improve his practice.

4.3.3: Teacher C - Kristina

Like the other teachers I interviewed, Kristina has also experienced some tensions throughout her teaching career that she continues to wrestle with and attempts to settle, resulting in years of professional identity formation from the time she was a student in school until her current role as a teacher. As Kristina looked back on her own experiences as a student she was reminded of what eventually brought her into the teaching profession.

Kristina mentioned a number of early experiences that she thinks might have led her into a career in education. Apparently, when she was younger, she used to play 'teacher,' and so that was in the back of her mind as a potential profession. She also taught in various settings from Grade 11 on in her home church. When she went to university she was originally intending on becoming a doctor, but she didn't quite want the level of stress that going through medical school would have incurred. Thus, she thought more about becoming a teacher and as she was finishing her Bachelor of Science degree, it was an alternate profession that she had in mind to be able to make use of her science degree. What eventually solidified her decision to enter the teaching profession was that, while on a missions trip, she tutored a young woman in high school mathematics and "absolutely fell in love with tutoring and with teaching her ... and so just the idea of teaching and then seeing this girl's eyes light up when she finally got the concept that had been eluding her, just thrilled me to pieces." With course experiences in both biology and chemistry, she aspired to become a high school science teacher and became just that after 2 years in the Faculty of Education After-Degree program at the University of Manitoba.

I wondered when I spoke with Kristina whether she had any inspirational teachers in high school, and while she couldn't think of any who made her *want* to become a teacher, she became very reflective upon the teachers she had in high school while she was in teacher education and in her early years as a teacher. She said,

> I was reflective upon my own teachers, and seeing the types of personalities and teaching habits that they had, and I now try to emulate some of those and I've even taken up some of the strategies and I thought, like, this is a really great chemistry example or a really great way of teaching chemistry, and I incorporate that into my own teaching.

She spoke of one Grade 11 teacher in particular who had great analogies and jokes to help the students remember certain concepts and she still remembers those analogies and jokes and uses them in her own teaching. I am sure that her experiences in high school had a part in shaping Kristina's professional identity, just as her experience in the education faculty further contributed to her evolving professional identity.

While Kristina was already thinking about her experiences in teacher education, I asked her to elaborate on her experiences, asking her what she saw as being the role of a science/chemistry teacher and what was important to her during teacher education. Kristina responded by saying,

> It was almost very grandiose in the sense that you want to teach them about science, and the methods of science, and the truth about how science has progressed ... And I wanted to give the kids a love of science ... I loved science and I wanted to extend that on.

She also stated that she wanted to make students aware of science in their society so that they could become scientifically literate; so that they could understand what was going on in the world when they saw news about cloning or using stem cell research and what some of the implications of that were and what exactly that was.

Although it sounded to me like Kristina was focused on becoming a more learner focused teacher in her teacher education program, I was interested in knowing where she would place herself on a teacher focused versus learner focused continuum. Kristina responded immediately that she would place herself on the more 'learner focused' end, but then promptly added " ...in my ideals." She clarified this by stating that this was how she was taught as she went through her teacher education experience. Kristina commented that she had a number of really great professors whose focus was on the learner such as in the general methods courses and the ones focused on the teaching of science. She also realized though that there were other professors that were not as focused on the learner – specifically mentioning the style of teaching she experienced in her chemistry and biology courses, which was similar as well to the style of teaching she experienced in high school. Kristina quotes,

> I was ideally [learner focused] and I tried to incorporate it, but a lot of the time I would fall back on my teacher directed learning because that seemed to be the easiest to fall back on because that's the way I was taught in high school, right? That's the way you were taught. You weren't taught with all these hands-on methods, and over the years I have tried to incorporate more and more of that, and I would like to continue to incorporate that but I definitely felt that tension at the beginning of my career where the time frame in which you had to plan and the time frame in which to do a course was

> definitely tight ... You fell a lot on the teacher directed learning rather than student centred.

I expected that Kristina's experiences in her early years in the teaching profession also contributed to her evolving professional identity. I was particularly interested in hearing about Kristina's first 2 years of teaching and what the main emphasis of her teaching was and what was important to her at that time. I mainly wondered whether Kristina was able to stick to her 'ideals' of becoming a more learner focused teacher. Kristina responded to me by stating that in the first 2 years as a chemistry teacher her focus was mainly on content and solving mathematical problems. She did mention, however, that there was some teaching at the particulate level as well – particularly in the 'gases' unit. Interestingly, this was the one unit she remembered learning in high school in that it was taught to her in a more 'visual' way and with particulate level references. Because of her solid understanding of this gases unit while she was a student herself, she was able to teach it to her students with visual and particulate representations as well, because "that was how I saw it in my own mind." But, while she did teach using multiple representations in the gases unit, she confessed, again, that she did not necessarily apply this style of teaching to the rest of the curriculum. Kristina admitted that she would teach the content "more or less with factual statements, rather than maybe throwing up visuals and drawing pictures of particulate movement." Kristina admits to being definitely less orientated towards that particulate level and more orientated towards "these are the facts, these are the numbers, let's do some calculations, give me a paragraph on how this works – evaporation and condensation – but don't dig too deep into what's actually happening on that molecular level."

After hearing Kristina describe some of the tensions she was experiencing in her first few years of teaching with respect to how she was actually teaching and how she really wanted to be teaching, I was interested in hearing more. I wanted to know more about some of the tensions that she struggled with in her early years of teaching, other than the 'time' factor that she had already mentioned. In response to my queries regarding tensions, Kristina did note a tension with respect to a 'common exam' or 'departmental exam' with her Grade 9 and Grade 10 science courses. She felt in these courses that there was a pressure to cover all the content that would be on the exam. Although in her chemistry course she didn't experience this pressure since there was no common departmental exam, but in Grade 9 and Grade 10 Science she experienced a little more anxiety ... "so covering things and and maybe not covering them quite as well because you needed to get through it."

It was obvious to me that Kristina struggled in those first few years to be the kind of teacher that she wanted to be, and that there were some tensions that she experienced that didn't allow her to be that more learner focused teacher like she had hoped. These experiences in her first few years of teaching contributed to her evolving professional identity, and I wondered if the latest chemistry curriculum introduction did as well. I asked Kristina how she responded to the orientation of the latest chemistry curricula in terms of the fact that the preface to the curricula advocates for a more multi-dimensional approach to the teaching of chemistry. I wondered if it fit with the way she wanted to teach. Kristina's response to this was "yes, absolutely." She recalls being particularly inspired by a Science Teacher's Association of Manitoba, Special Area Groups conference presentation by Dr. Lewthwaite for the 'Oxidation/Reduction' unit in Grade 12 chemistry.

> He was doing some idea of a particulate level and I absolutely fell in love what what he was presenting ... It fit in line with the way I wanted to teach ... He was basing it on the curriculum, so the idea of developing hands-on experiments where students could observe things ... and then bringing it down to that molecular level. It does very much fit into what I want ... how I want to teach ... how I think students would best learn.

It was obvious that the latest curriculum introduction combined with a very practical professional development session inspired Kristina towards the inclusion of multiple representations in the teaching of chemistry concepts, and I could sense form her that she desired to incorporate this style of teaching into her chemistry lessons. I was wondering then, how the CRYSTAL professional development sessions that she attended over the 5-year period influenced Kristina's style of teaching as well. While she was already inclined towards a more multi-dimensional approach to teaching chemistry, I wondered how much the professional development influenced her teaching practices further and what she got out of the sessions. Kristina's response to my question was not surprising:

> It gave me a lot of resources and encouragement ... to say that this is a valid way of teaching, and it can be done, and it can be done successfully. I was excited to go to those because I always came away with informational, relevant resources that I could use with my students and I think it just made me a better teacher that way. And, right off the hop, you know, I didn't have to adjust a lot of thinking because, I mean, I was already tended to be that way, but was also developing my own sense of being a chemistry teacher ... It just made me overall a better teacher and able to give my students a better experience in chemistry.

I wondered as well whether the CRYSTAL professional development sessions caused Kristina to reflect on her teaching practices more, to which she responded, "yes, definitely." She feels that it caused her to look at how she taught a concept in the past and think about how she could change it to make it better. It made her think about how she could bring that particulate level into her teaching to help enhance student learning and their perception of what's actually going on in and around their environment. I also wondered whether Kristina found this particular CRYSTAL professional development series to be more effective than, say, a one-time in-service. Kristina responded by stating that the CRYSTAL professional development sessions offered more consistency, which allowed her to remember more. She feels that in going to a one-day session,

> You learn something and you might take something away, while the rest of the stuff is put on a shelf somewhere, and you might remember the one thing, and then a month later you might completely forget it because there's other things to take your mind off of it and to distract you – other things like report cards, and this student is away sick. And then you have your administrators coming to you with something. So there's always something to occupy your mind.

Kristina continued by stating that, "but with having multiple sessions, you're constantly drawn back into that world – thinking about, 'what else in my teaching profession can be enhanced?' 'What else can I work on?'" Kristina appreciated the fact, too, that the professional development sessions covered multiple topics and "made you pull that enhancement of your teaching practice throughout the entire curriculum." She was alluding to the fact that all units in the Grades 11 and 12 curricula were covered over the course of the 5 years of professional development

sessions. Kristina also commented that by having the same group of people attending the professional development together allowed people to have more freedom to say what they thought because people began to trust one another enough to have open discussions without being afraid of being critiqued. Kristina remarked that,

> I think there was a large amount of professional sharing that went on and we took things away from the other teachers that we might not have otherwise. It's very rare when you get to sit down with teachers who teach your own subjects and discuss difficulties and successes, and I think that was, in and of itself, a huge benefit of CRYSTAL.

It was obvious that the CRYSTAL professional development sessions had a huge impact on Kristina's professional identity and teaching practice. I was interested as well in whether the sessions that ended 2 years prior to this interview continued to impact her teaching practices. I then asked Kristina to describe her current teaching practices and any influences the professional development still had on her classroom practice. Kristina responded by saying that the lessons that she changed and modified, to enhance or to put in the particulate level, she is still doing. She said she is continuing to draw on the CRYSTAL resources to make her curriculum better. She states,

> Just last semester and this semester as well, I pulled out a lab from one of the CRYSTAL resources package, and I tried it with my students and, even as a demonstration when I did it when I was running short on time, students understood and got that idea far more easily than if I had just rambled on about it as a teacher directed sort of lecture.

The activity that Kristina was referring to involved an experiment where students measured vapour pressure and following the experiment she elaborated on the concept by incorporating a molecular level discussion. She commented that,

> Just the observation of actually physically doing it and understanding was huge. And I don't think we do enough of that. I think that time is a huge factor in that. The time within the classroom is limited so to be able to get the students to do those experiments and then you still have to come down and talk about it, right, so you've got that within what is now less than a hundred teaching hours. And then also, you have the idea that you have time to prepare it all and then that takes time away – especially if you don't have a 'lab para.'

After hearing about Kristina's response to the latest chemistry curricula and her involvement in the professional development sessions I was wondering if she was satisfied with her current teaching practices. I was also interested in hearing about some other tensions she was experiencing that has prevented her from teaching the way she would like to teach. Kristina responded that she feels there is always room for improvement.

> Sometimes I am thrilled with my teaching because I just thought it was a fabulous lesson and the kids got it and I threw in all sorts of analogies and representations or did this experiment. And then other times that I am definitely not satisfied with my teaching where I think I just threw a lesson up on the board and it's teacher directed because that's all I could do at the time. And, that is usually because of time restrictions.

It seems that whenever I brought up the word ‘tension’ with Kristina, the ‘time’ factor came to her mind, whether it was preparation time or in-class time. She would always like to be doing more with the students, such as experiment more to figure out concepts, rather than performing the standard ‘cookbook’ lab. However, this all takes extra time – both with respect to preparation and in-class time.

Another tension that Kristina brought up was the limited technology in her classroom. There are not projectors for every classroom which makes it a challenge to show molecular simulations or animations, and now that her school division has granted access to ‘You Tube,’ there are things she would like to show her students but cannot, unless she arranges to have a projector in her classroom for a given class period.

I also wondered whether Kristina felt that she was able to get through the whole curriculum with her class, to which she responded, “I don’t get through the entire curriculum. There is one unit that I consistently leave out.” And this was both in the Grade 11 and Grade 12 curriculum. She attributed this to the fact that she focuses more on the particulate level in some areas, therefore it does not leave her enough time to cover everything. “So, is it still too content heavy? Potentially, yeah. Could I also adjust my teaching to get more in? Yes, I think so.” This brought up another huge tension for Kristina, and that is,

> Do I eliminate one or two outcomes here that really aren’t necessary in the big scope of things so that I can get at the other ones in the other units? Or, do I just do this unit in its entirety and in depth so that students have a greater understanding and then sacrifice something else?

Although Kristina feels that the latest curricula are still too content heavy, she remarks that it is definitely better than what it was. When reflecting back on the Grade 12 *Transitional* curriculum, Kristina commented that "there was no conceptualization that I remember in there that was really obvious ... that they asked us to do, and there was just a lot of math and a lot of rote."

After hearing about Kristina waffling back and forth between ensuring full course coverage and teaching for understanding, I was interested in knowing how the students responded to the different styles of teaching. Were students able to adjust to the multiple representations they were being exposed to, or did they enjoy more symbolic and procedural learning? Kristina's response was as follows:

> I think that's a very student-dependent question. I know in some cases my advanced students really appreciate the cookbook format and the procedural [learning]. But I think for other students who are not extremely math orientated, they enjoy a not procedural, a more hands-on [approach]. They enjoy getting into the lab and experimenting with things and they enjoy that multi-dimensional approach.

To help her students adapt to a more multi-dimensional approach to learning chemistry concepts, Kristina gives the students definite targets to aim for in her assessment of their understanding. For example, she says to her students, "the sentence you write to me ... the key word that you need to remember when you write this sentence is 'collision'" She says if she explains what the outcome is, and explains how to get there, the students do very well. Kristina says that she has received very positive feedback through her use of this approach and feels that if she hadn't done

that she thinks the students would have found it far more frustrating. One thing that Kristina also mentioned was that she finds that sometimes the high achieving students don't appreciate the multi-dimensional approach as much. She finds that they just want the information so they can regurgitate it back and just want to know how to solve the problem so that they can solve all the other ones like it. Her final comment was "if the kids are in it for ... just because they enjoy chemistry and they want to learn more about it, I think the multi dimensional approach suits their needs better."

Kristina's answers to my questions illustrated clearly that her professional identity had been evolving all along as she journeyed through her teaching years. My final request of Kristina was that she summarize for me some of the major ways her teaching had changed over the 6 years she had been teaching and what some of the factors were that contributed to the changes. Kristina's response was first and foremost a mention of the CRYSTAL professional development sessions. "[The CRYSTAL sessions] have impacted my chemistry teaching as well as prompted me to do more hands on learning. My tendency was to do that anyways but CRYSTAL was a reinforcement to help motivate me to continue to do that." When I asked Kristina if she thought she has become more learner focused over her 6 years of teaching, she responded with uncertainty.

> I think maybe with CRYSTAL there was a lot of growth – becoming student centred – and at this point I may have plateaued a bit. Have I become more student centred? I may have ... In my past 6 years as a teacher, my focus has always been students. I may have actually become a little more teacher centred in terms of time, like I still incorporate the same amount of hands-on learning as I did before, and I have always considered myself

> more student centred. So have I become more so? For a while yeah ... I don't think I have grown that much in the past year.

When asked about why she feels she has plateaued with respect to a more learner focused approach in her classroom, Kristina suggests that this was due to a recent major focus in her school division to work on assessment.

> That has probably been one of my primary changes in my teaching so I haven't been focused as much on developing student centred activities since it has been directed by what the division has asked us to do. That's sort of been side tracked a little bit.

As my conversation with Kristina ended it was clear that there were some major shifts in Kristina's professional identity and teaching practice over the years as she experienced a change in curricula, and professional development support, which allowed her to practice a more learner focused teaching style, but with competing pressures to cover content and focus on assessment she has been pulled in the opposite direction. However, she is reflecting more and is thinking more about her practice as evidenced by the tensions she mentions and her wanting to become a more learner focused teacher.

My Response to Kristina's Story:

During my conversation with Kristina, there were several moments where I felt that I could really identify with what she was sharing. Her work with church youth that partially inspired her to consider teaching as a potential career; and her experience tutoring along with the great deal of satisfaction that gave her when the 'light bulb' went on for her students. I, too, had

similar experiences. Especially with regards to the tutoring, I recall that amazing feeling of bringing someone to understanding on a particular concept. Kristina also spoke of her passion of wanting to give students a love for science and to improve their scientific literacy so they could understand what was going on in the world around them. This, too, resonated with me as I have often proclaimed that the reason I love teaching so much is that I enjoy passing on that love of science to others and seeing them grow to an understanding of science in everyday life. It was thus easy to connect with Kristina because of our similar experiences.

Kristina and I also shared about our mutual respect for Dr. Lewthwaite and what he has done for chemistry education in Manitoba. She shared that she was first inspired by him and by the molecular level representation at the SAG teacher's conference which he led, and from then on, she has been motivated to include this level, and the other levels of understanding in chemistry, more often in her lessons. However, while this multi-dimensional approach that she learned about and that the latest curricula were advocating for fit in very well with how she wanted to teach, and although the more recent professional development inspired her as well, she confessed that she has sometimes fallen back on her more teacher directed lessons, "because it [is] easy to do that."

Kristina shared that this was one of her big tensions in teaching as she wanted to be that more learner focused teacher, but with limited technology and time, she was finding it a struggle to conduct her classes the way she wanted to. Kristina felt that time within the classroom and also preparation time were the major reasons for her occasionally falling back on her teacher directed chemistry lessons. I could identify with Kristina on this level as well, as this was often

the reason why I struggled to keep a more learner focused classroom environment. I was never happy with my more teacher directed lessons, but I used them when needed just to get through some content when time was limited. Kristina shared though, that although she was not entirely satisfied with her teaching all the time, there were times when she was just thrilled with her teaching – usually when she used a more learner focused approach and the students were showing their understanding of a particular concept. This often meant, though, that some outcomes would have to be left out, in order to cover other outcomes in a more multi-dimensional way to increase that student understanding.

When Kristina shared this it made me realize that there is something very wrong with a curriculum in which it is difficult, if not impossible, to cover all of the outcomes thoroughly. It alerted me to the fact that it might be far better for the students if a smaller number of outcomes were covered more thoroughly and in more detail, as I presume Kristina is doing. Kristina confesses as well that the recent divisional push for assessment has taken time away from her using multiple modes of representation more often and that she has been 'side-tracked' a bit. She has also experienced some resistance to the multi-dimensional approach to teaching chemistry concepts from those students who prefer the more procedural teaching and learning, which makes it even easier to fall back on her more teacher directed lessons as well. And this, I could certainly identify with as well.

Though Kristina has struggled, the CRYSTAL professional development has had a huge impact on her teaching, which came through in her story overwhelmingly. I was both inspired and encouraged by that – that the resources and the professional development sessions were

changing Kristina' thinking and were inspiring her towards greatness. And, with so much professional sharing that went on – something Kristina was quite appreciative of – it shows that these long-term professional development sessions are great for building that community of teachers who can share and learn together.

Finally, my conversation with Kristina has led to my own development as a teacher as we spoke of some common tensions that plague our everyday teaching and as she shared with me her personal story of how she struggles to settle those tensions, and how it has led to her own growth as a teacher. I also admire Kristina for her admission that she sometimes teaches in a more teacher directed manner and is not always where she wants to be in her teaching practices. Kristina's story also inspired me with her obvious excitement and passion for teaching and her instantly recognizable goal of being a lifelong learner and to share her love of science and chemistry with her students.

4.3.4: Teacher D - Holly

As with all teachers I interviewed, Holly experienced some tensions throughout her teaching career, and how she continues to settle these tensions is a result of years of professional identity formation from the time she was a student in school until her current role as a teacher. As Holly looked back on her own experiences as a student she was reminded of what eventually brought her into the teaching profession.

Holly's decision to enter the Faculty of Education at the University of Manitoba was the direct result of having worked as a 'lab demo' in university while completing her Bachelor of Science degree. She grew up having no idea of what she wanted to do with her life, but found

that she was “pretty good at sciences and chemistry” and really enjoyed her science classes in high school, thus it was a logical choice to study sciences and chemistry at university. Holly’s experience as a lab demonstrator teaching first-year university students alerted her to the fact that she really enjoyed interacting with students and enjoyed explaining things to them. For the first time in her life, she had considered a career in education and went directly into the education faculty.

When Holly said that she really enjoyed her high school science classes, I was curious to find out what her science teachers were like and how they taught, because perhaps, deep down, her teachers may have inspired her in some way that she wasn’t aware, into considering the teaching profession as a career. Holly mentioned one teacher in particular who was both her chemistry and biology teacher, and it was both his ‘odd’ personality and his teaching that interested her. “He had some interesting stories to tell and had a good application of the science more than just teaching us about content.”

Now while Holly had an interesting high school science experience and a good university science experience, there didn’t seem to be any significant experiences with teachers or instructors that led her into the teaching profession other than her one experience as a lab demonstrator. And, although all of these experiences contributed to her evolving professional identity, I was wondering if perhaps her experiences in teacher education had a more significant impact on her than did her earlier experiences. I then asked Holly what she saw as being the role of a science/chemistry teacher and what was important to her at that point when she entered teacher education. Holly’s answer focused almost solely on the importance of student understanding in science. She learned and would follow the ‘activating, acquiring, applying’

sequence during her practicum and aimed to do many short demonstrations or discrepant events for students to try to increase their understanding in science. "I was trying to focus on the understanding and getting them interested in science and getting little applications of science ... and then trying to see or change their ideas about things."

From my discussions with Holly it appeared that she was very focused on the student, but I was very interested in hearing from her, whether she considered herself to be more content focused or more learner focused, on a scale of 1-10. Holly thought she would place herself somewhere in the middle – "maybe a five" – despite the fact that she would do a lot of demonstrations for the students to enhance their understanding of the concepts being taught.

During Holly's teacher education experience, then, she was obviously influenced to focus on student understanding and she seemed to really buy into that and made the effort to do those short demonstrations to enhance student understanding. Her professional identity seemed to be evolving during her teacher education experience such that she recognized what she needed to do to enhance the learning experiences of the students.

I then asked Holly to share about her first few years of teaching so that I could understand what further influenced her and what was shaping her professional identity. Specifically, I asked Holly to describe her early years of teaching in terms of what her emphasis was and whether she focused more on the content or more on the student. I also asked her to discuss any tensions associated with how she wanted to teach and how she was actually teaching. Holly responded to my questions by first discussing how she approached the teaching of the content to students. She described her method as being a consistent approach to content such

that she would always activate the students' prior knowledge first. That seemed to be the main method she took away from teacher education, and was something she said she practiced consistently with her students. Holly also emphasized a few times in our discussions that she was always looking to change students' misconceptions about things. She also mentioned that she tried to focus on teaching using multiple representations in chemistry – something she learned from Dr. Lewthwaite as a student in the Faculty of Education at the University of Manitoba. She really used to focus on whether students were really understating the chemistry. "I used to be much more into thinking about my lessons and how I was delivering them and what I was doing with the content." When I asked again about any tensions she experienced in those first few years of teaching, Holly immediately brought up the tension of 'survival' in being a new teacher.

> I wanted to do more… little activities or more labs, and just not having time as I was always prepping the stuff, so sometimes the content that I would do ... you always default, I think. In the end it really is easiest to just give them notes, and teach them, 'Here, go work on the worksheet for the next half an hour while I go relax and try to figure out what I'm doing tomorrow.'

I could sense that Holly was frustrated with her teaching in the sense that she consistently commented that she was not doing enough in terms of the hands-on work or real-life applications with some of the content, although she still maintained her focus with the particulate level. "I would say doing the actual applications of it and where this fits into their lives ... I think that's still missing and it always was." Holly further commented that several of those 'application' outcomes get cut as a result of the lack of time to cover all of the outcomes, thus the applications

outcomes – the outcomes not deemed essential chemistry learning by some teachers – are the ones that get left out. Holly also mentioned that the 'applications' outcomes also require extra knowledge on the part of the teacher (extra knowledge that she doesn't feel she has) and require more marking if given as a research project – and so they end up getting cut for these reasons as well. Besides, she adds, "it would be harder to be consistent if it is on an exam so it ends up being sort of easier to get rid of."

Although the latest chemistry curricula is the only curricula Holly has taught, I was curious how she responded to the orientation of it since it would have been different from the curricula she learned in high school and also from the curricula she had studied in university. The curricula were quite a bit more content focused prior to this and so I was wondering how she responded to the latest curricula's orientation in that it advocated for a more multi-dimensional approach to instruction in chemistry and if it fit in with how she wanted to teach. Holly replied that she responded favourably to this latest chemistry curricula since it resembled the approach to chemistry teaching that she had learned in teacher education – using multiple modes of representations in chemistry. Although she has been frustrated with her coverage of the 'applications' of chemistry due to both the extra knowledge required and the time required to mark projects, she doesn't feel that the curricula are too content heavy in that she wouldn't have time to focus on all the different modes of representation. Often, what she has done, is switched some of the applications outcomes to topics she is either more familiar with or finds more interesting than the ones suggested in the curricula such as 'chemical disasters,' which her students find very interesting. Holly's concern speaks to the inflexibility in the curricula to perhaps provide optional topics of study for some of the applications outcomes.

While the introduction of the latest chemistry curricula may not have had a profound effect on Holly – due to the fact that it is the only curricula she had ever taught and also because the style of teaching advocated for in the curricula was already being emphasized in her teacher education courses – I was wondering how the CRYSTAL professional development impacted her professional identity and teaching practices. Referring to the emphasis in the CRYSTAL professional development sessions on incorporating multiple representations in the teaching of chemistry concepts, Holly responds that what she got out of the sessions were,

> ... the consistent methods I was getting from [Dr. Lewthwaite] in university. I would say I was sort of following through with what my focus was coming out of the U of M with ... looking at the different levels and ... setting up my lessons in that way. But I think ... it's been great to get back to some sort of focus on my science teaching. Like when I go to those workshops it's the only time that I start thinking again about 'What I am doing in my class?'... 'How I am approaching my science teaching?'

Holly also commented that she felt that the CRYSTAL professional development was so much more beneficial to her role as a science teacher than some of the more general professional development offered in her school or school division where the focus is on assessment or dealing with parents or dealing with aggressive kids, which is why Holly appreciates the CRYSTAL professional development in that she feels that it is the only time she really gets to think about what she is actually doing for her teaching. She also feels that

> It is a good reminder about what I should be doing because I find that I start to forget about that and just sort of concentrate on all the other things that you get run down with

> at school, so it's been a good reminder on ... how I should be approaching my class in a better way or to approach my class in terms of the ... same sort of consistent methods that I've always been getting from [Dr. Lewthwaite] ... reminding me of why I was doing things to begin with.

Since the last time I had interviewed Holly about 2 years ago, I was wondering, now 2 years later, how much the CRYSTAL professional development has continued to influence her and impact her professional identity. I asked Holly to discuss her current teaching practices and to discuss how much the multi-dimensional approach to chemistry instruction is still a part of how she teaches. Holly commented that while she still incorporates the multiple modes of representation wherever possible, her school division has really been on a 'technology push,' which has her struggling to mesh the multi-dimensional approach to chemistry instruction, with the incorporation of technology. Holly feels that some of what she learned during the CRYSTAL professional development has been forgotten to make room for "...the technology and how to incorporate the technology ... and not that you can't make the two correlate ... but they've also been trying to make it more geared toward different ways to go through your class." She also comments,

> It has been a little bit of a shift for me – changing the way I have been going about my classes, in that I think I have sort of lost the focus a little bit about how I used to think about how I wanted to set up my science class.

My sense from Holly was that she was still trying to incorporate all of the different dimensions of chemistry learning – the symbolic, the macroscopic, the molecular and the human element –

but that it was a struggle for her to maintain that focus while trying to satisfy her school division requirement that she focus on incorporating technology in various forms and to alter her style of instruction.

I began to wonder then if Holly was satisfied with her teaching and if there were any other tensions associated with the way she wanted to teach and the way she was actually teaching. One tension that Holly mentioned was that she felt that she wasn't preparing her students well enough for university in the sense that she feels that she explains everything to them so well that they are no longer able to extract information for textbooks or other print sources and understand the information on their own. Her students are very reliant on Holly explaining everything to them. Her students would say, "I need to hear you explain it" and Holly feels that she is explaining things too much and that her students are becoming too dependent on the way that she is teaching them rather than trying to read some text and figure it out on their own. An additional problem too, she says, is that everyone she is teaching is of low literacy, so she struggles with how much to 'spoon feed' them and how much to let them figure out on their own – wanting to ensure that her students are still well-prepared for university content-wise, but also giving her students the necessary skills to extract information and figure things out on their own.

Having heard from Holly how her students relied on her for explanations I was wondering how her students were responding to her style of teaching – in particular her incorporation of multiple modes of representation. I wondered if they responded favourably to her teaching style or if they preferred more procedural learning such as writing content notes and completing worksheets. Holly said they her students do really well with the multiple modes of

representation, likely because she has used the appropriate terminology with them from the beginning. She would say to her students, 'now I'll explain this at the symbolic level' or 'draw a molecular level diagram of this' which has made them in the habit of learning in this way.

Finally, I wanted Holly to just look back over the 6 years she had been teaching and discuss some of the major ways her teaching has changed and whether she had shifted her thinking or her teaching continuum as well towards a more student centred approach. Holly remarked that her teaching has become more student-oriented now as compared with her early years of teaching. She has students doing more lab preparation on their own, such as making their own solutions and she does quite a bit less of 'here are notes, now let's do practice.' She feels that now that she has had more years behind her, there is more variation in what she does with her students. She commented that "it used to be always a very straightforward approach ... we'll do the content and apply the content." But now, she says, she has her class doing labs more for discovery rather than labs in which they already know the outcome of the lab going into it. For example, in a simple lab like boiling water, she will have her students think about things such as 'how can you change this to get your graph different?' and 'what can you do to change the boiling point?' Holly feels that since she knows more about the content now compared to 6 years ago, that she can let the students have a little bit more independence in doing things. She says,

> It's hard I find at first if you're not really familiar with the content, you want to be more structured because in a way it's more controlled ... you know what's going to happen. If you give them too much leeway you get to a point where you can't answer their

> questions, so yeah, there is more variation now with what I do with them and it's probably become a bit more student centred than what it was previously.

It was obvious that Holly had experienced some tensions throughout the six years that she had been teaching, but that she continues to persevere through any changes or interruptions in her preferred method of teaching, which is to incorporate a more multi-dimensional approach in her coverage of essential chemistry concepts – a style of teaching she discovered in her teacher education program and one that was emphasized in both the latest chemistry curricula and also in the CRYSTAL professional development workshops she attended. Holly's professional identity has obviously been impacted by several things in her life, but has been affected more recently as she has progressed through these last few years of teaching.

My Response to Holly's Story:

During my conversation with Holly, there were several moments where I felt that I could really identify with her. I felt an immediate connection with Holly as our entrance into the teaching profession came about in a similar manner. Holly's work as a lab demonstrator in university while she was completing her chemistry degree alerted her to the fact that she really enjoyed interacting with students and enjoyed explaining things to them. This experience prompted her to consider a career in education, much as the same experience did for me.

Holly's story differed from mine, however, by the fact that her experience in teacher education was more aligned with what current research suggests leads to greater understanding in chemistry learning, whereas as in my experience, there was more of a content focus. Because

she was a later graduate, she had already been exposed to the current research that suggested using multiple modes of representation in the teaching of chemistry concepts. Holly then responded favourably to these latest chemistry curricula since it resembled the approach to chemistry teaching that she had learned in teacher education, and no adjustment in her thinking was necessary, whereas with mine there certainly was.

One of the big tensions Holly has struggled with, however, was the inclusion of the human element in her teaching. Holly was finding that several of those 'application' outcomes get cut as a result of the lack of time to cover all of the outcomes. Holly also mentioned that the 'applications' outcomes also require extra knowledge on the part of the teacher (extra knowledge that she doesn't feel she has). Besides, she adds, "It would be harder to be consistent if it is on an exam so it ends up being sort of easier to get rid of."

I could identify with what Holly was saying in this regard because teaching the applications of chemistry definitely requires additional knowledge on the part of the teacher. I too struggled with this sometimes and it wasn't until I worked at developing some of the online resources for the CRYSTAL chemistry website that I came to understand about so many applications of chemistry. This is a struggle I am sure for many chemistry teachers as it takes time to learn about all the applications, and also time to prepare course materials for the students. So, while the latest chemistry curricula suggest exposing the students to STSE issues and including the relevant applications to the content the students are learning, there is little in the way of practical resources in the curricula for this. Holly made a really great point regarding this. In addition, Holly mentioned that she felt the curricula were too inflexible in that there

were little options to cover what the teacher or the students were interested in covering. For example, if the outcome stated that students had to investigate air quality, then that is what they had to investigate. I too struggled with the lack of flexibility in the curricula to include some personal interest topics or topics that are of more interest to the students. Also, there is little time to include any extra applications should interest arise on a particular topic.

Another tension that Holly struggled with that I could really identify with was that she felt that she wasn't preparing her students well enough for university in the sense that she feels that she explains everything to them so well that they are no longer able to extract information from textbooks or other print sources and understand the information on their own. Her students are very reliant on Holly explaining everything to them. Her students would say, "I need to hear you explain it" and Holly feels that she is explaining things too much and that her students are becoming too dependent on her. I, too, felt that way when I was teaching and I found it difficult to release the responsibility to the students to take more control of their own learning. Holly's story reminded me of that constant struggle I had with myself to not 'spoon-feed' the students so much so that they would be more prepared for university.

Holly's story also alerted me to the fact that it is so important to get students into the habit of explaining and drawing and using those multiple modes of representation right from the beginning so that they get used to it and so that there are no surprises on their tests or on the final exam. Holly said that her students do really well with the multiple modes of representation because she has made it a priority to illustrate them to her students' right from the beginning of the school year, which has made them in the habit of learning in this way. I believe that if

students are resistant, part of it might be because they are not used to it and need more exposure. I would sometimes blame the students for being procedural learners and for being incapable of change, but with some persistence, just as it can be done with teachers, it can be done with students as well. Holly really opened my eyes to this.

Finally, my conversation with Holly helped me to grow professionally as I reflected on some of the common tensions that have become a part of our teaching practices and as I sensed and was encouraged by her persistence in trying to get back to the better teaching practices she learned in teacher education. Holly's story also inspired me as I sensed her excitement and enthusiasm for teaching chemistry and her obvious commitment to the teaching profession.

4.3.5: Teacher E - Tom

Tom has also experienced some tensions throughout his teaching career that he continues to wrestle with and attempts to settle, resulting in years of professional identity formation from the time he was a student in school until his current role as a teacher. As Tom looked back on his own experiences as a student he was reminded of what eventually brought him into the teaching profession.

Tom immediately credited his high school science teachers for bringing him into the teaching profession. He said that he had some really great science teachers in high school who seemed like they really loved their job and who were really passionate about science. In addition he was appreciative of the fact that they were really good at building relationships with the students. Tom spoke about his physics teacher in particular. Tom describes this teacher as someone who was extremely passionate about physics and who got along really well with the

students. He said that this teacher was able to explain things really well and made concepts really easy to understand.

> You always felt like he was on your side and you were working together to learn the material rather than him just lecturing you about it and you have to go off and learn it ... He was just an all-around awesome teacher and a pretty awesome guy too.

When I asked Tom whether he thought that his physics teacher was more teacher/content centred or more student centred, he replied that,

> I would say he was a bit of a mix to be honest ... I mean, we did plough through the content but he ... and I think this is kind of the purpose of what we've been doing with CRYSTAL is that ... he kind of made it made more about the inquiry so, he let the students kind of go and try things and try to learn them on their own and then we would discuss afterwards ... but you would investigate things and you would come back together as a group and work through it and what not and I really like the way that he had his classroom set up.

This extremely positive experience in his high school science classes got Tom thinking that teaching would be something he would like to do. Consequently, Tom entered the Bachelor of Education program after completing 1 year of general science studies at the University of Manitoba.

Wanting to get a picture of how his professional identity was forming, I asked Tom about what his experience in teacher education was like and what he saw as being the role of a

science/chemistry teacher. Tom commented that he thought that his purpose as a science teacher was to, in addition to having to teach the content, "promote science literacy and critical thinking and those inquiry skills that help students to understand the world around them." He also thought it was important to bring in applications and try to connect the content in the curricular outcomes to the students' everyday lives and to help them develop an appreciation for science, and the human nature of science. He thought it was especially important to "make [students] kind of question things a little bit more and not take things at face value, and try to understand and figure out what's going on when they see something in the real world." Tom continued,

> I'm a firm believer in if it applies, you know like science applies everywhere, so we should be trying to apply it to the students as much as possible ... bring it to their world so that it means more to them rather than just lecture and do an assignment and quiz and test.

I wondered, then, if Tom thought that this was the kind of teacher he would become; if it was possible to be that inquiry-style of teacher who would be very learner focused. His response did not surprise me. Tom stated,

> I think in education you have these grand illusions of what you're going to be and how easy it's going to be and you're going to step in and be that way, but there's a lot more to it, I mean, we all know that there are many more demands than just teaching the class. So, I mean there's a lot more going on than just trying to teach in that style and also, obviously, that inquiry style does take a lot more preparation and a lot more effort and a lot more knowledge and experience on your part, and I think that's something ... I mean

> even that's ... going into 10 years of teaching now, it's something I am still working on .... I'm working towards that and I think it is something I will be working towards for the rest of my career.

This comment from Tom prompted me to ask about his first few years of teaching and what sort of tensions arose during those early years that prevented him from becoming the teacher he wanted to be. Tom talked mainly about survival in those first few years. Having taught 10 different courses in the first year and a half of his teaching, he was spending a lot of time preparing his resources and just 'surviving.' He noted,

> It was kind of the rougher kids in the school so it was a lot of survival and just getting through the content and teaching the curriculum and just maintaining the classroom management, those kinds of things, and preparation ... obviously that's going to put a tax on that style of teaching that we were talking about.

While these first few years he taught mainly Grades 9 and 10 Mathematics, as he got into the higher mathematics course and into teaching chemistry, another tension he mentioned was the divisional exams in some of the courses he taught.

> I liked them, don't get me wrong, they had some benefits and there were some good things about them, but one of the bad things about them was that is forced you to make sure – good and bad I guess – it forced you to cover the material, but then it became about covering the material.

This, he thought, left him much less time for mastery of concepts and it was necessary to move on to other topics, even if the students did not understand was was taught prior.

> Whether the kids got it or not, you're moving on, so if they don't get it it's up to them to go and figure it out, and that's not the way I like to run my room. I like to make sure the kids understand something before I move on.

Tom continues,

> So in terms of chemistry education I'd rather teach for understanding ... I like to ensure that the students fully understand one concept before moving on to the next, because ... [chemistry] really builds and if you're not good at the basics, you're going to get lost further along down the line.

Having stated that, it alerted Tom to another tension that 'eats away' at him, and that is that if he can't teach all the content properly, he is worried about setting his students up for failure in post secondary education should they choose to study chemistry. Tom did say, however, now that divisional exams are no longer in his school division, that it has been easier in some ways, but that tension was very real early on in his teaching career.

Another tension Tom brought up is 'time.' He says that the curriculum is set up for 110 hours of instruction, but that if he's lucky he gets more like 70 hours with all the interruptions with assemblies, field trips, and "this, that and the other thing." He said it seems that there is always something going on – especially with the Grade 12 students. He says that currently, since there are no divisional exams, he is under less pressure to cover everything as he is the one that

creates the final assessment, so if something is missed, then the students are not going to be punished for that. But, he says, if he is not able to finish the course in its entirety, then he is not ensuring that his students are as well prepared for the next level as they should be should they choose to take chemistry, "so there's a fine balance there – it's tough."

I asked Tom at this point whether he thought that the latest chemistry curricula were too content heavy, to which he immediately replied, "yeah, it is." And Tom wondered, "what do you cut? What should be cut? Should anything be cut?" Tom continued,

> It just creates that bit of a tension there because you want to do right by the students especially the students who plan on going on and taking chemistry in the future, but you also want to make sure the kids are getting stuff before moving on, so it's trying to draw the fine line of mastery versus covering content and it's tough.

While discussing these latest chemistry curricula, I wondered how Tom responded to its orientation, being that it advocates for a more multi-dimensional approach that includes not only the symbolic level, but also the human element, the molecular level, and the macroscopic level. I wondered if it fit in with how he wanted to teach. Tom replied that he wasn't too excited about the Grade 11 course at first because there were a lot of things in the previous *Transitional* document that he really liked.

> I found the first two units of the new [Grade 11] curriculum to be mostly theory based ... A lot of the calculation stuff was taken out and at the time I was a math teacher and a chemistry teacher, so it kind of went hand in hand and I kind of liked ... the calculation part of it.

However, Tom said that after he got used to the new course he actually really started to like those more theory-based units because he found that there were a lot of other things he could do with it such as demonstrations, simulations and investigations and "I think it fits with what we are trying to accomplish" (referring to the CRYSTAL professional development emphasis). Looking back at when the latest curricula were introduced he realized his frustration was that he had only taught the previous curricula for 2 years and spent so much time preparing materials and resources, only to have it changed on him and causing him to have to re-prep the material. "I mean, it wasn't a huge, huge change, but there were some things that did go away and some new things that came in, and so it was a bit of change." Tom also commented that for some of the new topics he had to go and re-learn some of the chemistry – particularly for 'atomic structure' as it had been a while since he learned it. However, he said, "at the end of the day I have a better understanding of it now than I did then, so that's one positive, I guess ... I've never known chemistry so well."

Tom's mention of his struggle with the introduction to the latest chemistry curricula caused me to wonder how the CRYSTAL professional development shaped his professional identity and influenced his teaching.

> I think that I bring in more of those modes of representation you were talking about ... I use a lot more simulations, a lot more manipulatives, and I take a more inquiry-based approach. I try to, instead of teaching the concept and then doing the lab, I have tried ... focusing on doing the lab first and then teaching the concept after and letting the students discover the relationships like gas laws, for example, or colligative properties or heating and cooling curves.

Tom has found that when the students discover for themselves that it means a bit more to them and they tend to understand the concepts better. He also said that he uses some of the online CRYSTAL resources and tries to set up his labs using the kind of methodology that are set up on the CRYSTAL website where the students are working though a procedure and they are asked questions within the procedure, such as 'why are you doing this?' 'Explain this part.' 'Draw this at the molecular level.' "I find that that keeps the kids thinking as they are doing it – they're not just reading instructions and following a recipe, so to speak." Tom says that he is also starting to include a lot of the human element in his teaching, such as when he did a precipitation lab with his Grade 11 class and had them look at a water treatment plant and how the experiment could be used at a water treatment facility. He says that this type of connection "brings in that real world or human element."

I was also wondering whether Tom felt that meeting with the same group at multiple CRYSTAL professional development sessions for an extended period of time was more or less beneficial than going to a one time professional development session, and his response was in favour of meeting with the same group over and over because he began to make good connections with other chemistry teachers at these sessions.

> I am a one-man band at my school for chemistry. I am the only chemistry teacher, so there's not a lot of people to dialogue with, you know, about new ways of teaching this and new labs and activities ... And [with the CRYSTAL professional development] you can talk to other people in other divisions and other schools and get to know other people around the city and the province and you start making those connections and you build some relationships and you kind of see what other people are doing at other schools and

> in other divisions and it's kind of refreshing to hear that we're all kind of in the same boat.

Tom contrasts this with a typical one-day professional development session where "you don't get to know very many people and you go and you leave and it's done." He also appreciates that multiple professional development sessions with the same group keeps the things that are learned fresh in the mind.

> Whereas, you go to one professional development and 2 months later you have forgotten about it and you are back into your old rut again. Change is hard. I kind of like the way that we had it set up, where you go a few months in a row and it keeps you on the ball.

I wondered as well if the CRYSTAL professional development sessions caused Tom to reflect on his old teaching practices more than he otherwise would have. Tom replied that indeed he had, because,

> Anytime you see somebody else bringing in new ways of doing things, or even just talking to other people and finding out how they're doing it, it makes you kind of think about what you're doing and how you could be doing something maybe better and what could you be doing better and maybe you should be trying something like that.

Tom feels that he reflected on his practices not only during the professional development sessions, but also after he went back to his classroom. It stuck with him, and he would continually think, "maybe I should try it this way" and think more about including that human element level in his teaching.

It was obvious that the CRYSTAL professional development workshops influenced Tom's professional identity and his teaching practices and so I was wondering if, 2 years after that professional development had ended, he was still being influenced by what he had learned and if he was continuing to implement some of the resources and strategies he had taken away from the sessions. Tom feels that he has been lucky in that he has been teaching some online courses in the last few years that have been less time consuming than in-class courses. Thus, Tom has had more time to take some of the ideas from the CRYSTAL professional development and also develop some of his own materials and seek out other resources as well. Although he said there were "lulls here and there," where he got 'comfortable' doing the same old thing in his classes, he would sometimes say to himself 'why don't you try something different next semester?' Tom feels that, in general, he has been incorporating manipulatives, activities and the different modes of representation "more often as time goes by."

> It's an ongoing process, right? It's never going to be perfect. It's one of those things you have to continuously work at and you're always trying to improve or seek out new things or you find the students are going through one activity and you think it's all great and they find ways to, not mess it up, but they find places where they get hung up on something or there's something where they can re-shape the questions or the procedure or the explanations or whatever, in a different way so that they would ... you know, so it comes across better. So you're always kind of improving and trying to find new ways of bringing it in.

Now that Tom had been exposed to both the latest chemistry curricula and also professional development to support the latest curricula, I was wondering whether he thought

that he had shifted his focus towards a more student-oriented approach. I asked him to place himself on a scale of 1 to 10, 1 being teacher focused and 10 being learner focused, and asked him where he would currently fit in. Tom replied that he would still be a five or six. "I am still kind of in the middle ... always trying to work towards more learner focused. I want to try to put the energy in the students' hands rather than in my hands." When asked his reasons for placing himself in the middle of that continuum, he responded that there's still a lot of teacher focused instruction in his classroom, "I mean, there's a lot of content, the Grade 12 course is huge – a big, big course ... If you want to cover the course, sometimes you've just got to chug through it."

Another significant tension that Tom brought up was that in the school division in which he teaches, all science (and mathematics) courses used to be given extra time to cover, such that the chemistry course, for example, was allotted 170 hours instead of 110. The problem with this, he says, is now that this is no longer and that each course is given the standard 110 hours cover the material, is that over the years, he got used to taking the outcomes deeper.

> You could take them in a lot of different directions ... We did take the outcomes a little deeper than they were intended in the *Transitional*, and then so now we are used to teaching those ... maybe different twists on an equilibrium question or something, and maybe we didn't need to go that far. But now that we did it for that number of years, we continue to do it because we think that's the way it needed to be.

This also became a concern he said with the divisional exams that were also around during that time in that because various people created the exam, every year something new would almost be added, because everybody's got their own little twists. Tom feels then that,

> The exams get a little bit more and more difficult than the outcomes really suggest ... So people start teaching those things in their courses because, they think 'Oh, it's on the exam.' So the content that you're teaching actually increases more than the curriculum is actually showing you.

As a result of the switch back to 110 hours, Tom said he had a really hard time finishing the course. "Grade 11 I can finish, Grade 12 – it's tough. It's very tough." However, with divisional exams now a thing of the past, he has less pressure to cover the outcomes in such a broad manner so as to include all of the 'extra's' that the exam creators were including on their exams. Although, Tom indicated that he still has to drop some of the outcomes, something which was done collaboratively with all chemistry teachers in the school division. He even admitted that in his current semester, he won't even get to an entire unit – electrochemistry. "It's horrible. I love that unit. But that's where I'm at right now."

Having discussed all of these tensions, I thought it fitting to ask Tom whether he was satisfied with his current teaching practices. Tom's primary response was,

> I think all in all I am more satisfied with my teaching because I am going to a more student centred classroom, but I mean there's still those tensions there and I think the biggest one is the covering the material and finding that balance between mastery and just getting through it.

Tom also brought up some other tensions such as student motivation and assessment practices which frustrate him on a regular basis. He finds it really difficult to move onto a new topic when he has students not handing in work, and not knowing where they are at with the material. Tom

alluded to a new policy coming out in the school division in which he teaches whereby students may not have the option of handing in assignments long after a unit is over, as is the case currently.

Tom mentioned several times that he was continually working at incorporating the different modes of representation in chemistry as opposed to the old procedural learning style, and so I was wondering how his students responded to that. I was wondering if some students would still rather have that cookbook lab and step by step notes and worksheets, or whether they have responded positively to this unique style of instruction that Tom has been working on during his teaching career. Tom replied that there are definitely a few students in every class who prefer that procedural learning style, and who say 'show me how to do it and I'll just do it.'

> They like to read, write and regurgitate ... I think you're always going to have those. And you can see it in their eyes when you ask them to explain why or to show it, 'draw it for me, draw me a picture, or explain at the molecular level' ... and you can see they are uncomfortable with that.

However, he says, he thinks that students are getting the idea that in chemistry, if they *understand* what is going on at that molecular level and can explain it and draw it and see it, then they are taking that abstract concept and making it more tangible. Tom tells his students that if they can understand why, they can figure their way through a question rather than having to memorize how to do it. He also feels that since he has been using this multi-dimensional method of instruction in chemistry more and more, that students are becoming more acquainted with it and are responding more positively to it than they did initially.

Finally, I asked Tom to summarize for me the major ways his teaching has changed over the past 9 years that he has been teaching. I was hoping to get a better look at how his professional identity has evolved throughout his career. Tom's response was as follows:

> Well ... I have started trying to put more energy and more ownership back onto the kids, onto the students, trying to get to that point where there is less time spent lecturing, modelling and practicing and putting more time into investigating. And I think what's going to contribute to that is more experience, more time, more comfort level, more of these professional development kinds things we've been doing along the way, more dialoguing with colleagues, those kinds of things. But it's ... more about trying to bring it to that student centred approach to teaching rather than teacher centred.

It was obvious that over the 9 years that Tom has been teaching that his professional identity has evolved and is continuing to evolve as he wrestles with some of the tensions he has experienced and as he continues to strive towards that more learner focused method of instruction that he desires in his classroom. Both the introduction of the latest chemistry curricula, combined with effective professional development to support the curricula, caused some major shifts in Tom's thinking and his teaching practice, illustrating that teacher change, although gradual, can occur when the necessary supports are put in place.

My Response to Tom's Story:

During my conversation with Tom, there were several moments where I felt that I could really identify with what he was sharing – both in what he believed to be important in his role as a chemistry teacher, and also in his teaching experiences with regards to those early survival

years and with the divisional exam pressures. With regards to what he felt strongly about in his role as a science/chemistry teacher, he thought it was important to bring in applications and try to connect the content in the curricular outcomes to the students' everyday lives and to help them develop an appreciation for science. This was first and foremost on my mind when I taught science and chemistry as well. I wanted students to love science and have an appreciation for science – something that I believe can only be achieved by connecting science to students' everyday lives.

Tom also reminded me about those first few years of teaching and how the focus was mainly on survival. As much as both Tom and I thought it was possible to begin our teaching career with a full-on student focus and teach using multiple representations in chemistry, it really wasn't. And as Tom states regarding his first few years of teaching,

> It was a lot of survival and just getting through the content and teaching the curriculum and just maintaining the classroom management, those kinds of things, and preparation ... Obviously that's going to put a tax on that style of teaching that we were talking about ... (Referring to teaching using multiple modes of representation).

I think we both had these grand illusions of what kind of teachers we going to be and how easy it was going to be, but there were just so many more demands than just teaching the class.

One of the other big tensions Tom has struggled with, and one I could identify with as well, was the divisional exams in some of the courses he taught. Tom says regarding the divisional exams:

> I liked them, don't get me wrong, they had some benefits and there were some good things about them, but one of the bad things about them was that is forced you to make sure – good and bad I guess – it forced you to cover the material, but then it became about covering the material.

I could really identify with what Tom was saying here. It really became about covering the material. That's what his focus was in his first few years, as it was with mine. That's about all we could focus on with all the pressure and the competition between teachers for the best grades on the divisional exams. And, because the whole curriculum had to be covered in its entirety, it left little time for mastery of concepts for the students because you had to move on to the next unit so quickly before real understanding could be achieved for the students.

Another tension that 'eats away' at Tom is that if he can't teach all the content properly, he is worried about setting his students up for failure in post secondary education should they choose to study chemistry. I, too, worried about this when I was teaching.

Also, like other teachers, Tom mentions 'time' as a primary concern in his teaching. He says that the curriculum is set up for 110 hours of instruction, but that if he's lucky he gets more like 70 hours with all the interruptions with assemblies, field trips, and "this, that and the other thing." He finds he is constantly trying to draw the fine line of mastery versus covering content.

In addition, in my conversation with Tom, I really appreciated his honesty when he spoke of still being in the middle of the content focused versus learner focused continuum. Tom specifically responded that there's still a lot of teacher directed instruction in his classroom, "I

mean, there's a lot of content, the Grade 12 course is huge – a big, big course ... If you want to cover the course, sometimes you've just got to chug through it."

Finally, my conversation with Tom helped me to develop professionally as we shared a lot of common struggles having taught in the same school division. Through Tom's story it was both interesting and insightful to hear his take on teaching in a division that held teachers to such a high standard. We both agreed that this was not necessarily a bad thing, but just hearing how he dealt with some of his struggles caused me to reflect on and learn from his experiences. Tom's story also inspired me, that with only 9 years of teaching behind him, he was 'on-board' and embracing change, and was still looking for opportunities to grow and improve his practice.

4.3.6: Teacher F - Kate

Like the other teachers I interviewed, Kate has also experienced some tensions throughout her teaching career that she continues to wrestle with and attempts to settle, resulting in years of professional identity formation from the time she was a student in school until her current role as a teacher. As Kate looked back on her own experiences as a student she was reminded of what eventually brought her into the teaching profession.

After high school, Kate studied sciences at university and was fairly sure that her 'dream job' would be working in a lab. Kate realized, fairly quickly, however, that she did not like it at all, finding that she needed more people in her day to day interactions. Consequently, with urging from her advisor's wife who was a teacher, and with the knowledge that a friend of hers was going into education, she applied to the Faculty of Education After-Degree program at the University of Manitoba following her degree in chemistry. So, while it "wasn't really in the

plans," perhaps the fact that her parents were also both teachers, combined with the urging from two different sources led her along this career path to becoming a teacher. It was also, she decided, "something I could do with my chemistry degree that I already earned."

After learning that her parents were both teachers, I was interested in learning from Kate, what her experiences were growing up and if, in fact, some of these experiences may have contributed in some small way to her decision to become a teacher. I learned from Kate that her mom taught elementary school and what Kate remembers most is the in-service days where she would follow her mom to school and help her in the classroom. She remembers, in particular, getting to write on the chalk board and cleaning the chalk brushes. Kate loved being in the school with her mom. Kate also remembers that her mom had classroom pets that she would take home every summer, and that many students would come to her house to visit the pets. Kate describes her home and school experiences at this time as "a very positive environment." Kate's Dad, on the other hand, was an administrator, so when Kate followed him to work, he was usually in the office organizing things. Kate fondly remembers having summers off as a family "which also appeals ... you have to say that." And she remarked that the environment at home "was always sort of educational ... learning was always of importance at home."

Kate then went on to describe the teachers she had in school – both the ones she considered inspirational, and those she considered not so inspirational. Kate spoke of her mathematics teacher first. She was really struggling with calculus, and her teacher pulled her aside one day and told Kate that he was there to help her and that whenever she needed that help, to just let him know and he would be there at lunch time, after school, during a spare – whenever. And Kate credits him for getting her through that course. "And I'll always remember

that because I always thought I wasn't very good at math and I ended up doing quite well in that course and I think it was all due to him ... his persistence." She also had another teacher – her biology teacher – who made her realize that her love for basketball was negatively affecting her school work in that she had missed so many classes due to trips and games and wasn't able to perform as well in a course she really loved. This discussion with her biology teacher made 'the light go on' for Kate, and she realized, "oh yeah, I should probably focus more on catching up on my material and staying more in class." She recalls those instances in particular; those really good life lessons. And then Kate remembered her chemistry teacher, "and that was not very inspirational ... I don't recall doing any labs, it was all 'sit at the desk' and he would sit by the overhead and write notes all the time." It made Kate realize when she became a teacher that she had to consciously be aware of her own teaching so that she was not emulating the chemistry teacher she had in school, but rather focus on challenging herself to try and explore new ways of teaching. She mentioned that perhaps it was her negative experience in chemistry that inspired her to become a chemistry teacher so that she could give others a better experience and "show others how fun it could be."

At this point in the conversation, I asked Kate to describe her experience in teacher education and what she saw as being the role of a science or chemistry teacher and what was important to her at that time. Kate first discussed her experience with coursework, which she didn't find particularly useful at all – especially coming from sciences. "It didn't seem rigorous enough." Kate was referring specifically to the fact that after having taken some higher level biochemistry courses, she was forced to go back and take an introductory biology course to satisfy certain degree requirements. However, she did mention that the courses that were very

good were the curriculum and instruction courses. "I think it's because you were doing what you love, but also it was useful ... you were planning units, and you were learning different activities, and writing tests." Kate also mentioned that she thought that the practicum was where she would have preferred to spend most of her time. She found this experience to be very beneficial and she had great experiences in all of her practicum placements.

> All of my cooperating teachers were really helpful and I found it amazing ... Here you are student teaching for the first time, and they leave the room and I remember dropping my organic chemistry kit everywhere, I was so nervous. But that's where you get the experience.

I then asked Kate, focusing on her high school chemistry placements in particular, what her cooperating teachers were like and whether she thought they were more teacher/content focused or more focused on the student. "I think it was a mix of both of them." She remembers one chemistry teacher that had a really good relationship with the students, but also another who would typically sit by the overhead and focus on the content and not really interacting with the students. She said for the most part, most of them were really good teachers.

Hearing Kate describe her experiences both as as student in school and also in teacher education clearly illustrated her evolving professional identity. I was wondering, then, what Kate's early years of teaching were like. I wondered if she was more focused on covering the content or whether she was keen to do labs and activities with the students. Kate's first year of teaching in particular was stressful in the sense that she got her job 3 days before the school year began, so she didn't have a lot of time to develop what she was going to teach and how she was

going to teach it. Thus, she taught a lot of what the previous teacher had covered – using his binders and his recommendations for time allotments for each unit. "So, in terms of content, that was kind of my life line." Kate also taught some general science classes, which were, at that time, lab and activity based. In the chemistry portion of the course they would do about three experiments per week, and from the experiments generate their notes and ideas. "So it was very different and I really enjoyed that course ... more inquiry-based, hands on, have them figure it out for themselves, for the most part. But for the chemistry course at that time the students worked through the 'Alchem' booklet. "So essentially it was 'here's your workbook' and we just worked on so many pages per day."

Kate also mentions that her early years of teaching were prescribed mainly by the department she was in.

> Being the new one in there, it's kind of 'here's what we are doing and we all do it the same sort of way and we all do the same labs at the same time,' so there was only so much you could do on your own.

It seemed to me Kate had little flexibility in that sense to try new things or do things her own way since the department all had to agree on how the chemistry course would be delivered.

So then asking Kate to still focus on her first few years of teaching, I asked her to discuss what the emphasis of her teaching was in terms of whether she was more content focused, or whether she was more learner focused and thinking about representing chemistry in multiple forms. Kate responded right away that she wasn't at all thinking that way. "I would say my emphasis was content." She mentioned that in her earlier years of teaching there was a

provincial exam in chemistry, "so that year I know it was 'pull out the curriculum, make sure we cover everything in the exact way we were supposed to cover it, so that we all do well.'" And also being a new teacher, she said she focused more on making sure she was teaching what she was supposed to and also building her notes and finding activities, making up tests – "things that we hadn't really done before." Although, influenced by one of her professors, she performed discrepant events quite often in her classes. "There was one year we tried to do a demonstration every single day, and it quickly tired out. I think it maybe lasted 3 weeks and then it was a little hard to prepare for that." The labs, Kate mentioned, were always a regular part of her teaching,

> But they came out of the curriculum and the content, so we only did it when it was a very important concept to stress – like something like mole to mole ratio, or ... distillation ... or a boiling point – like more confirmation labs.

Kate also mentioned that classroom management is an issue early on and that thinking about and teaching at the different levels didn't come until much later when she was working on her own Master's in Education and reading the recent research literature.

Speaking specifically then about the introduction of the latest chemistry curricula, I was wondering whether Kate was on board with what the latest curricula were suggesting, in terms of its advocating for a more multi-dimensional approach to teaching such as incorporating the human element along with the symbolic level and the macroscopic level and the molecular level. I wondered if it fit in with how she wanted to teach.

Kate replied that it did, indeed, fit in with how she wanted to teach.

> I think after reading all those articles it just made such sense. I looked over what I had been doing and realized it was all equations and memorizing algorithms or memorizing facts so, you know, to get them to understand it you have to go to the microscopic level and I just started doing that and, I am a visual learner, and I kind of questioned myself as to 'why haven't I been doing this more, in the past?'

Kate mentioned also that students seemed to be doing better with this method, "but the problem is they are not used to drawing, explaining ... I guess they would rather, just, 'Give me the formula and let me plug it in.'" Therefore Kate had to actually train her students on this method of instruction she was using and says that her first day of classes with students is explaining to them the different levels of representation and she gives them examples and lets them know throughout the course which of the levels she is focusing on and tells her students, "be prepared to draw what the particles are doing ... explain what is going on."

> So it's really becoming part of how I teach now. And if you look at their tests now ... instead of being more factual questions or algorithmic problems ... it's 'draw in a series of diagrams ... show ...' So, they're being tested – I would say more rigorously – and they actually understand it.

After hearing this from Kate, I wondered if she found that students were coming around and actually realizing that they were understanding better, or if they resisted at all. "I don't think they resist, because more of us are doing that, and a lot of my notes now have the diagrams in there, so they're used to it." And, she comments, that she finds that many students take advantage of using the diagrams because they can't often verbalize what they are thinking.

It was obvious that Kate was on board with what the latest curricula were suggesting and that her professional identity and teaching practice were indeed shifting towards more learner focused practice. I was also wondering then, how the CRYSTAL professional development sessions she attended further influenced her teaching. Kate immediately spoke of the resources she obtained from the sessions, commenting that,

> I use that stuff all the time ... There are new activities that I am now comfortable with that fit perfectly in places where I didn't have activities, or just looking at more examples for how to teach something. When you've been teaching for 20 years it gets a little stale in some places so it is nice to have something fresh that you can use.

Kate also spoke of the additional resources posted on the CRYSTAL website, stating that she often goes to the website to look for new activities or explanations for things and that she has given a lot of them a try. She said,

> If you go through my lessons you would recognize a lot of the CRYSTAL material in there ... There are a lot of them there that even if they are not that difficult I just never had the opportunity to see them before or come across them before and they fit perfectly.

One of the activities in particular that Kate mentioned was the electrolysis lab, with the two pencils, the batteries and the potassium iodide. A lot of the labs she had done previously with students were the ones that she was handed down when she started teaching, but they worked, so she just kept doing them. "So now you go back and ... draw what's happening in the beaker ... explain what the particles are doing ... going back and tweaking them so the students have to add

a little more thought." Kate also mentions that some of her colleagues who are newer to the profession have found the resources to be very beneficial.

In addition to asking about Kate's experience with the professional development sessions and how they impacted her teaching, I also wanted to get a sense of what she felt about having the professional development over a number of years and having a couple sessions a year as opposed to a one-day in-service. Kate particularly liked that the sessions were spaced far enough apart that it gave her a chance to go and work with the new material that she got, and then reconvene later on for a session on a different unit. She contrasts this with having multiple sessions several days in a row where it would be more information overload and it is likely that she would forget some things. Kate was also appreciative of meeting with the same group over the different years. "It was good ... We kind of built community ... It was kind of nice meeting people from other schools, to learn how they do it."

I also wondered if her attendance at the professional development sessions caused Kate to continually reflect on her teaching practices and to what extent. Kate's response was:

> It did, and it worked into our professional growth plan that we were going to work on the chemistry curriculum. So there were three of us that attended the CRYSTAL workshops and then we would go and take a day off and develop some of our units together using some of that material. So we worked on the gases unit, which I think was brand new, and I can't remember but we went to [the administration] and told them 'Here's what we want to do' and got the time to sit down with the curriculum and go through different activities and incorporate in some of what we had just heard or learned.

After hearing about Kate's reaction to the latest chemistry curricula and also her involvement in the CRYSTAL professional development sessions, it provided me with a clearer picture of her evolving professional identity.

I then asked Kate to tell me about her current teaching practices, so now 2 years after the professional development has ended. I wondered if she was still incorporating a lot of the new CRYSTAL activities and using the multi-level approach to instruction. Kate says that she is still using a lot of the CRYSTAL activities and, again, from Day 1 in her classes, instructs her students on the multiple modes of representation in chemistry.

> It's really been ingrained in me and my materials ... I would say even in the tests as well. If you look at how the tests have kind of changed and the assessment ... It's more focusing on different levels of representation and seeing if they can tell me symbolically or in words how different things are related or how they work.

It sounded to me that Kate was really comfortable, to the point where I assumed that she would be quite satisfied with her current teaching practices. However, I thought it best to ask her ... just in case I was wrong. So I asked Kate the question ... and, her response? "No, I'll never be satisfied with my teaching." Kate had always thought that she would teach for 4 years, get her courses set and then she'd be home by 4 o'clock and have a free evening. "I should have known better, I have parents as teachers! If they would have told me I would have more homework than my students, I may have rethought this!" Kate's latest adventure with respect to her teaching materials is transferring everything onto computer and creating PowerPoint presentations so that she can show students more of those multiple modes of representation.

> What I am loving, is you can animate it, so now here's my beaker and here is my sodium chloride and what happens to it when we put it in the water, so you can show it separating into different ions ... so the microscopic view is becoming more clear. You can also have different colors whereas if you're using overheads it's all black and white.

Kate also finds she can bring in that human element easier since she can throw in some clip art and video links as well into her presentations. She is finding she can bring more technology into her lessons since it is ready to go in her presentation, rather than having to go over to the computer, find the link she is looking for and, well, "why bother sometimes if it is only a 30 second clip." But if the clip is already embedded into her PowerPoint, it is much easier and definitely worthwhile to show.

I wanted to get back to some tensions now since Kate previously mentioned that she struggled when there was a provincial exam to cover the content and didn't have time for the multiple modes of representation as much. I am wondering if time is an issue for Kate or if she felt she could comfortably cover the entire chemistry curricula in the allotted time for each course. "You know, it still is a push to get it all in. We manage to cover everything, but in some places you wish you would spend maybe a couple more days or have done an activity." Kate also finds that they (as a science department) had to learn to let go of some things that are no longer in the curriculum that they really enjoyed teaching, but have also held on to some as well. This means that there are some outcomes that get less attention than others, and "we know we aren't doing it justice but it's because there are other things that we like doing [extra] activities for." What Kate is finding though, is that when she is really short on time, that the first thing to go is the activities.

> So for the solutions unit we've gone of mapped it out but we've had to pare out a few of the activities. Or what we've decided is we won't do it as a class but do it as a demo while they're working on this. So unfortunately those are the things that we take out and being second semester we know the exams have to be fair between the two, and we cover certain things in first semester so we have to maintain that for second semester. Again, we're always, I think, going to go for the content. Hopefully we are running out of time because we're doing lots of those activities throughout.

Another tension Kate reveals is the loss of teaching time due to school wide events ... "Today there was a 'march' ... and then they're doing a gym thing for Heart and Stroke. So it's those days that are creeping in there. If we had the teaching days it would be fine."

Finally, I asked Kate to summarize the major ways her teaching has changed over her years as a teacher so that I could get a final look at her evolving professional identity. Kate responded initially by saying that she has really gone away from focusing on the content.

> Now I realize that not all students are going into university chemistry and we have a large portion [of students] who are taking chemistry because, hey, it sounds neat and it was fun in Grade 10. So I've learned that we need to keep it linked to everyday and make those connections for them so that if this is their last chemistry course, they're getting something out of it – not just the rigor for university prep.

Another big change for Kate has been teaching using multiple modes of representation. "It's not all symbolic – notes and equations – and I find that very beneficial. They're getting a lot out of it that way."

Also, Kate mentioned that the focus in her science department lately has been on literacy, and they've been talking about how they need to teach students how to read science. Thus their focus has been on how to teach students to read problems, and asking them 'what information do you have? What information do you need? Where do you get the answers?' "So again it's more the processing skills or the problem solving skills and not necessarily the chemistry." So when Kate comes to a particular problem in chemistry, she will say to the students, 'we've seen this before ... Where have we seen this? And how did we solve it last time? What did that mean?' "Whereas before it was very cut and dry ... we're learning and here are the steps and here's how we do it. Kate has also tried more inquiry-based activities as of late, so instead of 'spoon-feeding' the students, giving them the chance to explore some ideas they might have. She says to her students, 'here is your lab problem ... see if you can design an experiment for this.' "We're putting them more in control, instead of me just saying 'here are the answers and here is how we do all this material.'"

It was obvious that over the twenty years that Kate has been teaching that her professional identity has evolved and is continuing to evolve as she wrestles with some of the tensions she has experienced and as she continues to work towards using the multiple modes of representation and more technology-infused lessons. Both the introduction of the latest chemistry curricula, combined with effective professional development to support the curricula, caused some major shifts in Kate's thinking and her teaching practice, illustrating that teacher change, although gradual, can occur when the necessary supports are put in place, and also when the teacher is highly motivated to embrace these changes.

My Response to Kate's Story:

During my conversation with Kate, there were several moments where I felt a connection between her story and my own. First, she thought that working in a lab would be her 'dream job' and it wasn't. I too, began work in a lab thinking that this was my calling in life, but quickly realized that, like Kate, I needed more people in my day-to-day interactions. And, like Kate, teaching was not in my initial plans, but it was something I could do with my chemistry degree that had a significant people component. Now, while our lives correlated on those particular aspects, I did not grow up as she did, with parents as teachers and where education was particularly valued, yet we both ended up as passionate chemistry teachers wanting to share a love of science and chemistry with our students, despite having had less-than-inspirational chemistry teachers in high school.

One of the big tensions Kate has struggled with was that she was really focused on content at the beginning of her teaching career. With a provincial exam in chemistry one year, she was not at all thinking about using multiple modes of representation in her teaching. Also, being a new teacher, she said she focused more on making sure she was teaching what she was supposed to be teaching and also building her notes, finding activities and making up tests – "things that we hadn't really done before." The labs she prepared for her students were also mainly confirmation labs as opposed to inquiry or discovery labs – another thing she struggled with. Her focus on the multiple modes of representation didn't come until much later when she was doing her own Master's of Education and reading the current research on chemistry teaching and learning. Also, the latest chemistry curricula and the CRYSTAL professional development

forced her to question why she was teaching the way she was and why she hadn't been teaching using multiple modes of representation before. The resolution of this tension as a result of further education, curricular change and professional development really helped Kate to grow and improve her teaching practice.

I could really identify with what Kate was sharing with regards to her early years of teaching and being so focused on the content and how, over the years, she was exposed to change that forced her to question why she was teaching the way she was and how could she improve her teaching practices. I, too, experienced this throughout my teaching career. And, as Kate shared, I sensed that she was really open to change and really wanted to always become better at her craft, and so I felt inspired by her in that way.

Another big tension that Kate identified in her teaching practice was 'time' – something I could easily identify with as well. She says "it is still a big push to get it all in." What Kate is finding is that when she is really short on time, that the first thing to go is the activities, which is unfortunate. But, her practice has evolved such that she really makes the effort to include as many activities as she can and "keep it linked to everyday ... so that if this is their last chemistry course, they're getting something out of it – not just the rigor for university prep." Another big change for Kate has been her teaching using multiple modes of representation. "It's not all symbolic – notes and equations – and I find that very beneficial. They're getting a lot out of it that way."

Finally, my conversation with Kate really impacted me and led to my own professional growth as I was encouraged that, despite some of her struggles, she has a really positive attitude

about educational changes. She seems to embrace change and run with it as opposed to resisting it. Any tensions she has experienced, she has attempted to settle and she has embraced them as true learning opportunities, which have contributed to her growth as a teacher. Kate's story also inspired me, in the sense that even after 20 years of teaching, she is still experiencing professional tensions and, consequently, looking for opportunities to grow and improve her practice.

4.3.7: Teacher G - Dave

Like the other teachers I interviewed, Dave has also experienced some tensions throughout his teaching career that he continues to wrestle with and attempts to settle, resulting in years of professional identity formation from the time he was a student in school until his current role as a teacher. As Dave looked back on his own experiences as a student he was reminded of what eventually brought him into the teaching profession.

Dave first responded by mentioning some of the really great science teachers he had in high school. There were some who he really looked up to and really admired for their passion. These great experiences in his science classes turned him towards these disciplines at a very young age and also inspired him to want to become a teacher. Following high school, he went into a faculty of education and ended up maintaining his focus on the sciences to ensure that he would be employable when he completed teacher education, and, in his words, "it paid off."

I questioned Dave a little bit further regarding his previous experiences and asked him about his motivations for wanting to become a teacher – wondering if there were any life experiences that contributed to his eventual entry into the teaching profession. Dave then

remembered that he was also inspired by his brother-in-law who was a teacher, football coach, and an all-around good guy. "He was pretty influential in my decision, but it was more, I would say, just some of the teachers I had and the powerful impact that they had within my life." Dave confessed that he was not a great student in high school, but some of the teachers he got along really well with made a difference for him and really brought him back towards school and made him realize his potential. I then asked Dave to describe one of his inspirational teachers, and he spoke of his physics teacher in particular, describing him as a "great guy, very enthusiastic, very energetic and loved his discipline." He says that he really "knew his stuff" and knew how to explain it to students in a meaningful way. Dave also described him as a very kind person. "One of the things that I was really kind of drawn to was his kindness ... He was just a really good guy overall."

Having heard a lot about what great people his science teachers were in high school, I was also curious to find out how they taught – wondering if they were vey content focused or if they incorporated a more learner focused instructional style. When I asked Dave how his science teachers taught, he replied that having gone through high school in the early 1990s, "a lot of the labs were photocopied handouts – I remember that ... kind of the 'cookbook' style." But he defends this by stating that the technology just wasn't around at that time and that we can teach differently now, because we have so much more access to technology. Dave actually found his teachers to be quite engaging with the students, for the most part, and he really made the effort to work hard for those teachers that he felt genuinely cared about him.

I then asked Dave about his experience in teacher education, wondering what effect the program had on his professional identity. "I found some of it very irrelevant ... I found it to be

very repetitive. If I had to write another paper on why I thought I would be a good teacher ... And by the time I was done I was tired of talking about my feelings. I really was." He did say, however, that some of the courses he took were really interesting, and he did walk away with some good material from his 'Curriculum and Instruction' courses. However, he found the philosophy of education and psychology-type courses to be very disinteresting.

> My feelings when I was in university was that just let me get into the classroom and kind of learn as I go, and anybody that I talked to when I was student teaching ... said 'you're going to learn a lot of things in the classroom but none of it is relevant at this point.' You know the best thing you can do is observe teachers, get involved, start student teaching, and learn how you are going to operate. And even I remember back when I started teaching ... – 9 or 10 years ago – it's very different from what I do now.

I wondered, then, what kind of teacher Dave thought he would become at that point when he was going through teacher education. He responded that, "I was a little deluded with that ... I thought ... this isn't so hard and, you know, I can do this ... maybe a little bit cocky and arrogant." Dave said that he learned pretty quickly, though, that to get the students where he needed them, requires a lot of work – something he learned even more so when he transitioned over to his current position in the urban high school. Dave admits that when he first began teaching, he was very keen and energetic, and wanted to try a lot of new things, and he still does those things,

> But I think you are just more willing to basically do everything at that point. I just remember being a little bit cocky and thinking okay, yeah, I can do this, and you know,

> you just learn a lot along the way – about how to deal with parents and how to deal with students and how you interact with students on any given day. It's all about reading people and you just become better and better at it the more you do it, the more you are involved with them.

I wondered as well if Dave had any inspirational professors or cooperating teachers in his experience in teacher education – someone, perhaps he was emulating his teaching after when he began in his first role. Dave mentioned his physics cooperating teacher in particular, who was a very good teacher and mentor to him. He described this teacher as very dynamic, who loved the discipline and loved working with students. Dave said he tends to gravitate more to people who are happy doing what they are doing as opposed to others who complain about the students and other aspects of the job. "It's not a positive environment and it begins to suck the energy away from what I love to do."

In hearing about Dave's positive attitude towards the teaching profession, I wondered if it was always that way – even in his early years of teaching. And I wondered how his teaching experience shaped his professional identity. I then asked Dave to look back on those first few years of teaching and discuss what the main emphasis of his teaching was and to consider whether he found himself to be more teacher/content focused or more learner focused. Dave responded that he was definitely more teacher focused at the beginning.

> I put a lot of effort into what I was doing, but you learn kind of as you progress through the profession that, you know, we need to put some ownership on the kids in terms of what they're doing and they need to take ownership for their learning as well.

Dave said that he worked very hard at the beginning developing his curriculum materials for the courses he was teaching such as preparing his binders and lessons, developing PowerPoint presentations and developing his labs.

> I was kind of a control freak, like, if I saw a lab that was half-decent in a text book somewhere I would recopy it or retype it myself just to put my own twist on it – just so that it made more sense to the students. Like sometimes there is this 'disconnect' and they don't really understand, okay 'what does this question mean?' Whereas if you have taught them a certain method or if you have given them, you know, a certain process of dealing with something then it kind of makes it more clear if you give them your own [version].

These initial years of teaching where there was so much to prepare sounded like it was a real source of tension for Dave; he was wanting to create more learner focused activities but the workload was extreme and he was feeling overloaded.

> I would say that it was very busy and it's tough and every first year teacher experiences this ... basically you kind of kiss your life goodbye for the first year or two. You are very, very busy. And it's tough to see the light at the end of the tunnel sometimes and you are thinking 'is it always going to be this way?' And it does get better and it does get easier you just learn to work more efficiently.

Having already mentioned this very real tension of finding time to prepare his teaching materials, I wondered as well if Dave experienced any other tensions in these first few years – perhaps pressures to cover the curriculum and time to cover the curriculum.

Interestingly, Dave described the curriculum situation as very 'loosey-goosey.' He says,

> we didn't necessarily follow a curriculum and I think we were even using an older curriculum in chemistry. The newer curriculum had come out 2 or 3 years previous and I think we were still teaching the old curriculum ... It was a very loose and relaxed atmosphere.

In fact, in Grade 10 science, Dave said he didn't even bother with the weather unit, and spent more time on the physics and chemistry to benefit those students who were going to study these subjects in post-secondary education. He said he had the flexibility to teach whatever parts of the curriculum he wanted as nobody was pressuring him to do otherwise. However, he realizes now that while the 'high-end' kids benefited from the extra instruction in physics and chemistry, the weaker students would have benefitted a little bit more from the weather unit. Also, since Dave was a part of a science team that worked together to create the final chemistry exam, they all got together to discuss what topics were testable, and which ones they didn't have time to cover. "It was very relaxed and it was kind of a comforting environment as opposed to coming to divisional exams which, as you know, is high energy and high stress." In fact, that very first year in his current placement he was still teaching the *Transitional* curricula, but had to change a lot of his materials and 'beef up' his content to prepare students well for the divisional exams that have traditionally been quite difficult. Dave said, was quite time consuming in that first year of his current placement.

In addition, Dave mentioned some other tensions such as the coaching expectation and the expectations that teachers be involved in other extra-curricular activities as well. While he

enjoyed this and said it was great because he made a lot of great connections with the students, "it definitely took away from my teaching."

After hearing about those difficult earlier years of teaching, I wondered how Dave responded to the orientation of the latest chemistry curricula and whether it fit with how he wanted to teach. Initially, Dave said, his focus was on revamping his materials to support the latest curricula. There were quite a few changes in both the Grade 11 and the Grade 12 chemistry curricula and so he had to 're-work' everything. I wondered as well how Dave reacted to the multiple modes of representation that the latest curricula suggested – incorporating the symbolic level, but also, the human element, the macroscopic level and the molecular level. Dave replied that he really enjoyed the molecular level – especially because with the latest technology it was possible to show the students some animations, which allowed them to understand the content much better.

> I mean with chemistry it's hard to know exactly what's going on, like if you're talking about melting point or freezing point, we don't really know exactly what's going on because you can't see the molecules, you know, doing what they're doing. But based on data we can kind of make that connection, and kids have a hard time making that graph and making that connection, but if you can show the kids some animations, for a lot of kids it really clicks.

It appeared that the introduction of the latest chemistry curricula caused some shifts in Dave's thinking and teaching practice and so I wondered as well how the CRYSTAL professional development sessions he attended impacted his professional identity and teaching

practices. It seemed as though Dave was already keen to include the molecular level in his teaching, but I wondered what else he took away from those sessions. Dave particularly mentions the exposure to some new animations and online labs that he wasn't previously aware of. He said he tends to use a mixture of both online and wet labs but likes what the online labs have to offer. "I'll do a redox titration that's an online lab. And it's way easier to do that than to try to get a redox titration to work with Grade 11 students ... it can be really challenging." Dave feels that some of the ideas he got from the CRYSTAL sessions really 'beefed up' his lab repertoire.

In addition to providing Dave with some great resources, I wondered if Dave found that attending the professional development sessions caused him to reflect more on his teaching practices. Dave replied that,

> Yeah, I guess in a way it did because ... any time you are given a new idea or a new concept, you think about what you've been doing and how you are going to change it ... When you are given all these new ideas you want to try and work them into your course somehow, so you have to question 'What am I going to take out?' 'How am I going to replace it?' 'How would I approach this?' So you really reflect heavily on it and it changes how you are going to go about teaching something like equilibrium.

And in addition to the many benefits of the professional development that Dave already discussed, I wanted to know as well what he thought of the continuous nature of the sessions that occurred over a few years, and the meeting with the same groups of people over and over, and

whether he found that to be more effective than, say, a one-day workshop. Dave responded very favourably to the continuous sessions:

> When you get to know people and you become friendly colleagues, you can feel comfortable to email somebody at any given time and ask 'hey what do you do for a lab to do reactivity series in redox,' or something like that... 'what are you guys doing over there for a demonstration on this?' You make those connections, you develop some friendships. It's much better.

Now 2 years after the professional development has ended, I am wondering if Dave is still being influenced by what he has learned by being a part of the CRYSTAL sessions. I then asked Dave to tell me about his current teaching practices and whether this is something he still thinks about now. Dave responded by saying that he found the CRYSTAL chemistry sessions to be outstanding.

> But I think we kind of tapped out that to its maximum at the time. I would like to see something like that come back in maybe 2 or 3 years and kind of get together with the same sort of people and see where we are at, and ask the same kind of questions of them.

Dave finds that he is just doing a lot of the same things now and is not really doing a lot of new things. These kinds of professional development sessions are where he gets his ideas from.

> It is through networking that you gain new ideas and you talk to other teachers. I find it is hard to just sit down and find things myself on the internet – if I am shown something I am way more likely to use it.

I was also wondering if Dave had progressed from more content focused to more learner focused in terms of his current teaching practices, and he replied that he is much more learner focused now. He feels that came with experience in that he is spending far less time preparing his teaching materials and can thus focus on developing more learner focused activities and spend more time interacting with and engaging with the students rather than just drilling the content into students' minds. "It becomes less and less taxing, so I put more of the emphasis on the students. As you progress as a teacher, I think it makes it easier." I asked Dave to elaborate on his response to include the reasons why he feels he is more learner focused now, and he feels that it is overall just the experience he has gained with everything between the professional development and just the experience he has had getting to know how to handle situations, and communicating with parents and communicating with students. "You get to become more familiar and more comfortable with [the job] and I think the students benefit from that."

I then asked Dave if he was satisfied with his teaching now. He replied that he doesn't think he will ever be satisfied. "I'm always changing things. You know, I think the minute your satisfied you might as well retire." He says he always wants to be better, he wants to do more things, and continue to challenge himself, "and that's the beauty thing about teaching is that you can do that." And, the other thing Dave mentions about teaching is that there is never one day that is identical to the last or to the next – they're all different. "It keeps you fresh ... I think that I am doing a pretty good job, but I also know that I want to do more and I want to be better."

I wondered then what some of the tensions were that were keeping him from being better. Dave mentions 'time' first and foremost. He feels that the workload and expectations are really high in his current placement as compared to what he experienced previously and he feels it is

"pretty taxing at times." He gets frustrated with a lot of the 'top-down' decisions that are made in the division that don't fit in with what he believes. He says that while divisional exams are no longer, the board immediately wanted to replace them with some kind of portfolio assessment or year-end project that Dave feels would not adequately prepare the students for exams in university.

> We [already] encourage them to enter science fairs. They do enough of that and I don't think that's the end all and be all in terms of assessment. We need to have them sit down and kind of assess what they know at the end of the year ... I don't think that we would be adequately preparing them for university if, you know, we started doing other things just to be cute and be hip and getting on with the latest jargon in education, and I find that we do that often in this division.

Being that divisional exams are no longer and to further understand Dave's experience in his school division and with the latest curricula, I asked him if he found that he was able to cover the outcomes in the time that he has. He feels that he is able to adequately cover the entire curriculum and still have a few days to review as long as he has a pretty average group. "If you have a below average group that maybe struggles a little bit it's a little bit more tough." He also notes that with any Grade 12 group he has in second semester, he finds it a challenge to complete the course since "The Grade 12's second semester are kind of mailing it in, so to speak, after May long [weekend] or after March break." Having said that, he really likes each chemistry curriculum and how they are laid out.

I asked Dave as well, how the students were responding to these latest curricula and whether they appreciate the multi-level instruction that the curricula advocate for. Dave said that he tends to focus his instruction on the molecular level – showing the students animations and having them draw the molecular view and explain what the molecules are doing. "There's quite a lot of work that goes into that – I am a big believer in [the molecular level]." Dave feels that his students really enjoy learning chemistry at the molecular level and that they appreciate that it gives them a different look at a concept. However, he still has the few students who will say 'give me the facts ... give me the equations ... let me work it out.'

Finally I asked Dave to summarize the major ways his teaching had changed over the last 9 years that he has been teaching, just so that I could get a better picture of his evolving professional identity over that time. Not surprisingly, Dave mentioned technology first. He is using more and more technology in his classroom and he will have a Smart Board in his classroom next year that he plans to make very good use of. "When I started I had a blackboard, so I would do a lot of the things on the blackboard and now I do most of my notes on PowerPoint and just tweak them from year to year." The CRYSTAL professional development sessions were also a huge influence on Dave – giving him many resources, animations and online labs. "There has been a huge evolution in teaching in the last 10 years and technology is the driving force behind it."

Dave also feels that in the absence of the CRYSTAL professional development, he would probably not be using the molecular level nearly as often in his approach to teaching chemistry concepts, and he would not have had the benefit of professional sharing that he experienced during the session, and for that, he is grateful.

It was obvious that over the 9 years that Dave has been teaching that his professional identity has evolved and is continuing to evolve as he wrestles with some of the tensions he has experienced and as he continues to work towards using the multiple modes of representation and including more technology in his lessons. Both the introduction of the latest chemistry curricula, combined with effective professional development to support the curricula, caused some major shifts in Dave's thinking and his teaching practice, only fuelling his passion for teaching even more.

My Response to Dave's Story:

During my conversation with Dave, there were several moments where I felt a connection between his story and my own. One thing that Dave said that I could identify with was his huge confidence going into his first teaching job. He thought that he could do it all and do it all well, as many of us do, but then realized very quickly that it is a lot of work to get students on board with what you are trying to teach them, and that there are many other aspects of the job other than just teaching that take time away from what you would like to be doing with the students – planning, marking and coaching but a few examples.

I also felt a connection with Dave with regards to some of the tensions he experienced in his teaching career. One of the big tensions Dave struggles with is 'time.' He feels that the workload and expectations are really high in his current placement and he feels it is "pretty taxing at times." He also gets frustrated with a lot of the 'top-down' decisions that are made in the division that don't fit in with what he believes. For example, he says that while divisional exams are no longer, the board immediately wanted to replace them with some kind of portfolio

assessment or year-end project that Dave feels would not adequately prepare the students for exams in university. What Dave said next really struck a chord with me. He said,

> I don't think that we would be adequately ... preparing them for university if ... we started doing other things just to be cute and be hip and getting on with the latest jargon in education, and I find that we do that often in this division.

I could really identify with what Dave was saying in this respect as I felt over the years that I taught, that our policies in the division kept changing with what the latest jargon in education was, and although I embraced the changes with a positive attitude, I often didn't understand the logic behind some of the decisions that were made.

Another major tension that Dave experienced that I couldn't relate to but could appreciate was that he experienced a huge, huge change going from his rural teaching position to his current urban placement in which there was much more pressure on him. Dave says of his former placement: "It was very relaxed and it was kind of a comforting environment as opposed to coming to divisional exams which, as you know, is high energy and high stress." In addition, Dave mentioned some other tensions such as the coaching expectation and the expectations that teachers be involved in other extra-curricular activities as well. While he enjoyed this and said it was great because he made a lot of great connections with the students, "it definitely took away from my teaching." I could definitely relate to Dave's feelings about this as well.

Finally, Dave mentioned the common tension that several teachers I spoke with have experienced and that I have experienced as well, and that is the few students who still say 'give

me the facts ... give me the equations ... let me work it out' as opposed to embracing the learning of chemistry in multiple modes of representation. I think that as teachers we all find these students who want procedural teaching and learning to be quite frustrating, but what I am realizing, having spoken to many teachers about this, is that we really need to train students earlier if we want them to embrace this more multi-dimensional type of learning when they get to high school.

More recently, Dave has felt that with more teaching experience behind him he is spending far less time preparing his teaching materials and can thus focus on developing more learner focused activities and spend more time interacting with and engaging with the students rather than just drilling the content into students' minds. "It becomes less and less taxing, so I put more of the emphasis on the students. He says he always wants to be better, he wants to do more things, and he wants to continue to challenge himself. I could really identify with Dave when he stated this. The CRYSTAL professional development sessions were also a huge influence on Dave – giving him many resources, animations and online labs and inspiring him to be that better teacher.

Finally, my conversation with Dave has contributed to my own growth as a teacher. When he shared his story with me and spoke of the many tensions he had experienced, he didn't complain about them but was more matter-of-fact when he spoke of what he needed to do to settle some of those tensions – a true sign of someone willing to embrace change and run with it as opposed to against it. I was both impressed and inspired by Dave's attitude towards change.

Dave's story also inspired me as he appears to be continually striving to improve his practice – a sure sign of someone committed to the practice of teaching.

4.3.8: Teacher H - Kevin

Like the other teachers I interviewed, Kevin has also experienced some tensions throughout his teaching career that he continues to wrestle with and attempts to settle, resulting in years of professional identity formation from the time he was a student in school until his current role as a teacher. As Kevin looked back on his own experiences as a student he was reminded of what eventually brought him into the teaching profession.

Kevin discovered early on in high school that he was good at chemistry, mathematics and physics, and used his knowledge and skills to tutor students in those subject areas. Tutoring is something he found that he really enjoyed, and he used these skills further to do some training of employees in his part-time work place in a meat department. "I just enjoyed working with people and developing a relationship with them and then there's that trust component." He also admitted that it felt pretty good when people looked up to him and respected him and wanted to learn from him. He also enjoyed the challenge of having to explain things to people in different ways to accommodate people's different learning styles. "And then later on I kind of realized that I was learning my craft way better than before because I was teaching it to someone else." But, interestingly, he didn't initially have education in mind as a potential career. After enrolling in sciences in university, he began to think about dentistry as a career option. However, after being put on the waiting list for dentistry in his second year of university, he decided he would broaden his career options and apply for dentistry (again) and also pharmacy

and education. "And education didn't really cross my mind, but I thought, 'I want to get on with life here.'" When education came up and the others didn't work out, it was clear that he was on a path to becoming a teacher. "And to be quite honest when I went to the education interviews ... just the sincerity of the facilitators and the type of people that were in the room, there was like a genuine caringness [sic] for people." Kevin was impressed by that and he remembers thinking, 'this is pretty neat, I like this sort of thing.'

Now while it wasn't Kevin's first career choice, it seemed that his past experiences tutoring urged him to at least consider the teaching profession as an option. I wondered as well, though, if there were any other motivating factors that urged him in this direction. I asked Kevin to elaborate on any life experiences, maybe early on, that might have led him to becoming a teacher that he may not have thought of initially. I asked him to think back to some of the teachers he had in school or any family members in the profession – wondering if any of them inspired him in some way. And, surprisingly, nobody stuck out for him.

> I remember they asked that question often in Faculty, you know like 'think of a favourite teacher that you had and what are some of the qualities that made them a good teacher' and I remember I always struggled with that question. And I mean, nobody really stuck out for me in elementary, middle school, high school ... I thought they were all very run of the mill, kind of the same.

While he says that none of his teachers were at all extraordinary, there was one instance, in his inorganic chemistry course at university, where he was quite inspired by his lab supervisor, who was a teaching assistant in the Faculty of Science.

> I just remember he had such a 'happy-go-lucky' personality like you could tell he absolutely just loved what he was doing. So he would always tell us about his student teaching, the funny things that happened and his experience so far. ... And we asked him about the lifestyle and he said ... 'you work normal hours and you get weekends off.' He was planning on going on trips with his fiancée in the summer and that sort of thing, and I mean that was kind of the icing on the cake, I guess. I just remember thinking when he was describing everything one day, and it's like 'I want to do what he's doing ... I want to do exactly what he was doing.' I basically just wanted to be like him.

Kevin said that it's like combining something you love doing with a lifestyle that also suits. As Kevin found out later, the reality is that there are really no free evenings and weekends after all, but I think overall, it was the actual teaching part and not so much the lifestyle that attracted him to the profession. It didn't have the huge start up cost of dentistry and the odd working hours of pharmacy that he had heard so much about. "It just seemed that teachers seemed to have more time to do things that they were interested in."

Kevin also had the experience of being a teacher's assistant in the Faculty of Science as well, and he really enjoyed the 'aha' moments.

> It's kind of funny ... they talk about that in the Faculty and I just remember sitting in class and kind of rolling my eyes, and thinking 'how many of those 'aha' moments can you have every day?' And ... I find there are actually quite a lot of them.

Having sensed Kevin's excitement for the teaching profession, I wanted him to describe his experience in teacher education, wondering what its impact might have been on his

professional identity. I then Kevin to discuss what he saw as being the role of a science or chemistry teacher and what was important to him at the time. First he spoke of the fact that he actually got a lot out of the program, contrary to what his peers experienced. He worked hard and "was willing to put in multiple more hours of work just look into things a lot more and just to get something more out of it." And it angered him to hear of his colleagues describing the education program as 'a waste of 2 years of their life.' It seemed that Kevin had the traits of a true teacher and lifelong learner. As one of his colleagues said to him recently, 'a good teacher can sit through something boring and still learn from it.'

Kevin found the 'Curriculum and Instruction' courses to be the most useful to him in teacher education. "Wow! I can actually use a lot of this directly in my class" he thought. And, having expected the teaching of these courses to be the same way he was taught high school, he was pleasantly surprised, recalling that his high school experience was far more traditional and content focused. Although, having experienced being in the confines of the IB program, he realized that it was likely the program and not the teachers that made his experience more traditional.

Going back to what Kevin saw as being the role of a science/chemistry teacher, he said that his beliefs align with what is stated in the general outcomes of the science curriculum documents. Specifically, he feels it is important to provide a sense of wonder about the world and how it works, get students ready for careers that they might need chemistry for and then use that knowledge and the understanding of the process of chemistry to address issues and different concerns around the world. "The two most important things are, to me, modelling how to build a

healthy relationship with people, and then also model just a love for lifelong learning." Kevin shares,

> I always open my class with the same introduction ... I share an interesting fact of the day, something that I've read or whatever ... I have this big list of stuff whenever I come across something. So, I mean it's fun for them and it's kind of a hook, it gets them listening to me, right? It kind of cuts out all those other distractions. And also, at the same time, I hope it models that I like to learn things that I didn't learn before and just keep doing that – never to be satisfied with what you know.

Having heard from Kevin his beliefs about how a science teacher should be and how he wanted to be, I was wondering what his early years of teaching were like and what issues or tensions he faced in those first few years, as certainly, these early years had an impact on his professional identity. His first year of teaching was overseas at an International Canadian college in Cairo, Egypt. He was supposed to be teaching chemistry at a Manitoba curriculum school, but that didn't work out and so he got a job at a college teaching 'engineering math' and 'calculus for business' – "courses that I am not qualified at all to teach." He describes the experience overall as a positive one, however, after a year he had enough of constantly fighting the corrupt systems of education and the government. He admits that he wasn't using any of the practices that he learned in education. "I was just trying to survive and fit into the university ways of doing things, which I think is just not pedagogically good at all." That was Year 1 of teaching for Kevin. The following year, he began teaching chemistry at his current school placement. Kevin mentions that,

> I think when I came out of faculty I knew how I wanted to teach things and I think I had a solid sense of what I wanted to do, but the first year of teaching chemistry ... I honestly ... I just wanted to get a handle of the outcomes, just getting through as much of the curriculum as I could.

He feels that now he is able to reflect on his teaching more and "design it a lot better", but at first he admits that he was teaching the way he was taught, which was mostly expository teaching – lecture, notes on the overhead, etcetera. Interestingly, when he recently connected with a few students from his first chemistry class that have since gone on to university, they said that his style of teaching really helped them as they were already used to the lecture style. However, he knew from a lot of formative assessment that they were just learning processes, and they were not ingraining the information, and they didn't understand it to a level that he wanted them to.

I wondered what some of the other tensions were that were preventing Kevin from teaching the way that he wanted to be teaching. Lack of time and resources were a huge tension for Kevin, he said. He was desperate for good resources in his first year of teaching chemistry, relying mainly on 'Google' to obtain any teaching materials and getting only symbolic-level teaching and assessment resources and 'cookbook-style' labs. Thus he ended up using resources from the web CT online chemistry course, since it was the only set of resources he could find with an answer key. "I found that a huge challenge ... how do I do this? I mean, I don't have time to design the homework and do the homework every single day."

The following year, Kevin attended the CRYSTAL professional development sessions and basically used the CRYSTAL website to obtain teaching materials and relied on a few other sources, if necessary, and gradually made the resources his own eventually.

> So, I mean, reflecting on those 2 years, I knew I was getting closer to how I wanted to teach in that in every lesson my goal was to hit all four dimensions of understanding in chemistry – so looking at the macroscopic level ... the symbolic level the microscopic level and then the human element or the application.

Kevin found that by incorporating all of the different levels of understanding in chemistry, that both he and his students were able to really enjoy chemistry as it should be enjoyed. "I think when [students] choose to take chemistry they expect to do something. I expected that too in high school but didn't really get that."

Now that Kevin was finding time to capture a lot of those extra dimensions in his teaching of chemistry, I was wondering if he felt that he had enough time to cover the whole curriculum, and include a lot of those multi-level activities as well. He responded promptly with a "most definitely not." Kevin's goal when he teaches the course is to cover everything, but he usually has to leave out a unit for the Grade 11 and the Grade 12 course. Kevin then described for me how he addresses a particular outcome.

> I find it's like you almost need a traditional type lesson to explain the concept ... plus I think the kids need something to look back on in order to get ready for the tests and the exam and that sort of thing. So, I do a lot of ... fill in the blank notes and examples, and that's kind of like the lesson. And, I'll try to have a demo ... and then a show them a

> simulation or we'll do a role play or some sort of manipulative activity to bridge the psychological understanding. And then the next day will be something hands-on that addresses the same concept ... or if I do two or three of those lessons then the next day is like an activity where ... the whole class is working.

Kevin found that those first few years of teaching were full of tensions. In addition to just surviving day to day with the workload involved in preparing lessons, he found it a challenge just to get to know how the whole school operates and where to find things and what chemicals were available, and how much of the chemicals were available, and safety considerations and so on. He also recalls that because his teaching was mostly expository in those first few years, he found that the relationships with the students also suffered.

> ... because I am just struggling to get through the content, so the kids don't really have a chance to work cooperatively, and I don't have a chance to get in there and ask them deeper questions or poke at their understanding a little more or challenge them. So then it's like they almost seem less motivated too ... but I realize I am only human too, and I know I did my best.

Since it seemed like Kevin was well-versed on the multiple modes of representation in chemistry, I was wondering what his response was to the latest chemistry curricula, which advocates for the use of multiple representations in the teaching of chemistry. I wondered how he thought about it compared to the *Transitional* document that he studied in high school and in a faculty of education. I wondered how it affected his professional identity.

> I can definitely say that the new curriculum totally aligned with the way that I wanted to teach. [Dr. Lewthwaite] would have us read papers on the pedagogy in chemistry, you know, the latest research with the ... we didn't have the tetrahedral-type of dimensions that seem to be taking over – we more had just the triangle of the three. But I mean, it didn't end up changing a whole lot because ... I quickly realized, 'what's this fourth element?' and I realized a lot of the times we do that anyways, [make it] relevant to the kids lives, so of course you put in applications.

The latest chemistry curricula, then, did fit in with how Kevin wanted to teach. He still feels though, that it could be improved quite a bit more still. He feels that it is not written for chemistry majors. He has major in chemistry but was only 2 out of 10 in his Faculty cohort who did, and he feels that the curricula might be too geared towards teachers with a solid background in chemistry.

> I mean they get this thing and they are basically relying on this. I mean, I think of myself, and you know I have taken a few chemistry courses and there's a lot of things in there, and I am scratching my head, I mean 'how do I do this?' And so some things that I find are specific, so I appreciate all the online links, kind of a little explanation of what we might find on that website. But then, I find some other things that are very general and I couldn't see how someone else could implement it. I am looking at the curriculum and it looks at outcome 9, 10 and 11 in Electrochemistry ... so it says, 'Activity or demonstration: Students construct an electrolytic cell using a solution of copper II sulphate, copper metal strip, nickel or quarter, and a 6-volt battery. The copper from the solution plates onto the nickel. Reversing the current removes the plated copper from the

> nickel.' I mean that's all it says for this activity, so ... it's like okay, 'Solution of copper II sulphate ... whoa ... what concentration?' So if you don't have trained chemistry, I don't see how anybody, even myself, like first year teaching, I wouldn't have any clue. Like '1 mol/L, would that be good enough?' That should still work ... 'How may nickels or quarters should I use?' Yeah, you can tell the person who wrote it maybe has been teaching for forty years and they just can do it but not as someone starting out.

Kevin feels that for several of the resources he would have to write out a procedure, test it out himself, and do the questions himself, "and if I want them to be good questions, that's going to take hours and hours, which is why I appreciate the CRYSTAL resources so much and ... in my opinion those are way more valuable than the curriculum itself." He feels that the extra background information provided in the CRYSTAL resources is a huge benefit to newer teachers or teachers without a solid chemistry background. "That's all I use, honestly, like if you look at my teaching binder. I hope funding keeps going for that kind of stuff."

Then as a result of the introduction of the latest chemistry curriculum and from his experiences in teacher education, Kevin was already oriented towards using the multiple modes of representation in chemistry. I was wondering how the CRYSTAL professional development sessions also influenced his beliefs and teaching practices.

> Even though I ... kind of saw myself on that track, it still influenced me so much ... It's set apart from anything I've been to (chemistry related) because it's like ... well I find [Dr. Lewthwaite] especially really forces us to think deeply about what our students might be thinking or what their misconceptions are, and for us to reflect on that. It's

> almost like it's doing like all these complex things at once, it's like, you know, testing diagnostically with the kids, like what their previous knowledge is.

He finds that a lot of the CRYSTAL resources are not just, 'what is this? What is that?' but rather, 'explain this' and 'if we were to change it to this, what would happen?' and then 'draw and explain this at the molecular level.'

> So it's doing that repeating piece, it's doing that diagnostic piece, and it's hitting the different dimensions of learning as well ... When I go through [the CRYSTAL resources] I love it because it does everything in one package that I can actually give students, which is fantastic.

For Kevin, the connecting with colleagues was "absolutely huge," like having those teachers there that have been teaching for a while – especially the good ones. He felt he gained so much from collaborating with other teachers of chemistry and hearing their ideas of how they approach certain topics in chemistry.

Now that the CRYSTAL professional development has ended and it is 2 years later, I wondered if those sessions were still impacting Kevin today. I then asked him to tell me about his current teaching practices, wondering, again, how his professional identity has been impacted.

> I will say that how I want to teach has not changed too much. I feel like I am way more effective just because I am aware of a lot more now – I know how to find it. It's almost

> like I've connected the dots, like, when I started it's kind of like these isolated things that you do. Now I find that I can see the big picture.

Kevin said he has really been focused on getting through the 'deep thinking' questions with his students.

> I gave them the pH activity where they have all the different well plates and the serial dilution so there's a lot of stuff going on there and they have to color all the things ... and they are asking me all these questions about this and that. ... I say you have to do this type of thing – you're not going to understand what's going on here unless you work through this.

Having heard Kevin talk about the approach he uses in his class, with the deep thinking questions and the multiple modes of representation, I was wondering how his students were responding to this and whether he could think of any other tensions preventing him from teaching the way he wants to. Kevin admitted that it has been difficult. The chemistry teacher that was there before him was very traditional and focused more on procedural learning and so the students have that expectation when they are in his class as well. "I find that they think it's hard and that's the word that goes around my school."

> And, when you think about what parents and what the general public want in education, they always say 'we want our kids to be able to think critically and analyze the situation and make good decisions.' And I feel like this [multi-dimensional] approach is ... how to do that, but then there's this resistance [from the students], and I almost have to explain a lot of the pedagogy before I start teaching.

In the first few days of class, then, Kevin is finding that he has to teach the students,

> ... alright there's this multi-dimensional approach, and we are going to be focusing on each of them in different ways. You have to make sure you understand the connections between all them and understand the different representations. How can we represent this concept in each of these four ways?

Kevin realized this after teaching the multi-dimensional way in his second year of teaching and found that students had no idea what to do when they came to a statement like, 'represent this at the molecular level.'

As Kevin reflected more on some of the tensions he has experienced, he brought up technology as a big one.

> I mean I want to show some kind of simulation or video or something pretty much every class – that's my goal. But I mean ... I have to rent a projector cart and then get it from another room and start it up and log into the computer and all this kind of stuff, and ... It's sad to say, but a lot of the times, like I have something and I want to do this, but I just don't. I'm just like, you know what, I can't afford that extra 10 minutes.

He also, commented on the fact that there is only one laboratory in his school, which poses a problem when he wants to do something more spontaneously. Kevin teaches in a classroom without a lab and so if he wants to do a demonstration or a lab activity, he has to make arrangements to switch classes, which can sometime be a hassle.

Another big tension that Kevin mentions is not having access to assessment that assesses the way that the curriculum is designed with the 'multi-level.' "I find myself teaching that way ... I just think it's such a big thing and then when I go to test or quiz, it's symbolic," Kevin states, agreeing that it's the easiest way to test and see if the students understand. He also feels that he is somewhat 'limited by the system.' "Like I need to punch in some marks, right? And I am trying to work with this thing that [Dr. Lewthwaite] cooked up with the whole ... the different dimensions of learning and the merit excellence chart."

And finally, after hearing about Kevin's teaching life story and all of the tensions he had experienced, I asked Kevin to summarize the major ways his teaching has changed over the years, hoping to get a final look at his evolving professional identity. Kevin again mentioned the importance of modelling relationship building and a love and enjoyment for learning for his students. This is an area in which he has made considerable leaps as his teaching has changed from mostly expository to instruction which is more learner focused.

> First year, I mean, because of the expository, the students ... there was that lack of relationship so they weren't just willing to dig in and understand and ingrain the concept more, and that was because there was little room for interaction and cooperative learning.

He also feels that he is now more a 'facilitator of learning,' rather than the 'this is how you do it,' 'I'll give you the tools to do it yourself.'

> I am realizing that the students want to enjoy doing things. ... Students, they want to do things and figure things out for themselves – especially in science – and I find that interesting even in the Google generation of teenagers where they want the answer now.

> ... I think they still find enjoyment in figuring something out for themselves because they don't really have a chance to do that too often.

One example that Kevin uses to illustrate this was during a recent lesson on 'electrochemical cells.'

> In building the electrochemical cells, I didn't have the chemicals and the stuff that the lab called for, so I thought I figured out an alternative that would work, and it ended up not working, and, you know, I was kind of starting to panic but then I found, I'm actually going to do it wrong I think every time from here on in, because what happened was the students figured out it was wrong and they were actually able to explain why it was wrong, and they came up with their own theory as to what might be the cause for it. ... It's such high-level thinking – and that's the whole point of science, right? Things don't work out and so you figure out what went wrong. Because you're so used to, kind of like, alright, I kind of know what's going to happen and then they are kind of shocked, right, and they go around in their groups and oh, 'what did you get, what did you get?' They start talking and it's just fantastic, and like I said before that's a formative ... like all these things come together – the formative, and then from that I know that that they understand all the concepts I want them to in doing the activity. So, I think that's fantastic.

It was obvious that over the 5 years that Kevin has been teaching that his professional identity has evolved and is continuing to evolve as he wrestles with some of the tensions he has experienced and as he continues to work towards using the multiple modes of representation and

stimulate that love for learning within his students. Both the introduction of the latest chemistry curricula, combined with effective professional development to support the curricula, caused some major shifts in Kevin's thinking and his teaching practice, further fuelling his passion for teaching.

My Response to Kevin's Story:

During my conversation with Kevin, there were several moments where I felt that I could really identify with what he was sharing. Kevin spoke of his experience tutoring and how he realized that he was learning his craft way better than before because he was teaching it to someone else. Kevin also spoke of his experience as being a teacher's assistant in the Faculty of Science, where he really relished in the 'aha' moments. These comments from Kevin brought back similar memories of my own experiences and demonstrated a connection between our stories. Kevin also spoke of two things of utmost importance to him in teaching: Modelling how to build a healthy relationship with people and modelling a love for lifelong learning – items that are of importance to me as well.

Kevin's story also reminded me about my own positive experience in a faculty of education. Kevin spoke of the fact that he actually got a lot out of the program, contrary to what his peers experienced. He worked hard and "was willing to put in multiple more hours of work just look into things a lot more and just to get something more out of it." And it angered him to hear of his colleagues describing the education program as 'a waste of 2 years of their life.' I could really identify with what Kevin was saying here as my experience in the Faculty was

similar in that I wanted to get as much out of the program as I could, despite others viewing the program in a negative light.

One of the big tensions Kevin struggled with was the mainly expository teaching he relied on in his first year of teaching. He didn't want to teach in this way – lecture-style and notes on the overhead, etc. – but lack of time and resources are what he cites as reasons for teaching in this traditional style. He also recalls that because his teaching was mostly expository in those first few years, he found that the relationships with his students also suffered. However, Kevin was able to settle these tensions after his involvement in the CRYSTAL professional development sessions as he was exposed to more currently promoted methods of teaching chemistry and was provided with teaching materials to support using multiple modes of representation in his teaching of chemistry. He was already oriented this way due to his experience in teacher education, but due to lack of time and resources was unable to teach in this way. He found later on that his relationships with his students improved when he was better equipped to deliver the chemistry courses in a more multi-dimensional manner. I could really identify with Kevin in that lack of time and resources were the main reasons why I, too, struggled with improving my teaching style, and I too, found that my relationships with my students improved greatly when my teaching approach improved.

Another tension that Kevin mentioned was that he usually has to leave out a unit for the Grade 11 and the Grade 12 course due to the large number of outcomes to be covered in each curriculum, which he would prefer to cover more in-depth, rather than just briefly touching on each outcome. I constantly struggled with this as well, as did a number of other teachers I

interviewed. Our conversation reminded me that one has to find the balance between mastery and covering the content, and that with such a large number of outcomes to cover, this will be a constant source of tension for teachers.

One thing that Kevin said that really impacted with me was that he feels that the current and past chemistry curricula are not written for chemistry majors. He made a great point and gave the example of one of the suggested electrochemistry activities that provided only basic information for the teacher such that if the teacher did not have a solid background in chemistry, it would be quite difficult to interpret. As he read through this one activity I realized that, indeed, without a degree in chemistry I would have had a difficult time interpreting the set-up of the experiment and I realized that other teachers may have had this issue as well and might maybe leave out the experiment altogether. I was glad that Kevin pointed this out as it points to a huge flaw in the curriculum.

Another tension that Kevin brought up, which I found interesting is that the chemistry teacher that was in his placement before him was very traditional and focused more on procedural learning and so the students had that expectation when they are in his class as well. Thus, for the first few years, Kevin felt that he had to explain a lot of the pedagogy before he started teaching using multiple modes of representation as the students were not used to this style. I was in a similar situation when I began teaching and so I could really relate to what Kevin was saying here.

Another big tension that Kevin mentioned that I hadn’t considered is not having access to assessment that assesses the way that the curriculum is designed with the multi-level approach.

It reminded me that testing cannot just be done at the symbolic level, but must also include the other levels of representation in chemistry as well.

Despite these tensions, however, Kevin noted that the latest chemistry curricula, the CRYSTAL professional development, and the CRYSTAL resources had a huge, huge impact on his style of teaching – motivating him to use multiple modes of representation when presenting each of the outcomes in the chemistry curricula.

Finally, my conversation with Kevin has led to my own professional growth as we shared some common tensions and as we reflected on and discussed resolutions to those tensions. We had a particularly insightful discussion that brought to the surface some things to consider in my own teaching. Kevin's story also inspired me, in the sense that his passion for teaching chemistry is astounding and that he is always looking for opportunities to grow and improve his practice.

4.4: My Final Response to the Participants

I have learned a great deal from the teachers participating in this study. Through my conversation with them, and as I have read and re-read their transcripts and created their stories, I couldn't help but reflect on my own teaching life story, and be transformed by theirs.

The participants' stories have demonstrated there are many parallels and some differences among all of our teaching life stories, but ultimately, their stories have brought to the surface some of the many tensions and struggles – some surprising – that the participants have experienced throughout their teaching journeys and that have contributed to their growth. Their

stories have thus challenged me, have inspired me and have enhanced my own professional learning as well.

As I read through and digested the participants' stories I was not surprised at the generous number of parallels between their stories and mine and also between each other's stories. As teachers, we all seem to wrestle with the same issues and have the same struggles, yet we usually continue to seek growth and we continually evolve as changes come our way and as the focus in the world of education changes.

The participants' stories again reminded me how our professional identities as teachers evolve. We observe others teach, we emulate them and then we find our own ways of doing things as we sort out our own beliefs about teaching and learning. When certain events such as a new curriculum introduction and professional development challenge our beliefs, it causes us to reflect more on our beliefs about teaching and learning such that tensions may surface, causing us to struggle to settle those tensions. In the midst of change and struggle, our professional identities continue to evolve, and we may experience changes in our teaching practices as a result.

I believe that it is these tensions that we as teachers experience that cause a particular disequilibrium in our beliefs about teaching and learning, and that this imbalance or internal struggle causes us to seek out ways to improve our teaching, thus eventually leading to teacher change. Without this imbalance in our thinking, however, we would continue on teaching as we always had, and as I did, with very little growth and development. This concept of 'disequilibrium' stems from the work of Piaget who suggested that when a person's experience

with their environment is a part of their mental model, it is easy for them to assimilate the experience. However, when their experience results in something unexpected, it results in disequilibrium which causes confusion or frustration in the person. Piaget believed that eventually a person moves back into equilibrium once their cognitive structures learn to accommodate the new experience. He believes that this is what drives the learning process as people do not like to be frustrated and will try to return to a more balanced state by mastering the new challenge (McLeod, 2009). Thus, when the latest curriculum introduction and supporting professional development challenged the participants' beliefs about teaching and learning and caused this disequilibrium in them, it ultimately led to growth and development in their practice, albeit to varying degrees. And, interestingly, as their beliefs were challenged, it caused these teachers to become even more dissatisfied with how they were teaching – wanting to improve their practice even more and to continue with more professional development and with their professional learning communities.

My own professional identity has certainly evolved through my conversations with the participants and as I have prepared this thesis, such that it has made me realize that in my last few years of teaching I was simply 'coasting' in my role as a teacher. I would say that I was improving slightly as my subject matter knowledge and thus my confidence improved, but my beliefs were not being challenged as I didn't experience the significant tensions of a curriculum change or becoming challenged through professional development as the participants had. Thus, my experience in graduate studies, and in particular through this study and through my conversations with the participants, has alerted me to the fact that this disequilibrium or

imbalance is necessary for teacher growth and development, otherwise one risks becoming stagnant in their role as a teacher.

I firmly believe as well that the participants' professional identities have indeed evolved – especially as a result of the latest chemistry curriculum introduction and supporting professional development that brought this imbalance in their thinking to the surface. Furthermore, I think that as they have experienced changes in their own thinking and beliefs, it is alerting them to these tensions and is propelling them towards further change as they realize that they still have a long way to go to become truly learner focused teachers. And, I think that the participants have perceived these changes in themselves as well.

The most significant aspect in which I feel that the participants perceived changes in themselves was in their professional orientation (Lamote & Engels, 2010), that is, in their beliefs about teaching and learning, which all participants perceived had shifted towards more of a learner focus. As I looked back over the participants' stories again, I became aware of some other aspects of teacher professional identity evolving such as their evolution into extended professionals (Lamote & Engels, 2010) as they worked collaboratively with others during the professional development sessions and sought to expand their knowledge and seek out new ways of teaching. As well, I believed that through their experiences during the professional development sessions, their self-efficacy and commitment to teaching (Lamote & Engels, 2010) improved as they gained the confidence to try out some new teaching strategies and resources.

Finally, I am thankful to have had these conversations with the teachers participating in this study, to remind me about both the struggles and also the successes, and to remind me that I

am not alone in my role as a chemistry teacher. My conversations with them also made me realize the importance of building that collegial relationship with others who are in the same role – to develop trust, to share stories with one another and to rely on each other for support – so that we can all continue to grow in our practice.

4.5: Chapter Summary

In this chapter, the participants were re-introduced by sharing their teaching life stories – that is, how their professional identities have evolved through their school and work experiences. As I created the participants' stories, I couldn't help but reflect on my own teaching life story, and be transformed by theirs. Following the participants' stories, I personally responded to their stories and found there were many parallels and also some differences between mine and their teaching life stories and also among all of our teaching life stories. But, ultimately, what their stories have made me aware of are the many tensions and struggles that they have experienced throughout their teaching journeys and that have shifted their thinking and have contributed to their professional growth. Consequently, through speaking with the participants and creating their stories I have been both challenged and inspired, and my own professional learning has been enhanced as a result. My hope is that the participants will continue to use the tensions they experience as learning and growing opportunities, such that their professional identities will continue to evolve along with the changes that have become a fairly constant part of the teaching profession. It is my hope as well that their teaching practices continue to improve and align with what is deemed to be research-based best practice (Awenowicz, 2009) in chemistry.

Chapter 4 highlighted the narrative inquiry analysis that was used to synthesize the data collected from the narrative interviews. The type of analysis selected was a 'narrative representation' in which stories were created from the interview data, followed by a thematic analysis of the data through my personal response to the participants (N. Wiebe, 2009). This chapter concluded with a final response to the participants that illustrated what I have learned from the participants and how they have impacted my own professional learning.

The final level of analysis and discussion includes my response to my research questions, followed by a weaving of my analysis with the research literature and Bronfenbrenner's (1979) Model of the Ecology of Human Development to better frame my understanding of the data that was collected (N. Wiebe, 2009). This final level of analysis is necessary because "narrative inquiry requires going beyond the use of narrative as rhetorical structure, that is, simply telling stories, to an analytic examination of the underlying insights and assumptions that the story illustrates" (Bell; Conle; Golombek, as cited in Bell, 2002). This analysis will be carried out in Chapter 5: Results and Discussion.

Chapter 5: Results and Discussion

5.1: Introduction

Chapter 4 outlined the analysis of the data collected from the narrative interviews and included the teaching life stories of the eight participants in this study, followed by my personal response to the participants' stories illustrating my own professional growth. This chapter provides an overview of the study and includes the answers to the six research questions posed and a data analysis with respect to the research literature and Bronfenbrenner's (1979) Model of the Ecology of Human Development. In addition, implications of the research for teachers, teacher educators, student faculty and Ministers of Education are discussed.

5.2: Overview of the Study

This study employed a qualitative narrative inquiry approach in which the teaching life stories of eight chemistry teachers were created from their responses given to questions asked during the narrative interviews. The narrative interviews conducted included questions that focused on the participants' teaching life stories; that is, what brought them into the teaching profession, what their experience in teacher education and their early years of teaching was like, and how their current teaching practices are. I was particularly interested in whether the participants' teaching practices had evolved as the latest curricula had, with more of a proclaimed focus on the learner. Recall that in the context of this study, the term *learner focused* is used to signify the instructional approach suggested in the preface to the latest chemistry curricula; that is, a classroom learning approach that is more constructivist in nature and that

focuses on generating student understanding of chemistry concepts through the incorporation of humanistic STSE issues and multiple modes of representation as the curricula suggests. Participants were also asked to discuss any tensions associated with how they wanted to teach and how they were actually teaching. The data collected from the interviews and the resulting created stories answered the research questions posed in section 1.5 as discussed in the following section.

5.3: Review of the Findings

As outlined in Section 1.5, six research questions were developed for this study and answers to these research questions were obtained from the data collected during the narrative interviews and the resulting teaching life stories of the eight participants in this study.

The first research question was: What were some of the influences/motivations on teachers' decision to enter the teaching profession?

According to Bronfenbrenner's (1979) Model of the Ecology of Human Development, structures closer to the individual exert the most influence on the individual and thus a teacher's evolving professional identity, which has been initially shaped by their childhood experiences in education (Lamote & Engels, 2010), can have a significant impact on the development of the teacher.

The qualitative data showed that the participants' decisions to enter the teaching profession were quite varied and included, but were not limited to, work with youth in tutoring, church and camp situations, which the participants described as positive, fun and rewarding

experiences. Many participants commented that a 'people' component was important to them in selecting their career path, either because they had some skills in connecting with people, or because they saw it as necessary for personal fulfilment. For some participants, it was an inspirational teacher who motivated them to enter the teaching profession, whereas for others it was simply a back-up plan or a last minute idea, or just something they could do with a science degree that they had already received. Finally, many participants also commented that the 'lifestyle' of a teacher was attractive, referring to Christmas, spring break and summer holidays in which they would not be required to work.

One participant, Kevin, had not initially considered the teaching profession as an option, but applied as a back-up to two other faculties he was interested in that were more difficult to get into. However, when he went to a faculty of education interview, he was pleasantly surprised by the people he encountered:

> ... Just the sincerity of the facilitators and the type of people that were in the room, there was like a genuine caringness for people. I was impressed by that, and I liked that, and I remember thinking, 'this is pretty neat, I like this sort of thing.'

For another participant, Kate, whose parents were both teachers, education was highly valued in her home growing up, but she initially thought that working in a pure science lab would be her dream job, and then quickly realized that she needed more people in her day to day interactions. And although it wasn't in her initial plans, she decided to enter a faculty of education to make use of her science degree and to satisfy her need for a people component in

her life. Perhaps it was also her experience with an inspiring calculus teacher who made her realize her potential and encouraged her towards the teaching profession:

> I was really struggling with calculus, and he pulled me aside one day and he said, 'I am here to help you and whenever you need that help, just let me know and I will be here at lunch time, after school, during a spare.' ... And he got me through that course. And, I'll always remember that because I always thought I wasn't very good at math and I ended up doing quite well in that course and I think it was all due to him ... his persistence.

For yet another participant, Kristina, becoming a teacher was always in the back of her mind. She would play teacher when she was younger, she taught youth in her home church, and she had some positive tutoring experiences that led her into the teaching profession after earning her science degree.

> I was able to tutor a young girl, or a young woman actually, in her high school mathematics and I absolutely fell in love with tutoring and with teaching her, and that solidified my decision to become a teacher. ... Just the idea of teaching and then seeing this girl's eyes light up when she finally got the concept that had been eluding her just thrilled me to pieces.

The qualitative data showed, as I expected, that there were various reasons why the participants chose teaching to be their career, and their reasons did not, as they have indicated, necessarily have to do with their previous schooling experiences. Bronfenbrenner's (1979) model would suggest, however, that the participants' professional identities begin to form as a

result of these microsystem-level childhood schooling experiences and may impact how they might eventually develop as teachers.

The second research question was: What were teachers' perceptions of their changing professional identities and teaching practice prior to and as a result of the introduction of the latest Manitoba chemistry curricula?

For this particular research question, the qualitative data showed similar responses between participants who had been teaching for around the same number of years. For this reason, the following discussion will be presented by first giving a general idea of what the data showed with respect to the teaching practices of participants early on and then when the latest chemistry curricula were released. This will be followed by a discussion of the results from the teachers who have been teaching for around 20+ years, around 10 years, and less than 6 years, as their experiences in secondary education and in a faculty of education varied according to their number of years in the profession.

The qualitative data showed that in general, the participants seemed to have these illusions of grandeur coming out of teacher education where they thought they would be great teachers and that teaching would be easy, and that they would be better teachers than their own science teachers were. However, their first few years in the profession were more difficult than they expected, and while in 'survival mode' they were forced to be more teacher directed and focus mainly on content due to either their lack of knowledge in the subject area, or the lack of time to consider and prepare to teach using multiple modes of representation in their teaching of chemistry concepts. This is not surprising, as Supovitz and Turner (2000) found that content

preparation was the most significant teacher factor affecting curriculum implementation. Also, a lack of content knowledge was found to have an effect on teacher confidence and the ability to teach chemistry in the manner intended by the curriculum designers (Kruse and Roehrig, as cited in Roehrig et al., 2007). For some teachers, it was just that they were not aware of some of the more learner focused ideas when they began teaching, or it was that the more learner focused ideas just weren't around yet (for the teachers who had been teaching longer).

When the latest chemistry curricula were introduced, it challenged the participants to shift their professional identities and teaching practices. However, as Brown & Edelson (2003) attest, a new set of curricula provides no guarantees of instructional transformation. As Bronfenbrenner's (1979) model would suggest, structures further from the teacher have less impact on the teacher. Thus a mandated curriculum document, a macrosystem-level influence, would not likely shift teachers' pedagogy directly, without any further offer of support. Now especially since it is a more humanistic STSE set of curricula which may challenge teachers' professional identities (Pedretti et al., 2006) and be a real challenge to implement, it could be the reason that these types of curricula are making "fewer strides in practice" (Pedretti et al., 2006).

The participants, then, were in general not satisfied with their teaching practices, blaming some of the other responsibilities inherent in the job (coaching, preparation, content knowledge, marking, administrative work, needy kids, classroom management, etc.), and it was likely that some form of support – resources and instructional techniques – would be necessary if the latest chemistry curricula would be implemented as intended. Fullan (1981) states that the implementation of a new program, in this context a new chemistry curriculum, will likely require

changes in materials, approaches and beliefs and that without these changes, implementation will not occur. Fullan (1981) also states that beliefs may be the hardest of the three factors to change since beliefs are based on the core values a person holds. Thus, as Fullan (1981) would suggest, a new curriculum introduction alone would not be enough to cause teachers to implement the latest curricula as intended. For those participants who were more change-oriented around the time of the latest chemistry curriculum introduction, it was more due to their experiences in graduate studies or their association with Dr. Lewthwaite that prompted them towards change.

Again, what follows is a more specific discussion of the results from the teachers who have been teaching for around 20+ years, around 10 years, and less than 6 years, as their experiences in secondary education and in the Faculty varied according to their number of years in the profession.

~20 + years of teaching: Noah, Mike and Kate

The qualitative data showed that for the teachers who had been teaching for around 20 years or more, their experiences as a student in secondary education were more focused on content and were teacher directed. There was lots of traditional teaching – lecture and seatwork – and this is how these participants tended to start out in their careers as well. The focus in their early years of was mainly working through content, with some activities and demonstrations here and there. Some participants just went along with what other colleagues were doing – especially in the beginning – while some participants with standard divisional exams or a provincial exam in chemistry, were forced to be more focused on the content due to the pressure. But, for the

most part, the participants spoke of trying to incorporate visual representations of chemistry where possible, although, the experimental work was mainly confirmation labs, they confess.

For these participants who had been teaching for around 20 years or more, the qualitative data showed that the latest chemistry curricula alone did not prompt teacher change, as Bronfenbrenner (1979) would suggest, but rather it was their association with Dr. Lewthwaite (in Noah's case) or their own work in graduate studies (in Mike and Kate's cases) that encouraged them to shift their professional identities and chemistry teaching practices when the latest chemistry curricula were introduced. These participants spoke of the fact that either their connection with Dr. Lewthwaite, or their own work in graduate studies had caused them to reflect upon their teaching practices and really focus on what the latest chemistry curricula was encouraging them to do, such as focusing more on student learning and understanding, and less on content.

The latest chemistry curricula, then, generally fit in with how these participants wanted to teach and made them reflect and wonder why they hadn't been doing it all along. For Kate, it was her reading of the current research into teaching and learning in chemistry that prompted her to reflect on her teaching practices:

> I think after reading all those articles it just made such sense. I looked over what I had been doing and realized it was all equations and memorizing algorithms or memorizing facts so, you know, to get [students] to understand it you have to go to the microscopic level and I just started doing that and, I am a visual learner, and I kind of questioned myself as to 'why haven't I been doing this more, in the past?'

Kate's reflection on her teaching practices as a result of reading the current research about teaching and learning brought about a kind of 'transformational learning' (Mezirow (1981) in her such that it caused her to challenge her own beliefs. In other words, the chemistry curricula alone were not enough to prompt a change in her – possibly because the latest chemistry curricula were not designed in such a way as to encourage the use of more humanistic STSE issues and multiple modes of representation in all of the outcomes, since rather this style of teaching is promoted mainly in the preface to the curriculum documents.

~10 year Teachers: Tom and Dave

The qualitative data showed that the two teachers, Tom and Dave, who have been teaching for around 10 years both had very positive high school experiences in science where the pedagogy was more learner focused, although with content still being a priority. They both also spoke of their exceptionally passionate and caring teachers. When they entered the teaching profession they both discovered that there was way more to teaching than they realized; there were other demands of the job that would occupy their time and their 'head space' such that a focus on the content was all they could do in the beginning. The qualitative data showed that both Tom and Dave, at some point in their careers, experienced the pressures of preparing students for a divisional exam in chemistry, and although they believed that science should be applied to everyday life, these demands and pressures prevented them from being the teacher they wanted to be. Tom discovered that more time, more preparation and more experience were required to teach in the more learner focused style suggested by the latest chemistry curricula. He wanted to teach for understanding but the demands of divisional exams forced his teaching to

be more content focused and teacher directed. He feared that if he was not getting through all the content, then he was not well-preparing his students for post-secondary science. His biggest tension was mastery of the concepts versus getting the content covered. Tom commented,

> You want to do right by the students especially the students who plan on going on and taking [chemistry] in the future, but you also want to make sure the kids are getting stuff before moving on, so it's trying to draw the fine line of mastery versus covering content and it's tough.

Tom's concerns are very real, and are supported by the research literature which indicate that "the ideologies of pre-professional scientific training, mental training, and screening for college entrance challenge any move to reform school science into a subject that embraces a humanistic perspective" (Fensham, as cited in Aitkenhead, 2003, p. 7).

Dave was also more content focused and teacher directed at the beginning of his career – mostly due to the fact that he was busy setting up his courses and teaching materials, but also because of his involvement in extra-curricular activities. So even though the first school division in which he taught was very 'loosey-goosey,' as he puts it, his inability to become a more learner focused teacher was a result of these other factors. When Dave transferred to his current school division, he had to make content his primary focus due to the pressure of preparing students for divisional exams, which was a huge tension for him.

The qualitative data showed that for the latest chemistry curricula Tom found the change difficult. He had just finished preparing all of his teaching materials for the *Transitional*

chemistry documents, and, being a math teacher first, he liked the heavy math component of the curricula. However, he gradually began to appreciate the latest chemistry curricula more and more as he became more accustomed to it and as he got his materials prepared. The qualitative data showed that Tom believed in using multiple modes of representation, but that he found it difficult to change his teaching practices based on what the latest curricula were suggesting. In other words, it would take more than just a new curriculum introduction to alter his teaching style. I could sense from Tom that, being the only chemistry teacher in his school, he was lacking the encouragement and support and dialoguing opportunities that a larger school with a larger science staff might have to offer. He commented about being a 'one man band' at his school, which could greatly hamper his attempts at implementing the latest chemistry curricula successfully. As Arnott (1994) states, teaching is a 'collective enterprise' and the interaction of teachers with one another is critical to the implementation success of any new initiatives. Also, according to Roehrig at al. (2007) school administrators should be providing structured time for teachers to work and plan together in the first year of any implementation project. They also believe in the importance of a 'trained teacher leader' such as a department head to guide the planning sessions. How is Tom to engage in this planning time as the sole chemistry teacher and science department head in his school?

The qualitative data showed that when the new chemistry curricula were introduced, Dave was still very focused on content due to the pressures of preparing students for divisional exams, and he too, wanted to teach chemistry using multiple modes of representation. The qualitative data showed that while Dave wanted to teach in this manner, the introduction of the latest curricula was not enough to change his teaching practices. The other pressures inherent in

the job were competing against his many attempts at implementing the latest curricula as intended. Although he bought in to what the latest chemistry curricula were suggesting, as Coenders et al. (2008) suggest, "even when teachers initially subscribe to a reform developed by others, there is no guarantee that the reform is implemented or sustained" (p. 321).

~6 years of teaching: Kristina, Holly, and Kevin

The qualitative data showed that Kristina was already oriented towards a more learner focused classroom approach from her experiences in teacher education. She was taught by some "great professors whose focus was on a learner centred mode of instruction." Kristina struggled to incorporate this in her classroom however, and often fell back on her more content focused and teacher directed methods due to in-class time constraints and the amount of preparation required for more learner focused activities. The qualitative data showed that she focused on straight content and math in the first few years of teaching, but that she desired to use more multiple modes of representation in her teaching of chemistry concepts. A few years into her career she was inspired by a SAG presentation by Dr. Lewthwaite, which changed her views on teaching. Kristina 'fell in love' with the molecular level representation of chemistry. She felt that the latest chemistry curriculum introduction fit in very much with how she wanted to teach. Although she was inspired to teach in this way, it was not enough to inspire her to make the changes necessary in her teaching to make multiple modes of representation in chemistry a classroom focus.

Holly was also greatly influenced from her professors in the Faculty and tried early on to be that kind of teacher who focuses on student understanding. She states that she was around a

‘5’ on the content focused to learner focused continuum. The qualitative data showed that Holly used to be much more intentional in teacher education about using multiple modes of representation in chemistry, but in her first few years of teaching, time was a tension for her and she would default to her more teacher directed instruction as a means of survival. When the latest chemistry curricula were introduced, then, she struggled especially with incorporating the more humanistic content due to a lack of time and lack of knowledge about some of the outcomes. She cited time constraints as her main challenge in researching and learning the more humanistic content to have enough confidence to teach it. As Barnett and Hodson state, “knowledge that enables teachers to feel more comfortable in the classroom and to enhance their sense of self is likely to be embraced; knowledge that increases anxiety or makes teachers feel inadequate will almost certainly be resisted or rejected” (as cited in Aitkenhead, 2003, p. 40). The qualitative data showed, then, that the latest curriculum fit in with how she wanted to teach, but she struggled to keep it going with all the demands inherent in the job, showing that it takes more than just a mandated curriculum document to effect teacher change.

Similarly, Kevin was really motivated to become a great teacher and apply, as a teacher, all that he learned from his great professors in teacher education. His high school experience was mainly teacher directed, but in a faculty of education he was exposed to a more learner focused approach to classroom instruction. Kevin’s main focus was to convey to students to “never be satisfied with what you know.” His first year of teaching in Cairo he describes as “not pedagogically good at all,” but he knew how he wanted to teach – using the learner focused methods he learned in the Faculty. The qualitative data showed that he also ended up being mainly content focused and teacher directed in his second year of teaching in Winnipeg, mainly

due to the need for survival. So, while his goal was to hit all four levels of understanding in chemistry, he was struggling due to time constraints. In fact he had to leave out a unit in both Grade 11 and Grade 12 chemistry so that he could attempt to teach using multiple modes of representation in the other units, which is a more time consuming approach. The qualitative data showed then, that while the latest curricula totally aligned with how he wanted to teach and was consistent with what he learned in teacher education, he was still struggling to implement the latest chemistry curricula as intended. When he reflects on his first group of students he taught in chemistry, he comments that the students were prepared for the university style of doing things (mainly lecture) as a result of being in his class, but,

> I didn't want to do things that way because it got them used to the style, but I knew from formative assessment and that, that it was almost like they were just learning processes ... they were not ingraining the information or they weren't understanding it to a level that I wanted them to.

The qualitative data showed that in many cases, the participants entered the teaching profession with illusions of grandeur and were surprised at how difficult it was to teach in a manner other than content focused and teacher directed. The demands on them were far too great and they were simply doing everything they could to survive. The qualitative data also showed that, in general, the participants were responding positively to the latest curricula, regardless of their backgrounds and early years of teaching. Despite this, many of them were struggling to implement a more learner focused style of instruction using multiple modes of representation, citing a lack of time as the main reason for not doing so. This was not surprising

as lack of time was identified as a major barrier to the implementation of an innovation in an extensive review of the literature by Fullan and Pomfret (1977).

Additionally, some participants felt that they didn't have the knowledge to implement the curricula as intended. Welch (1979) noted that in his 20-year study of science curriculum development that a lack of science content background causes teachers to feel insecure and thus they hesitate to implement new curricula. Furthermore, in Aitkenhead's (2003) review of several research studies, it was noted that when a humanistic perspective was introduced in new curricula, teachers did not feel they had adequate background knowledge to deal with humanistic content. Finally, others who had been teaching longer simply said that some of the more learner focused ideas weren't around when they began teaching and so they had already adopted their more content focused and teacher directed style by then. In fact many participants were unable to implement the latest chemistry curricula as intended until they became participants in the CRYSTAL professional development sessions as is discussed in the following research question.

The third research question was: What were teachers' perceptions of their changing professional identities and teaching practice as a result of their participation in the CRYSTAL professional development workshops?

Professional development is seen by many (for example, Supovitz and Turner, 2000) as the best bet for changing teaching practices. Studies show that one-time professional development sessions may not significantly change the ways that teachers teach, but when professional development is offered on a continuous basis, a significant change in teaching practices can occur (see, for example, Coenders, Terlouw & Dijkstra, 2008). In a previous study

of Manitoba teachers implementing a new science curriculum, the degree of implementation was closely related to attendance at in-services or workshops (Manitoba Education, Planning and Research, 1984).

The qualitative data showed that the CRYSTAL professional development sessions definitely influenced all eight participants in the study towards using multiple modes of representation in chemistry more often to explain chemistry concepts. In addition, the CRYSTAL participants were provided with ready-made resources to support the latest curricula, which as Brown and Edelson (2003) attest, can be a great asset to teachers who lack the required resource development expertise. All participants agreed that the resources were incredibly valuable to them in their implementation of the latest curricula.

As Noah commented, the professional development has made him aware of representing chemistry in multiple ways so that students will understand the concepts better. For Noah, the professional development sessions led him to a greater understanding of the nature of models in chemistry, something he relays to the students as well.

For Mike, the professional development sessions encouraged him to reflect more on his teaching practices, asking himself, “why do you do what you do?” This process of critical reflection on one’s teaching practices thus challenging old beliefs and ideologies and encouraging a work towards change illustrates the concept of ‘transformational learning as described by Mezirow (1994).

For Kristina, the professional development sessions gave her practical teaching resources that she could use in her classroom. A study by Coenders et al. (2008) noted that there were far fewer implementation problems when resource materials were developed to support a new chemistry curriculum, and so it is likely that these resources assisted her in implementing the latest chemistry curricula as intended. The professional development sessions also gave her the knowledge and confidence to use multiple modes of representation in her teaching of chemistry. She feels that this approach has made her a better teacher and she felt it gave her students a much better experience in chemistry. She stated that the professional development sessions made her reflect on how she could be teaching certain concepts better. Kristina states,

> I think there was a large amount of professional sharing that went on and we took things away from the other teachers that we might not have otherwise. It's very rare when you get to sit down with teachers who teach your own subjects and discuss difficulties and successes, and I think that was, in and of itself, a huge benefit of CRYSTAL.

Holly's response was similar to Kristina's in that she feels that the professional development sessions brought her back to what Dr. Lewthwaite taught her in university about the multiple modes of representation in chemistry. It caused her to reflect on and start thinking again about what she was doing in her classes. The sessions were a good reminder about how she should be approaching her teaching.

Kate says that she uses the professional development resources all the time – obtaining a comfort level with the new activities now and giving her something fresh to use after 20 years in the profession. The sessions have also caused her to reflect on her practice more and have forced

her to tweak her labs to make students think more and draw out what is happening at the molecular level.

For Tom and Dave, whose responses were similar, the professional development sessions caused them to use multiple modes of representation more often in their classrooms. As well, the sessions encouraged them to use a lot more simulations, more manipulatives, and a more inquiry-based approach to their investigations. Tom commented that, "it means a bit more to the students when they discover for themselves." The professional development sessions have also encouraged Dave and Tom to tweak their labs to use the multi-level approach more, where the students draw out what the molecules are doing. Tom states that he is also including a lot of the human element in his teaching now.

And finally, for Kevin, the CRYSTAL resources he obtained at the professional development sessions and from the website were, in his words, "fabulous." In fact he uses them as a primary resource for teaching. The professional development sessions were a huge influence on him, commenting that,

> The CRYSTAL [professional development] is set apart from anything I have been to ... [Dr. Lewthwaite] forces us to think deeply about what our students might be thinking or what their misconceptions are, and for us to reflect on that.

It is not surprising that the CRYSTAL professional development sessions impacted the participants greatly as it has been found elsewhere in the research literature that long-term professional development improved teachers' attitudes towards reform and their use of reform-

based and inquiry-based teaching practices (Supovitz & Turner, 2000, p. 965). As well, as Arnott (1994) states, the availability of resources is important in any implementation effort and especially in a science program which is "resource-based and activity-oriented" (p. 30). In fact, student survey data collected prior to this study has shown that teachers who have taken part in the CRYSTAL professional development sessions and who have been provided with these ready-made resources are using visual images, historical contexts, manipulatives, and explaining chemistry ideas at the molecular level more often, and are starting to abandon, to some extent, their more textbook-focused teaching style (Peltz & Lewthwaite, 2008).

In addition to these extremely valuable components of the professional development sessions, the qualitative data showed that the participants in this study reported that the being a part of a supportive community long-term was of great benefit to them. As Arnott (1994) suggests, teaching is a 'collective enterprise' in which the interaction of teachers with one another is critical to the success of any new initiatives. As Fullan notes, the quality of relationships among teachers is strongly related to implementation success (as cited in Arnott, 1994). As well, as Bronfenbrenner (1979) would suggest that relationships with close colleagues, being a microsystem level influence, might have a strong impact on the individual. The participants commented,

> [I like the] collegiality ... getting people together and bouncing ideas off one another, and sharing ... meeting several times during the year over several years ... you get to know the people better and I think there's a greater degree of sharing. [Mike]

> I kind of like the continued group over the years ... It was good. We kind of built community. ... It was kind of nice meeting people from other schools to learn how they do it. [Kate]

> You make those connections, you develop friendships. It's much better [than a one-shot professional development]. [Dave]

> For me, the connecting with colleagues was absolutely huge. [Kevin]

And for one participant, it was the building of trust over the course of the professional development sessions that impacted her the most:

> To have the same people attending [for all the sessions] you have a little bit more freedom to say what you think because for some people, having an open discussion requires a certain amount of trust and ... a lot of us are afraid of having our teaching practices critiqued ... so to have an open group of trust where we all want to learn and have something positive to say, it's really helpful. [Kristina]

In summary, the professional development sessions had a significant impact on all of the participants from the professional sharing and collegiality to the great resources, and also to the awakening they experienced in being encouraged to use multiple modes of representation in their teaching of chemistry more often. The qualitative data showed that the participants' professional identities were impacted greatly by their involvement in the CRYSTAL professional development sessions.

The fourth research question was: What were some of the tensions teachers have experienced throughout their teaching career associated with a potential conflict between their own beliefs and their current teaching practice, especially in response to the latest curriculum introduction?

Many of the participants spoke of time and the over-loaded curricula as being major tensions which have prevented them from teaching using multiple modes of representation in chemistry. The qualitative data showed, then, that while teachers supported the latest chemistry curricula in its orientation, many participants felt that they couldn't deliver the curricula completely and in the intended manner due to some of these tensions.

The qualitative data showed that Noah feels that the curricula are still too heavy and are laden with way too many calculations, making it "a big test of algebra, [leaving] the chemistry behind." He also feels that the large number of outcomes is "indicative of the lack of trust in teachers to be able to come up with something that's good ... it's way over prescribed in terms of time ... teachers should be given some leeway." While he feels that, "yeah, there are some things that should be prescribed," he also feels that teachers should be able to take things in a direction that they feel is important for their students at that time. Noah also commented that another factor preventing him from teaching the way he would like to is that, the students are asking for procedural teaching and learning, and he feels that that kind of learning is not going to help them if they go on to science – to figure out things that aren't known yet. Noah's comment about students wanting procedural teaching and learning is consistent with results from a recent research study (Lewthwaite & R. Wiebe, 2010), in which the authors provide an account of a

teacher of chemistry in Manitoba responding to the latest chemistry curricula in the manner intended, and allowing his students, in turn, to respond to his teaching of this latest curricula. Interestingly, the results showed that the students were not all completely on-board with this latest learner focused approach that the teacher was suggesting. Perhaps as another participant Mike commented to me earlier, this more learner focused type of instruction in science has to begin when students are in elementary school so that by the time they reach high school they are more accustomed to the style.

The qualitative data showed that Mike feels that the curricula – especially the Grade 12 – are still way too heavy and over-loaded with content:

> I still see the curriculum as being as set of content-based outcomes for the most part. So I still see it that way. ... There's still room to take that in to contextualize the concepts more – maybe reduce down some of the concepts and then take certain concepts and contextualize them.

Interestingly, the latest curricula provides little flexibility, though it advocates for a greater humanistic STSE focus, which implies that the curricula should be more flexible – particularly if one is to incorporate relevant contextual information to support the main content.

Mike also comments that he is never really satisfied with how he teaches now, mostly because of time. "I just don't have enough time to do things the way I want to do things," referring to the planning part of it. Another of Mike's big tensions are that he feels that students are not open to discovering and developing the concepts on their own, and are rather, "sitting

there and waiting for me to tell them what the answers are rather than them wanting to find the answers." Finally, Mike also mentioned the tension of preparing students for divisional exams. Although they are no longer, it was a big tension earlier on in his career.

For Kristina,

> I think that time is a huge factor ... the time within the classroom is limited ... time to prepare it all. [Kristina]

The qualitative data also showed that Kristina feels that she is lacking the necessary technology to show some of the online animations and simulations to students. Also, she feels that the curricula are still too heavy in that there is not enough time to get through entire document – especially if teaching using multiple modes of representation. She questions,

> ... do I eliminate one or two outcomes here that aren't really necessary in the big scope of things so that I can get at the ones in the other units? Or do I just do this unit in its entirety and in depth so that students have a greater understanding and then sacrifice something else?

Kristina also feels that many students like the procedural teaching and learning, which prevents her sometimes from delivering the curricula as intended.

The qualitative data showed that for Holly, a big tension for her is that her school division is on a big technology push, so that has been her focus more recently. She comments that in some ways it ties into what she learned during the professional development but in other

ways it has taken her focus away from using multiple modes of representation as she is trying to focus on technology. She feels, then, that she has lost the focus a bit due to school division pressures – an exosystem level (Bronfenbrenner, 1979) influence.

The qualitative data showed that, for Tom, the curricula are still too content-heavy and doesn't lend itself well to a more learner focused approach to instruction, stating, "if you want to cover the course, sometimes you've got to chug through it." Tom feels that he has had to drop some of the outcomes and he might even skip an entire unit in the Grade 12 chemistry course because it has far too many outcomes to cover in the allotted time. He also speaks of the students who want procedural teaching and learning which sometimes prevents him from using multiple modes of representation in his teaching of chemistry concepts.

For Kate, the qualitative data showed that time is always a factor that prevents her from teaching using multiple modes of representation as the curricula suggest, stating that the first thing to go is usually the activities or she would replace an activity with a demonstration instead as it takes up less time. This makes her teaching more content focused and teacher directed than she would like it to be, making her main tension the balance between covering the content versus mastery of concepts through the use of activities that incorporate a more multi-dimensional approach. "It is still a push to get it all in. We manage to cover everything, but in some places you wish you would spend a couple more days or have done an activity."

The qualitative data showed that Dave cites time and a heavy workload as some of his main tensions, calling it "really taxing at times." He also spoke of some of the board office decisions that have really disappointed him. In particular, he was faced with divisional exams

and then, when the divisional exams were abandoned, the board wanted to replace them with some kind of portfolio assessment or a year-end project. Dave strongly feels that this type of assessment won't prepare students well for university as they need the experience writing exams. He also feels that with below-average groups it is tough to cover the curriculum in its entirety (for both the Grades 11 and 12 curricula).

The qualitative data showed that a big tension for Kevin was that his relationships with his students suffered in the beginning due to his more teacher directed instruction:

> Because I am just struggling to get through the content, the kids don't really have a chance to work cooperatively and I don't have a chance to get in there and ask them deeper questions or poke at their understanding a little more or challenge them. So then it's like they almost seem less motivated too.

Also for Kevin, his other main tensions are that the students are not used to learning in multiple modes of representation and need to be taught the pedagogy first. Kevin also struggles with the lack of technology in his classroom to show simulations and do online labs, and a lack of lab space to do even a short demonstration or activity. As well, Kevin struggles with creating assessment to match his teaching with multiple modes of representation as his tests are mainly symbolic. Finally, Kevin's biggest tension is that the curricula activity suggestions are too vague – especially for chemistry minors. He feels that without a chemistry major, and even with one, newer teachers would struggle as he did with incorporating some of the suggested activities in the curriculum due to them being written as though they were for experienced chemistry teachers.

The qualitative data suggest then, that the participants continually struggle to implement the curricula as intended and according to their beliefs about teaching and learning due to the several tensions noted above. Time appears overwhelmingly as a tension that prevents these teachers from delivering the curricula using multiple modes of representation, and also, many participants spoke of the tension of parents and students who want more procedural teaching and learning, and also the tension of a lack of technology and over-loaded curricula. However, these factors, which in Bronfenbrenner's (1979) model are mainly mesosystem, microsystem and exosystem levels of influence, haven't entirely prevented these teachers from implementing the curricula as intended, as the CRYSTAL professional development sessions so strongly influenced them that they continue to attempt whenever possible to include all levels of understanding in their teaching of chemistry concepts. Many participants feel, however, that they still have a long way to go towards achieving a greater learner focus in their classrooms. Perhaps these tensions are challenging them to reflect even more on their practice and are causing them to seek greater improvement in their teaching practice.

The fifth research question was: Are teachers satisfied with their current teaching practices? And, what are some of the ways their teaching practices have changed over the years and what factors do they attribute the changes to?

The qualitative data showed that many participants are still drawing from the CRYSTAL resources and from what they learned at the CRYSTAL professional development sessions, and comment that during CRYSTAL there was definitely lots of growth with regards to their teaching practices. However, after a few years of no professional development, some have

plateaued and some have experienced lulls here and there, while many still make what they learned from CRYSTAL part of their daily repertoire. Are these teachers satisfied with their teaching, then? And, how have their teaching practices changed over the years?

The research literature would suggest that continuous professional development and resource support are paramount with respect to teachers' teaching practices. For example, Supovitz, Mayer, and Kahle found that,

> Highly intensive (160 h), inquiry-based professional development changed teachers' attitudes towards reform, their preparation to use reform-based practices, and their use of inquiry-based teaching practices. Further, they found that these changes persisted several years after teachers concluded their experience (as cited in Supovitz & Turner, 2000, p. 965).

In addition, it is perhaps also the microsystem level (Bronfenbrenner, 1979) influence of the relationships with close colleagues that were developed at these professional development sessions that have inspired the participants to continue to use the information and resources they gained from the professional development sessions.

The qualitative data showed that Noah is mostly satisfied with his teaching and is constantly "trying to refine the craft." Noah stated that the CRYSTAL professional development caused him to think more, made him more unsure, and made him question himself more, leading him to conduct his classroom in a more learner focused manner. However, he still comments that,

> A good chunk of what we do is teacher centred, quite frankly, because for well, some of the things that I mentioned, there's an expectation that we will do that and we will teach as opposed to just giving some assignments, or let's look at this and then getting the kids to figure this out.

So, Noah says that while he has progressed to being far less teacher centred now, he can't completely leave the teacher centeredness, because "we have not made students independent enough learners to be able to do things on their own." As I looked back over Noah's story, I noted that his professional identity had evolved through the change in curricula and supportive professional development such that he was thinking about and reflecting more on his teaching practice, and also trying to improve his practice, despite the many tensions that he faced.

The qualitative data showed that, for Mike, the CRYSTAL professional development along with his work in graduate studies have led him to be generally dissatisfied with the way he teaches and always asking himself the question, "why are we teaching what we are teaching?" and "why on Earth do we teach this and why do we teach it this way?" He has been asking himself these questions and is never really satisfied with the way he teaches now mostly because of time. "I just don't have enough time to do things the way I want to do things, to plan it – mostly for prep work, for one." However, Mike also comments that the resources and simulations he obtained during his involvement with CRYSTAL were very beneficial, causing him to now focus less on content and more on understanding, and developing more activity-based lessons where the students develop concepts on their own more. He also attributes his progress in teaching to knowing the content a whole lot better now than he did when he first

began teaching. As I looked back over Mike's story, it was obvious that his professional identity had evolved through the change in curricula and supportive professional development, as well as through his experience in graduate studies, such that he was questioning himself a lot more now and reflecting more on his teaching practice, and also trying to improve his practice. And although he has faced the tension of time constraints on an ongoing basis, he still has managed to make use of the CRYSTAL resources and simulations more often in his classroom and has tried to focus more on teaching using multiple modes of representation and human context.

The qualitative data showed that Kristina is not completely satisfied with her teaching.

> Am I satisfied with my teaching? I would have to say there is always room for improvement. Sometimes I am just thrilled with my teaching because I just thought it was a fabulous lesson and the kids got it and I threw in all sort of analogies and representations or did this experiment. And then other times that I am definitely not satisfied with my teaching where I think I just threw a lesson up on the board and it's teacher directed because that's all I could do at the time. And that is usually because of time restrictions.

Kristina elaborated on her comments by stating that because of the major focus an assessment in her school division, that her development of more learner focused activities has been sidetracked a little bit, citing time as her main tension. She did state that, however, that the CRYSTAL sessions have had a huge impact on her teaching practices – meaning the use of more hands on activities and more games in her classroom. Although she was already tended that way, the CRYSTAL professional development motivated her to continue to do that. She states that there

was lots of growth during CRYSTAL but that she has plateaued a bit now and has not seen much growth in the past year. As I looked back over Kristina's story, I noted that her professional identity had evolved through the change in curricula and supportive professional development, but even though she was already tended towards more constructivist and humanistic methods and often used them in her classroom, she sometimes became sidetracked when school division pressures changed her focus. So, while she was greatly impacted by the CRYSTAL professional development, the tensions she experienced caused her to plateau every now and then, but I sensed from her that she was continually reflecting on her teaching practice and also trying to improve her practice, despite the many tensions she experienced.

The qualitative data showed that Holly is not satisfied with her teaching now. She feels that she 'spoon-feeds' her students too much and wants to put more ownership on the kids, but finds that some have such low literacy they can't find information on their own. She struggles then with not feeling like she is preparing her students well for university. Holly says though that she has become more learner focused and less teacher directed now, which she attributes to both the professional development sessions and having more teaching experience. Holly comments that "when you're less familiar with the content, you want to be more structured because it's more controlled." As I looked back over Holly's story, I noted that her professional identity had evolved through the change in curricula and supportive professional development such that she was more learner focused now and less teacher directed. She also attributes the changes in her teaching to a few more years of experience under her belt. She seems to be thinking about and reflecting more on her practice, and also trying to improve her practice, despite the many tensions such as time that seems a constant battle for her.

The qualitative data showed that Tom is somewhat satisfied with his current teaching practices:

> I think all in all I am more satisfied with my teaching because I am going to a more student centred classroom, but I mean there is still those tensions there and I think the biggest one is covering the material and finding that balance between mastery and just getting through it.

Speaking of the few years that have passed since the professional development sessions, Tom commented that he is now incorporating multiple modes of representation more often as time goes by, but with lulls here and there. He feels that it is something he constantly has to work at it, and is always trying to improve his teaching and seek out new ideas. He feels that sometimes it is easy to fall back into his old rut again after no professional development in the last while. As I looked back over Tom's story, it was interesting to note the changes in his professional identity over time. For example, a result of the latest curriculum and CRYSTAL professional development, Tom says he now puts more ownership on the students and spends less time lecturing, modelling and practicing and more time investigating. He attributes his changes in his teaching practice to more experience, more time, more comfort level, more professional development (CRYSTAL) and more dialoguing with colleagues. He feels that he is still trying to work towards a more learner focused approach, but that the curricula are still far too content-heavy and doesn't lend itself well to a learner focused environment.

The qualitative data showed that Kate is still incorporating multiple modes of representation in her classroom, stating that "it's been really ingrained in me and my materials ...

I would even say in the tests as well." She says that she now incorporates more links to everyday life and is going away from the rigor for university preparation. She feels that her lessons are now more inquiry-based and more about having students explore ideas on their own. Kate comments, "no, I'll never be satisfied with my teaching." She feels that now since she is transferring everything to PowerPoint and can now animate things and include more clip art, video links and applications, that the incorporation of technology is helping a lot with her use of multiple modes of representation. As I looked back over Kate's story, I noted that her professional identity had indeed evolved through the change in curricula and supportive professional development such that she was using the CRYSTAL resources more and thinking about and reflecting more on her teaching practice. Also, it seems that her practice has indeed improved, despite some of the tensions she has faced, based on her comments regarding her use of more inquiry-based activities and focusing more on using multiple modes of representation in her teaching.

The qualitative data showed that Dave is not satisfied with his teaching now. "I don't think I'll ever be satisfied, I'm always changing things. You know, I think the minute your satisfied you might as well retire." Dave says that he always wants to do more and wants to be better, commenting that he would like to see the professional development come back in a few years to see where everyone is at. He feels he is doing a lot of the same things now and not as many new things and needs some new ideas and more networking with other teachers. He does feel that he is more learner focused now – attributing this to not only the professional development but also to knowing the material better. As I looked back over Dave's story, it was obvious that his professional identity had indeed evolved through the change in curricula and

professional development and peaked at the point where he was still attending the professional development sessions. Since that time, he has admitted to plateauing a bit due to the professional development ending, but still continues to use the resources he obtained at the sessions and has placed a greater emphasis on the use of technology in his classroom. Despite the fact that he has plateaued, he still feels that he is more learner focused now as compared to when he began teaching.

The qualitative data showed that Kevin feels that he is much more effective now because he has more experience and that he is getting closer to where he wants to be every year. He sees himself now more a facilitator of learning and feels he has come a long way from his first year of teaching chemistry which he describes as mainly 'expository teaching' to the point where now he is more learner focused and building those relationships with the students. As I looked back over Kevin's story, I noted that his professional identity had evolved through the change in curricula and supportive professional development such that he was orienting himself towards a more learner focused classroom. It seems that he is also thinking more and reflecting more on his teaching practice, and also trying to improve his practice through his more consistent use of multiple modes of representation in his teaching.

In general, the participants were not entirely satisfied with their teaching practices – as evidenced in the tensions previously described – but many of them were so strongly influenced by the CRYSTAL professional development sessions, that they felt that they had at least shifted their beliefs about teaching and learning such that they were focusing more on learners' understanding by incorporating multiple modes of representation and human context in their

teaching more often. Although some of the participants have experienced lulls within the 2 years since the professional development has ended, they seem to more firmly believe that a more constructivist and humanistic, or learner focused, approach to teaching and learning is best if they want their students understanding of chemistry concepts to be enhanced. However, the fact that none of the participants were completely satisfied with their current teaching practices indicates that they still believe they have a long way to go towards a truly learner focused classroom. Perhaps ongoing professional development, and especially the meaningful collegial interactions, is what are needed to continue to inspire them towards a greater emphasis on humanistic STSE applications and the use of multiple modes of representation in chemistry. After all, as Krajcik et al. reported, teachers' beliefs were beginning to change only after long periods of professional development (as cited in Roehrig et al.). As documented, it was determined that "even in the most intensive professional development or pre-service programs, changes in beliefs usually only occur for teachers predisposed to the goals of the professional development program" (Holt-Reynolds; Krajcik et al.; Richardson; as cited in Roehrig et al., 2007, p. 886).

Perhaps, however, the participants' beliefs about teaching and learning haven't been significantly impacted, since after all, each individual teacher will teach according to their own beliefs and values (Stake & Easly, as cited in Gehrke, Knapp & Sirotnik, 1992). These beliefs and values are often based on the experiences these teachers had when they themselves were students (Tsai, 2002) and may be very difficult to change completely. I, myself, am guilty of being content focused, despite what I know now about effective teaching and learning in science. This could be due to my own traditional experiences in high school science and also a result of

being in an academic science program prior to entering a faculty of education. The tensions these teachers continue to experience may result exclusively from realizing what they know is good teaching practice, but an inability or determined commitment to become the teacher they would like to be. The professional development sessions may have alerted these teachers to more effective methods of teaching and learning in chemistry, but unless the professional development continues, it might be very easy for these teachers to fall back on their more content focused and teacher directed ways. This is because, if there is no reason to address the tensions, teachers will likely continue to coast in their roles, and teacher change will thus be unlikely.

> Finally, the sixth research question was: How do the personal stories of the teachers participating in the study influence my own professional learning?

Each of the participants' stories impacted me in some way. I could relate to them all in one way or another, and in many ways, our stories were incredibly similar. I learned about what brought the participants into the teaching profession and what their early years of teaching were like, and that for many participants, their experiences were not unlike my own. I learned about what the participants' main tensions were in their early years of teaching and how they struggled to settle those tensions. I learned how the latest chemistry curricula began to shift their thinking about teaching and learning, and how the CRYSTAL professional development sessions caused tensions in their beliefs about teaching and learning and greatly influenced their teaching practices, particularly in the short-term. I have learned from the participants about the benefits of having a professional sharing community, such as that which was established during the CRYSTAL professional development sessions. I have learned from the participants that change

is difficult, but that it is both necessary and certain in the field of education. We can either embrace change for the benefits of our students, or we can try to ignore change, much to their detriment. Teachers can learn new ways of doing things and apply those ways of doing things – particularly with the necessary supports in place, but without these supports, I have learned from the participants that it is quite easy to fall back on our old ways of doing things – such as the teacher directed and content focused methods of teaching that we as teachers have all embraced at some point in our careers. I have learned from the participants that some of the current pressures they struggle with such as time to deliver a curriculum as intended, are not unlike the tensions I experienced as a teacher as well. Finally, I have learned that to become a truly learner focused teacher might require much more than the professional learning opportunities the CRYSTAL professional development sessions offer. I have learned that the sessions certainly exposed teachers to new ways of doing things, but that it may not have been enough to fully change their beliefs about teaching and learning and it may not have been enough to encourage them to continue using these teaching practices regularly, as impediments to change abound and prevent them from becoming the teachers they would like to be. In fact, more continuous long-term professional development such as that which was offered in the CRYSTAL sessions might be the only way to continue to impact these teachers' teaching practices. The qualitative data indicated that teachers need those constant reminders, or else fall back on their more content focused and teacher directed ways. In the absence of those reminders, tensions pertaining to what we believe we should be doing as teachers, how we should be teaching and what we should be teaching aren't likely to be addressed, and thus change will be unlikely. After all, it is these tensions associated with our professional beliefs about teaching and learning that cause us

teachers to be in a state of disequilibrium. Thus, teaching and learning in chemistry is only likely to improve if we, as teachers, seek to settle those tensions and continually seek improvement in our practice.

Consequently, as I read through and digested the participants' stories, I was not surprised at the parallels. As teachers we all seem to wrestle with the same issues and have the same struggles, yet we continue to seek growth and continually evolve as changes come our way and as the focus in education changes. I can only hope that the participants' teaching practices, and my own as well, continue to improve and align with what is deemed to be research-based best practice (Awenowicz, 2009) in chemistry.

Finally, having shared our stories with each other, I have felt personally connected to the participants through our conversations and email exchanges, such that, at the very least, I have gained eight new collegial relationships with the participants that I will have the opportunity to professionally share with in the future.

The findings of this study have been summarized by addressing the six research questions, which has revealed teachers' evolving professional identities in response to curriculum change and professional development, and has provided some indication that the manner in which a teacher implements a given curriculum is based on their professional identities, or more specifically their beliefs about teaching and learning. Teachers have revealed some tensions associated with how they want to teach and how they are actually teaching and many are still not satisfied with their current teaching practices. The findings indicated, however, that teachers feel that the professional development associated with the latest chemistry

curriculum introduction has greatly influenced their professional identities and has improved their teaching practices. The next section highlights some implications this research has for teachers, teacher educators and Ministers of Education.

5.4: Implications of the Research

By examining teachers' evolving professional identities as they journeyed through school, teacher education and their teaching careers, this study contributes to the current research literature and to teachers' own understandings of what has shaped their professional identities, how they negotiate the tensions associated with how they want to teach and how they are actually teaching, and how their teaching practice continues to be impacted as their professional identities continue to evolve through factors such as curriculum changes and reflective practice associated with long-term professional development.

As mentioned in section 1.6, the major implication of this study is that if teachers' professional identities are evolving and they are changing their teaching practices as a result of exposure to long-term professional development where reflection on teaching practice is enhanced and encouraged, then teacher support in the form of long-term professional development is an important and necessary component of the curriculum implementation process if teacher growth is being sought.

Thus, this study will be especially significant to chemistry teachers in Manitoba concerned with implementing the latest chemistry curricula in the manner intended by its developers, which includes a more constructivist and humanistic, or learner focused, approach

incorporating multiple modes of representation and human context. In addition, this study will be of importance to those chemistry teachers who want to work at re-defining their professional identities and chemistry teaching practice through ongoing reflective practice and professional development, and by incorporating research-based best practice (Awenowicz, 2009) into their teaching. Additionally, the understanding gained from this research will inform my future teaching practice and will contribute to a greater understanding of professional identity and teaching and learning in chemistry for all chemistry educators.

Some implications of this research not previously mentioned and that were realized upon conclusion of this study are those implications for teacher educators and students in and education faculty, as well as professional development leaders and Ministers of Education. The implications for teacher educators is that students in an education faculty need to be presented with the concept of professional identity and be given opportunities to examine where their beliefs about teaching and learning lie and whether their beliefs align with the intentions of a given curriculum document. Because, as research suggests (see Coenders at al., 2008), a given curriculum will only be implemented as intended if it aligns with teachers' beliefs about teaching and learning. This study also has implications for professional development leaders as they must understand adult learning theory (Mezirow, 1981) if they are hoping to facilitate teacher development. Finally, this study has implications for Ministers of Education since they must understand that mandating a new curriculum document is not going to ensure its implementation without long-term professional development to support the intended curricula.

To date, there have been no other studies (as far as I am aware) on teacher professional identity shifts following a change in the Manitoba science curricula and professional development support. In fact, although there are several studies regarding the concept of teacher professional identity, there is a paucity of information in the literature regarding secondary science teacher professional identity. Thus, this study serves fill a gap in the literature in this area.

5.5: Summary

This chapter included an overview of the study followed by answers to the six research questions posed including an analysis the data with respect to the research literature and Bronfenbrenner's (1979) Model of the Ecology of Human Development. In addition, implications of the study for teachers, teacher educators, Faculty students and Minsters of Education were presented.

Chapter 6: Conclusions and Opportunities for Further Research

6.1: Conclusions

The title of this research study is *Exploring Professional Identity in Response to Curriculum Reform and Professional Development: The Teaching Life Stories of Chemistry Teachers*, and represents the main purpose of the study which was to explore the professional identity changes over time of eight teachers of chemistry in Manitoba.

Specifically, the purpose of this study was to gain some insight into teachers' evolving professional identities by determining what motivated them to enter the teaching profession, what their experiences were like in teacher education, what their experiences have been like as teachers of chemistry and what motivates them to teach the way they do now. In addition, specific questions were asked of the participants so as to determine how they were responding to the orientation latest chemistry curricula in Manitoba with its more constructivist and humanistic, or learner focused, approach and emphasis on multiple modes of representation, and whether they feel that their participation in the CRYSTAL professional development workshops have assisted with any changes in their teaching practice, both during the sessions and after the sessions had ended. Finally, this study aimed to determine what might be some of the professional tensions associated with a potential change in teachers' beliefs and teaching practice as a result of a new curriculum introduction.

This study, then, began with my own personal teaching life story that prompted me to want to hear the stories of others, while also answering the following six research questions:

1. What were some of the influences/motivations on teachers' decision to enter the teaching profession?

2. What were teachers' perceptions of their changing professional identities and teaching practice prior to and as a result of the introduction of the latest Manitoba chemistry curricula?

3. What were teachers' perceptions of their changing professional identities and teaching practice as a result of their participation in the CRYSTAL professional development workshops?

4. What were some of the tensions teachers have experienced throughout their teaching career associated with a potential conflict between their own beliefs and their current teaching practice, especially in response to the latest curriculum introduction?

5. Are teachers satisfied with their current teaching practices? And, what are some of the ways their teaching practices have changed over the years and what factors do they attribute the changes to?

6. How do the personal stories of the teachers participating in the study influence my own professional learning?

The research questions were answered through a narrative inquiry approach in which narrative interviews were conducted over the telephone with eight teachers of chemistry in Manitoba who were faced with implementing a new set of chemistry curricula and who participated in long-term professional development associated with the latest curricula. The narrative interview questions centred on their evolving professional identities through their school and work experiences. The interviews were analyzed using the process of narrative representation and thematic analysis whereby the teaching life stories of the participants were created from their narrative interviews. Finally, the stories were analyzed with respect to the research literature and Bronfenbrenner's (1979) Model of the Ecology of Human Development.

Again, the findings of this study revealed teachers' evolving professional identities in response to curriculum change and professional development. As well, it has provided some indication that the manner in which a teacher implements a given curriculum is based on their professional identity, or more specifically their beliefs about teaching and learning. Teachers have revealed some tensions associated with how they want to teach and how they are actually teaching and many are still not satisfied with their current teaching practices. The findings indicated, however, that teachers feel that professional development associated with the latest chemistry curriculum introduction has greatly influenced their professional identity and has improved their teaching practices.

Finally, this study has revealed an understanding of the primary influence of tensions on professional growth. I have learned that it is the tensions we as teachers experience that cause a particular disequilibrium or imbalance in our beliefs about teaching and learning, and that this

imbalance causes us to seek out ways to improve our teaching, and can, potentially, lead to teacher change. Without this imbalance in our thinking, however, we would continue on teaching as we always had, and, as I did, with very little growth and development. My own professional identity has certainly evolved through my conversations with the participants and as I have prepared this thesis, such that it has made me realize that in my last few years of teaching I was simply 'coasting' in my role as a teacher. Although slight improvements in my teaching were apparent as my subject matter knowledge and my confidence improved, my beliefs about effective teaching to promote learning were not being challenged as I didn't experience the significant tensions of a curriculum change, nor was I challenged through professional development as the participants were. I have, thus, realized that a disequilibrium or imbalance in one's beliefs about teaching and learning is a necessary component of teacher growth and development.

Finally, the results of the study indicated that teacher change to support what the latest curricula are suggesting has, in fact, been gradual, but that it has been propelled by the participants' involvement in long-term professional development and its associated reflection component provided by teacher educators at the University of Manitoba. As well, the participants' stories have revealed that to continue to settle some of the tensions they have experienced and to propel further change in their practice, continuous long-term professional development or, at least, an opportunity to engage in critical dialogue about teaching practice is likely vital.

6.2: Opportunities for Further Research

Previous research, confirmed by this study, has shown that teacher change is both difficult and gradual, but that it can be propelled by professional development to support the implementation of new initiatives (see Supovitz and Turner, 2000). Thus, a mandated curriculum document will not likely bring about change in teachers, but rather, as Bronfenbrenner (1979) suggests, it will be interactions of the teacher in his or her own microsystem that are more likely to bring about teacher change. The research suggests that teacher beliefs and dispositions are a key factor in contributing to change (Roehrig at al., 2007), as is involvement in long-term professional development (Coenders, Terlouw & Dijkstra, 2008) in bringing about teacher change.

This study has contributed to the research literature by illustrating teachers' evolving professional identities as they journeyed through school, teacher education and their teaching careers, and illustrates their response to curriculum change and how they feel that the associated professional development has impacted their teaching practices. This study has also contributed to teachers' own understandings of what has shaped their professional identities, how they negotiate the tensions associated with how they want to teach, how they are actually teaching, and how their teaching practice continues to be impacted as their professional identities continue to evolve through factors such as curriculum changes, professional development and reflective practice.

Despite these contributions to the research literature and to teachers as well, the results I reported need to be supported by further research and a larger study.

My suggestions for future research include:

1. A larger study involving other teachers of chemistry in Manitoba who have been faced with implementing the latest curricula and who have participated in long-term professional development to support the latest curricula so as to verify the findings of this study.
2. A study in which actual teaching practices of chemistry teachers are observed before and after a curriculum change and long-term professional development, rather than just teacher perceptions of their teaching practices.
3. A larger-scale study on teacher satisfaction in chemistry to determine whether teacher satisfaction is dependent on the support they receive.
4. A study which examines the effects on teacher growth and development of principal support as a curriculum leader vs. principal support as an administrator or manager, to determine if the presence of a curriculum leader has an effect on teachers and if it facilitates teacher change.

6.3: Chapter Summary

This chapter concluded the study by presenting an overview of the entire study with concluding remarks regarding the results of the data analysis, followed by my suggestions for further research in the area of teacher professional identity.

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Appendices

Appendix 1: Teacher Interview Questions March-April 2009

1. How long have you been teaching chemistry? What is your response to the new curriculum?

2. The new curriculum attempts to provide a more balanced exposure to chemistry by making connections between the more abstract (symbolic, quantitative) levels and the visual (molecular) and the experimental lab level and applications of chemistry to everyday life. What is your response to this?

3. Do you see this more integrated or balanced approach being evident in your teaching? To what degree? Can you give me an example?

4. How are the students responding to this? Does it assist them in their learning? If they are responding positively, does this influence you to do it more?

5. If you look back over the time you have been associated with CRYSTAL, do you think your teaching practice has changed in any ways, either slight or major? If so, how? Are you satisfied with the degree of change? Explain.

6. Over the time you have been associated with CRYSTAL, do you think your thinking about your teaching has changed? That is, are you thinking more or differently about your teaching? If so, how?

7. If you are thinking considerably about your teaching, what is influencing you in not making, or in making these thoughts more evident in your teaching behaviour? So, if you are thinking about changes, what is making these changes happen or not?

8. One suggestion of the new curriculum is to expose students to the 'human element' of chemistry, i.e. the stories behind chemistry – people, events, applications and the environment. Does this happen in your classroom? What assists you in making these connections? Why do you make these connections?

Do you have any further comments?

Appendix 2: Ethics Approval Certificate

UNIVERSITY OF MANITOBA | Ethics
Office of the Vice-President (Research)

CTC Building
208 - 194 Dafoe Road
Winnipeg, MB R3T 2N2
Fax (204) 269-7173
www.umanitoba.ca/research

APPROVAL CERTIFICATE

April 4, 2011

TO: **Gayle Peters** **(Advisor B. Lewthwaite)**
Principal Investigator

FROM: **Stan Straw, Chair**
Education/Nursing Research Ethics Board (ENREB)

Re: **Protocol #E2011:024**
"Teachers' Perceptions of Shifts in their Professional Identities and Chemistry Teaching Practice"

Please be advised that your above-referenced protocol has received human ethics approval by the **Education/Nursing Research Ethics Board**, which is organized and operates according to the Tri-Council Policy Statement. This approval is valid for one year only.

Any significant changes of the protocol and/or informed consent form should be reported to the Human Ethics Secretariat in advance of implementation of such changes.

Please note:

- **If you have funds pending human ethics approval, the auditor requires that you submit a copy of this Approval Certificate to the Office of Research Services, fax 261-0325 - please include the name of the funding agency and your UM Project number. This must be faxed before your account can be accessed.**

- **if you have received multi-year funding for this research, responsibility lies with you to apply for and obtain Renewal Approval at the expiry of the initial one-year approval; otherwise the account will be locked.**

The Research Ethics Board requests a final report for your study (available at: http://umanitoba.ca/research/ors/ethics/ors_ethics_human_REB_forms_guidelines.html) **in order to be in compliance with Tri-Council Guidelines.**

Bringing Research to Life

Appendix 3: Email Letter to Participants

Dear Colleagues,

Re: Master's Thesis Research Project

I have been working on my Master's of Education degree with Dr. Lewthwaite at the University of Manitoba, and for my thesis I hope to interview chemistry teachers who I spoke with in 2009 that were a part of the CRYSTAL professional development workshops. Of the 32 teachers I interviewed, 8 were selected by both Brian and me to participate in this follow-up interview for my thesis. You were chosen as one of those 8 participants based on your responses during the preliminary interviews and based on Brian's perceptions of you as your facilitator during the professional development sessions. In other words, you are a select group of teachers whom we feel will contribute greatly to this research study.

So, as a teacher of chemistry who has been a part of implementing the latest chemistry curricula in Manitoba, you have been exposed to curricula which advocates for a more multidimensional approach to the teaching of chemistry. This change in curriculum may have required you to change your own personal beliefs about teaching and learning and may have required you to modify your instructional practices. When we spoke in the spring of 2009, I was able to get a good sense of how you responded to the latest chemistry curricula and how you were implementing these curricula in your classrooms. And now, 2 years later, I am interested in speaking with you again, by telephone, for approximately 30-45 minutes to discuss

your evolving teacher identity. I will specifically ask you to discuss what brought you into the teaching profession and what your motivations were for becoming a teacher. I will also ask you about your experience in teacher education, about your early years in teaching, and how the latest chemistry curricula and supporting professional development have impacted your teaching today. So, essentially, I would like for you to tell me your teaching life story. Your participation in my research study can greatly enhance our understanding of some of the tensions associated with a change in curriculum and how this impacts our teacher identities.

The interview questions are attached so that you will have the opportunity to reflect on the questions ahead of the interview should you choose to participate in my study. I have also enclosed a more detailed letter of intent and a consent form for you to sign and return, again, should you choose to participate.

Please respond to this email with your intention to participate in this study, and include **a few possible times to reach you** within the next few weeks and a **contact number** as well. Evenings or weekends are the best time for me to contact you.

As a fellow teacher of chemistry I understand how incredibly busy you are. I would really appreciate you making the time to contribute to this research study.
Thanks in advance for your cooperation!

Gayle

Appendix 4: Letter of Intent and Teacher Consent form

Letter of Intent, Teachers

Letter of Consent, Teachers

Free and Informed Consent

Research Project Title: Teachers' Perceptions of Shifts in their Professional Identities and chemistry Teaching Practice.

Principal Investigator: Gayle Peters

MEd. Thesis Advisor: Dr. Brian Lewthwaite

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

Dear Colleague,

As a teacher of chemistry who has been a part of implementing the latest chemistry curricula in Manitoba, you have been exposed to curricula which advocates for a more multidimensional approach to the teaching of chemistry that may or may not have required you to modify your beliefs and instructional practices. Your participation in my research study can greatly enhance our understanding of some of the tensions associated with curriculum change – particularly when it requires one to shift their professional identities and teaching practices to become more aligned with what the latest curricula are proposing.

When we spoke in the spring of 2009, I was able to get a good sense of where you were at with your teaching of the new chemistry curricula, and now, 2 years later, I am interested in speaking with you again, by telephone, for approximately 30-45 minutes to discuss your present beliefs and teaching practices. I will specifically ask you to discuss what brought you into the teaching profession and what your motivations were for becoming a teacher. I am also hoping you can tell me about your experience in teacher education, about your early years in teaching, and how the latest chemistry curricula and supporting professional development have impacted your teaching today. I am also hoping to understand some of the tensions you have experienced associated with a change in the chemistry curriculum.

The telephone interviews will be audio-taped using a digital recorder and then immediately transferred to a password-protected computer. Interviews will be transcribed verbatim by me, the principal researcher, and participants will be sent the transcripts for verification.

This research study does not involve any risk, and may be a benefit to all of us chemistry educators as it will provide important insight into the effect of a curriculum change on our evolving professional identities.

This research will lead to the creation of my M. Ed. thesis. Your participation in this research is voluntary and your confidentiality and anonymity are assured. All data collected will be transcribed by me, the principal researcher, and participant names will not be shared with anyone, including my thesis advisor or my advisory committee. Pseudonyms will be used for all participants in the final thesis. All data collected will be kept in a password protected computer in my locked home and will be destroyed within 5 years. If you agree to participate, you will be provided with a summary of the research results via email by April, 2012.

Please respond to this email with your intention to participate in this study, and include a few possible times to reach you and a contact number as well. I have enclosed the interview questions so that you may reflect on them ahead of the interview. The use of this data will be limited to this research, as authorized by the University of Manitoba. You also have the opportunity to express concerns to me or with my thesis advisor Dr. Brian Lewthwaite at the Department of Education at the University of Manitoba. Our contact information is below.

I greatly appreciate your participation in this research. Again, I understand the incredible amount of time you put in to your job. I genuinely appreciate your time and your contribution to this research study.

Thank you. I look forward to speaking with you again!

Sincerely,

Gayle Peters

g_peters@bell.net

[redacted]

Advisor: Dr. Brian Lewthwaite

lewthwai@cc.umantioba.ca

[redacted]

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

Simply email me, the principal researcher, if you wish to withdraw from the study and all data collected to that point will be destroyed.

The University of Manitoba Research Ethics Board(s) and a representative(s) of the University of Manitoba Research Quality Management / Assurance office may also require access to your research records for safety and quality assurance purposes.

This research has been approved by the Education/Nursing Research Ethics Board at the University of Manitoba. If you have any concerns or complaints about this project you may contact any of the above-named persons or the Human Ethics Coordinator (HEC) Margaret (Maggie) Bowman at 474-7122. A copy of this consent form has been given to you to keep for your records and reference.

Please sign, and send back to me, the principal researcher, either by fax ([redacted]), email (g_peters@bell.net), or postal mail ([redacted]). Thank you.

Participant's Signature _____ Date _____

I would like to receive a summary report of the findings:

_____ _____

Yes No

Please mail a summary report of the findings at:

_____

_____

_____

Appendix 5: Narrative Interview Questions 2011

1. What brought you into the teaching profession? Can you tell me about that?

2. What were your motivations for becoming a teacher? Were there any life experiences, maybe significant ones, which led you into becoming a teacher?

3. Describe your experience in teacher education. What did you see as being the role of a science/chemistry teacher? What was of importance to you?

4. Looking back on your early years of teaching, what was the emphasis of your teaching? What was important to you? Were there any tensions associated with how you wanted to teach and how you were actually teaching?

5. How did you respond to the orientation of the latest chemistry curricula? Did it fit with the way you wanted to teach?

6. In what ways has the CRYSTAL professional development influenced your teaching?

7. Tell me about your teaching now. What is important to you now as a teacher? Why do you teach the way you do?

8. Are you satisfied with your teaching? Are there tensions between the way you teach and the way you would like to teach?

9. Summarize the major ways your teaching has changed over the years you have been a teacher and indicate what the major contributors to these changes have been.